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TRANSACTIONS

OF THE

WISCONSIN ACADEMY

OF

SCIENCES, ARTS, AND LETTERS.

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CONTENTS.

TITLES OF PAPERS PUBLISHED IN THIS VOLUME.

DEPARTMENT OF SOCIAL AND POLITICAL SCIENCES.

PEASANT COMMUNITIES IN FRANCE.

By WILLIAM F. ALLEN,
Professor of Latin and History in the University of Wisconsin.

The investigations into the system of collective property in land, which have recently thrown so much light upon the early history of institutions, have been for the most part confined to the Teutonic and Slavonic nations of Europe. Among these nations, collective property in land has been found to have been nearly universal in early times, and in many of these, clear traces of it exist to the present day. In regard to the nations of southern Europe, the field has hardly been explored at all. Mr. Maine, in his last work, "The Early History of Institutions," says, in relation to France, that "this darkness has recently given signs of lifting" (p. 5), and that "M. Le Play and others have come upon plain traces of such communities in several parts of France." Bonnemère, in his "Histoire des Paysans," devotes a chapter to these communities; La Chavanne, in his "Histoire des classes agricoles," discusses them at some length; and Laveleye, in his "Primitive Property," describes them in two or three very interesting chapters. Nevertheless, there has been no systematic and exhaustive examination of this subject for France, such as the works of von Maurer and Thudichum for Germany, and of Nasse for England.

Some light may perhaps be thrown upon this inquiry by an examination of such registers of seignorial estates as are accessible, to ascertain whether any traces are discernible in them of a systematic organization of the peasantry, such as is manifest to the most superficial glance in England. I have, in former years, read to this society the results of an examination of such English documents of this class as I had within reach, from which it appeared that the peasantry, down to the fourteenth century, fell into regular organized classes, holding their lands in a precise manner and in uniform parcels. As a modest contribution to the investigation, I propose to present the results of a similar examination into such French documents as have come within my reach.

It should be remarked at the outset, that the probabilities are against any such uniformity, whether in France or in any other of the countries occupied by the so-called Latin nations. The Teutonic and Slavonic nations are on the whole homogeneous in race, and as a rule have occupied the territories where they are now found from the very beginning of our historical knowledge of them. The population of France, on the other hand, is not only mixed, but has been subjected at several times to violent and sweeping revolutions. It was, no doubt, practically a homogeneous people when conquered by the Romans 2,000 years ago. The Gauls, a Celtic nation cognate to the Gaels of Scotland, are found in clans somewhat similar to those of Scotland — clans which appear to rest upon a common origin, either real or assumed, like the original subdivisions of most primitive peoples. But this primitive and homogeneous people, with its primitive and uniform institutions, has been at different times subdued by at least two great conquests: first by the Romans, then by the German tribes. It has changed its language, its religion and its customs, and it is fair to assume that it has modified its internal organization and its mode of holding land as well. Assuming, as we are perhaps entitled to do, that the Gallic tribes in Cæsar's time held their land in common, it is still probable, first: that this tenure of land was not held in village communities, like the Germans and Slavonians, but in clans, like the Celts of Britain; and secondly, that even this degree of community of tenure was broken up in a large degree by the shock of successive conquests. Wherever, on the soil of France, we find a Germanic colonization on a large scale, we may expect to find village communities; elsewhere, we may expect an irregular and unorganized peasantry, the result of disturbing influences from without — precisely as similar cases have now at length brought about a similar irregularity and unorganized tenure of the soil in Germanic countries. It confirms this expectation, that the greater part of the village communities, described by Bonnemère and La Chavanne, as existing in France, are found in the essentially Teutonic portions of France, like Franche Comté; but it would not militate with this view if such communities were found sporadically in every part of France, because there were, as a matter of fact, extensive settlements of Germans scattered all over France.

The documents which I have been able to examine in this investigation belong entirely to the ninth, tenth and eleventh centuries: to a period, that is, before the full establishment of feudalism, and in which, therefore, we may expect, if anywhere, to find the primitive organization of the community.

Of these documents, the first is the most important and instructive for my point of view. It is the Polyptichum of the Abbot Irmino; a register of the estates belonging to the Abbey of St. Germain des Près in the time of Charlemagne. In the fullness and minutetness of this survey, we are reminded of the greatest medieval work of this character, the Domesday Book of William the Conqueror; but this Polyptichum is confined to only a small part of France, all within forty leagues of Paris. Moreover, Domesday Book is a public document, drawn up for the use of the government, while this is a private register of the estates belonging to a religious corporation.

The first point that strikes one on examining this register is that the estates are not enumerated according to public divisions of the territory, but are grouped into what are called *fiscs*: in this grouping, there is the greatest irregularity,* bits of land scattered here and there in different villages, being combined merely for purposes of administration. Now, in English documents of this nature, we find the public divisions uniformely observed, even in reference to private estates. What is of even more importance, is that tenures of land in England are always given in hydes or aliquot parts of the hyde — the hyde being the part of land falling to a full member of an organized community; in the French

*Prolegomena, p. 30.

documents, on the other hand, estates are given by their dimensions, which vary very greatly.

For example:* Erlenteus and his wife Hildegarde hold one *mansus* (peasant's holding) containing six *bunuaria* about [five acres] of arable land, three *aripenni* [thirty-six rods] of vineyard, and two and one half of meadow; besides this, he has of allodial property three *bunuaria* of arable land, and one *aripennus* of meadow. And so throughout: land is held not in uniform and equal portions, but always in specified and varying amounts. In ten holdings, for example, in *Theodaxium*,† the *bunuaria* of arable land range from two to twelve; the *aripenni* of vineyard from two and one half to four and one half the *aripenni* of meadow from one and one half to two and one half.

Nearly contemporary with this document in date, is the Polyptichum of the Abbey of St. Remi, at Rheims. In this register we find a totally different system. Each estate is given under the term *mansus*, and the size of the *mansus* is not described. It is a natural inference, therefore, that that *mansi* were of uniform extent, corresponding, therefore, to the English *hyde.* Now these lands, being in the neighborhood of Rheims, at a considerable distance to the east of Paris, may very easily have been settled under a different system. Moreover, being near the German frontier, there was in all likelihood a larger proportion of German population than in the neighborhood of Paris. However this may be, we find, in the dissimilarity of these nearly contemporaneous records, a confirmation of the *a priori* probability that the tenure of land in France would be irregular or heterogeneous.

Appended to the Polyptichum of St. Remi are fragments of a rather later date, of the description of some estates in the neighborhood of Treves, still further east, and in a country of nearly pure German population. Here, as might be expected, we find a complete uniformity in the tenures, so far as the incompleteness of the documents permits us to form a judgment. The *mansi* are spoken of as being themselves definite and uniform quantities of land, like the English *hyde;* and their extent, in acres, *bunuaria* or *aripenni*, is not alluded to.

*Book XXV. 8. †Book XIV.

There remain two documents considerably later and far less complete in this respect than the two Polypticha, but which completely support the view already taken, that there is not likely to be found any near approach to uniformity in the peasants' holdings. In the Cartulary of the Abbey of St. Père de Chartres there is a complete lack of uniformity. Grants of land are, to be sure, usually stated in *mansi*; but *mansus* has not necessarily, like *hyde*, the meaning of a definite share in a village community, but means a peasant's property of whatever extent. And when we come to the detailed description of estates, there is hardly a vestige of uniformity as between the several estates. This description is very meagre in amount, and is copied into the Cartulary from some old papers, the copyist himself professing himself unable wholly to understand them. The date of these document is assigned by the learned editor, Guèrard, to some time before A. D., 1000.

In one or two of the estates there are to be sure some indications of uniformity in the condition of the peasants of the same estate: e. g., in Cavanuis Villa (p. 37), are given the names of twenty-one peasants (*agricolæ*), all of whom paid the same dues to the convent; nothing is said as to the size of their holdings. In Cipedum there are ten peasants, all paying the same dues. But next follows Comonis Villa, with four peasants, two holding five *bunuaria* and paying three measures of corn; two holding six *bunuaria* and paying four measures. On the next page, Abbonis Villa has thirty-three peasants; twenty-one of these paid one shilling, and the rest sums varying from six pence to three shillings. On page 40 begins the enumeration of seventeen holdings, paying ten different sums, varying from six pence to fifteen shillings. Only two of these, to be sure, are called *mansi*, but these two pay respectively two and five shillings, and one *mansellus* three shillings.

There remains the Cartulary of the Monastery of St. Bertin at St. Omer, in the extreme north of France, therefore in a territory largely settled by Germans. The date of these registers is about the middle of the ninth century. Here we find, as might be expected, a uniformity almost as great as in England. The estates are regularly stated in some such manner as this: "*Mansa XV per bunaria XII, et ille dimidius per bunaria VI*" — "fifteen *mansi* of twelve bunuaria each, and a half one of six bunuaria." The size of the *mansus* varies exactly as that of the virgate in English manors*; that is, it is generally uniform in the same villa, but ranges in the different villas from ten to twenty-four *bunuaria*, with sometimes, however, two or three different standards in the same villa. For example, in Pupurninga there are ten *mansi* of twenty-four *bunuaria*; ten of twenty; ten of fifteen; seventeen of thirteen, and one-half *mansi* of eight. We find also a large number of peasants with independent holdings, not given as *mansa*, and very irregular in amount; like the freeholders of England.

The result of this inquiry, which embraces all the documents relating to France which I have been able to examine, is completely to confirm the expectations which appeared probable on general grounds. We find here and there, especially in those provinces which had a considerable German element in the population, decided indications of uniformity in single villages or estates, sometimes even on a larger scale. But as a whole, uniformity is not the rule but the exception; the communities, if they were such, appear to have been isolated and scattered amid a population which was prevailingly irregular and heterogeneous.

*See Transactions, Vol. II, p. 223.

THE ABOLITION OF THE JURY SYSTEM.

BY CHARLES CAVERNO.
Lombard, Du Page County, Ill.

It may seem a bold project to advocate the abolition of the jury system. We have been taught to regard the writ of habeas corpus and the trial by jury, as little less than gifts of Divine inspiration. The writ of habeas corpus may still stand. The Time Spirit has not passed adversely upon that, and is not likely to.

But candid examination will hardly be able to resist the conclusion that, in this country, trial by jury has outlived its usefulness.

The history of trial by jury will here be treated of only incidentally. Sources of information respecting the history of the jury system are in the hands of the legal profession, and lie open to all. Few other institutions have undergone so many changes as this. To speak of trial by jury is to speak of something whose content of meaning depends upon time. The institution has taken on a new phase and parted with an old one, in almost every century since the Norman conquest.

Jurors were originally summoned to aid a court in a matter of dispute, by a declaration of facts within their own knowledge. Now it is legally a disqualification for a man to know anything about the case in hand — practically, a disqualification for him to know anything else. When the court could put men of the vicinage on oath, to help it with a statement of the facts they knew, there was life and health in the jury system. Later, when this group of witnesses took on the further function (that out of which the grand jury grew), of suggesting to the court matters in their vicinage, connected with the public weal or the public peace, which they thought the court should look after, there was life and health in the system.

But when now the court has to inform the jury of the facts, and then tell them substantially what facts they shall hand back to it, as found by them, it is apparent that we have an institution which has little setting in reason and, as matter of fact, has little respect with those familiar with it in practice.

In trial by jury to-day we have a marked instance of an institution, sapped of its strength by the growth about it of a multitude of petty restrictive details. Force that does not go to stalk, goes to shoot, till life is smothered by its own abnormities.

IN CIVIL CASES.

That trial by jury in civil cases is not an essential element of civilization, and is not necessary to industry and commerce, is apparent when the fact is known that jury trial in such cases has never had place on the continent of Europe, was not in fact introduced into Scotland till a period within the memory of men still living.

Lord Mansfield, toward the close of his illustrious career at the end of the last century, advised against the introduction of the jury in civil cases into Scotland.

Lord Campbell said that the principles underlying Mansfield's objections were unfortunately overlooked when jury trial in civil cases, in 1807, was introduced into Scotland. He further adds, "The experiment, I am afraid, has proved a failure, and Lord Mansfield's objections been fatally verified."

While as much as this would not be allowed by all Scotch lawyers to-day, yet the claim is distinctly made, that all the advantages which have arisen in Scotland with the introduction of the jury system are not due to that system at all, but are due to a contemporaneous rectification of the Scotch system of pleadings.

Trial by jury in civil cases is distinctively English in origin and limited in practice to England and the colonies — Scotland being allowed for as above stated.

Great Britain and America do not transact all the business of the world. There has been done and is doing a vast deal of business on the continent of Europe. If all this business has been transacted without the jury system in legal matters, we may at least conclude that that system is no social necessity.

If there has been and is no call for the establishment of the system on the continent, by the commerce there located, then we may judge that the system, in such cases, is not even of apparent social convenience. But the argument against the system is only partially made when you look at continental commerce. In England itself the tendency has been, in the growth of legal practice to wrest department after department from under the incubus of the jury system. Just think how much business is covered by equity, probate, and admiralty. Yet they are exempted from the jury system.

Lord Mansfield said that equity grew up in England to rectify abuses resulting from the jury system. This statement at once explains why it is that England and her colonies are the only countries where law and equity have been divided and assigned to separate courts. The jury system was only adapted to coarse, crude business. Anything requiring care or nice discrimination had to be sent to another court, which, significantly enough, was called a court of equity, as though something like even justice might be there expected. How important the equity side of law is, lawyers understand. The stretch of equity over legal business must increase more and more with the growing complexity of civilization.

Take probate business; as a rule, that is exempt from the jury system. The statutes sometimes commit special matters to juries, or they are found by way of appeals to other courts. But what a reach there is to probate business. All the property of a country passes through probate, generation by generation. Yet the difficulties of this huge business are normally met without the intervention of a jury. The value at stake in matters passed upon in common law actions cannot compare with the values that are adjusted in probate, nor do such common law actions present problems of greater interest or intricacy.

To admiralty in England, and usually in this country, the jury system is not applied. "Britannia rules the waves." The jury system is peculiarly a British institution, yet Britain has taken good care that the right arm of her power and prosperity should not be fettered by the jury system. She has followed the adage, "*Ne entor ultra crepidam.*"

Trial by jury may be a palladium of British liberty, but Britain has had wit enough not to trust her invaluable marine interests to landlubber juries. It is readily apparent why this exception is made. The ordinary citizen cannot pass understandingly upon matters so technical and peculiar as maritime business involves.

But then, is it not apparent that all business is rapidly tending to infold the same difficulty? Can marine affairs present any greater difficulties to an ordinary jury than arise out of the industries we are now plying on land? If it is undesirable to have juries pass upon shipping interests, how comes it desirable to have them pass upon cases which spring out of railway business, out of manufacturing, patents, telegraphy, banking?

Is not commerce by land becoming as technical and peculiar as commerce by sea?

If there were no objections to the character of juries as ordinarily raised, yet the tendency of all business to what Herbert Spencer would call greater "heterogeneity," is reason enough for the abolition of the jury system in all civil cases.

The lot cannot any longer be expected to select a man for a juror who can in any wise be of any assistance to a court or to parties litigant. Originally the jury was called not only to aid the court with information which they possessed, instead of being instructed by the court, as now, by the impartation of both fact and law, but for generations it was only upon one kind of matter of dispute that the aid of a jury was sought.

Questions respecting titles to land called into existence the institution of the jury. The expression, "a jury of the vicinage," preserves to us a reminiscence of the day when the sole business of a jury was to give the court information in respect to possession and reputed title to land in their vicinage.

In the commotions consequent upon the Norman conquest, questions of this kind were frequent.

Titles rested not in record but in possession. Twelve men from the vicinage could tell the court who had been in possession of a certain piece of land, or along what line of descent it was reputed among them that possession came. That was a simple office, easily discharged. In England, and in this country, wherever the old common law forms are used, the writs summoning juries still preserve the direction to summon men from *the vicinage*, when knowledge of matters naturally consequent upon being of the vicinage disqualifies the juror for the very service to which he is impliedly called, and sends him from the jury panel to the witness box. It is a long tale to tell how legal practice wandered from that to this. Is it to severe too say that there was sense in that, but that reason has dropped out by the way to this?

But the argument against juries in civil cases can be strengthened by still other considerations.

There is a constant endeavor to escape them by trials by the court alone or by references from the court. Generally, it may be stated that a jury is the terror of a good cause and the hope of a bad one. A case that wants a jury usually has an eye to possible aid from that peculiar character — the twelfth juryman. Arbitration is growing more and more frequent as a means of escape from the jury system. Various guilds and associations in the industries and in commerce, make as part of their constitution, provision for the settlement of disputes that may arise among their members. With higher moral culture, more and more will be made of the principle and practice of arbitration. Where juries are preserved, ultimate confidence in no case is placed in them. Provision is always made to review their work by another tribunal. It is not worth while for society in any civil matters to preserve so cumbrous and expensive a system in which after all it puts so little trust.

It is good theory to say that the province of the court is to pass on law and that of the jury on fact. But it is often a question of law what facts shall be taken into consideration, and often a question of fact what the law is.

This division between fact and law is one which can rarely be clearly made in practice.

Alexander Hamilton says: "Though the true province of juries be to determine matters of fact, yet in most cases legal consequences are complicated with fact in such a manner as to render a separation impracticable." When the court gives the law to the jury, the court has already inferentially found the facts, and when the jury find the facts they inferentially apply the law. *Fact and law are so involved that they belong to one mind.*

There is a constant tendency for fact to pass up into the order of law. A few facts make a custom, and custom is law. It is hard to say where fact leaves off and law begins. The tendency of civilization is to make law at the expense of fact. In the subdivision of labor in law, lawyers do not attempt to cover all the realm included in their profession. One devotes himself to the law of Patents, another to the law of Railways, another to the law of Real Estate. Yet we take indiscriminately from the mass of the people juries to sit indifferently, now on the delicate interests involved in one of these great departments, and the next moment on those of another. We set a hod-carrier to pass upon facts (as, for instance, upon those which constitute negligence) upon which a lawyer would give no opinion unless he had made them a life study.

We have no need here to discuss the character of our jury service. The service itself, as we practice it in civil cases, is inherently absurd.

IN CRIMINAL CASES.

Trial by jury in criminal cases, at various dates within a century, has been introduced into many of the nations on the continent of Europe. It came in, in several instances, as a result of the political commotions of 1848.

The popularity of trial by jury is in its application to criminal cases. But a little study detects the fact, that this popularity has arisen out of one peculiar class of cases.

When Hallam eulogizes Magna Charta, especially the clause which is supposed to establish the right of trial by jury, he lets us see from what quarter the popularity of this institution has come. He calls it "The Keystone of English Liberty," and says that it is one of "the bold features which distinguish a *free* from a *despotic monarchy.*"

It is because of its *political* service in monarchical or aristocratic governments that the jury system has come by its high reputation.

Tocqueville sees this and says, that "trial by jury is emphatically a *political* institution."

You detect the ring of *political* intent in the speeches of the continental orators advocating the introduction of trial by jury into their several countries.

It is easy to see how this comes about. Monarchies and aristocracies often make political crimes out of what men of progressive and democratic tendencies consider the liberties of the citizen.

The jury becomes popular because, taken from the people, it naturally will be a defense against conviction of these political crimes.

But in this country, we are expected yet to glorify an institution which has lost all significance and appreciation as a protection of liberty. We have no monarch to declare the liberties of the citizen political crimes. We have no ranks in society who can make crimes out of encroachments by the lower orders upon the claims of privilege. The ballot has taken the wind from the sails of trial by jury as a defense of liberty, and left it as

> "Idle as a painted ship
> Upon a painted ocean."

Trial by jury has not had a cargo to carry in the interest of liberty since the government was founded, and it cannot get one.

The social conditions in this country are such that trials like the famous state trials in England—Horne Tooke's and Hone's for example—can never arise; and if they should, the ballot will always be the swiftest instrument to cut the knot which they present. Political rights with us find their solution in suffrage, not in jury trials. Politics settles political rights, courts assenting or dissenting. As long as the courts are in the hands of the people, politics may be trusted to take care of political rights. If it could be shown that courts have stood in the breach for liberty, it will be found that any effective service has been rendered by courts of last resort, where juries never come.

In this country, then, trial by jury, considered as a bulwark of political liberty, is serviceless. The only remaining function of the jury is to do justice in cases of accusation of universally acknowledged crime. We are to inquire whether it is fulfilling that office. It is high time we looked this institution straight in the face — high time that we stripped it of the glamour in which it is clothed, brought from other ages and other circumstances. There is one plain question to be asked of it, *is it protecting society in cases of crime?* If it is not doing that, its sole occupation is gone.

We have few statistics to help us to a judgment on this matter, and from the nature of the case, if we had, they could never be conclusive. There must be a problematical element in all our judgments on the subject.

Quetelet gives us one set, however, that are very suggestive.

In 1830, on the introduction of trial by jury into Belgium, the ratio of acquitted to accused in that country was found to be just doubled. Now no man can demonstrate that this result made against social protection, and did not make in favor of protection of innocence; but one familiar with the history of criminal trials in this country for the last quarter of a century will judge that this result did make against social protection and in the interest of crime.

Common fame may be trusted for the assertion that for a generation there has been a substantial failure of justice in this country in criminal trials. The rule is that great criminals escape.

Jury trial has come to protect criminals and not society. If a criminal fails to be protected, it is simply because the resources offered by the jury system have not been well worked — wit and money fail him, not opportunities for their successful use.

Look along the line on which the criminal can operate. If we had arranged it with special eye to the disaster of society and the defense of crime, we could scarcely have done better. Juries take their rise in boards which, in the large cities, have been delivered to "the bondage of corruption."

Out of the same board of supervisors came forth the Tweed frauds and juries. In such extremity of virtue, if crime does not find its opportunity, it is modest. When we are star-gazing, we bring up in pit-falls at our feet. We can see jobbery in congress, but we stumble heedlessly over it in our primary representative bodies. The original constitution of the jury in the great centres of population is in low, bad hands. Judges *have* been found with self respect enough to dismiss whole panels as unfit and unsafe for public service. The whole list often fills Horne Tooke's bill against a jury list in his day — "a basket of rotten oranges from which one has his choice." No rational account can be given of some juries, but that they are of the criminal class, put in by the criminal class, for the benefit of the criminal class.

Then comes the facility of tampering with juries through the sheriff's office. The reputation of that office is not immaculate. No office in the gift of the people lies so open to temptation from rascality. It is a place of peculiar attraction to the "rough" element. They furnish more candidates for this office than for any other, and succeed usually in having some representative in it. That element will serve itself and its own. A great outlay of effort is not required. A shrug of the shoulder or a wink, and there is a dead lock in the jury.

Then society breaks its own center in the provision for summoning talesmen. The men who are anxious to serve somebody are always on hand. The old jury soldier is a well known character. Whether he is one of the devil's poor or a poor devil, he is equally open to the use of artful crime.

Finally, add the technics of judicial procedure, especially as they find expression in the ignorance and indifference, (qualifications in some states now abolished by express statute), by which jurymen are secured who are too ignorant to know of crimes committed about them in society, and too callous, morally, to express any opinion concerning them if they do, and there seems to be no special reason why crime should not secure immunity and society fail to be protected. The system, as we have it, is a standing peril to society.

If it be said that the service must be reformed, the reply is that all attempts at reform will necessarily be partial, spasmodic. The line is too long to guard, and then it is not worth guarding. Society has lost interest in the institution. The attitude of business men toward jury service plainly shows that the system has outlived its usefulness. Judges scold and fine, yet business men slip through their fingers, and the old soldiers take their accustomed seats. It is not worth while to try to reform an institution whose service is so universally distasteful to men of character and occupation. The only question deserving consideration is, whether practical injustice would be likely to result to those accused of crime from the abolition of the trial by jury.

Presentment by grand jury was once thought to be as essential to the protection of those accused of crime as final trial by petit jury. Yet the grand jury has gone by the board in many states, to nobody's damage. The petit jury might follow it with as little injury. Any man accused of crime could find security enough in the ordinary course of law without the jury system. He can have as many new trials as he can show reason for. If capital punishment were abolished in all of the states, as it is in many, then we could say that in all cases, as long as natural life might last, courts would be open to applfcation for new trial on the ground of newly discovered evidence.

Granting these privileges, society would be likely to mete justice as evenly and unerringly as is possible to man.

Why should everything about crime be adapted to and managed in the interest of criminals? Is not society's right to protection as high as the individual's right to protection?

An individual has no right as against society to that which practically leaves it defenseless. It is an incidental matter but I cannot forbear to mention the probable influence on the bar of the abolition of jury trials.

The morals and manners of equity practice are certainly heaven-high over those *nisi prius* or of criminal courts. There is no reason why the attempt to get at facts in cases civil and criminal cases should corrupt the manners and morals of the bar any more than the attempt to get at law, and yet every body knows that it does. The cause of it is in the standing temptation there is in the jury.

A good illustration of the nature of this temptation and of what it can lead lawyers to do is well set forth, in a few words of Sir Nicholas Throckmorton, who was tried for high treason in 1554.

"MASTER SERJEANT, I know how by persuasions, enforcements presumptions, applying, implying, inferring, conjecturing, deducing of arguments, wresting and exceeding the law, the circumstances, the depositions, and confessions, unlearned men may be enchanted to think and judge those that be things indifferent or at the worst oversights, may be great treasons. Such power, orators have, and such ignorance the unlearned have."

But the processes that win with a jury are powerless with the court. It would be a happy result for the bar if all possible temptation to such processes were removed.

We have instances enough to show that a master of rhetoric *can* convince a jury that it is perfectly natural for men to unjoint their heads and carry them under their arms during a shower. But whether it is worth while for society to tax itself heavily to support an institution for the sake of giving such rhetoricians exercise, is or is not much of a question, according as it is viewed.

The jury system has indeed such age as it has to recommend it.

But, as Forsyth well says: "A better reason for the continuance of an institution must be given than that it has been handed down to us by our forefathers."

Professor Christian has expressed the opinion that the rule of unanimity in verdicts could not have been introduced in any age by deliberate act of the legislature.

If it were an original question with us, whether to introduce jury trial as we have it, either in civil or criminal cases, the proposition would fail to find respectable support.

POSTSCRIPT.

The abolition of term sentences in criminal cases, recommended by the governor of Wisconsin, Hon. W. E. Smith, in his first annual message, has a bearing upon the abolition of the jury system in such cases, to which attention is invited.

The board having the charge of criminals must always have before them the question of the actual guilt of a prisoner, as well as the equities existing in case of clearly ascertained crime. Such board would always be in position to pass upon a question upon which a jury can pass only once, and at once.

Those accused of crime, and against whom a prima facie case is made out before a judge, have in such a board the benefit of a *standing* jury.

The abolition of term sentences is a step in the right direction; but, once taken, it reduces the jury system to the position of the fifth wheel to the social coach.

Jan'y 21, 1878. C. C.

THE ORIGIN OF THE FREEHOLDERS.

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[This is a portion of a paper read at Racine, July 11, 1877, revised and enlarged.]

The accepted view at present as to the origin of the class of freeholders is, that they represented the old village community, and that their court, the Court Baron, represented the old village assembly. Sir Henry Maine says (Village Communities, p. 137): "We cannot doubt that the freeholders of the Tenemental lands correspond in the main to the free heads of households composing the old village community." Prof. Stubbs speaks (Constitutional History, Vol. I, p. 399) of the "court baron, the ancient gemot of the township." And Mr. Digby says (Introduction to the History of the Law of Real Property, p. 38): "There can be little doubt that tenure in socage [that is, freehold] is the successor of the allodial proprietorship of early times." And again (p. 43): "The manor court is the successor of the ancient assembly of the village or township."

In opposition to this view, I undertook to show in a previous paper * that the so-called customary tenants, who were as a rule serfs, were the representatives of the old village community; and suggested that the tenants in socage, or freeholders, were "specially privileged *villani*." I propose at present to develop this last point further, and show that free socage was in its nature a feudal tenure and that the freeholders as a class had a feudal origin.

First, it should be noted that free tenure was of two kinds: by chivalry or knight's service, and by socage or agricultural service; and that the two classes of tenants, although differing widely in the form of their services and in social position, formed neverthe-

* See Transactions of the Academy, Vol. II, p. 220.

less legally one class. The lists of free tenants, *libere tenentes*, always begin, as is natural, with the most honorable class, the tenants by knights' service, and then continue without a break with the tenants by socage. And all the freeholders, *omnes libere tenentes*, composed the court baron of the manor, and owed suit to the court of the hundred and the shire. Now, as the two categories of freeholders composed but one class in law, it is natural to suppose that they had the same origin. The tenants by chivalry were of course a purely feudal class, holding their estates by the strictly feudal tenure of military service. The tenants by socage, it is natural to suppose, may have had a similar origin.

As a matter of fact, the two classes came into existence at the same time. Tenure by chivalry was, as a matter of course, introduced when the feudal system was introduced. The precise time and manner of this is still a matter of uncertainty. What is certain is that feudalism, in its complete form, did not exist in England at the time of the Norman Conquest (1066), but that it is found completely developed at the accession of the House of Anjou (Henry II.), in 1154. Now this interval of about a hundred years is precisely the time in which the tenure by free socage and the class of tenants by socage made their appearance.

Even as late as Domesday Book (1086) there was no freehold (except by military tenure), and no class of rural freeholders. But the Boldon Book (1183), and the Abingdon Cartulary, of about the same time, contain lists of freeholders of both the military and the agricultural class, and standing above the mass of servile tenants. It is therefore *a priori* probable that the tenure by free socage and the class of free socagers came into existence in connection with the establishment of feudalism, and as a part of this process. It is true, as I pointed out in a former paper,* that there is a large class of *sochemanni* enumerated in Domesday Book; but, first, this class is confined to a few counties in the east of England; and, secondly, it appears to have been a class of persons, not a category of tenure; — there were *sochemanni*, but no *socagium*. There was likewise found in the eastern counties a class of freemen, *liberi homines;* but they appear to have been

*Transactions, Vol. I, p. 167.

allodial proprietors, not free *tenants.** Whatever, therefore, the origin and status of these two classes may have been, they could have had no *historical* connection with the later freeholders. Even the county of Kent, where villenage in its proper form is said never to have existed, had neither *liberi homines* nor *sochemanni* in Domesday Book.

I will now take up in succession the several features in which the free socagers stood related to the manor and its lord.

First, their tenure was in its form strictly feudal. They were formally enfeoffed with their lands, by "livery of seisin," were subject to most of the feudal incidents, and were regarded as having a definite legal interest; while the serfs or customary tenants held their lands by prescriptive title, and were in strictness of law only tenants at will, not being "regarded as having any legal interest in the land at all." Their estates, as I have shown on another occasion, were exceedingly variable in size and nature; but often they were regular portions of the customary lands, which they held upon the performance of the customary services, or a part of them.† It was not uncommon for one of the customary tenants to have also a freehold. ‡

Next to the tenure of land comes the manorial court, in which the jurisdiction of the manor was exercised. This was known as the Court Baron, and its judges were the free tenants of the manor, whether by chivalry or by socage. The constitution of the court was strictly feudal.§ Every feudal lord had his feudal court, composed of his immediate vassals, those, that is, who were peers of one another. The feudal court required, for its mainten-

*"It is characteristic of the growth of tenure that in Domesday (if the index is correct) we hear of different classes of tenants, but not of different species of tenure; of *liberi homines*, but not of *liberum tenementum;* of *milites*, but not of tenure *per militiam;* of *sochemanni*, but not of *socagium;* of *villani*, but not of *villenagium.*" Digby, p. 40, n. 1.

†"The tenure of a certain number of these fields is freehold."— Maine, Vill. Comm., p. 137.

‡ In the manor of Ledene, out of nine customary tenants, each holding a virgate of fifty acres, six also had freeholds, varying from one to thirteen acres.— Gloucester Cartulary, iii, 126.

§ The *liberi homines* are almost confined to Norfolk and Suffolk; the *sochemanni* to these counties and Nottingham, Northampton, Leicester and Lincoln.

ance, a minimum of tenants. Now the Court Baron of the English manor fell if there were not at least two freeholders to take part in it. It followed, moreover, the feudal rule, that the judgment, both as to law and to fact, was given by the tenants, the suitors or peers of the court—the lord or his steward only presiding. The name, moreover, Court Baron, is hard to explain by English etymology; but, as the French manorial court was called *Cour de Baronnie*, it is easy to suppose that the name was introduced along with the feudal system itself. On the other hand the customary tenants, the compact and organic body of the peasantry, had no function in this court, except that of lookers-on. They had their own court — the Customary Court — whose powers were "administrative rather than judicial," † in which, therefore, they had no real power, such as the freeholders had in the Court Baron, being hardly more than witnesses.

This was, in short, such an assembly as that of the members of a corporation might be expected to be after the corporation had lost its effective powers; we may, therefore, consider it to represent the assembly of the mark or village community, reduced to a servile status. The freeholders, it should be remarked, "are not, generally speaking, suitors at the Customary Court," from which it follows, almost of necessity, that they did not, *as freeholders*, have any share in the administration of the community, but only in so far as they held customary lands.

In the next place, the rights of the two classes in the waste differed: each had the right of common appendant to his arable land, but that of the copyholder or customary tenant was by the custom of the manor, while that of the freeholder was "by virtue of his individual grant, and as incident thereto."* This would show that here too the customary tenants represented immemorial antiquity, the freeholders a special and recent grant.

It remains to supplement these general arguments by special examples of the genesis of freehold. This is not easy to do, inasmuch as the period of the development of this class, the century following the Norman Conquest — is very barren in docu-

† Digby, p. 216.

*Digby, p. 215. Williams, Law of Real Property, 467, compare, 483.

ments of the required character. When we begin to meet with rent-rolls and other records of the manors, the freeholders are already a large and recognized class. There are, nevertheless, a few statistics which appear fully to prove the point in question.

The manor of Beauchamp, in Essex, was the property of the Chapter of St. Paul. At the time of the Exchequer Domesday (1086) it contatned twenty-four *villani*, ten *bordarii* and five *servi*; no freeholders. In 1222, in the document known as the Domesday of St. Paul, there were thirty-four *libere tenentes*. This class, therefore, had come into existence in this interval. Now it so happens that for this manor we have the fragment of a record, of the year 1181, known as the Domesday of Ralph of Diceto. Its importance can be judged from the fact that this is the only manor I have been able to find, of which there is a rent-roll in existence at two different periods; by means of this we are able to compare the condition of the manor at an interval of forty-one years. Unfortunately the list of the *operarii* (as the customary tenants are here called) is incomplete; the *libere tenentes* are eighteen in number. From this it appears that the class of freeholders was not merely a new class, originating in the century after the Norman Conquest, but that it was a class that was steadily added to, having more than doubled its numbers in less than fifty years. Nor was this wholly by dividing the estates; for the lands held by them were, during this period, increased from 667 acres to 744.

The continuousness of the tenures is shown very clearly by these lists; more than half of the estates of both classes can be traced from father to son, or other relative, even after the long space of forty-one years. In only one case is the same tenant found. Robert, son of Wlurun, a customary tenant, held, in 1181, an entire virgate of land. In 1222, he appears as holding only a half virgate of customary land; but his name stands also in the list of new freeholders, as holding another half virgate. Evidently being one of the richest and most prominent of the serfs, he had been converted into a freeman and a freeholder by being enfeoffed with half of his customary estate, the other half remaining in villenage. Lambert Gross, in 1181, held two half virgates of customary land. In 1222, his widow, Alice, held one half virgate by the same tenure, and his son William the other half, as a freehold. Here are two clear cases of the conversion of serfs into freemen, and of customary tenure into freehold.

It would appear, therefore, to be proved that the freeholders, or tenants by free socage, were, as a class, the creation of feudalism; that the feudalization of England was accompanied, or rather accomplished in detail, by the creation of a body of immediate tenants to the lords of the manors, who, without these, would have had no complete jurisdiction. The tenure itself would appear to be simply the French *censive*, or agricultural fief, which is in its nature and form wholly analogous with the fief proper; it may also have had some analogy to the tenure by which the *sochemanni* of the eastern counties held their land, and from this to havereceived the name *socagium*. If this view is correct, it would follow that the feudalization of the township, its conversion into the manor, consisted in the introduction of this new class of tenants, holding by a new tenure. For this purpose leading villeins would naturally be selected, and the cases of Robert son of Wlurund and Lambert Gross show very clearly the process. That this class, new and of foreign and feudal origin, became the most valuable and characteristic of the English institutions, is due to the strong vitality and power of assimilation of the English constitution, whose trial by jury was also of foreign origin, and which even turned an exceptionally despotic royalty into an instrument of freedom.

THE DUTY OF THE STATE IN ITS TREATMENT OF THE DEAF AND DUMB, THE BLIND, THE IDIOTIC, THE CRIPPLED AND DEFORMED, AND THE INSANE.

BY R. Z. MASON.

In the progress of modern civilization, the state has come slowly to a recognition of certain duties and obligations to these unfortunate classes. At present we take up the subject in the interests not only of humanity and of sound political philosophy, but also in the interests and light of modern science. Perhaps we shall commit a grave mistake in venturing to draw our conclusions solely from the cold suggestions which the teachings of the most advanced investigators in science might supply. Humanity certainly has claims upon us which the dictates of our spiritual natures must respect. Shall we adopt the modern theories of evolution and the language of Herbert Spencer, "the fittest shall survive," and be induced thereby to turn out the unfortunate idiot, the insane or the deformed cripple, with nothing but his own resources to depend upon, to compel him to struggle for a precarious existence by battling with the relentless forces of nature, and sharp competition with the fierce selfishness of individual life? Would this course be in accordance with the instincts of man's better and higher nature? Whatever theories we may adopt as to our origin, we cannot ignore the fact that we belong now to a cultured race, to those whose gentle humanities are to be as much regarded as the mere elements of physical strength or intellectual acumen. If we did spring from the brute, we cannot afford to act quite like him. But the subject has another phase which it is proper we should carefully examine. The question arises, whether the state shall expend its hundreds of thousands of dollars per annum in the almost hopeless effort to correct congenital malformations, to subdue the frantic manifestations of insanity, to counteract the subtle forms of organic disease, and to educate the feeble-minded and still allow these pre-natal and constitutional disorders to flow on through countless generations of the unborn. Of course we assume in our argument, that it is the province of the state, acting from considerations of the highest political economy, to care by systematized and organized effort, for such of the unfortunate as cannot care for themselves, or whose wants friends cannot supply. The insane can, not unfrequently be rendered happy and useful, but even sane. The idiotic can, by skillful treatment of the educator be developed into the *self-reliant, self-sustaining* intelligent being. The orthopedic surgeon can bring beauty out of deformity, and can so change those flexures that deform and weaken the physical anatomy, as to bring nature to her true and original lines, and impart a new strength and vitality.

But the prosecution of all these lines of experiment and modes of rendering the combined skill of the civilized world available, require large outlays of time and money. And is it not vastly better that the state, acting in her organic capacity as the agent of human society, should encourage and aid by her own means, the foundation of institutions for such purposes, rather than to leave the large numbers of these unfortunate people to the ill-directed and uncertain efforts of poor, and often unintelligent families, to get along with their herculean difficulties as best they may? Is it not better, therefore, that the state should tax herself a little to help the blind to become an intelligent, self-sustaining member of society, or to cure a child of some *dwarfing* deformity or some *smiting* paralytic stroke, rather than tax herself much by and by in maintaining these victims of relentless misfortune in poor-houses in the long years of their future? Such a question can, I apprehend, have but one answer.

But above and beyond all this, the state has another and more important duty to perform to society, than that of merely taking care of such as have come into the world under the blight of some terrible misfortune. This other and higher duty is so to modify its legislation as to prevent the propagation of congenital idiocy, deforming insanity and organic disease. I know that in venturing to discuss this subject by treating it as a function properly belonging to the state, I may be assuming what will not be readily conceded. To prevent, if possible, these serious misfortunes, is unquestionably the duty of somebody. Or must we admit that man, intelligent and immortal, is such a creature of blind and reckless passion, that he must be permitted to go on through the vast æons of the future as he has done in the past, reproducing himself, depraved and demoralized as he is, transmitting his anatomical defects, his physiological *idiosyncrasies*, his organic imperfections, in the most marked manner, in order that posterity may have the opportunity to cultivate the moral virtues by taking humane care of the insane, the blind, the deformed and the idiotic. It is not too early in the history of man, I more fear it is too late, to ask the question, should a radically defective organization be allowed to perpetuate itself by reproduction? To this I would answer, that for the good of the race it should not. This must be our conclusion unless we are prepared to adopt the modern school of Euthanasists, who take the ground, that when a human being cannot live and be happy, he has the right to claim of society the boon of death, legally administered. I would modify the proposition by saying rather, that such an unfortunate had a right not to be born; yet, having been born, perhaps the Euthanasist may say that he has the right to ask the privilege of an early, painless death. Yet the original question still recurs, What is the duty of the state towards this large and constantly increasing class of incurables and unfortunates?

First, I answer as to those in existence. Let them be taken care of in the most economical and best systematized way which science, art and experience can devise. Let alms-houses, the insane hospital, the deaf and dumb, and blind asylums, still stand as monuments of the generous and humane spirit of the age. Let the crippled and deformed have ready access, if need be, by public charity, to all sources of relief which the world's best wisdom can supply. It is better that the state pay the expense of putting a man in a condition so that he can take care of himself, than to tax the public through an entire generation for the support of a cripple in the poor house. But secondly, I propose to show a rational answer, it may be *imperfectly* and *impractically*, to the second branch of this question, to wit: the duty of the state to the unborn generations, with which our successors will have to deal The state establishes a state board of health, to whom it commits the various questions concerning the public health. It requires the individual to conform to such sanitary regulations as are found necessary to protect life, health and property. But is there any more reason why the state should see that offensive and mephitic vapors and gases should be promptly neutralized by chemical agents, why nuisances should be abated or removed from civilized communities, than there is why the state should interfere to arrest the descent, through long lines of generations, of the germs of incurable diseases, which are sure to become the object of the world's pity when allowed to develop into the full proportions which we witness in our hospitals and public alms houses? Should it be the province of a state board of health to tell me that my sewers need chloride of lime or carbolic acid, and not be their function to tell me that my posterity will be smitten with incurable insanity, provided a contemplated marriage is consummated? Should he be allowed to intrude into my back yards and order me to remove the offal, which carries on its *wings* the pestilence and plague, and yet must not be allowed to have at least some voice in arresting, by counsel or by law, the descent of those congenital disorders, that prey at an earlier or later date on half the population of the civilized world.

We take remarkable pains in selecting and crossing breeds of the domestic animals. Here at least we try to study and harmonize with the laws of nature. The royal and aristocratic families of Europe are very strict in the marriages of their sons and daughters. We recognize the universal law that physical qualities, character, breeding and education begin long anterior to birth. But unfortunately for the ruling classes of Europe, the primary principle on which their intermarriages are based, is not in respect to the laws of nature. Their idea is a purely conventional one, and their society is purely artificial, where nature and her economy in the processes of reproduction, are as much ignored as with the bulk of mankind elsewhere. Their intermarraiges come from rank, based on wealth, and on freedom from the restraints of law and labor; a condition of things best calculated to deteriorate what there is good in any generation of men. If the doctrine is true, that the fittest only should live, then it follows as a rational corollary that, in a society of rational men, where the interests of a race capable of indefinite development are blended, that "the fittest only should be born." To reproduce and fill the world with posterity is not always a duty. Certainly not always a privilege. The law makes it a crime where the parties have not taken the legal steps to provide, as far as may be for the protection, the education and general wellbeing of future offspring. Why should not the law adopt the sound maxim, that no person has the right to throw upon the charities of the world, his diseased, deformed and insane offspring.

The laws of generation are now sufficiently well established so that good scientific and medical authority can determine with tolerable certainty the probable issue of a given marriage, so far as health is concerned. Yet, even this generation continues to introduce into the world, children marked with these congenitial defects, as if it were a matter of the slightest concern whether children were well or ill born. Society should here erect an impassable barrier, so that no person, man or woman, who failed to present the requisite credentials of a sound mind in a sound body, free from all forms of congenital and organic disease, no matter what social standing or wealth might distinguish them, should become the head of a family of children. This is the aristocracy of nature. No man is well born who inherits the appetite of a drunkard or the feebleness and frailties of a consumptive. No person is ill born who comes into the world with all his mental and physical faculties bright with the bloom of health and vigor. All theories of progress and true social development are useless and abortive unless these ends are first secured.

But should our legislators see practical difficulties in the way of a system of legislation so radical and revolutionary in the social life and economy of the people as the above programme would indicate, still the least it can do is to introduce these biological remedies to the attention of the public, in the education of the young. It is ignorance that has destroyed us in generations past. It is ignorance of the functions of life and of the laws of reproduction that destroys us to-day. We cultivate with more skill even the grapes and grains than we do the propagation and reproduction of our own species. Marriage is a hap-hazard affair, the result of caprice or fancy, instead of being the result of judgment and knowledge of the fundamental laws of being. Science and the public law, are alone, perhaps insufficient to do justice to this noble cause. They invoke the aid and co-operation of the pulpit and of the public teacher. A wise supervision of this subject is indispensable to the future wellbeing of the race. False standards of delicacy must be set aside. Morbid sentimentalism must give way to the suggestions of common sense and a rational philosophy.

DEPARTMENT OF ARTS.

ART AS EDUCATION.

BY ALFORD PAYNE.

INTRODUCTION.

Having been asked to prepare a paper for this scientific assemblage, I have chosen as a subject, Art as a means of Education. But why comes one, unpractical, unscientific, into this learned body? The answer is, he comes in all sincerity to commend to popular notice, through the prestige given by your academy, a class of truths, as educational, which he thinks are not valued as they should be.

Are we not generally liable, if not to overestimate our own special lines of study, at least to undervalue the departments of knowledge which we have not much considered? Rare is the man, who, with Lord Bacon can make all departments of knowledge his province. The clergyman is thought to live too exclusively in dogmatic theology; the lawyer sees this, and listens with a critical sharpness based on a conviction of the immense value of a knowledge of jurisprudence, coupled with thorough legal training; and he may, perchance, undervalue theology, for, like the physician in Chaucer, his study may be "but little in the Bible." We may trace this tendency in all classes of men, even, it may be, amongst students of physics and artists, and so on till we find it illustrated in the shoemaker who *knew* there was *nothing like leather*. Realizing this tendency in myself, but earnestly desiring to value every department of knowledge justly, and feeling that in this regard, I could ask no better or fitter audience, I ask your attention to Art as a means of Education.

Of the mechanic arts, admirable as are their results, we do not now speak. But our concern on this occasion is with those arts which are called *par eminence* Fine Arts, or more commonly "Art." These serve not for mere material uses, for our comfort, or convenience, or for the facilitation of business; not to sustain the natural life, or even to promote in any way mere physical well-being; but they speak directly to the intellectual and moral nature of man, adding to his stock of knowledge, educating or leading forth his noblest powers, conducting him both onward and upward, by inciting to love and delight in the beautiful and good. How necessary is this moral elevation, we realize from the words of the poet, "unless above himself he can erect himself, how *mean a thing* is man!" Art, so understood, is the embodiment or utterance of those ideas modified by the imagination, whose nature it is to awaken sensibility or emotion.

Then how wide the realm of art! Every object in nature, every fact in history, every truth in science, and nearly all such have their poetic aspects, whose tendency it is to awaken feeling, may become the subject of art. Nay, the realm of art extends above and beyond nature; every thought and imagination concerning the mind of man, and its relations; concerning the supernatural; concerning other states of existence; concerning God himself, is the legitimate subject of art. Still more, every influence given to these thoughts and imaginations by our moods and feelings becomes in itself poetic.

The chief elements of art are the sublime, the beautiful, the characteristic, the humorous, the fantastic and the grotesque.

The particular modes of manifestation of art-feeling, or language of art, are poetry, painting, statuary, music, and architecture.

Poetry is art in articulate language; painting, in color, form, light and shadow; statuary, in form only; music, in sound; and architecture is art in the application of beautiful and grand forms to uses, in the construction of buildings.

Having defined art *generally*, let us now look more particularly at art-ideas as differenced in *kind* from truths of science. Scientific truth is statement of that which *is;* it derives its character as truth by virtue of its agreement with things as they really exist.

Art-truth is statement always with regard to these *qualities* of things, which have power to move our affiections. Scientific truth is the actual food of the mind. Being appropriated and assimilated, it becomes actually a part of our intellectual being. By it we grow. By it we advance. By it the world indeed moves. Nearly all scientific truths, have, as before said, their poetic side, and, so considered, become art truths.

The function of truths, of art, is especially to *elevate* the mind and to develop or educate its powers. But the value of art generally, and of art ideas particularly, can only be properly estimated by those who have the noblest and most exalted conception of the human soul and its interests. We wish to be in the highest degree practical; and to be so, we must exalt those truths which tend to the greatest good. Alas! many, who are often considered practical, value those truths only which serve merely as the *means* of life, and entirely ignore or despise that higher class of truths which concern intimately the *objects* of life, the very purpose of existence. "These men speak," as Ruskin says, "when they speak from their hearts, as if houses, and food, and raiment, were alone useful, and as if sight, and thought, and admiration were all profitless; men who insolently call themselves utilitarians, and, if they had their way, would turn themselves and their race into vegetables; men who think, as far as such can be said to think— that the meat is more than life, and the raiment than the body; who look to the earth as a stable, and to its fruit as fodder; and so comes upon us that woe of the preacher, that though God hath made everything beautiful in his time, also he hath set the world in their hearts so that no man can find out the work that God maketh from the beginning to the end."

Now, that is most practical, which is most useful; and that is most useful, which best serves the purposes of existence; and all admit that those purposes are best served by the most perfect education. This most perfect education is the leading forth, the fullest development of all our powers, and pre-eminently of the noblest powers of our whole nature.

This education, art claims as its direct function. To man alone, of created beings, does art speak.

> "In industry thou'rt mastered by the bee;
> The worm more skillfulness than thine hath shown;
> Thy knowledge, all high spirits share with thee,
> But Art, Oh! man, hast thou alone."

Man has the mind possessed by the animals, and he has more. He has powers far removed from theirs and different in kind. He has an understanding trammeled and limited by the senses, as they have; and he has a judgment which uses the senses for its expression, which is not limited by them, but which makes its affirmations positively, independently, and often in opposition to their dictation.

Sharing the judgment in common with the lower animals, where shall we find the distinction between us and them? Shall we not find it in this, that we possess a *moral* sense, or the power of conceiving right and wrong abstractly as principles; that we possess imagination, that high imagination which "bodies forth the forms of things unknown," as essential to the man of science as to the poet, to a Lord Bacon, as to John Milton; and above all, that power of affirming principles or laws, so surely that we never question them; principles which are the grounds of all mathematical, metaphysical and ethical science; that power whose assertions are as postive and undeniable as that "God liveth."

These faculties we know we possess, and we have as yet no reasons for supposing they pertain to inferior creatures.

Plato taught that in the mind of the Creator, there existed ideas which were the types or patterns of all his creations. Also that human souls are so formed in the Divine image, and so partake of his nature, that they also perceive and delight in these divine forms. Here we have the source of all transcendental philosophy. It accords also with scriptural teaching, for we are told that man was made in the image of God, and this image must have been of the Divine mind. The adoption of this conception underlies the philosophy of a majority of the greatest minds which have been vouchsafed to us. That this faculty of intuition, or direct beholding of essential truth, does exist in us, was held also by Lord Bacon, Dr. Ralph Cudworth, Kepler, Luther, Hooker, Pascal, Leibnitz, Fenelon, Immanuel Kant, Sir Wm. Hamilton, Cousin, Wordsworth, Coleridge, Mrs. Browning, and a host of other minds most influential. Coleridge says, "it is evident that there is an intuition, or immediate beholding, accompanied by a conviction of the necessity and, universality of the truth so beholden, not derived from the senses, which intuition gives birth to the science of mathematics; and when applied to objects supersensuous or spiritual, is the organ of theology and philosophy.

This higher power is the source of all art; and to this faculty all art is addressed. So, the radical meaning of the word poet is, *maker*, and the art faculty is universally called the *creative faculty*. Goethe sings—

> "Oh that the true creative power
>   Through all my sense were ringing,
> Like juices ready for the flower,
>   From out my fingers springing."

It is apparent that all the forms of musical art, all the sublime conceptions of the great masters, are purely creations. They seem the most spiritual of all the forms of art; there is in them no fitness to awaken emotions either painful or unpleasant; they serve only to elevate and delight us. This is indeed the true end of all art. It may be depraved, as may all things pure; it may even be forced into the service of vice; but the association is so incongruous, that to the reflecting mind, evil is made only the more revolting. It is a question whether any subject which is to a greater extent painful than otherwise, should ever be embodied in art; for example, Landseer's "Death of the Stag," and the group of the Laocoon, and only the beauties developed in their treatment can reconcile us to them.

The scientific man compares truth with truth, fact with fact, and, by a process of induction, arrives at general propositions, or laws; he uses the judgment in accordance with sense, in observing and comparing, and he uses the higher faculty of his reason, in establishing principles. The artist observes particular objects in nature, forms in his mind a general conception of his proposed subject, selects, arranges, modifies, and refers all to the standard in his mind, which is his ideal of beauty, or grace, or power, or whatever quality he may require, and so forms a perfect whole, based indeed *on* nature, conforming *to* it, but which is *not nature*, not imitation, not reproduction, but, as far as it is art at all, *is his creation.* Intimately concerned in this creation is the principle we call *taste.* Taste is the power of perception of those qualities, which, inhering in thoughts and things, render them fit subjects for art. This taste is not judgment, we must carefully avoid this notion, but by it the mind affirms directly and positively. It is to the mind in regard to qualities in truths, what the bodily senses are in regard to sensible qualities of material things, such as flavors, odors, and the like.

We pronounce as positively and independently of judgment, concerning the beauty of a flower, the grace of a musical melody, or the grandeur of a thought, as concerning the sweetness of sugar, or the sourness of vinegar.

To all it is not given to perceive these qualities in the same variety, and with equal accuracy; just as we may vary in perceiving *sensible* qualities. Yet, these qualities remain, and do not vary; sweet is sweet, and sour is sour; and hence, from the unvarying nature of these qualities, arises truth or untruth in the expression of them. Hence, we have truth of beauty, of humor, of power, or of any other element of art.

Possessed with this thought, hear Schiller—

> The truth which had for Centuries to wait,
> The truth which reason had grown old to find,
> Lay in the symbol of the *fair* and *great*,
> Felt from the first by every child-like mind.
>
> T'was virtue's beauty made her honored so:
> A finer instinct shrunk back, when it saw,
> The ugliness of sin, ere Solon made the law,
> Forcing the plant unwillingly to grow.
>
> Long ere the thinker's intellect severe
> The notion of eternal space could win,
> Whoever gazed up at yon starry sphere,
> That did not feel it prophesied within!

A glory of Orion round her head,
  Behold her in her majesty!
Her keen glance all but purer Demons dread,
  Consuming where she looks, she rides on high.

Above the stars, upon her sunny throne,
  Urania — the stately, the severe!
But she has laid aside her blazing crown,
  And stands — in Beauty's form, before us here.

She puts on loveliness' enchanted belt,
  Becomes a child, is hailed by simplest youth.
What here as *Beauty* we have felt,
  Shall one day come to us as *Truth*.

Now let us consider briefly, the influence of art in educating and elevating the mind. An artist, gifted with a soul alive to all the influences of sight, and sound, and thought, around and within him, produces a work: it may be an Oratorio; Handel's Messiah; a statue, The Night, or the Day, of Michael Angelo; a painting, The Last Supper, by Da Vinci; a temple, The Parthenon; a poem, or any one of the myriad works which make up the true wealth of the world! In the production of such a work, the artist, by his innate love for, and sympathy with the elements of which we have spoken, perceives them intuitively in objects of nature or in thought, or from his own mind creating these qualities, clothes the thoughts he presents with them, and thus we, who of ourselves might not perceive these poetic qualities, or create them, have them forced upon us, and the art faculty is gradually awakened and developed within us.

And the great art-work which has served us, once created, lives forever. Lives to delight and quicken the souls through all the ages.

That the art sense is so gradually produced, that this is the general process of art-education is I think, the experience of all artists, and we have upon it the testimony of so consummate an artist as Goethe, who gives as his own experience

"For when I think how, year by year,
  This sense hath kept unfolding;
Where once the barren heath spread dear,
  Now springs of joy beholding."

This sense, he speaks of in the verse just preceding, as the "Creative power." And this sense is not unfolded, and these springs of joy are not disclosed, except to the earnest humble votary who waits upon the oracle within. This also, Goethe shows in his enigmatic —

PARABLE.

Poems are colored window-glasses!
    Look into the church from the market-square:
    Nothing but gloom and darkness there!
    Shrewd Sir Philistine sees things so:
    Well may he narrow and captious grow,
Who all his life on the outside passes.

But come, now, and inside we'll go!
    Now round the holy chapel gaze;
    'Tis all one many colored blaze;
    Story and emblem, a pictured maze,
Flash by you: — 'tis a noble show.
    Here feel as sons of God baptized,
    With hearts exalted and surprised.

Art does not only awaken this art-power, but with this awakening comes constantly delight, admiration, love, and all the nobler emotions, purifying and lifting the whole being. Coleridge says of poetry (and what is true of poetry is true of all forms of art), "poetry has been to me its own exceeding great reward; it has multiplied my enjoyments, it has soothed my affections, it has endeared solitude, and it has given me the habit of wishing to discover the good and beautiful in all that meets and surrounds me."

De Quincy divides all literature into two classes; one is of *information*, the other is of *power*. The one speaks to the understanding; the other, to the higher faculty we have been considering, and always through affections of pleasure and sympathy. "Remotely it may travel towards objects in the Lumen Siccum, a phrase of Lord Bacon for the pure reason, but proximately, it must act, or it loses its character as literature of power, in and through that humid light, which illuminates the mists, the irridescent hues, and the glittering points of human passions, desires, and genial emotions," Lord Bacon speaks thus of the influence of poetry: "Poetry serveth and conferreth to magnanimity, and therefore it was ever thought to have some participation of divineness, because it doth raise and erect the mind, by submitting the shows of things, to the desires of the mind. Milton speaks of, "our sage and serious poet Spencer, whom, he adds, 'I dare be known to think a better teacher than Scotus and Aquinas.'"

Nothing has yet been said of the *extent* of the influence; its nature only has been noticed; but where does it not extend, it is every where; we cannot excuse art's influence. It is in our books, our periodical literature, the ornamentation of clothing and furniture, the decoration and refinements of our homes, in music, all rural adornments, in the beautiful commingling of exquisite buildings and gardens, with natural scenery in the suburbs of cities. It is in all architecture, from the most primitive, through the simple but sublime forms of Egyptian art, the chaste and classic elegance of Grecian, to the wonderful variety and exquisite beauty of the finest Gothic cathedrals.

Even the art of past ages, which has been long buried, is being constantly exhumed for us; and as the Palimpsest, or old parchment, from which the original treatise has been obliterated to give place to the chronicles of after times, and to which, art can restore the original writing, so almost all the habitable earth has in it, concealed by the deposition of ages, the life and art of a by-gone world. And these are being constantly revealed to us by exhumation, in Rome, in Greece, in Pompeii, in Egypt, in Assyria, etc., and most recently on the site of ancient Troy, by the wonderful "finds" of Dr. Schlieman.

All this *influence* is *education.* The perception of truth in the simplest forms of art always gives enjoyment, and the realization of the various truths of beauty, grace, and power, which combine in any perfect work, carries the mind beyond delight, to gratitude, admiration, and even adoration. And the "human soul is in the most exalted position, when it reverences; when it adores." This is the education art accomplishes for us; what do we for art?

How long has it, or any branch of it been considered an essential part of an educational course? Thirty years ago, the most done in this direction was through the professorship of Belles lettres in our colleges. This comprised instruction in Rhetoric, and on English authors of all classes; but without any consideration of literature as educational, or any recognition of the value of art in mental development. In the English universities, there was a professorship of poetry, but regarded mostly as a sinecure. In some select schools, young ladies seminaries, etc., claim was made to an art department, because young ladies were there misled and corrupted in their *natural* feeling for art, by exercises in water-colors, Grecian painting, scratching off marble dust, and other puerile quackeries. In our cities the rudiments and practice of vocal music have been not uncommon; but there never yet has been, and there is not now, any practice or teaching of the principles and value of any form of art, in our common schools, in any part of this land, except in a very few instances, which shall soon be noticed. More than this, the most astonishing ignorance prevails generally, not only with the advanced scholars, but among the teachers. It is frequently the experience of artists, that visitors to their studios, occupying high place in the professions, show a wise modesty in the expression of judgment, or show that modesty would have been wise. Critics generally get no farther than to think close imitation the best art; and tell of the birds plucking at painted grapes. Yet this proves not that the art was good, "but," says Goethe, "that the critics were only poor birds."

Too often our critics look into the church from the market-square; they do not step within.

With the teaching of Ruskin a "new departure" is taking place. Schools of design, with special reference to art in manufactures, and ornamentation have been put in operation in several English cities. A professorship of art has been established in Oxford, which is filled by Mr. Ruskin; who teaches the cultured young men of England, the supreme value of the arts in all the refinements of life, and in that development of the intellect and the moral natnre, for which alone life is given, as has never before been done in the history of the world.

In this country, three or four years ago, Walter Smith from London, England, was appointed "state director of art-education for maps, in the common schools of the state." A manual of his system has been published, which consists of graded exercises in ornamental and symmetrical forms. These forms are to a great extent idealized forms of natural objects, or as he calls them, conventionalized forms. He has taught many of the teachers, and is still directing *their* teaching. Some of his pupils are now engaged in introducing his system in the larger cities of the Union, when they can find favor in the eyes of boards of education, as lately in the city of Chicago.

This teaching, as a beginning, I regard as of inestimable value in disciplining the hand and eye, and awakening the mind to the perception of beauty in line and form. Yet in this system, the "picture element" is almost entirely excluded. Light and shadow color, composition, expression and most of the essentials of pictorial art are not at all studied. All this must follow, and this leads me to consider lastly the best means of bringing this wealth of knowledge and feeling home to the minds and hearts of the people; and in this connection, the universality of the faculty to receive it.

Time was, when all science was mystery, and secret guilds monopolized the arts. The philosopher was in league with the evil one. The church said, "thus far shalt thou go, and no farther." All research was unpractical. "What nature hides within," O thou philistine! No finite mind can know.

> **" Now that for sixty years I've heard repeated,**
> **And oft' as heard, with silent curses greeted,**
> **I whisper o'er and o'er this truth eternal:—**
> **Nature doth freely all things tell;**
> **Nature hath neither shell nor kernel.**
> **Whole everywhere, at each point thou canst learn all ;**
> **Only examine thine own heart,**
> **Whether thou shell or kernel art."**

Where is the kernel of nature? say, but in man's heart.

This element of sincerity with one's self is the first requisite for progress, either in science or art.

Not long since, no one could sing without some special gift.

Now, all can learn to sing, except some rare individual with imperfect organ of hearing or voice. Not long since, no one could learn to draw, without a *special* gift, and now, if a boy shows some aptitude to imitate nature, the fond parents and friends say, "what a gift the boy has!" What a genius he is! Because, perhaps he has drawn a cat or a candlestick so that one may almost immediately say that it was not intended for either a cow or a capstan. A few years back, John. S. Chapman, artist, uttered the truth, that "any one who can learn to write, can learn to draw." And this we now begin to understand. Of course we require gifts; and thank God we have, all of us; and one of the best gifts we have, is the love of beauty, beauty in all its manifestations, in flowers, animal life, in trees and rocks, in streams and skies, in form, and sound, and thought, and *life is full* of it. And the power of enjoyment — which means the art-faculty is as universal as the material provided for it.

"I know I could never be an artist." No, sir, you do not. "I know I have not the gift." Dear Madam, you are full of gifts. You do not know what gifts you have; and your knowledge of them can come only by your development of them.

Of course, these gifts vary in power, as do other gifts, which are presumed to exist in all; the judgment, memory, power of comparison, etc. It often happens, however, that the person most gifted, your genius, will be satisfied with mediocrity, and the humble, slow, but earnest seeker for excellence will go far beyond him. "Nothing" says Sir Joshua Reynolds, is ever denied to well directed effort. When Domenichino was called "the ox," by his fellow students, for his slowness and lack of gifts, his master, Annibal Carracci said, "he is an ox who will till well the field he plows," and he surpassed them all.

What is needed, in my judgment, to make our system of education more complete, so that we may be less onesided, and our powers may be symmetrically developed, so that, as men and women, we m y be rich with wealth, which long lay in us all unconsciously is, 1. To introduce generally in our primary and graded schools, such system of drawing, as that of Mr. Walter Smith, supplemented by simple picturesque designs, with some effect of light and shadow; slight artistic sketches of natural objects. 2. In higher schools, practice on more complex designs from nature, and on good copies from antique and modern statuary; this should be accompanied by some instruction in the first principles of art, and the connection between the arts in their nature and influence. 3. Connected with every state system of education, should be an art professorship. The incumbent should devote all his time to the duties of his office, instructing teachers in the cities, and students in the normal schools, visiting them periodically, lecturing on the elements of art, and directing them in their practice. He should also attend all educational conventions within the limits of his state, and create and continue an interest on this important matter; and, 4. In each of our colleges and universities, should be an Art Department, supplied with a museum of works of art, of all kinds; these should be added to constantly, by gifts from all sides, and the collection would grow with the institution. Each institution should support a professor of the history and principles of art; and lectures and systematic teaching of the history of schools and styles should be given, and of the philosophy of all the arts, illustrated by specimens always at hand, in the museum.

When this state of things exists, the reproach of such general ignorance will pass away; and this will be the smallest gain. Then love of art will be sincere, and intelligent; and love of nature also will increase. Then will beauty come to us as truth. Then will we feel and know the truth, that —

"Freely through Beauty's morning gate,
Canst thou to knowledge penetrate;
The mind, to face truth's higher glances,
Must swim sometime in Beauty's trances;
The heavenly harping of the muses,
Whose sweetest trembling through thee rings
A higher life into the soul infuses,
And wings the upward to thee soul of things."

THE HARMONIC METHOD IN GREEK ART.

BY MR. J. R. STUART.

A great deal is said in a vague way of the ideal in Greek art, as if that ideal were a fixed form or pattern, by which the artist worked out his statues. Were this possible, the art would become a manufacture and we should have statues turned out by the lot, like so much furniture, of the correct pattern. Whereas, the work of the Greek sculptors was the result of constant, earnest study and observation. A lifetime was sometimes devoted to a single work, and, among the thousands of statues produced, there was an infinite variety in the model. The massive muscle of Hercules, the superhuman grace and greatness of Apollo, the matronly Juno and lovely Venus are each a distinctive type. To combine these types, to place the head of Hercules on the body of Apollo, for instance, we feel at once would produce a monster. Each statue must be in harmony with itself, and this leads us to what Walker, in his 'Analysis of Beauty,' has called the "*harmonic method*" of the Greeks.

There are certain general, proportional measures used by artists in constructing their figures, such as eight heads to the whole height, which was sometimes varied as low as seven and a half heads. Six feet (lengths of the foot) to the height, as Vituvius tells us, was the practice of ancient artists. A man standing with arms extended; the extreme extent of his arms is equal to his height. So, also, the measure from the centre of one mamma to the centre of the other, equal to the distance from each to the pit above the breastbone.

There is something needed, however, beyond these rules of general application, and we now approach the chief difficulty, which evidently found a stumbling block to even Leonardo da Vinci. That harmonic method which, strange as it may appear, will be found to afford rules that are at once perfectly precise and infinitely variable. Says Walker. The harmonic method of the Greeks — that measure which Leonardo called "the true proportion;" "the proportion of an individual in regard to himself.;" "which should be differènt in all the individuals of a species," but in which "all the parts of any animal should be compared to the whole;" and which, as Bossi adds, "Varies in every figure, according to the age, circumstances and particular character of each." In short, this method for the harmony of parts in each distinct individual; this method, presenting rules perfectly precise, yet infinitely variable, has, in all its elements, been clearly laid down before the reader (though not enunciated as a rule) in the *locomotive*, *nutritive* and *thinking* systems, or, generally speaking, of the *limbs*, the *trunk* and the *head*, and in the three species of beauty founded on them.

These, it is evident, present to the philosophic observer, the sole means of judging beauty by harmonic rule, the great object of Leonardo da Vinci's desires and regrets. They present the great features of the Greek method, if that method conformed to truth and nature, as it undoubtedly did. This will be rendered clearer by a single example.

Thus, if any individual be characterized by the development of the nutritive system, this harmonic rule of nature demands, not only that, as in the Saxon English, the Dutch and many Germans, the trunk shall be large, but consequently that the other two portions, the head and the limbs shall be relatively small. That the calvarium shall be small and round and the intellectual powers restricted; that the head shall nevertheless be broad, because the vital cavities of the head are large, and because large jaws and muscles of mastication are necessary to the supply of such a system; that the neck shall be short, because the locomotive system is little developed; that it shall be thick, because the vessels which connect the head to the trunk are large and full, the former being only an appendage to the latter. That the lower limbs shall be both short and slender; that the calves of the legs shall be small and high; that the feet shall be little turned out, etc. So, also, if any individual be characterized by the locomotive system, the harmonic rule demands not only that the limbs shall be large, but consequently that the other two portions, the head and trunk, shall be relatively small; that the calvarium shall be small and long, and the intellectual powers limited; that the head shall be long, because the jaws and the muscles are extended.

Again, likewise, if any individual be characterized by the development of the thinking system, the harmonic rule demands, not only that the head shall be large, but consequently that the other two portions, the trunk and limbs, shall be relatively small; that the head shall not only be large, but that the upper part, the calvarium, shall be largest, giving a pyramidal appearance to the head; that the trunk and limbs, however elegantly formed, shall be relatively feeble, the former often liable to disease, the latter to accident.

It must be borne in mind, however, that there may be innumerable combinations and modifications of these characteristics, certain greater ones, nevertheless, generally predominating.

The following are some of the principal rules, which, either by intuition or distinctly defined, guided the practice of the ancient Greeks:

First, in regard to the thinking system. In the head, in particular, may be observed *character*, or a permanent and invariable form, which defines its capabilities and *expression* or temporary and variable forms, which indicate its actual functions. As character is permanent and invariable, it depends fundamentally on permanent and invariable parts, the *bones*. And as expression is temporary and variable, it depends on the shifting and vital parts, the *muscles*.

The suggestion of the bony structure, then, giving character, and of the action of the muscles, giving expression, we find always represented in a masterly manner by the Greeks, minuter forms which are universal, and without which nature is imperfectly represented. These are details of the highest order, because the means of expressing intellect, emotion or passion. Between these intellectual means, these higher details and those of a lower order, the great artists of Greece distinguished. The lower details, such as wrinkles and folds of the skin, projecting veins, peculiarities of the hair, beard, etc., these have always characterized inferior artists and decadent art.

When the ancient artists increased the facial angle beyond eighty degrees, they believed that an increase of intelligence corresponded to that conformation. By increasing the angle beyond eighty-five degrees they impressed upon their figures the grandest character, as in the Apollo, Venus and others, whose facial angle extends to or exceeds ninety degrees.

Observing the nature of the angle, we perceive that it tended in no way to raise the forehead, but to throw it forward or to lengthen it. Whence the expression of long head for wise head, which has not yet given place to broad head, preferred by German craniologists in compliment to their own organization. The general rule was, that the forehead's height should equal the space from the forehead to the bottom of the nose, or from the nose to the bottom of the chin.

The next rule is in regard to the *form* of the nose, in nearly the same line with the forehead, and with very little indentation between the parts.

The nose is the inlet of vital emotion or pleasure, the eye of mental emotion, while the passions depend on the mouth and ear. The emotional, the higher faculties, were expanded by this raising of the junction of the forehead and nose, while the lower faculties of passion, the mouth and ear were relatively decreased. While developing the higher organs of emotion all impassioned expression was suppressed, and thence the bestowal of that calmness and simple grace, which is the highest quality in all representation. In inferior beings, however, when passion is expressed, the features are varied by the Greek artists, as they are in nature. Such are the great ideal rules for the head and functions of thought.

As regards the *nutritive system*, the vital and reproductive, the Greeks similarily idealize. The Venus of Milo may be taken as the type of this system. The head and torso are all that is visible of the body. The head presents all the loftier qualities already discribed in the intellectual and emotional, but calm, sweet and self-poised, while in the torso, the nutritive system is perfectly developed in the full expansive forms and exquisitely rounded costumes. A representation of eternal perfected womanhood and feminine loveliness.

Next of the *locomotive system* and the ideal rules for *its* treatment by the Greeks.

Of the works of ancient art which have been preserved, the Apollo Belvidere is conceded to possess the highest qualities. In this statue we find all of these principles developed and combined. The full intellectual brow, the thin, quivering nostril and fine yet sensitive lips, the column-like throat, the well developed limbs and trunk, but the last subordinated to the first, the higher faculties of the intellect.

The Antinous is unsurpassed among ancient statues for grace and beauty. But in comparing the Antinous with the Apollo we find, that, when the former fills us with admiration only, the Apollo strikes us with surprise. To, at least, as much grace and beauty as is found in the former, there is a superaddition of greatness, an appearance of something more than human, which one is at a loss to describe. This is the more surprising when we find, that the legs and thighs are too long and too large for the upper parts.

Now, Hogarth suggests that this has been done with a purpose, and that this greatness is really owing to what has been considered a blemish. The Apollo is greater in size than the Antinous, but if we consider a moment, we feel that were the Antinous enlarged to the Apollo's height, this would not produce the superiority of effect. Says Hogarth: "The Antinous being allowed to have the justest proportion possible, let us see what addition, upon the principle of quantity can be made to it, without taking away any of its beauty. If we imagine an addition of dimension to the head, we shall immediately conceive, that it would only deform. If to the hands or feet we are sensible of something gross and ungenteel. If to the whole length of the arms, they would be dangling and awkward. If by an addition of length or breadth to the body, we know it would appear heavy and clumsy. There remains then only the neck with the legs and thighs to speak of. To these, we find, that not only certain additions may be admitted without causing any disagreeable effect, but that thereby, greatness, the last perfection as to proportion is given to the human form, as is evidently expressed in the Apollo."

This is well done by Hogarth (says Walker). It requires but little anatomical knowledge to see the reason of this. The length of the neck, by which the head is further detached from the trunk, shows the independence of the higher intellectual system upon the lower one of mere nutrition and the length of the limbs shows, that the mind had ready obedience in locomotive power. Here again we find the expansion of the higher faculties and the subordination of the lower.

This principle that all the parts of any animal should correspond to the whole, is the same adopted by comparative anatomists in their constructions. But in representing the human form, the Greeks had an insuperable advantage over the modern. Now only were the opportunities for observation and comparison infinitely better, from the habits and costume of the people, but the Greek man himself was undoubtedly developed to a far higher state of perfection, than has been done either before or since by any other people. Jaine has given in his art in Greece a very exhaustive treatise on the mode of life and training which produced such results, the perfect model and thence the perfect statue. It is probable that we can never equal them in their particular branch of sculpture, but by following the method practiced by them, our own work will certainly be more perfect.

We have something analogous to it in the training and improvement in the breeding of horses. The heavy Clydesdale or Norman horse with massive limbs and muscles, at once suggests his fitness for the laborers of Hercules, to whom he is analogous in form, while the lithe form, clean limbs, broad front and quivering nostrils of the English thoroughbred, or the Arab of the Nedjid, suggests the warrior and hunter, the very Apollo of horses. Without doubt, as our jockeys are connoisseurs in the points of horse flesh, so were the ancient Greeks in the points of man flesh, and the method of their artists was based upon such knowledge, cultivated by centuries of observation and experience.

DEPARTMENT OF LETTERS.

LETTERS AN EMBARRASSMENT TO LITERATURE.

By PROF. W. C. SAWYER, of Lawrence University.

Without letters there could be no literature; but with them, its development must be in proportion to the facility with which they symbolize and record our thoughts. Intellectual activity is stimulated through the eye quite as readily as through the ear, and recorded thought stirs the soul only less potently than the human voice.

The utterances of the tongue — not the traces of the pen and the impressions of the types — constitute language. Speech is made up of the symbols of thought; literature, of the symbols of speech, and is, accordingly, two removes from the energies of the soul itself. The tones of the voice, however, travel but a short way and perish before they have reached more than a few thousand ears — not allowing for the possibilities of the telephone — while the recorded words and deeds of buried generations will perpetuate their memory, in many lands and literatures, to the end of time.

There are some reasons for supposing that the present advantage of writing, over speech, may be increased tenfold with the increasing facilities for the production, distribution, and consumption of literature. The chief obstacle to the growth and perfection of our literature is in the mechanical difficulty of writing, together with the consequent evil effects upon reading and general culture.

Leibnitz has said, "Give me a good alphabet and I will show you a good language." The world has been suffering for centuries from the vain endeavor to form good languages — or literatures rather, for the languages have almost formed themselves — without the least regard to the sort of alphabet used. A single language exhausts our score and six letters, and the next is forced to fit this same garment to its altered proportions.

Human speech is made up of the various phonetic effects of the air passing through the mouth and nose, as modified by the tongue, the teeth, the lips, the uvula, and the vocal chords. We know, by the physical laws of phonetic change, that every modification of these physiological organs must produce a distinct sound. No language uses nearly all the possible voice modifications; but each one employs a certain definite number of them — our own using about forty — and makes up for the deficiency of symbols by arbitrarily assigning some group of letters to represent the phonetic elements of each word of the language. One result of this practice is, that in different languages, different powers are given to the same letter. This is rapidly becoming a greater and greater evil, as the study of the languages, especially the modern, becomes more general and more necessary. It is not easy to overcome the power of a fixed habit and give a new sound to a familiar letter. Especially is this difficult when the new power of the letter differs but little from the old, as when, for instance, we learn the continental *o* — a simple sound — or when a student from the Continent learns our *o* — a diphthong. I set this fault of the alphabet among the chief reasons why we come so far short of mastering the orthoëpy of foreign languages. The importance of this feature of linguistic study cannot well be overestimated.

The fact that there are less letters in the alphabet than there are elementary sounds in our language leads to the fatal necessity of employing the same letter in different capacities. This unsettles the powers of the alphabet, and disturbs the logical order of education, even for the children in our common schools. Unfortunately the confusion thus necessitated does not stop with the limit of the necessity. The demoralization consequent upon the unsystematic use of letters with variable powers has greatly increased the burden of a common education. The first letter of the alphabet is given, by some careful orthoëpists, nine distinct sounds, as in *ale*, *any*, *care*, *pan*, *pass*, *arm*, *idea*, *what* and *all*. The same uncertainty attends all the vowels, though the variations are most numerous in the case cited. This leads to the extraordinary phenomenon of representing about fifteen elementary vowel sounds in about forty-seven different ways in the same language. The consonants afford but little relief, the simple surd palatal sibilant being represented in twenty-two ways, requiring in all forty-seven letters. The language affords many examples of sounds variously represented by dissimilar characters, among both vowels and consonants. The habit of representing simple sounds by digraphs like *ph*, *sh*, *th*, *ng*, *wh*, *ah*, *aw*, etc., is very expensive and by no means luxurious. The various spellings of the same syllables, as in *tion*, *sion*, *cion* and *shun;* the various pronunciation of the same combinations of letter, as *ough* in *though*, *through*, *bought*, *plough*, *cough* and *enough;* and the hundred and twenty-four silent letters out of every thousand in an average book, constitute a material and moral burden that the age can ill afford to carry.

Our alphabet could be employed to far better advantage than at present; but its crudeness discourages all refinement in its use. It is barbarous in both its origin and its character. It mingles surds, sonants, gutterals, dentals, labials, and vowels and consonants in such perfect confusion that to inquire for their principle of arrangement could be understood only as a jest.

A startling statement has been made by Mr. James W. Shearer, that only five words in the English language are pronounced as they are spelled. The word *no* is among the number. It has a consonant that is nearly, though not quite, uniform in its use. But the vowel *o* as heard in this word, represents two elementary vowel sounds — the first being the exact contenental *o* and the other a short vanishing *u*, like the vowel of *moon*. This combination corresponds with the name of the letter and its popular "long" sound.

In this word, the sound of *o*, which Mr. Shearer, in all probability, has set down as the proper sound occurs, according to Professor Whitney's table of frequency, only one hundred and seventy-six times in ten thousand words, while "short *o*," as in *not*, occurs two hundred and fifty-nine times. Strictly speaking, there is no knowing when a word *is* "pronounced *as spelled*" in our language, though we can generally be sure that our words *are not* pronounced as spelled.

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One of the chief elements of elocution is orthoëpy. A careful and correct articulation marks refinement and scholarship everywhere. Nothing is better established in philology than the universal indolence of the organs of speech. This is attested by all forms of assimilation, as well as by the dropped syllables of all the uncultivated Teutonic and other dialects. It is not for euphony that we say *collateral* for *con-lateral*, but for economy of articulation. The *n* contact, of the whole tongue with the hard palate, completely obstructing the passage of the breath by the mouth, is unlike that of *l* by only a part of the contact, the sides of the tongue being withdrawn from the palate or teeth, while the lips remain as before. To save the effort of this slight variation of the position of the tongue, we assimilate the *n* to the *l*. This disintegrating tendency is a force that operates perpetually against the correctness of our pronunciation. Some of the corruptions of utterance are attended with corresponding changes of orthography; but these changes have been capricious, and spelling and pronunciation have become so completely divorced that no rules can longer account for all the disagreements between orthography and orthoëpy.

If the symbols of our writing were exact, all the tendency of reading would be toward purifying, instead of corrupting, our utterances. A distinct symbol for every sound in our speech, with its power fully described and thoroughly practiced in connection with learning the forms of the letters, would correct every error of pronunciation Every written or printed word would then suggest and impress its proper sounds, and reading and elocution could not fail to make the most rapid advance. The orthoëpy of our language is demoralized by its barbarous alphabet, and, till that is reformed, it cannot expect to recover any fair standing.

One of our literary disabilities which we charge, with some asperity of feeling, to our orthography, is the difficulty of rapidly reading, or skimming, books to gain their leading thoughts, or to discover their views upon some special subject. Even under its present difficulties, this method enables a student to make a far wider acquaintance with literature, and to give a better authority to his authorship, than if he should read altogether by the deliberate examination of every page and word.

The mechanical difficulty of rapid writing also, troublesome in every literary pursuit, is peculiarly so in the higher education. The use of lectures, in university instruction, is embarrassed so much by the necessarily slow and burdensome process of writing out the lectures of the professors that we cannot afford to make that use of lectures which is so popular in Germany, and which, but for this obstacle, might be very useful in our own educational methods.

Only five or ten years ago, spelling reform was looked upon as the impracticable notion of a few dreamers. At present, it has the support of the leading philologists of England and America. Indeed, the only work in this interest which is likely to abide, has been done by our foremost linguistic scholars. Reports very favorable to this reform have been made by committees of both the *American Philological Association* and the *National Educational Association.* Some special organizations have been formed, both in this country and in England, to promote this same end. The Germans also have taken active measures to correct the comparatively few and slight orthographic defects of their language. The Royal Commission, appointed by Minister Falk, reported such modifications as violate the historic spelling just about as often as they violate phonetic principles. Such a compromise, though now the law of the Empire, could not hope for great popularity; but it is noteworthy that the complaint that reaches our ears is chiefly on account of the half-way character of the reform, rather than because the sacred order of the letters has been disturbed. Under such sentiments, a Reform League has been formed in Germany aiming to complete the reform, and introduce it into common use. They make a forcible showing of some of the advantages of the reform, in the following mathematical fashion:

"If, after the adoption of phonetic spelling, each child at school were to save only one lesson in spelling every week, that, for sixty millions of Germans, would amount to a saving of five million years. Each child would save forty-eight hours in a year, which, if we reckon each day as consisting of twelve working hours, would give four days in a year, or thirty-two days during the eight years spent at school. Each child would therefore save about one month at school, twelve children one year, sixty millions of German children five millions of years. These might be applied to some better purposes than to find out whether we should write *libe* or *liebe.*"

These same considerations apply in English with tenfold more force. If, therefore, the Germans will not tolerate even a moiety of the few phonetic defects of their orthography, what satisfaction can we expect from a half-and-half reform of our own? But our reformers are inquiring not how little change will satisfy the people, but how much they will suffer. They put too low an estimate upon the public intelligence, and are far too sensitive about being compared with Josh. Billings and other gentlemen who spell better in jest than other people in earnest. Fortunately the public is conservative enough to cling to the old system till a better one is found. A reform that needs reforming must always be unsatisfactory. Several systems of spelling by the aid of the old alphabet, with or without modifications, are now before the public. They exhibit evidence of careful study and economy almost heroic. But economy, carried to the pitch of saving a few new symbols at the expense of saddling upon unborn generations another irrational method of writing, becomes a groveling parsimony.

Mr. Bell's system of "Visible Speech" is the most thoroughgoing attempt yet made to form a simple, exact, and universal system of phonetic rotation. This was never intended for general use, and, as Prof. W. D. Whitney has shown, is not perfectly adapted to replace the alphabet; but it has demonstrated the grand possibilities of phonetic symbolism.

Thanks to such men as Mr. Bell, Mr. Ellis, and Profs. Haldemann, March, and Whitney, we have at last a rapidly maturing phonetic science, which is both the indispensable condition, and the sure promise, of a rational alphabet.

DEPARTMENT OF SPECULATIVE PHILOSOPHY.

MR. SPENCER'S SOCIAL ANATOMY.

By H. M. SIMMONS, of Kenosha.

The ancient and hackneyed simile comparing social to animal structure, at length assumes scientific form in Herbert Spencer's last volume ("Principles of Sociology"). His comparison is very ingenious. Individuals are the cells of the social structure; although not in physical contact like animal cells, still through language and various influences they become virtually in contact. The earliest social organizations are small and loose groups where each individual retains a large measure of independence; like a cluster of vorticellae or a sponge, where each cell retains its separate life. But with advancing society the organizations grow larger, population like animal tissue grows denser, and the individual like the cell becomes more dependent on the aggregate, as the differentiation of structure and function advances. A savage tribe, like a rhizopod, is homogeneous, each part serving for any kind of work at demand. But with advance society separates into classes, with increasing division of labor, just as rising animal structure shows its increase of organs.

The first differentiation in Mr. Spencer's analysis is between outside and inside. In the animal, outside hardens and assumes organs of defense and attack, while inside becomes stomach and varied alimentary system. So society separates into an outer class of masters, warriors, and rulers for protection, and an inner class of slaves and laborers for procuring and preparing sustenance. Between inside and outside must be another system to distribute the sustenance when prepared. This becomes circulation in the animal and commerce in the state. Finally in the outer layer of the animal arises a varied nervous system, with organs of sense and will for the regulation of the whole; so in the dominant class in the state arises government with its varied means for obtaining information and executing orders for the regulation of the whole. So in social as in animal structure, Mr. Spencer traces three systems: first, the inner sustaining system, — alimentation in the animal, and productive industries in the state; second, the distributing system, — circulation in the animal and commerce in the state; third, the regulating system, — the nervous structure of the animal and the government in the state.

Mr. Spencer traces the analogies in detail. As the simple alimentary canal becomes divided into organs for mastication, disintegration and the various processes of digestion; so the rude industries of a savage tribe grow diverse in the arts of civilization, with the same method. As for instance, the liver originating in separate bile-secreting cells scattered along the intestine, becomes at length concentrated in a viscus with direct and ramifying branches; so an industry commencing with separate workmen scattered through the community, gradually becomes concentrated in factories and a great manufacturing center.

The distributing system shows still more remarkable parallels. Commerce commences with shifting paths through forests and prairies, like the unwalled and changing lacunæ in animal tissue. But with advance the paths grow straight, and fixed in fenced roads, like the walled blood vessels; and culminate in the double-tracked railroads separating the outgoing and incoming currents, — the arteries and veins of the social structure. These great channels of distribution in their ever-ramifying divisons grow smaller in roads and lanes, and end in unfenced cart-tracks across the fields, — the capillaries of commerce. As circulation commences in the lower animals feeble and irregular, but culminates in the steady pulse of the mammal; so commerce commences in feeble barter, and rising through the irregular fair, comes at last to the steady pulse of the daily market. Here and there a manufacture, like a secreting gland, draws from the current the crude material, which it works over into more refined products and then returns to the circulation. So in the animal and social economy alike, the sustenance is carried where needed.

The regulating system shows a like parallel in details. The lowest tribes are nearly without government, as the lowest animals without nerves. Then comes the rude chief, like a simple ganglion. Then comes the union of tribes, with one and its chief raised to a kind of leadership, like the lower articulate with segments partially subordinate to the head. Then comes monarchy, with its king controlling all subordinate rulers and members, like a vertebrate with its nervous system fully centered in the brain. But, as in the rising nervous structure, cerebrum and cerebellum, the deliberative centers, imperceptibly arising, come to overshadow and control the sensory centers; so in the state, deliberative assemblies, imperceptibly arising, come to overshadow and control the personal will of the monarch, and government becomes constitutional instead of autocratic, reasonable instead of impulsive and passionate. Finally, as in the animal, the internal functions are regulated by the sympathetic and vaso-motor systems acting automatically; so the internal functions of the state, its industry and commerce, come to be self-regulating, and need no interference from the government.

These comparisons, doubtless, seem fanciful to many. But if life is one, as we are learning, then such resemblances are natural. Of course such parallelisms must not be pressed to details of structure; but in functions, they are not only natural but necessary. Society, like any other living thing, must have its sustenance and distribution, and its organs for these functions; and Mr. Spencer's analysis seems in general not only ingenious but true.

But, on a few points, Mr. Spencer seems open to criticism. The animal digestive system seems to correspond not to all the productive industries of the state, but only to the manufacturing industries. Digestion, like manufacture, takes the raw materials of nature second-hand and prepares them for use. Hence digestion is only part of the sustaining function. Beyond the secondary process of preparing the sustenance lies the primary process of getting it. Outside the animal digestive system are organs for gathering food for digestion; and outside of manufactures are the various agricultural, mining, lumbering, and other industries, for gathering from nature the material for manufacture. All these processes, of course, belong to the sustaining system. So the sustaining system is not all inside, as Mr. Spencer makes it, but partly outside. It is outside before it is inside. The protozoon is sustained by absorption through the surface, before stomach cavity arises; and a savage tribe is sustained by the external industries of fishing and hunting before manufactures arise.

This criticism does not injure the parallel, but helps it. In this external part of the sustaining system, we may also trace the analogies between the animal and social structures. As the sustaining system of the rhizopod is a mere surface folding around the food coming in its way; so the lowest savages merely absorb the uncooked roots, berries and molluscs that chance brings them. But with the beginnings of stomach come cilia to entrap and absorb food, and tentacles to range through the water at random and capture prey; so with the beginning of domestic life and the arts, some men become hunters and fishers, the tentacles of the tribe roving at random to entrap and capture game. With advance in the animal, the external organs become fierce with appendages for fighting; so advancing society produces its warrior class to win sustenance by attack and plunder, — the claws and fangs of the social body, growing more deadly as they become pointed with bronze and steel. But as in the rising animal scale, fierce claws at length give way to supple hands and cunning fingers, gathering a better sustenance; so in the social body, the military class in time give place to the industrial, and what was once the claws of the state become the productive hand of civilization, peacefully gathering from field, forest, earth and sea a far richer sustenance than war can steal.

Again, one is forced to ask why Mr. Spencer has said nothing of the *respiratory* system. Respiration is the function most characteristic of and most essential to animal life. The sustaining and distributing systems of which he says so much are purely vegetative, — belong to a tree as much as to a man. But one of the chief differences separating the animal from the vegetable is respiration. The animal absorbs oxygen, and the higher he is in the scale, the more perfect his organs for absorbing it. In the lowest animal the oxygen is absorbed from the water through the general surface of the body; then through specialized places on the surface, which in time fold and branch into gills; finally it is absorbed more rapidly from the air through the perfect lung of bird and mammal. Respiration seems the special mark of the rising animal, and comes to be the most important function of all. Eating may be omitted and the sustaining system lie idle for days; but not breathing. Consciousness may be suspended and the regulating system deranged; but the respiration must go on. From respiration, too, come the warmth and energy of higher life. The contrast between the torpid reptile and the frigate bird which, as Michelet says, "takes his breakfast on the Senegal and dines in America," comes largely from the contrast in breathing powers. Even that higher life we call spiritual is as closely linked with the breath as its name implies. Foul air dulls and fresh air quickens the thought. Even moral excellence seems somewhat dependent on good breath. "Let everything that hath breath praise the Lord," says the Psalmist, and probably nothing else will. The old fabulists were wise to figure Satan as a dragon, — a poor-lunged creature, perhaps one of the extinct gilled halisaurians. High life comes with breathing. To the sustaining and distributing systems of the vegetable, must be added a respiratory to make the animal; and it seems strange that Mr. Spencer should have omitted this from his parallel.

We may not be able to trace the social gills and lungs or any details of the respiratory structure, but the respiratory function is plain in society. Respiration means consumption. Breathing is burning, and the different methods are only so many ways of keeping the fire. Gills furnish a poor draft; perfect lungs show pipes, chimney, and heaving bellows at the bottom, and keep the animal well burnt out. Stomach and lungs balance each other. Stomach feeds and lungs eat; stomach accumulates and lungs consume. The tree gathers and keeps, and so grows bigger every year; the animal gathers and spends itself, turns its fiber into force, warmth and action, and so after a little does not grow bigger, but grows better, ever burning out the old and keeping itself renewed. Respiration means consumption of old tissue.

Society shows this process,— not the mere consumption of which the political economist speak, but the deeper consumption of the social tissue itself. Men whose work is done are removed like worn-out cells from the body. As even the older and solider framework of the body is slowly removed, and our very bones change; so even the older and more fundamental institutions are slowly consumed and renovated in a healthy state that breathes and lives. As this process of consumption works in nerve and brain more rapidly than anywhere else; so in a healthy society, thought and opinion show still more rapid change, as old errors are abandoned and new knowledge gained. This respiration in society as in the animal, brings higher life by removing the effete and poisonous elements from our institutions. Buckle said the best work of legislators had been in undoing the work of their predecessors. Advancing knowledge and thought do, indeed, eat away old opinions as oxygen consumes the brain, but like that, for good. No need to restrict thought. There may, indeed, be social stages to which knowledge is fatal, as free air is to fish. But we need not on that account restrict thought, any more than we enact laws to keep fish in the water. Few men are too eager to come out into the higher air, and whoever will, let him. Some think this is the way lungs have come. It is safe for society to absorb its gills and develop lungs as fast as it will. Knowledge and thought do indeed, like oxygen, burn out old errors; but like that, respect life, and harm nothing good. In state and body alike the organism's own vitality is ever renewing the wasted tissue, and giving us better than we lost. The respiration which consumes is yet the breath of life.

With all these parallels between the animal and social structure, we should note one contrast, to which Mr. Spencer refers. Consciousness does not become centralized in the state. There is no social sensorium. In the social body, unlike the animal, consciousness is retained in each individual cell. So much does individualization seem to be one of the ends of nature. Constituting one body, we yet remain separate persons. Growing ever more organized in one social structure, we become ever more personal too. These two processes go on side by side, — the organization of the whole and the perfection of the parts.

NATURE AND FREEDOM.

BY JOHN J. ELMENDORF, S. T. D.,

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Problems which concern the will have always been favorite questions with American psychologists. There has seemed to be a special fascination in the problem of reconciling the thought of an infinite, omnipotent Being with what men know, or think that they know of freedom in themselves? I do not hope to add anything towards the solution of the question; on the contrary, I only allude to it because I desire, as far as possible, to exclude it, in order to consider the relations of man to nature, of the free thinker to that phenomenal world which is one of the most attractive objects of his contemplation and study.

I notice at present a wide divergence between philosophy in its strictest sense, as based on analysis of the necessary thought of the free *ego*, and sciences of nature; i. e., of the world of phenomena which are observed, classified, and made the objects of induction, along with an attempt at founding a philosophy upon them exclusively.

The spheres of the two seem to me to be far apart, and their methods, though each involving the other, essentially different. On the one side is the domain of intelligence, freedom, will, consciousness, morality, duty, activity. Here is an intelligence so absolute that it hardly seems to be individual, because its note is an absolute oneness in all men; here is a will, an activity, which is identified with our own personality which attends to and observes all outward phenomena, all inward states, seeks to find their unity and their laws, and demands the *how* and the why in all things. It criticises itself, and sits in judgment on its own faculties. To understand it, our method is necessarily introspective, and analytic of any concrete act of volition or of intelligence.

On the other side is a world of phenomena in which apparently rule blind necessity, unvarying, inflexible order. We are sensitive, but passive beings in their presence. It is the realm of effects which we are regarding, effects transferred, transmuted, but, so far as we can discover, unalterable. We see how, conditions varying, the consequent varies, and therefore can conceive of unlimited change. But because nothing is self-moved, we must regard this phenomenal world as passive. (If we apply to it the term activity, we merely mean the transfer of an impulse received, not self-produced, and measure the result by the antecedent.) Its characteristic note is individuality; generality, law, is the mind's discovery, and what the mind reads on that printed page of nature. If we seem to find intelligent will any where, there we know or assume a second *ego* like ourself.

Our method is inductive from these phenomena. Analysis, if employed, is for reducing the complex to the simple, nothing more; we group and classify, and, by induction, construct our chain of antecedents and consequents. Further than this we cannot go, and even the very validity of our inductive process itself carries us out of this phenomenal sphere into the other on which it rests.

Here then are these two spheres so unlike to be received. What is their unity? How shall the man who is exclusively devoted to one of them "s' orienter," by getting a fairer and fuller view of the truth. Can the scientist reconcile himself with the philosopher; the believer in human freedom, morality, divine law of conscience, intelligence, obligation, the student of metaphysics, the "science of the sciences," with the strictly scientific observer whose mind looks outward at phenomena reflected in impressions on himself? The problem opened is a wide one. I desire to offer only a few matters of thought.

But, as preliminary to the discussion, it may be well to notice the wide difference in the very nature and habits of men themselves, in the tendency of different eras. One man; and such will be a leading representative of our own age, is a most acute observer of natural phenomena; from earliest childhood he has been observing, collecting, comparing, trying experiments; and his whole end is given to his noble work. Bring before him a new fact, a trifling variation in a familiar species, the prospect of some new discovery in nature, and to the eagerness of a child is added the prompt grasp, the far-reaching vision of the scientist of our day. But try him with some philosophical theorem, the very one, it may be, which he himself is unconsciously assuming; it glides off from the surface of his mind, making no impression there; or, if he venture on philosophical statement at all, it is of the crudest, most disjointed, or even inconsistent nature. He would not be the true scientist, which he is, if he were equally prompt and clear in the sphere of metaphysics. On the other hand, there have been certain periods when men would have found these remarkable facts about the moons of Mars, or the fossils of the far West, the most barren or trifling topics for a rational man's interest, and viewed with a smile or with pity the busy triflers who so wasted their time. Instead of the fact, they could have demanded the universal, the idea. Until they had found that, they would seem to themselves to have no place on which to plant their feet, and would totter as on quicksands. We must willingly accept these differences, cheerfully grant to each class its sphere and only desire that each should kindly recognize the other. Let the scientist, like the shoemaker, "stick to his last," see where the limits of his science are, wide enough, indeed, for any mortal man, but that outside of them lies a "science of the sciences," which criticises, regulates, judges his conclusions, so far as they can be abstracted from the particular facts where he alone is supreme.

I begin with a brief

HISTORICAL RETROSPECT.

In the Nicomachean ethics the profoundest thinker of antiquity only incidentally touches the question before us, while seeking to ground the principles of virtue and vice, of responsibility, of rewards and punishments, on the free, active principles in man, because the passive, i. e., impressions, sensitiveness, "nervous shocks," as Spencer calls them, are not in our own power, and they therefore contain no foundation for responsibility. With his strong, good sense, Aristotle simply regards as voluntary what we know in consciousness to have an intrinsic principle of action, and consciousness is accepted as an ultimate criterion in all knowledge, without any attempt to discriminate between the conceivable, and the objectively true. We originate our own neutral action or energy. Whatever be the motives, or "con-causes," the mind is known in consciousness to be active; and not, as it might appear from another point of view, the merely passive recipient of impressions coming from without, which it in turn communicates, as a sort of electric telegraph.

The involuntary is found where the passive predominates, i. e., where the principle of motion is from without. Aristotle also makes a distinction, instructive enough, between (1) will, as above described, seeking an end prescribed by nature, an end necessarily sought, i. e., a will, "determined;" (2) will, βούλησις, which adds hope of obtaining that end, (3) deliberate preferences προαίρεσις, which is the intelligent choice of particular means for getting that end, the intelligent action of a rational man knowing what he wills, and selecting the means, which can be clearly distinguished from irrational desire in man and brute, which pushes equally both of them towards an end, with apparently the same determined necessity as the unknown force by which a crystal is shaped into one form and cannot take another.

This being the free man, as Aristotle views him, his reason which is hardly personal and individual in his proper self, discerns certain necessary principles, apodeictic truths, no matter how he got them, assumed in every thought. They are not derived from any special science, but underlie all sciences. They admit of investigation, analysis, rigid statement not of proof. They constitute the first philosophy.

In Aristotle's physical treatises, we find the objective world, as far as the thinking mind, had then explored it. Thus, the problem is opened; Epicurean and Stoical morals, necessarily touched the question before us; I am not aware that any step further was made towards an answer.

Christian dogmas necessarily give an added importance to the question, and it is prominent enough, from St. Augustine's time, through the middle ages; but the aim was, not to reconcile freedom and nature, but to find how the infinite and absolute stand, towards the finite and relative. The question of determinism and liberty, of indifference, which I have said is not before us, otherwise Aristotle's analysis of will, rules eighteen centuries; to move voluntarily, is to move, *a principio intrinsico;* man judges of the means to attain ends, which he understands, and selects those means.

But when the tendency of thought began to desert the "Gnothi seauton" the one aim of so many ages, and to attend to the phenomena of an outer world, revealed in consciousness through our senses, phenomena, so strangely undervalued, by many leading minds before; then necessarily arose a new impulse to thought, concerning nature and freedom. I regard Hobbes, as the representative thinker of the new era. It is well to place him with reference to his age and circumstances. He is secretary to the Lord Chancellor, who collects "centuries" of observations on sounds, fruits, plants, etc., and who without discovery or original thought, gives a new impulse to empirical science, showing us the "promised land," which he did not enter, and calls metaphysics, a spinning of spiders' webs out of the thinker's brain. Kepler was dead only some ten years. Galileo, was just buried. The Royal Society, itself, just founded, along with other such societies throughout Europe, is the clearest indication of men's minds, outward to the phenomena of nature. A philosophy for their science was indispensable, and Hobbes provided it, the "patriarch of positive philosophy," as Comte calls him. We know only, says he, phenomena and their chain of sequences. Contrast this, with the previous philosophy of which Dante is the popular representative. Proceeding to nature from what is known in consciousness of the active *ego*, and reasoning by analogy, there would be nothing unphilosophical in the assumption, that natural phenomena are caused by the active and productive power of spirits like us; and this is Dante's theory. How different with Hobbes! The phenomena of the active *ego*, are by him, little regarded. The mind is almost or altogether a passive thing, moved as other passive things are moved. So it takes its place in nature's chain of many links, pull on any one, the whole is moved; or rather, this chain pulls itself; freedom has disappeared.

And yet the opposite aspect of the truth obtrudes itself once more, under the name of " force," only there is no honest analysis of the meaning of that convenient symbol; no strict interrogation of consciousness, no straightforward endeavor to ascertain what it is, of which we are conscious; what phenomena, what processes, what results. The belief that our thought, our mental act, the force we exert is free, is itself a phenomenon the most constant of all phenomena; it requires to be accounted for. If our consciousness is false here, it may be false in any thing. "I will," "I will not," a child's word, clearly distinguishable from, " I want to etc," " I do not want to, etc.," raises three questions to which Hobbes, gives no answer. 1. What does it mean? 2. Where did the reality it expresses begin? 3. How, by introspection, do we become aware of it, and try to account for it? While Hobbes fails us here, it may be doubtful whether his method, though developed, has since yielded a better or a different result.

Locke, with his analysis of power, as " a simple mode, whose idea is derived from choice or determination," evidently seems to be reinstating freedom once more. But the mind is regarded as passive in the formation of ideas, and Hume's subtile criticism causes it to disappear altogether. So the question of its freedom necessarily vanishes with it; and as for metaphysics, the best synonym for them, is a want of common sense. We owe to two men, it seems to me, deliverance from this excessive preponderance of the phenomenal, the passive, as a factor in thought — to Reid and Kant. The latter, perhaps will give an impulse to thought, in which objective nature will once more disappear, remaining only as modes of the *ego*, so that we shall merge the objective in an extreme idealism; but the sharp distinction in self, of desire, from rational will, the clear discrimination of the empirical, both as object and as method, the domain of the sciences, from the universal; the domain of philosophy with its own special method of analysis, of institutions and interrogation of consciousness, these, if once grasped, are an anchorage amid these fluctuating waves of thought.

But to Reid's strong Scotch common sense, albeit somewhat superficial, we owe some principles which we are not likely to lose:

1. Already intimidated by Locke, that active power is conceivable only in a being possessed of will and intelligence. Whence came the ready inferences; *a*, that sciences of practice, deal only with a series of consecutive phenomena; *b*, that cause, either efficient or final, is not an element of those sciences; *c*, that in such sciences, force is a mere abstraction, an unknown, undiscoverable; force necessarily assumed throughout, since we are studying its effects, but left as an unknown quantity without inquiring what more it means than what we see; and *d*, that Prof. Tyndall, has made a mistake when he wandered from heat, sound and glaciers, which he understands, to dabble in philosophy, and will prove himself a true scientist by confining himself to his proper work, where he will have all the honor and success which he so justly deserves.

2. We have learned through Kant and Reid, that law or will in nature, is fundamentally different from cause or force; the one, which J. S. Mill has so well analyzed, the invariable sequence of phenomena; the other, a thing incapable of definition, perhaps, as being an ultimate principle, yet, found everywhere in language, because, in its concrete reality, it is in all men's thoughts and experience.

3. That free choice is directed to an action willed, being the choice of means to an end, while desire is of an end.

4. That will, by repeated actions, creates habits, not instinct, which is a name for another unknown x in the sphere of nature, not of consciousness. I mean that a certain series of effects are seen in brutes, and something like them in men. Not knowing any more, we group them and then call their unknown cause instinct.

5. As the result of all these, that metaphysics, philosophy, has its own sphere, as the sciences have theirs, and we shall do well to separate them.

Finally, to conclude our historical retrospect, we have Spencer, with his American disciple, Fiske, endeavoring once more to construct a philosophy of the phenomenal in aid of contemporary science. That both of these writers fail to give an account of the phenomena of consciousness is a verdict which cannot here be justified. That the problem of nature and conscious freedom is not to be solved by annihilating one of its factors, I will not repeat; but will only ask that an analysis of mind, whose ultimate point, is element of mind equals nervous shock, even if it allow Mr. Fiske to substitute "psychical shock" must necessarily fail to satisfy many who earnestly seek for truth. For it leads us to ask,

1. What are elements of mind in *me*, whose self is known, if known at all, as an enduring, invisible unit; at least that is what I mean when I say "I," and you must first prove that I am wrong; and in doing it, you also will use the same word, and I shall understand the same enduring, indivisible unit in you.

2. What one-sided tendency led a writer on psychology to employ nervous shock as the ultimate element of mind?

3. Call it psychical shock, and what is the thing that is shocked, not known apart from its shocks; but known as shocked? Or, if the question be relegated to the unknowable, how is a shock of self related to a perceived shock of the air, or the inferred shock of an electrified body? A figure of speech settles nothing in philosophy or science. One of the above is a fact of consciousness referred to self; the other, to something outside of *ego;* the air, when the brain is shocked.

4. Granting that Spencer and Fiske have rendered some account of the passive factor in phenomena, what is to be said of the active, which our consciousness reveals and Mr. S., we presume, employed in finding out his explanation?

An historical retrospect is instructive as showing the tendencies of thought, and giving some account of opinions now prevailing. I come to the

PRESENT STATE OF THE QUESTION,

Is any reconciliation possible where there is such wide divergence? Only, I maintain, when we acknowledge and keep steadily in view the dual aspect of the truth. This is not by any means a fundamental dualism, from the metaphysical point of view. But sciences of phenomena, as the accidents of true being, may be separated by their objects and methods, from the science of true being with its proper method; whether we are dualists or *monists*, while we still recognize the mutual dependence of the two spheres of knowledge which necessarily involve one another. Entire disregard of either side, subjective, or objective, active or passive, phenominal or real, material or formal, to employ the old phraseology, widens the gulf of separation. Frank acceptance of different methods in different spheres for different ends may aid both parties in reaching the common meeting place.

Nature is all around us, and reflected within us, inviting us to investigate, to master it. Phenomena are to be carefully observed, experimentally produced, classified, and referred to general laws. This is the objective, the passive, which the free conscious thought of man is reducing to order within him by discerning the order in it, and without him. Thence come to us the notions of constraint, of necessity, of energy communicated to something which is passively removed, and of invariable sequence. And this is all that the mind thus knows. It knows no power, no cause; but only a transfer, merely of sensible effects, whose resultant always remains the same, and it arrives at that consumation of physical discovery, the conservation of energy. Thus far I believe all are agreed, for the analysis of the empiricist himself finds nothing more than this in cause or force. The mind indeed requires an attraction called "force" to account for these effects, because the free soul demands that they shall be accounted for. But it will only confuse language and thought, to confound such an assumption, giving unity to sensible results, with intelligent will in ourself as a name for our spontaneous activity which we know in exercising it, or with cause as expressing a notion derived from our own spontaneous and productive activity; which also we know in exercising it.

Let one travel on the road of the senses as far as he may, he is still at an infinite distance from the infinite form which christians call God, and from his own free self. For no aggregate of phenomena is any more than an aggregate, even when it vanishes in the indefinite, which we are so apt to confound with the infinite; this indefinite sum of phenomena has not led us a step towards active being, finite or infinite.

Beside nature, then, is this active *ego* of ours, attending by its intelligent will, to this wonderful world of phenomena; conscious that itself chooses to regard, now this one, now that one of its own passive sensations and feelings; that it actively moves from within to meet influences which it does not produce, and intelligently applying rational laws to their investigation. The free soul is conscious, indeed, of motives to ends which it cannot help desiring; but it intelligently chooses means to reach those ends. In concrete application, it were folly to deny this. It is only the abstract and universal form of it which the student of nature may ignore or oppose. Here there are facts of a different order from those phenomena, from even those phenomena of sensibility, which also consciouness reveals to the attending mind for its scientific inductions, inductions which themselves are based on those higher truths.

To develop this point may delay us a moment. And avoiding as far as I may, any metaphysical question connected with the will, I offer, as a test of the distinction between nature and self-freedom, our intelligent consciousness of motives and of purposes in our mental action. It is evidently possible to overlook the very starting point of investigation, which is that, in mind, as a unit are the willing, the motive, and the purpose. While even so subtle a thinker as Edwards, analyzing what is essentially one, may put motives on the one side, the *ego* on the other, and calculate the force which one part of an indivisible entity exerts on another, as if he had a problem in mechanics to solve, and may easily prove that the movable part is moved in the direction of least resistance, or strongest repulsive force. But "determinism" is not our subject. The facts given in consciousness are these. We know what end we seek, i. e., we know our motive; we choose the means with deliberation, in our own purposes look forward to the future, and determine our future acts. Language informs us that other men do the same.

But pass to the sphere of nature, of objective phenomena, and internal, passive states. It is necessarily present. Its past is in memory, in our mind. Its future only prophetically there. There is no possible induction which can put motives or purposes there, until we introduce the notion of an intelligent being ruling nature. Anthropomorphically, poetically, or philosophically, if you will, it may be affirmed, but no *inductive science* can inclose conscious intelligence within a crystal or an art, as certainly as we know our own in considering our motives. For who pretends that when a Colorado beetle lays its eggs on a potato leaf, it has in view the prospective comfort of future larvæ?

Motives, then, may be regarded as "con-causes," as conditions of natural action, for this intelligent *ego* of ours acting, but not acting towards anything or for anything, is inconceivable; it is nonsense. And we know also that we do not create the ends which we seek. But, on the other hand, to consider motives without regarding the mind's assent would contradict our continual experience. We may, if we will, ask what causes the assent; but we shall find no answer. To transfer physical associations to the facts of self-consciousness would be unscientific. We can have no induction from phenomena, because the very concept of power of cause is not in them. Experience simply tells us that we will, assent, move mentally, and then something outward follows. But it is a universal experience that when we do not assent, we do respect, when we assent, it is mental motion, when we energetically assent, we act energetically.

I work, finally, to obviate some possible misapprehension, and anticipate some objections. In the appeal to consciousness, nothing is said of the sphere of the unconscious in its relations to mind, because the question belongs to philosophy; the inductive sciences as such have nothing to do with it. Neither is a dualism in the sphere of being either maintained or denied, but only the contrast between inductive sciences based on a series of consecutive, and, so far as we see, inseparable phenomena, and the philosophy of the free self, its thought, its intelligence, its relations to nature on the one side, and the Infinite and Absolute on the other.

1. We hear much of the universality of law. But, on finding by our analysis, as an ultimate factor of consciousness a free self, energizing from within, we do not find its freedom to be an exemption from law. Büchner, in his "Matter and Force," most unjustifiably assumes this. The error is like that in theology of

assuming that the miracle is a violation of law. If this were the case, then the contrast between the free subject, and the passive object in which we always discover law, would be greater. But exemption from law would be irrational, immoral, blind chance, precisely what the soul is not. But this freedom is consciously and intelligently taking to one's self a law which, as the "categorical imperative," is reason's universal law, this free self-discovery. It is by this that we are brought into due relation to the world of rational beings, and freely take our place among them, citizens, not slaves, in that illustrious commonwealth.

It is *ego*, also, which discerns law in nature, and, by assenting puts its free self under that, using nature's laws for its own ends and purposes. Because freedom is not in nature, we could not think of advising crystals how to form, nor of counseling the society of bees, nor of exhorting the birds; though we may separate and combine the energies of these slaves of nature to serve our plans. But because we believe that other men also have self-freedom, and language utters free thought, we speak of rights, justice, counsel, advice for free men. If sciences of nature have no place for these, and I do not see that consistently they have any, then empirical, inductive sciences are not exhaustive of truth; and, instead of awkward attempts to insert them where they do not belong, it would be better frankly to acknowledge the two-sided aspect of the truth.

2. It may be objected that if a man's character, if all his antecedents, circumstances, motives, were known, his actions could be infallibly predicted, and, consequently, he is a part of nature, and his mind wholly an object of scientific induction.

But I reply:

1. That this proposition itself is not a scientific induction from observed facts. For these are only of the present; the past is retained by mind; the future is not given at all. Neither in this case can we verify our prophecies, and so confirm our hypothesis, since all turns upon an *if*. The subjective sphere to which the objector refers is only known in our own consciousness; so he either begs the question, or asserts only that self, under these conditions can predict its own acts.

2. If the objection states a fact, it means only that self-freedom is moral and rational, logical and orderly, and so *ego* freely assents to and follows its own laws. If we knew the order, and could look forward through the aims and intentions, i. e., if we were the very individual in question, we could predict his course, presuming him to be as rational as ourself. How this resembles the prediction of an eclipse, where the phenomena are objective, are before the eyes of all, I fail to see.

3. Lastly, it may be said that, after all, the problem is not solved. I do not say that from the metaphysical standpoint, consciousness spans the gulf between mind and matter; between subject and object. It is sufficient for my purpose, in pointing out the limits of the sciences of nature, that those sciences being purely inductive from phenomena, whether of external sense, or of internal sensibility, must regulate these critical questions to philosophy as being out of their sphere. The moment we regard the results of will in our own limits, we have passed into the sphere of nature and the sciences; we are to search for the invariable antecedents of the lifting of our arm, and may, possibly have a regret *ad inf.* in the transmutatious of energy. We find no production; action and reaction are equal. Perhaps a molecular vibration in the brain is transmitted into motion in the fingers, which vibration has also its antecedent, loosely called, its cause. But what we know in the mental spheres, is pure and true activity. We not only desired to move our arm for rational ends, we willed it. Experience only has shown its result in the outward sphere, etc., that the arm moved. We might have willed and no such result have followed. But, the antecedents being there, we expect the consequent, and even introduce that strange word necessity, the consequents *must* follow, which surely the experience does not contain.

Consciousness does not span this gulf; the objection is admitted; yet as a known fact, the free self directs its act towards this other phenomenal world, even in examining it, classifying its phenomena, and reasoning upon them. How, then, can he who explores the heavens, ignore the existence of his telescope? In other words, how can the devotee of nature ignore his own mental existence, while in every word, he is declring his own spiritual activity and freedom?

Consciousness may not tell us how we pass from subject to spirit; from mind to matter, though it may clearly reveal the fact; but to make the *ego* convertible with a nervous shock or any part, or the whole sum of sensible or conceivably sensible phenomena is spanning the gulf by ignoring one side of it. Spencer and Fiske try to translate the force, the active, into the passive, the externally necessitated; the proportion, I act, I am acted upon; and so thought becomes confusion, language, empty babble. We know not how to argue with certain thinkers; for we find ourselves carried back to the premises which we, with the rest of mankind, have assumed as not needing proof. Premises are treated as assumptions, till finally nothing remains admissible except individual impressions, "psychical shocks," and we do not know why we should admit these, since there is nothing left to be shocked, or what to infer from them, since we ourselves, the observer and the reasoner, are only a series of these shocks.

In summing up then, I find the position of Reid, for the scientist, a sufficient and practical foundation. In nature, causes so called, J. S. Mill, has well enough analyzed, as invariable sequences. I see no occasion for controversey, if we understand our terms. But the constant use of such words as "causes," "force," in different sense, seems to me to aid the old logomachy. Causes, in the sense of efficient and productive power, or purposes intelligently aimed at *i. e.*, final causes we see not in nature. But consciousness goes along with our observations; consciousness of voluntary attending, generalizing, inferring; *ego* a mirror reflecting the objective, but arriving at results in another sphere than that of images, and attaining ends which we aim at or produce. From language we cannot elminate this side of the truth; "I make," "I produce," "I cause." Something sensible, indeed may follow, but "I will this volition" is an ultimate fact, admitting of no further analysis, except it be that of Des cartes' "*cogito.*" If it be itself, an effect, no consciousness declares it to be so, therefore we have no object of scientific inductions, the subject-matter belongs to philosophy. Motions are not causes; neither of them are invariable sequences. The two former are in the mind, as aspects of the active self, and by its own laws referred to other beings, as similar activities: the latter are in the mind as observers of passive results which it only observes.

As there has been a senseless irrational antagonism between science and the christian faith, whose methods and spheres differ so widely, so these may seem to be between the empirical road, the broad high-way of the science, and the narrow, difficult path of metaphysics. But the antagonism is not real. The aims are different, the mental powers employed are distinct, the method, consequently, is different. The instrument of the one is induction, of the other analysis. The scientist has sometimes vexed us, sometimes provoked a smile, by the assumption that all things in heaven and earth are subject to him. But we have looked again, and there was speaking another free, proud self, like us; he has been taking for granted what we wished to understand, or, at least, to investigate more closely by asking, how he knew, and with what, and by what does he know anything, and so we only smiled at him, and said, let us both go our several ways, and do the best we can for the truth.

DEPARTMENT OF NATURAL SCIENCES.

NOTES ON CLADOCERA.

By EDWARD A. BIRGE, Ph. D.

During the past three years I have collected Cladocera at intervals. The group has been little studied in this country, though thoroughly worked up in Europe. I have found several new forms, including one new genus, and now publish a synopsis of the work hitherto done by me.

I give only the more important references under the synonymy The works most useful for reference on this group are:

O. F. Müller, Zoologiæ Danicæ Prodromus. 1776.
" Entomostraca. 1785.
Jurine, Hist. d. Monocles qui se trouvent aux environs de Genève. 1820.
Liéven, Branchiopoden der Danziger Gegend. 1818.
Baird, Natural History of the British Entromostraca. 1850.
Fischer, Ueber die Crustaceen aus den Ordnungen der Branch. und Entomos. 1851.
" Ergänzungen, Berichtigungen und Fortsetzung zu der Abhl. ü. d. in der Umg. von St. Petersburg vorkommenden Crustaceen. 1854.
Liljeborg, De Crustaceis ex ordinibus tribus; Cladocera, etc. 1853.
Koch, Deutschlands Crustaceen, etc. 1835.
Schödler, Neue Beiträge zur Naturgeschichte der Cladoceren. 1863.
" Die Cladoceren des frischen Haffs. 1863.
" Zur Naturgeschichte der Daphniden. 1877.
Leydig, Naturgeschichte der Daphniden. 1860.
P. E. Müller, Danmarks Cladocera, 1868..
Kurz, Dodekas neuer Cladoceren. 1874.
Weissman is now contributing some very valuablé papers on structure and physiology to the Zeitschrift für Wissenschaftliche Zoologie.

In my notes, all the above papers are cited by the name of the author, or, if necessary, by adding to his name a single word.

SECTION 1. CALYPTOMERA. Sars.

Family 1. Sididæ.

GENUS 1.

SIDA. Strauss, 1820.

SIDA, Strauss, 1820. (Mem. sur les Daph. Mem. Nat. Hist., VI, 157.)
Liéven, Liljeborg, Leydig, Baird, Schödler, Sars, P. E. Müller, Kurz.
SIDÆA, Fischer.

SPECIES 1.

SIDA CRYSTALLINA. O. F. Müller.

DAPHNE CRYSTALLINA, O. F. M. Zool. Dan. Prod., 2405.
For the long synonymy of this species, see P. E. Müller, Danmarks Cladocera, p. 101–2.

There appears to be no well marked difference between our species and that of Europe. I wish to notice only one or two points with regard to it. Claus (Zeit. Wiss. Zool. Vol. XXVII) asserts that he has seen a second maxilla in Sida. I have looked for it carefully, and under most favorable circumstances, but have failed to find it. I am inclined to question its existence. The appendage has been seen by no other observer, not even G. O. Sars.

The projection on the inside of the basal joint of the legs ("processus maxillaris," Sars), is triangular in shape, with ten stout spines and a large number of setæ. This may be homologous to the "appendix interior" (P. E. Müller) in Pollyphemus.

Cambridge and Southampton, Mass.; Madison, Wis. Quite plenty everywhere.

GENUS 2.

DAPHNELLA. Baird, 1850.

DAPHNELLA, Baird, Schödler, Sars, P. L. Müller, Kurz.
DIAPHANOSOMA, Fischer.

SPECIES 1.

Plate II. Figs. 1–4.

DAPHNELLA EXSPINOSA. sp. nov.

Length, circ. 0.85. mm.; height, 0.4 mm.
Length of head, 0.25 mm.; of valves, 0.60 mm.
Diameter of eye, 0.07 mm.

Length of head less than half that of the valves. Antennæ reaching only about two-thirds the length of the valves when bent backward. Post-abdomen without caudal teeth. Eye large.

The valves are marked only by the ends of the "stutz-balken." Their edges bear numerous small, movable spines (0.0013 mm. long). The shape and general proportions resembles those of D. brachyura (Liéven). There are, however, marked differences in details.

The indentation between head and body is greater than in D. brachyura. The post-abdomen has no caudal teeth. The terminal claws have three teeth and are not serrate. The appendages of the male, in which the vasa deferentia open, do not reach so far as the base of the terminal claws. In D. brachyura they reach beyond the claws. The vas deferens opens, not near the heel of the foot-shaped termination, but below the instep. The antennules of the male are longer proportionately.

Southampton, Mass., 1878. Common.

Family 2. Daphnidæ.

GENUS 1.

MOINA. Baird, 1850.

SPECIES 1.

MOINA BRACHIATA. Jurine.

For synonymy of genus and species, see P. E. Müller, pp. 132–133.

Pool beside railroad, near Yahara river, Madison, Wis., July, 1877. Present in immense numbers.

GENUS 2.

CERIODAPHNIA. Dana.

CERIODAPHNIA, Dana. U. S. Expl. Ex. Crustacea, Vol. II, p. 1265.
" Sars, P. E. Müller, Kurz.

SPECIES 1.

Plate I. Figs. 1–2.

CERIODAPHNIA DENTATA. sp. nov.

Head angulated in front of antennules. Shell reticulated with hexagonal meshes. Terminal claws with a row of teeth on outside and finely serrate inside.

The head is prolonged, and is distinctly angulated in front of the antennules. The shell of the head and body is reticulated with hexagonal meshes. The lines of reticulation vary from almost imperceptible to very strongly marked, in different specimens. The shell may be transparent or opaque. There is a distinct projection at the junction of the dorsal and posterior margins, almost a spine. The fornices are broad and projecting, but are smoothly rounded over and have no angular projection. The post-abdomen is of moderate size, truncate, with seven or eight caudal teeth on each size, and with scattered, very fine hairs. The terminal claws are armed with from 0 to 8 (usually 6) teeth on the outer side. The teeth vary much in size, are often exceedingly fine, and rarely altogether absent. There is also a row of very fine teeth extending to the tip of the claw. This is only to be seen in good specimens and with a high power ($\frac{1}{5}$ Wales), and sometimes, though rarely, cannot be seen at all. The abdominal process is rather blunt, and has fine hairs scattered upon its surface, as has also that part of the abdomen behind it. Cambridge. Southampton and vicinity, Mass.; Madison, Wis. Male not seen. C. reticulata (Jurine) has the terminal claws provided with teeth, but in this species the fornices are "permagnæ et valide prominentes" (P. E. M.), and have a sort of triangular projection in front. The fornices in this species are of medium size, and have no such projection. C. reticulata has the head "obscure angulatum" in front of the antennules; this is manifestly so. Finally, C. reticulata has no fine teeth on the terminal claw. C. nitida (Schödler) (= quadrangula, Leydig) has the armature of the terminal claws, but is reticulated with quadrangular meshes. The name is given on account of the teeth on the terminal claws.

SPECIES 2.

Plate I. Figs. 3–4.

CERIODAPHNIA CONSORS. sp. nov.

Length circ. 0.5 mm.

The head is prolonged, rounded at the apex, not angulated in front of the antennules. The shell of the body is large, round, or square with rounded angles, but with a more or less prominent angle behind, as in the preceding species. The shell is strongly marked with a reticulation of hexagonal meshes. The fornices project moderately, but are rounded and smooth. The post-abdomen is broad, not narrowed toward the apex, but is obliquely truncated, so that the caudal teeth lie on the lower margins. There are about eight of these moderately large, recurved teeth on each side. The terminal claws are large and smooth. The color is transparent or opaque, passing through a reddish brown to nearly black. A variety has the areas of the meshes marked by little rounded prominences. Male not seen. Madison, 1877, with the preceding species, in pools of tolerably clear water; not common.

The shape of the post-abdomen distinguishes this species from all but C. rotunda, Straus. It is plainly not that species, as that has the shell of the head bent into a right angle below the eye, and ornamented with spines. The specific name is given from its habit of associating with the preceding species. I have never found it alone.

SPECIES 3.

Plate II. Figs. 8, 9.

CERIODAPHNIA CRISTATA. sp. nov.

Length, circ. 0.7 mm.

Head not angulated in front of antennules. Post-abdomen with a dorsal row of teeth. Valves with irregular meshes around the edges and perpendicular striæ across the middle, as in Simocephalus.

In general shape this species resembles C. dentata. The head is rounded regularly over in front, not angulated in front of the antennules. The valves are marked much as in Simocephalus.

The post-abdomen is broad, somewhat truncate below, with large, smooth terminal claws, and four teeth on each side of the arms. The dorsal margin of the post-abdomen is produced into a crest which bears eight or nine teeth, largest at the distal end of the row. The apices of these teeth are directed upward. This feature curiously recalls the teeth of the post-abdomen in Eurycercus.

The eye is very large; the macula nigra is of moderate size, and is angular.

The name is given on account of the crest on the post-abdomen.

Southampton, Mass., 1878. Rare.

GENUS 3.

SIMOCEPHALUS. Schödler, 1858.

SIMOCEPHALUS, Schödler, Branch. der Umg. von Berlin, p. 17.
" Sars, P. E. Müller, Kurz.

SPECIES 1.

Plate I. Fig. 6.

SIMOCEPHALUS AMERICANUS. sp. nov.

Length, 1.5-2.5 or 3.5 mm.

Head angulated in front, with three or more teeth at the angle.

Terminal claws long and slender, with a row of fine teeth on each side. Teeth of equal size in each row. Macula nigra rhomboidal.

The head is separated from the body by an obvious depression. Its upper margin curves pretty regularly downward to the point where the fornices approach it more closely, where it bends downward abruptly, and after a short distance is bent again, so as to form almost an acute angle with the front margin. At this angle are three or more short teeth. The fornices project considerably. The superior margin of the valves is arched, serrate, and produced into a short spine behind. In old animals the back is so much arched as to bring the spine near the middle of the hinder edge. In the young it is near the top of the hinder edge. The posterior and part of the ventral margins are serrate. The anterior margin is concave. The valves have the markings characteristic of the genus. The abdomen has two blunt, weak processes.

The post-abdomen is broad, compressed and truncate. Its greatest width at the top is often greater than its length to the insertion of the terminal claws. These are long and slender, with a row of fine teeth on each side. The teeth are of equal size in both rows, and are about 0.01 mm. long. There are eight or nine caudal teeth in each row, geniculate, and bearing a row of fine setæ. Besides these, there are often five or six other very fine teeth, completing the row across the post-abdomen.

The antennules are freely movable, slightly curved, shaped like a truncated cone, and ornamented with several short cross rows of fine teeth. The antennæ and their branches bear the same ornament, and on the basal joint are a pair of short, two jointed setæ, projecting upward from a slight elevation, and a similar seta near the insertion of the branches.

The macula nigra, as seen from the side, is rhomboidal, with the upper angle sometimes a little prolonged.

A rudimentary haft-organ is found in young animals, but disappears in the adults.

The male resembles in general the young female. The testicle is very large, extending the whole length of the body. The vasa deferentia open on both sides of the post-abdomen, at the angle opposite the insertion of the terminal claws. They thus cross the intestine in their course.

Color, corneous to opaque yellow. Calcareous concretions are sometimes, though rarely, found in the valves.

Everywhere common.

This species combines the characteristics of several European species. In general appearance it resembles S. serrulatus (Koch). The post-abdomen is more like that of S. exspinosus (Koch), as is also the macula nigra. The serration of the terminal claws resembles that of S. vetulus (O. F. Müller). It thus differs from S. serrulatus in two of its characteristic peculiarities — the shape of the macula nigra and the serration of the terminal claws.

SPECIES 2.

Simocephalus Vetulus.. O. F. Müller.

Daphne vetula.		O. F. Müller, Zoöl. Dan. Prod., N. 2399.
Daphnia sima.		Liéven, Fischer, Liljeborg, Leydig.
"	vetula.	Baird, l. c., p. 95, P. X, fig. I.
Simocephalus vetulus.		Schödler, Branch, p. 18.
"	"	P. E. Müller, l. c., p. 122, Pl. I, figs. 26–27.
"	"	Kurz, l. c., p. 29.

Very common everywhere, with the preceding species. Both species are almost always taken at the same time, but the number of individuals of S. Americanus is usually greater.

GENUS 4.

Scapholeberis. Schödler, 1858.

SPECIES 1.

Plate 1. Fig. 7.

Scapholeberis Mucronata (?) O. F. Müller.

Daphne	mucronata,	O. F. Müller. Zool. Dan. Prod. No. 2404.
Monoculus	"	Jurine. Monocles, etc., p. 137.
Daphnia	"	Liéven. l. c., p. 30, T. VII, fig. 1–2.
"	"	Liljeborg. l. c., p. 44, T. III, fig. 6.
Scapholeberis	"	Schödler. l. c., p. 23.
Daphnia	"	Leydig. l. c., p. 187.
"	"	P. E. Müller. l. c., p. 124.
"	"	Kurz. l. c., p. 28.

Length, 0.7–0.8 mm.

I give references for the variety "fronte lævi" only, since

Schödler (Zur Naturgeschichte der Daphniden, 1877, p. 24) is very positive in his statements that the variety "fronte cornuto" is a distinct species. All the specimens which I have seen want the horn.

P. E. Müller says of the genus, of which he has seen only this species, "Antennæ immobiles." So Liéven, "Die Tastantennen kommen mit denen dieser Art. (D. pulex) überein." Other authors are silent on the subject, though it might possibly be inferred from Fischer's figures that he considered the antennules to be movable. They are always free in the specimens which I have seen. The correspondence in other respects with S. mucronata is so great that I do not like to make this a new species. It is, at least, a marked variety, to which the name "fusca" might be appropriately applied.

My specimens have all the different markings which, in different European localities, are considered characteristic of the species. Thus Müller says, "Areis hexagonalibus reticulata." Schödler says: "Eine reticulirte Cuticula ist nur auf dem Kopfe, namentlich um den Rüssel herum, deutlich wahrzunehmen: der Schalenklappen entbehren derselben, sind aber in der vorderen Partie leistenartig gestreift. Diese Leisten verlaufen in ziemlich gleicher Richtung mit dem Vorderande, und gehen, namentlich gegen den Unterrand, mehrfach in einander über. Die Mitte der Schalenklappen aber lässt nur eine feinkörnige Cuticula unterscheiden." I have seen specimens from the same pool which exhibited markings agreeing with both these descriptions, and other specimens which showed still other variations.

SPECIES 2.

Plate I. Figs. 8, 9, 10, 10*a*.

SCAPHOLEBERIS NASUTA. sp. nov.

Length, circ. 1 mm.

Rostrum pointed, antennules large, and movable. Shell of valves covered with pointed elevations.

The head is separated from the body by a marked depression. The lower margin of the head is slightly concave. The rostrum is prolonged into a rather sharp beak, at whose apex the continuations of the fornices unite. The beak does not project downward, as in S. mucronata, but backward, and in its natural position lies between the valves. The valves closely resemble in shape those of S. mucronata. The shell of the head is reticulated, as is also that of the area *a* (Plate I, Fig. 9). The area *b* has a few strong striæ and a few cross markings connecting these. There are only one or two striæ parallel to the lower edge of the shell, and occasionally, in large specimens, two or three parallel to the hinder edge. The rest of the valves bear numerous small pointed projections. The "mucro" is short and blunt. The antennules are much larger than in S. mucronata, though they do not project beyond the rostrum. They have a flagellum and a cluster of knobbed sense hairs, and are freely movable. The rami of the antennæ are never opaque. The macula nigra is long and large, and somewhat resembles that of Simocephalus vetulus. The post-abdomen has the same general shape as that of the preceding species, but is not opaque. The terminal claws have several fine teeth on their outer sides.

The male has the continuation of the fornices prolonged into a rounded projection on each side of the rostrum. These protect the large curved antennules, which are abundantly provided with sense-hairs. The vas deferens opens close behind the terminal claws.

Color greenish white, varying to opaque, but usually quite transparent.

In antennules and macula nigra this species resembles Simocephalus much more closely than does the preceding species. Embryos very closely resemble those of Simocephalus.

GENUS 5.

Daphnia. Schödler, 1858.

Daphnia, Schödler. Branch. der Umg. von Berlin, p. 10.
" Sars, P. E. Müller, Kurz.
" and Hyalodaphnia, Schödler. Cladoceren des frischen Haffs, p. 16.

Daphnia, as thus limited, forms a very natural group. It contains the crested forms of the Daphninæ, and thus recalls the genera Acroperus and Camptocercus, among the Lynceidæ. Like those genera, too, the members of this group are transparent, and their post-abdomen is narrow and elongated, although by no means to so great an extent as in the Lynceid genera.

No subsequent writer has agreed with Schödler in distinguishing Hyalodaphnia from Daphnia. And with good reason, since the sole characteristic of the genus is the absence of the macula nigra; and as this structure is small or rudimentary in all the species of Daphnia, its absence does not form a generic difference.

Daphnia is not a genus typical of the sub-family Daphninæ, but is rather an extreme form. Moina is the least specialized.

SPECIES 1.

Plate I. Fig. 11.

DAPHNIA PULEX. De Geer, var. denticulata. var. nov.

For the long synonymy of this oldest and best known of Cladocera, see Baird, British Entomostraca, and P. E. Müller, Danmark's Cladocera, p. 110.

In size, shape and markings, this animal agrees with D. pulex. There are, however, some differences. The lower margin of the head is not so convex as in D. pulex. The abdominal processes are very slightly hairy, or not at all so, instead of being covered with hairs. The terminal claws, like those of D. pulex, are armed with teeth at their base, but have besides a row of very fine teeth extending along the whole length of the claw. The number of abdominal teeth is greater than has been noted in D. pulex, being 18–20 instead of 15, the highest number noted in D. pulex (P. E. Müller, T. I, fig. 4). On these grounds I make it a distinct variety, named from the teeth on the terminal claw.

Cambridge, Mass.; Madison, Wis.

I have seen a blind specimen of this species. The eye-capsule was ruptured, and the lenses and pigment scattered in the cavity of the head. The optic muscles and ganglion were in great part absorbed. It was a large and healthy animal and lived nearly a week in captivity, when it was eaten by a neuropterous larva accidentally put into its glass. It had a marked peculiarity in its motion. It frequently turned four or five somersaults in rapid succession, and invariably went through similar gyrations on coming in contact with any object. The eye was probably ruptured while moulting, as deformities of the head from this source are not uncommon. I have seen a deformed Simocephalus, in which the eye had evidently been destroyed by the same cause, which had elongated and compressed the head.

This is perhaps the species found in Lake Superior, and noted by S. I. Smith (Fish Commission Report, 1872–3, p. 696).

SPECIES 2.

Plate II. Figs. 5–7.

DAPHNIA LÆVIS. sp. nov.

Length, 2–3 mm, exclusive of spine.

Transparent, crested, head rounded in front, not prolonged into an angle. Terminal claws smooth. Abdominal processes separate. Macula nigra present.

The spine may be as long as the body in young animals, or short and blunt in old individuals. The outline of the head is angular in embryos and young animals, but is regularly curved in adult specimens. A marked crest, more prominent in young than in old animals, runs along the front and top of the head. Below, the outline of the head is nearly straight, sometimes a little concave in the middle, prolonged behind into a sharp rostrum, whose apex lies close to the edge of the valves. The outline of the valves is on the whole elliptical, nearly resembling that of the preceding species. The spine, however, is attached at about the middle of the distance from the dorsal to the ventral edges. The spine has two rows of teeth, one above and one below. Exceptionally, there may be also a row on each side. The lower margin has a row of short spines. The markings of the valves, the antennules, antennæ and post-abdomen, resemble the corresponding parts of D. pulex. There are about nine caudal teeth in each row. The terminal claws are smooth. The abdominal processes are not united. The macula nigra is small. The hepatic coeca are quite small, often rudimentary, being greatly reduced in size, their cavity obliterated and their tissue degenerated. Specimens of every age, except very young, may show this peculiarity. The "haft-organ" is wanting in adults, though found in embryos.

The male resembles in shape the new born female. The antennules are movable, short and stout, with a flagellum, and a cluster of sense-hairs, not on the end of the antennule, but a little proximad. The "haft-organ" is present.

So far as I know, this is the only crested species with a macula nigra in which the terminal claws are smooth. The name is given on account of this peculiarity.

I found this very beautiful species only in a small, muddy pool near Mt. Auburn Station, Watertown, Mass., 1875. It was present in great numbers, and with a copepod formed the entire crustacean life of the pool.

Sub-family 2. Lyncodaphninæ.

GENUS 1.

Lathonura. Liljeborg, 1853.

Lathonura, Liljeborg. l. c., p. 55.
" Schödler, Sars, P. E. Müller.
Pasithea, Koch, Leydig, Liéven.
Daphnia, e. p. O. F. Müller.

SPECIES 1.

Lathonura Rectirostris. O. F. Müller.

Daphnia rectirostris,		**O. F. Müller. Entomostraca, p. 92, Tab. XII, fig. 1–3.**
Pasithea	"	**Koch. l. c., H. 35, Tab. XXIV.**
"	"	**Liéven. l. c., p. 42, Tab. XI, fig. 1–3.**
Lathonura	"	**Liljeborg. l. c., p. 57, Tab. IV, fig. 8–11; V, 2; XXIII, 12–13.**
"	"	**P. E. Müller. l. c., p. 139.**

The male of this species I have once seen. It is smaller than the female, being about 0.5 mm. in length, while the female may be 0.8 mm. Its back is less arched than that of the female and its ventral margin more convex. The valves gape widely below. The testicle has a thick coat of muscular fibres, both circular and longitudinal, and the vas deferens opens just in front of the anus. The antennules of the male resemble those of the other sex, and the feet of the first pair have a moderately large hook, but no flagellum or a rudimentary one.

Cambridge, Mass., 1876. Rare.

GENUS 2.

MACROTHRIX. Baird, 1843.

MACROTHRIX, Baird. Ann. Mag. Nat. Hist., Vol. XI, p. 87, 1843.
" Liljeborg, Schödler, et al.
ECHINISCA, Liéven.

SPECIES 1.

Plate I. Figs. 12–13.

MACROTHRIX ROSEA. Jurine.

MONOCULUS ROSEUS, Jurine. l. c., p. 150, Tab. XV.
ECHINISCA ROSEA, Liéven l. c., p. 31, Tab. VIII, figs. 3–7.
MACROTHRIX " Baird. Brit. Ent., p. 104.
" " Liljeborg. l. c., p. 47, Tab. IV, figs. 1–2; Tab. V, fig. 1.
" " P. E. Müller, p. 136, Tab. III, figs. 1–4.

My specimens agree closely with Müller's description. He says, however, "Der findes et lidet udviklet Hefteapparat paa samme sted og af samme Bygning som hos Eurycercus." In these specimens it is considerably larger than in Eurycercus, and lies decidedly further back.

I have seen one male of this species. It is about 0.3 mm. long. The antennules are curved as in the female, and besides, curved outward toward the base, and again inward toward the apex, so as to appear somewhat bow-shaped, as seen from the front. They have five cross-rows of stout, short, black hairs on the outside of each antennule, and a rather long flagellum near the base. The sense-hairs are short and curved inward. The first feet have a very long hook, stout at the base, its apex projecting from between the valves and bent inward toward the median line, so that the ends of the two hooks are almost in contact when at rest. The ends are covered with fine teeth. The post-abdomen has the same general shape as that of the female. The hairs on it are finer, hardly perceptible. There are no terminal claws, and the post-abdomen is prolonged into an elevation about 0.05 mm. long, on whose summit the vas deferens opens.

Madison, Wis., 1877. Not rare in shallow and weedy water.

Sub-family 3. Bosmininæ.

GENUS 1.

Bosmina. Baird, 1850.

SPECIES 1.

Bosmina Longirostris. O. F. Müller.

Lynceus longirostris, O. F. Müller. Entomostraca, p. 76, Tab. X, figs. 7-8.
Bosmina " Sars, l. c., p. 153.
" " Schödler. Cladoceren des frischen Haffs. p. 45, figs. 16–17.
" " P. E. Müller. l. c., p. 146, Tab. III, figs. 8–9.
" " Kurz. l. c., p. 29.

Length, circ. 0.39 mm.

These specimens agree with Bosmina longirostris in all respects except size, which is considerably greater in our form.

Cambridge and Southampton, Mass.; Madison, Wis. Rather rare.

SPECIES 2.

Bosmina Cornuta. Jurine.

Plate 11. Fig. 10.

Monoculus cornutus, Jurine. l. c., p. 142, Tab. 14, figs. 8–10.
Eunica longirostris, Koch. l. c., H. 35, Tab. XXIII.
Bosmina cornuta, Sars. l. c., p. 280.
" " Schödler. Clad. fr. Haffs. p. 49, Tab. III, figs. 18–22.
" " P. E. Müller, l. c., p. 147.

Specimens belonging to this species were found at Easthampton, Mass., Aug., 1878. Length, 0.3 mm.

FAMILY 3. LYNCEIDÆ.

Sub-family 1. Eurycercinæ.

Sole genus and species.

EURYCERCUS LAMELLATUS. O. F. Müller.

For the synonymy of this species, see P. E. Müller, l. c. p. 162. Fischer's L. laticaudatus is the only instance where the animal has been described under a specific name different from Müller's.

I wish to note only a few points in the anatomy of this species. The ventral margin of the valves is set with short, stout, movable spines. These bear near near the base a row of backward projecting hairs. The antennules have a crown of long teeth around the apex, from within which rise the sense-hairs. On the basal joint of the antennæ, about the middle of its hinder side, is a large tubercle, covered with short, stout, black spines. The anterior margin of the valves is strongly convex, and the lower loop of the shell-gland is prolonged into the convexity, thus making an open loop, whose long axis is parallel to that of the body. Leydig's figure of the animal is quite incorrect in this particular, and indeed, his figures in general, so excellent in other respects, are little to be trusted in this. His figure of the legs of this species is very accurate.

Sub-family Lynceinaæ.

GENUS 1.

PLEUROXUS. P. E. Müller, 1868.

LYNCEUS. e. p. autorum.
PLEUROXUS ET PERACANTHA. Baird.
" " ET RHYPOPHILUS. Schödler.
" " Sars, Kurz.

SPECIES 1.

Plate I. Figs. 19–20.

PLEUROXUS PROCURVUS. sp. nov.

Length, 0.5 mm.

Rostrum bent forward and upward at tip. Hinder margin and anterior margin armed with teeth. Valves striate around edges.

The shape in general is oval. The dorsal margin is high, arched, sloping steeply toward the posterior margin, with which it forms a sharp angle, almost a tooth. The posterior margin is short, straight, and has seven or eight teeth. Of these, the first upper tooth points obliquely upwards, the succeeding two also upwards, though less steeply, and the rest either outward or slightly downwards. The posterior margin joins the ventral in a rounded angle. The ventral margin is concave, and has somewhat sparse, abundantly plumose, setæ. The forward margin is strongly convex, and has numerous small teeth on its lower half. These point downward or backward. The valves are marked by striæ, which are very plain around the edges. At the upper part of the posterior margin they are parallel to the back, gradually changing their course so as to become perpendicular to the ventral margin about its center. The succeeding striæ incline backward, and become at last parallel to the anterior margin. There is an area in the center of the valves which is either obscurely reticulated or smooth. The rostrum is long, stout, and abruptly bent outwards into a hook at its tip. The post-abdomen is long, laterally compressed, truncated, with a dorsal row of teeth, consisting of a cluster of four or five stout and long spines at the lower corner, and eight or ten teeth following these, arranged somewhat in pairs. In this and all other cases of a dorsal row of teeth, which I have seen, except in Eurycercus, the teeth are not exactly on the dorsal margin of the post-abdomen, but are set on the sides, usually each alternate tooth on the same side, so that there are really two rows of teeth. The keel of the labrum is somewhat tongue-shaped, running into a long, rounded projection behind. The ephippium forms on the rear upper part of the shell. It contains one egg. Two summer eggs are produced at one time. The color is yellowish, but remarkably transparent. The male was not seen.

Glacialis, Cambridge, Mass., two specimens, 1875. Southampton, Mass., 1878; common. Madison, Wis., July and August, 1877; common.

The teeth on the posterior and anterior margins of shell at once distinguish this species from all others with recurved rostrum. It combines the general appearance of Pleuroxus with the rostrum of Rhypophilus, and the anterior and posterior marginal teeth of Peracantha. The name is given from the shape of the rostrum.

SPECIES 2.

Plate II. Fig. 11.

PLEUROXUS STRAMINIUS. sp. nov.

Length, circ. 0.6. mm. Height, 0.35 mm.

Post-abdomen slender, its dorsal side concave. Valves marked by hexagonal meshes.

The dorsal margin is not greatly arched. It forms a short but well marked projection at its junction with the posterior margin. A similar projection, not a tooth, is seen at the junction of the posterior and ventral margins. Rarely, a very small tooth is present there. The valves are marked by elongated, hexagonal or irregular meshes. The rows run obliquely downward and backward. The surface is also marked by the "stütz-balken" and by minute striæ. These last are confined to the meshes and do not cross the lines of reticulation. The post-abdomen is long, slender, somewhat curved, truncated at the end, with a large number of fine, slender teeth on the dorsal row. The terminal claws have the usual two spines, and are serrate. This last characteristic is not always to be seen. The antennules have six or eight sense-hairs besides the flagellum. The eye is much larger than the macula nigra.

The rostrum of the male is much shorter than that of the female, the post-abdomen is more slender, and the terminal claws are very slightly removed from its ventral edge. The vas deferens thus opens between or slightly above the terminal claws. Except for the regular sexual difference, it otherwise resembles the female. Color, straw-yellow, opaque.

P. straminius is most nearly allied to P. hastatus (Sars). The females are nearly the same. They differ in proportions, hastatus being higher proportionately. The lines of reticulation are horizontal in P. hastatus, oblique in straminius. The former is "eine der durchsichtigsten Species" (Kurz), while the latter is just the reverse. The valves differ widely. In P. hastatus the head is very small, the rostrum slender and strongly curved, and the post-abdomen tapers gradually to a point. In P. straminius the head is longer, the rostrum short, blunt, not much curved, and the abdomen shorter and truncated at the end.

Cambridge, Mass., 1875; common. Not found in Madison, Wis., where its place seems to be taken by P. procurvus and P. denticulatus, which are far more common there than in Cambridge.

The name is given on account of the color.

SPECIES 3.

Plate II. Fig. 12.

Pleuroxus insculptus. sp. nov.

Length, circ. 0.27 mm. Height, 0.18 mm.

Valves strongly marked by hexagonal reticulations. One tooth at lower posterior angle of valves.

This is by fàr the smallest species that I have seen. The dorsal margin is little arched, so that the hinder margin is not much shorter than the height of the valves. At the junction of the posterior and ventral margins, there is a strong tooth formed by a semi-circular incision in the posterior margin. Sometimes there is a second very small tooth above it. The ventral margin of the female is very slightly concave, the concavity lying in the rear half of the margin. The shell is marked as in the preceding species, but the lines are much more distinct. At first sight only the diagonal striæ are manifest. Closer inspection discloses the true nature of the sculpture. The rostrum is rather short, the fornices quite broad. The post-abdomen is short, broad, truncated, with a dorsal row of eight or ten teeth. The terminal claws are serrated and have the usual two basal spines. The last (eighth) seta of the antennæ is not always to be found. The eye is quite large; the macula nigra much smaller. The male is narrower proportionately. Its rostrum is short and "stumpy." The post-abdomen is strongly concave below, dorsally; with about the same number of teeth as in the female. The end is somewhat rounded. The terminal claws have very small basal spines and no serration.

The name is given on account of the deeply cut reticulations.

Cambridge, Mass. Glacialis, 1876. Rather scarce. Southampton, Mass., 1878. Not uncommon.

SPECIES 4.

Plate I. Fig. 21.

PLEUROXUS DENTICULATUS. sp. nov.

Length, 0.5–0.6 mm. Height, 0.35–0.45 mm.

Anterior margin of valves armed with small, backwardly projecting teeth. Rostrum not bent forward.

The dorsal margin is very convex, descending rapidly to the posterior margin, which is consequently relatively short. At the junction of the posterior and ventral margins, there are two, three or (usually) four teeth, or in young specimens none. Of these, the upper tooth curves upward, the others outward, or the lowest a little downward. There is a series of fine teeth on the lower part of the anterior margin, directed downward or backward. These lie inside the row of setæ. The shell is marked as in P. procurvus. There are also striæ on the head, of which the lower run parallel to the edge of the fornix, the upper parallel to the outline of head. The rostrum is long, pointed, and curves backward. The post-abdomen resembles almost exactly that of P. procurvus. There is often a black pigment deposited in its lower part. The male has a shorter rostrum, hairs instead of teeth on the post-abdomen, whose lower angle is rounded. Color, greenish or yellowish.

Glacialis, Cambridge, 1876. In muddy or clear water. Madiison, 1877. Common.

This species is allied to P. trigonellus (O. F. Müller), from which it differs in shell markings, and very greatly in the male. (Vid Kurz, Pl. III, fig. 2.) P. Bairdii, Schödler (= P. trigonellus, Baird) has the striæ all parallel and extending over the shell, a rounded and gibbous post-abdomen, and other differences. It differs from these and all other species of Pleuroxus, in its limited sense, by the possession of teeth on the anterior margin. From this fact, I have named the species P. denticulatus.

SPECIES 5.

Plate I. Fig. 22.

PLEUROXUS UNIDENS. sp. nov.

Length, 0.85 mm. Height, 0.46 mm.

Shell little arched on dorsal margin. Lower posterior corner of valves rounded. A tooth just in front of the corner. Valves marked by striæ.

In its proportions, this species approaches P. straminius, the back being comparatively little arched, so that the height is about one-half the length. In the shape of the front part of the animal, there is also a close resemblance to P. straminius, and in the relative length of the post-abdomen. There are, however, great differences. The upper posterior angle is prolonged into a projection, quite characteristic, seen, I believe, in no other species. The lower corner is rounded, not angulated. Some distance before it is placed a single minute tooth. From this peculiarity, the species has received its name. The bristles of the lower edge are much larger in front. They become very small behind, and seem to be smooth there instead of plumose. The valves are marked by striæ. One set occupies the upper half of the valves and runs approximately parallel to the back. A second set runs nearly parallel to the lower edge. The upper stria of this set is complete, and those of the upper set run into it where their curvature will not permit them to reach the posterior margin without meeting it. At the front part of the valve is a set parallel to the forward edge. These meet the second set in an area which is irregularly reticulated. The striation is very plainly marked. The post-abdomen is long and stout. The hinder end is truncated, but the corner is slightly rounded off. There are two rows of 18 or 20 pointed, rather long, caudal teeth. The terminal claws have the usual two basal spines, and are serrate. There are two small projections (one of which is shown in the figure) on the abdomen, which can hardly be anything else than a rudimentary sixth pair of legs, although they are situated some way back of the fifth pair. It was wanting in one of the dozen specimens which I examined, or at least I could not find it. If it is a rudimentary sixth leg, this is the first case in which this structure has been found in the Lynceinæ. It confirms the opinion which I had formed on other grounds, that Pleuroxus is the genus which stands as the most generalized type of this sub-family. Color, yellowish, transparent. Male not seen.

Lake Wingra, Madison, Wis., Sept., 1877. Rare, only about fifteen specimens found.

This is the largest species of Pleuroxus yet seen, and P. straminius seems to be the next in size.

SPECIES 6.

Plate II. Figs. 13, 14.

PLEUROXUS HAMATUS. sp. nov.

Length, 0.4–0.45 mm. Height, 0.21–0.25 mm.

General shape like that of P. unidens. Valves marked by oblique striæ, and by short, irregular, horizontal striæ.

In general shape this species approaches closely to P. unidens, though the back is somewhat more arched. The posterior margin of the valves is concave, the lower angle rounded, and entirely without teeth. The valves are marked by striæ running as in P. denticulatus, and by short, faintly marked striæ, which run nearly horizontally. These cross the oblique striæ, and are found all over the shell of valves and head. The species is, in markings, the third of a series. P. unidens has only striæ, and those continued quite across the valves. P. denticulatus and P. procurvus have striæ at the edges and irregular markings in center, while the present species has striæ around the edges of valves, and also the short markings all over them.

The post-abdomen closely resembles that of P. denticulatus.

The feet of the first pair in the female are furnished with a tolerably stout hook, of which a sketch is given in Pl. II, fig. 14.

This is, I think, the only case where this distinctively male appendage is found in the female.

Southampton, Mass., Aug., 1877. Not rare.

SPECIES 7.

Plate II. Fig. 15.

PLEUROXUS ACUTIROSTRIS. sp. nov.

Length, 0.35 mm. Height, 0.22 mm.

Beak, long, pointed, and bent backward at the tip. Teeth of post-abdomen very fine. Bristles of lower margin of valves stout and plumose.

In general shape this species closely recalls P. hamatus. It is readily distinguished by the long, pointed rostrum, whose apex nearly meets the valves when in its natural position. The valves are reticulated as in P. insculptus, although not so plainly. There are no teeth on their ventral margin.

The post-abdomen is broad, compressed, truncated, with numerous fine caudal teeth. The terminal claws have only one basal spine.

In rostrum this species closely approaches Harporhynchus (Sars), as also in the single basal spine of the terminal claws. In general, however, the species is so thoroughly Pleuroxus-like in appearance, that I keep it under that genus for the present.

Southampton, Mass., July, 1878. Very rare.

GENUS 2.

CHYDORUS. Leach. 1816.

CHYDORUS, Leach. Sup. Brit. Encyc., Art. Annulosa.*
" Baird, Schödler, Sars, Kurz, P. E. Müller.

SPECIES I.

Plate II. Fig. 19.

CHYDORUS SPHÆRICUS. O. F. Müller.

One of the oldest and best known species of Cladocera For

* Teste P. E. Müller.

synonymy, see Kurz (l. c., p. 77). The mandibles are articulated, not where the fornix joins the valve, but behind this point. This fact is noted by Kurz in C. ovalis, and his figures show that the same is true of C. globosus; although his description of C. globosus would imply otherwise. A chitinous ridge runs from the the point of articulation of the mandible, above the junction of the fornix and the valve, along the under side of the fornix to the rostrum. It does not stop at the junction of fornix and valve, as figured by Kurz in C. ovalis.

This species is common wherever I have collected, and is present in dense swarms near the surface of the water on bright, warm, calm days. It is one of the earliest of the Lynceinæ to appear in the spring.

SPECIES 2.

CHYDORUS GLOBOSUS. Baird.

For synonymy, see Kurz (l. c., p. 18).

One specimen from Lake Wingra, Madison, Wis., Sept., 1877.

GENUS 3.

CREPIDOCERCUS. gen. nov.*

The head is immovable. The rostrum is sharp, but does not extend downward for more than half the distance between the articulation of the mandible and the ventral edge. The dorsal margin is much arched, and rounds evenly over, terminating behind iu a somewhat sharp angle. The posterior margin is sinuate, concave above, then convex. Just in front of the junction of the posterior and ventral margins is a single strong, recurved tooth. The ventral margin is slightly concave and the anterior margin strongly convex. The valves are marked by the "stützbalken," as in all Cladocera, and by an obscure reticulation of irregular hexagonal meshes, most clearly marked in the hinder portion of the valves, where the longer axis of the meshes runs obliquely downward and backward.

* From χρηπίς, shoe, and χέρχος, tail.

The upper part of the dorsal margin of the post-abdomen is prolonged, and runs nearly parallel to the posterior margin of the valves, while the lower part is parallel to the ventral margin, and makes nearly a right angle with the upper part. The apex is rounded and bears two small terminal claws, each of which has a small basal spine.

The general shape of the post-abdomen is like that of a shoe, whence the generic name. It is much compressed laterally, and its armature consists of numerous bristles scattered somewhat irregularly over its surface.

The usual pair of setæ project backward from the post-abdomen; and the ventral margin of the valves is fringed with somewhat long, plumose setæ.

The antennules are of moderate size, do not reach to the end of the rostrum, and have a flagellum and eight to nine sense-hairs. The antennæ are about as large as in Pleuroxus, and bear eight setæ ($\frac{3\,0\,0}{3\,1\,1}$) and three spines ($\frac{1\,0\,1}{1\,0\,0}$). The keel of the labrum is somewhat prolonged backward, as in Pleuroxus, but not to so great an extent.

The eye, macula nigra, intestine, anal coecum and shell-gland present no points of especial interest.

The shape from above is an elongated oval, broadest through the fornices. The valves gape considerably below.

The animal moves by strong and sudden blows of the antennæ. With a single stroke it darts for a short distance, and then returns to rest, ordinarily not moving again until disturbed. It may, however, swim for a considerable distance by repeated strokes of the antennæ, but on the whole is decidedly sluggish, remaining for hours at rest. The extreme suddenness with which it starts into motion is very remarkable. The antennæ are ordinarily bent downward along the anterior margin of the valves, and I have never been able to see them raised preparatory to a saart. It passes instantaneously from rest to motion, and, without any warning, is gone from the field of view in the microscope. It can also move slowly, as I have noticed, by strokes of the abdominal feet upon the cover of the live box in which it is kept. The post-abdomen does not seem to be employed as an aid to locomotion.

SPECIES I.

Plate I. Fig. 18.

CREPIDOCERCUS SETIGER. sp. nov.

Length, 0.4–0.5 mm. Height, 0.27–0.32 mm.

Measurements from one specimen.

Length, 0.37 mm. Height, 0.25 mm. Length of hind margin, 0.12 mm. Length of spine of ventral margin, 0.017 mm. Length of setæ of ventral margin, 0.02–0.04 mm. Diameter of eye, 0.028 mm. Diameter of macula nigra, 0.01. Length of antennule, 0.044 mm. Length of post-abdomen from "heel" to "toe," 0.11 mm. Length of terminal claw, 0.016 mm. This specimen was rather below the average in size.

The color is yellow, rather opaque. The specific name is taken from the setæ with which the post-abdomen is armed. Madison, Wis. Rare. Male not seen.

This species is to some degree intermediate between Alona and Pleuroxus. It resembles the first in the size of the rostrum and the single basal spine of the terminal claws. In general shape and markings it recalls Pleuroxus. Graptoleberis is the only form whose post-abdomen at all resembles that of Crepidocercus. Thc mode of motion is quite peculiar.

GENUS 4.

GRAPTOLEBERIS. Sars, 1867.

GRAPTOLEBERIS. Kurz.
ALONA, e. p. Baird, Schödler, P. E. Müller.
LYNCEUS, e. p. Leydig, Liljeborg, Fischer et al.

SPECIES 1.

Plate I. Fig. 17.

GRAPTOLEBERIS INERMIS. sp. nov.

Length, 0.6–0.8 mm. Height, 0.30–0.35 mm.

There is no indentation at the junction of head and thorax, but the dorsal margin rounds regularly over from the point of the rostrum to the posterior margin. The junction here is not well marked, and at the lower corner the posterior margin does not form a sharp angle with the ventral. The corner is rounded, but on it are two strong teeth like those of G. testudinarius (Fischer). The ventral margin is straight. The front half bears long, straight, closely set, plumose setæ, while those on the hinder part are shorter and more scattered. The meshes of the reticulation are mostly hexagonal on the head, quadrangular or irregular on the body. The lines of the network in the front and lower part of the valves radiate from the junction of valve and fornix. The first few rows run to the ventral margin. The succeeding rows bend and run parallel to that edge. Those on the upper half of the valves are parallel to the dorsal margin, and there are one or two imperfect rows in the middle of the valves where the two sets meet. The upper set are continued on to the head, running around parallel to the edge of the fornix. The lower, dorsal, margin of the post-abdomen bends upwards just below the anus, and thus makes the apex pointed. There are about eight clusters of three or four hairs each, on each side. The terminal claws are small and unarmed. The eye is only of moderate size, smaller proportionally than in Alona. While in Alona the diameter of the eye, in an average specimen may equal $\frac{1}{15}$ of the total length, in G. inermis, it equals only $\frac{1}{21}$–$\frac{1}{28}$ of the length. The macula nigra is about two-thirds as large as the eye, a little smaller than in Alona. Male not seen.

This species resembles G. testudinarius in most particulars (see the excellent description of this species, Kurz, l. c., pp. 50–53). The differences are, the eye in this species is small instead of large; its shape is rounded, not "nearly triangular;" the macula nigra is not greatly smaller than the eye; the terminal claws are smooth and not "ornamented with teeth;" there is no trace of an elevation on the back, where the outline of the head meets that of the back; the posterior lower corner is rounded, though armed with teeth, and not prolonged into a sharp angle.

The outline in general more closely resembles that of G. reticulatus than that of G. testudinarius. In most respects, however, it more closely approaches the latter species.

Cambridge, Mass., 1876, two specimens.
Madison, Wis., Sept., 1877, Third Lake. Rare.
Southampton, Mass., 1878. Rare.

GENUS 5.

ALONA. Sars, 1862.

This genus was first established by Baird, 1850, but was limited to a small portion of its former extent by Sars. I am not sure that Alonella should have been separated from Alona, but on the whole, prefer to keep the genus as Sars left it.

SPECIES 1.

Plate II. Fig. 16.

ALONA ANGULATA. sp. nov.

Length, 0.4 mm. Height, 0.25 m.

Shell marked by rectangular meshes.

The dorsal margin is considerably arched, terminating in a more or less obvious angle at the hinder corner. The hinder edge is convex, as is also the front margin. The ventral margin is provided with plumose setæ. The rostrum is pointed, as seen from the side, and extends down nearly to the ventral edge of the shell. The fornices are broad, the distance between their edges being nearly equal to the greatest distance between the valves. They are extended forward to the end of the rostrum. The shell is obviously striated, the striæ running obliquely downward and backward. Close inspection discloses a set of cross markings, making the shell reticulated with oblong meshes. The post-abdomen is broad, and truncated at the end. It has a row of about twelve teeth on each side, inserted a little way from its lower, dorsal, edge, and their points project behind it. Along the middle of the post-abdomen, on each side, runs a row of very small scales furnished with clusters of short hairs. The antennules are rounded at the end, and the sense-hairs are set around the end, not upon it. They have besides a flagellum. The basal joint of the antennæ reaches about to the edge of the fornix, the branches nearly to the lower edge of the shell. They have $\frac{3\ 0\ 0}{3\ 1\ 1}$ setæ and $\frac{1\ 0\ 0}{1\ 0\ 0}$ spines. The last seta is, as usual, very much smaller than the others. The macula nigra is much smaller than the eye, about one-third as large in diameter. Two young are produced at once. A very young specimen showed no striæ. In the adult, these are about 0.025 mm. apart.

The male is somewhat smaller than the female and of slightly different proportions. It is 0.35 mm. long and 0.2 mm. high. The rostrum projects farther forward and not so far downwards. The post-abdomen is rounded at the end, without teeth, but with a row of fine hairs. The vas deferens opens below the terminal claws. The body behind the heart rises up to the top of the cavity of the valves. This position makes the abdomen hang down nearly perpendicularly when at rest. The coils of the intestine are larger than in the female, and the testicle lies immediately on them. The front legs have the usual hook. The cross markings of the sculpture are scarcely to be seen; otherwise it resembles the female.

The reticulation of this species excludes it from all others of this genus except A. guttata (Sars, Crust. Clad. i Omgn. of Christiania, p. 287). In that species, however, the rostrum is shorter, the macula nigra much larger ("oculo parvo minor," Müller), the post-abdomen "apice rotundato," and its teeth much smaller. The general outline, too, is different, and the reticulation, instead of running obliquely across the valves, is horizontal. It is also one-fourth larger: 0.5 mm. instead of 0.4. A. reticulata (Schödler, Neue Beitr., etc., p. 25), if not identical with A. guttata, is even more unlike the present species.

Cambridge, Mass., 1876. Not rare.

SPECIES 2.

Plate I. Fig. 16.

ALONA PORRECTA. sp. nov.

Length, 0.34 mm. Height, 0.19 mm.

Anterior portion of valve with a sinus. Lower angle of post-abdomen acute. Shell striated with horizontal lines.

This and the following species will be more briefly described. There is no evident angle at the junction of the dorsal and posterior margins. The lower edge bears setæ and has no sinns. The front edge has a very slight sinus, or none at all. The valves are marked by faint horizontal striæ. The rostrum does not extend so far downwards as in the preceding species. The post-abdomen has its usual claws, each with its basal spine, which is not serrate. The teeth of the post-abdomen are about twelve in each row; three or four at the end are larger than the rest. There is besides, a row of hairs above the row of teeth. The lower angle of the post-abdomen is not rounded. The male is of the same general shape as the female. Length, 0.34, height, 0.18 mm. In the armature of the post-abdomen this species approaches nearest tô A. tenuicaudis (Sars); but in other respects, e. g. shape of shell, and especially of post-abdomen, is quite different.

Cambridge, Mass., 1876.; Madison, Wis., July, 1877. Not common.

SPECIES 3.

ALONA GLACIALIS. sp. nov.

Length, 0.3 mm. Height, 0.19 mm.

Anterior margin of valves without sinus. Valves horizontally striated. Lower corner of post-abdomen rounded.

This species differs from the preceding chiefly in the post-abdomen. This is rounded at the lower angle, and the teeth, about fourteen in number, are of equal size. There is also a second row of hairs. The forward edge of valve is strongly convex, otherwise much like A. porrecta. This species approaches perhaps most nearly to A. lineata (Fischer). There are, however, great differences. The size of A. lineata is nearly twice as great. The post-abdomen has, according to Müller and Schödler, only one row of teeth and no hairs. According to Kurz, it has hairs, but a deep incision in the lower end. In either case the dtfference is well marked. The shape is also different. A. glacialis is relatively much broader behind than A. lineata (vid. Schödler).

Glacialis, Cambridge, Mass., 1876.; rare. Male not seen. The specific name is taken from the pond in which it was chiefly found.

SPECIES 4.

ALONA SPINIFERA. Schödler.

ALONA SPINIFERA. Schödler (Neue Beiträge, p. 18, Pl. I, fig. 17-22).

Specimens belonging to this species were scantily found in Madison, Wis., and were quite common in Southampton, Mass.

SPECIES 5.

ALONA OBLONGA. P. E. Müller.

ALONA OBLONGA. P. E. Müller, l. c., p. 175, Pl. III, fig. 22–23.

Length, 0.9 mm.

One specimen, closely agreeing with Müller's description, was found in Merrill's Springs, near Lake Mendota, Madison, Wis., Sept., 1877.

On the front side of the second joint of the outer antennary branch was a cluster of spines. In this it differed from Müller's description.

SPECIES 6.

ALONA TUBERCULATA. Kurz.

ALONA TUBERCULATA. Kurz, l. c., p. 51, Tab. II, fig. 3.

The chief difference between my specimens and Kurz's, seems to be that mine have a greater number of rounded elevations than his.

The shape of the post-abdomen does not appear to be identical, but so brief is his description that I am not sure of any difference. I therefore prefer to leave it under that species for the present.

Southampton, Mass., 1878. Rather common.

GENUS 6.

ALONOPSIS. Sars, 1862.

ACROPERUS, e. p. Schödler.
ALONOPSIS. P. E. Müller, Kurz.

SPECIES I.

Plate I. Fig. 14–15.

ALONOPSIS MEDIA. sp. nov.

Length, 0.55 mm. Height, 0.35 mm.
Length of male, 0.4 mm.

Rostrum prolonged and shell sharp, somewhat quadrangular in shape, marked by striæ.

The dorsal margin is convex, the hinder margin nearly straight. Its lower angle is rounded and without teeth. The lower margin is concave, and has long, plumose setæ. The front margin is strongly convex. The post-abdomen is long and slender, resembling that of Camptocercus, and is notched at the distal extremity. It has two rows of fine teeth and some small scales above them. The terminal claws are long, slender, with a basal spine, a spine in the middle, and are serrated. The antennules are long and slender, but do not reach to the end of the rostrum. They have each a flagellum and sense-hairs. The antennæ are small and have eight ($\frac{300}{311}$) setæ and two ($\frac{100}{100}$) spines. The labrum resembles that of A. leucocephalus, but is slightly prolonged at its apex. The intestine, coecum, and color resemble those of Acroperus. There is a trace of a keel present on the back.

This species is in some retpects intermediate between A. elongata (Sars) and A. latissima (Kurz). In general shape, rostrum and marking of valves, it most nearly approaches the former, while it approaches the latter in the post-abdomen, its shape, teeth and armature of terminal claws. Hence I call the species A. media.

GENUS 7.

ACROPERUS. Baird, 1850.

ACROPERUS, e. p. Schödler.
ACROPERUS. Müller, Sars, Kurz.

SPECIES 1.

ACROPERUS LEUCOCEPHALUS. Koch.

LYNCEUS LEUCOCEPHALUS, Koch. l. c., H. 36, Pl. X.
? A. HARPÆ. Baird, l. c., p. 129, Pl. XVI, fig. 5.
L. LEUCOCEPHALUS. Fischer, Ergänzung, u. s. w., 1854, p. 11, Pl. III, fig. 6–9.
A. LEUCOCEPHALUS. Schödler, Müller, Kurz.

Cambridge, Mass., Madison, Wis. Common.

Kurz says: "Die Acroperus-arten sind die besten Schwimmer unter den Lynceiden." This is not true of our species, which is far inferior in strength and rapidity of motion to both Crepidocercus and Pleuroxus. The same is true of Alonopsis and Alona.

The last genus, indeed, is given to haunting the bottom of the water, and often is found resting among the debris at the bottom of the jar in which it is kept.

GENUS 9.

CAMPTOCERCUS. Baird, 1851.

CAMPTOCERCUS. Baird, Sars, Schödler, P. E. Müller, Kurz.

SPECIES 1.

CAMPTOCERCUS MACRURUS. O. F. Müller.

Length, about 1 mm.

LYNCEUS MACRURUS.	O. F. Müller, Prod. No. 2397.
" "	Liljeborg, l. c., p. 89, Pl. VII, figs. 2, 3.
CAMPTOCERCUS "	Schödler, Neue Beitr., p. 35, Pl. II, figs. 39–41.
" "	P. E. Müller, l. c., p. 164, Pl. III, fig. 12.

Cambridge, Mass., Madison, Wis. Not common.

SECTION II. GYMNOMERA. Sars.

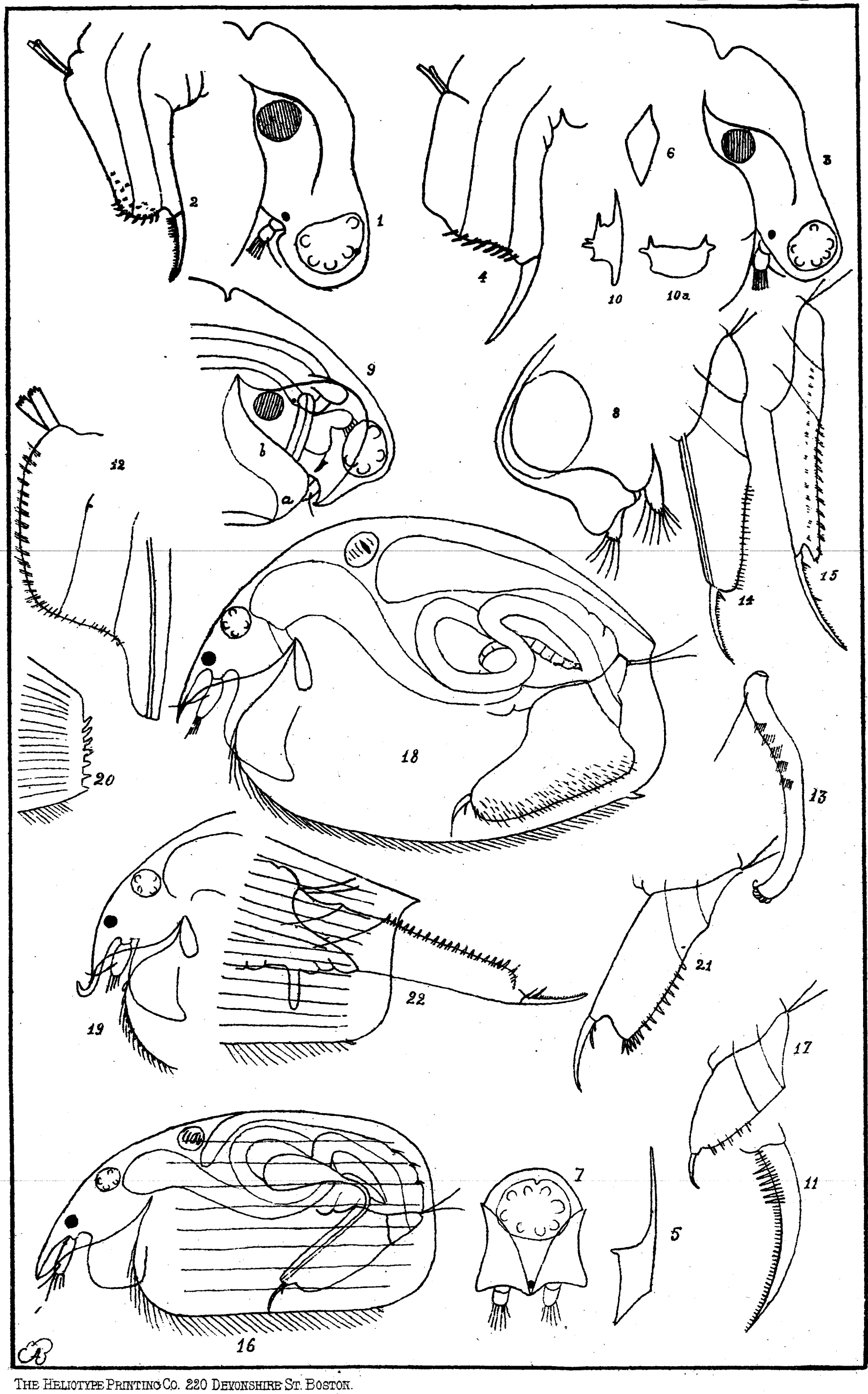
POLYPHEMUS PEDICULUS. De Geer.

One specimen only. Cambridge, Mass., Oct., 1876.

EXPLANATION OF PLATE I.

Fig. 1. Ceriodaphnia dentata, fem. Head × 80.
2. " " " Post-abdomen × 130.
3. " consors, " Head × 80.
4. " " " Post-abdomen × 130.
5. Simocephalus vetulus, " Macula nigra × 260.
6. " Americanus, fem. Macula nigra × 260.
7. Scapholeberis mucronata, fem. Head from below × 160.
8. " nasuta, male. Head seen obliquely from below × 260.
9. " " fem. Head × 80.
10, 10 a. " " fem. Macula nigra from side and from below × 260.
11. Daphnia pulex. Terminal claw.
12. Macrothrix rosea, male. Post-abdomen × 260.
13. " " " Antennule × 260.
14. Alonopsis media, " Post-abdomen × 160.
15. " " fem. " × 150.
16. Alona porrecta, male. × 150.
17. Graptoleberis inermis, fem. Post-abdomen × 150.
18. Crepidocercus setiger, fem. × 148.
19. Pleuroxus procurvus, fem. Front part of animal × 150.
20. " " fem. Hind part of valve × 150.
21. " denticulatus, fem. Post-abdomen × 150.
22. " unidens, fem. Hind part of body and valves × 95.

Plate I.



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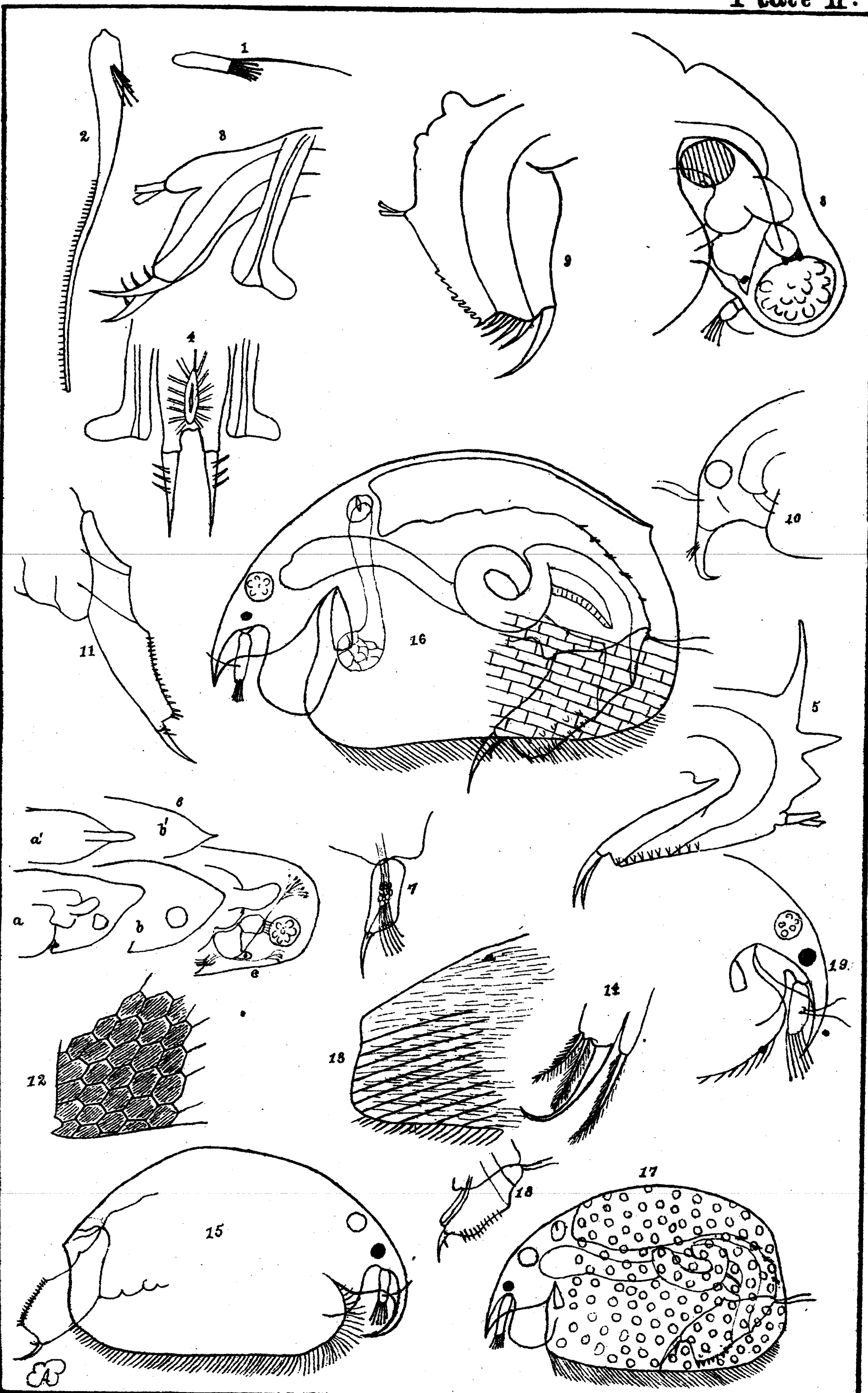
EXPLANATION OF PLATE II.

Fig. 1. Daphnella exspinosa, fem. Antennule × 140.
2. " " male. " "
3. " " " Post-abdomen × 140.
4. " " " " "
5. Daphnia lævis, fem. " "
6 a, á. " " " Embryo, outline of head.
6 b, b′. " " " Young, "
6 c. " " " Adult, "
7. " " male. Antennule × 140.
8. Ceriodaphnia cristata, fem. Head × 130.
9. " " " Post-abdomen × 130.
10. Bosmina cornuta, fem. Head, etc., × 150.
11. Pleuroxus straminius, fem. Post-abdomen × 140.
12. " insculptus, " Details of marking.
13. " hamatus, " " "
14. " " " First foot × 148.
15. " acutirostris " × 135.
16. Alona angulata, fem. × 135.
17. " tuberculata, fem. × 135.
18. " " male. Post-abdomen × 140.
19. Chydorus sphæricus, male. × 150.

Plate II.



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ON THE FAUNA OF THE NIAGARA AND UPPER SILURIAN ROCKS AS EXHIBITED IN MILWAUKEE COUNTY, WISCONSIN, AND IN COUNTIES CONTIGUOUS THERETO.

BY F. H. DAY, M. D.

Wauwatosa, Wis., Dec. 27, 1877.

It is stated as an axiom by high paleontological authority,—that "Since rocks are identified more by their fossil contents, than by their lithological character, a name descriptive of the latter is of less importance than formerly, when fossils were the subordinate characters of a mass;" and although paleozoic characters have assumed the supremacy over all others in distinguishing sedimentary strata, "still the lithological terms must not be overlooked; for if properly understood, they will be unerring guides in tracing the condition of the surface, for more than hundreds of miles in extent."

Changes in the lithological features of a rock which may render observations unsatisfactory, are accompanied by greater or less variation in the nature of the fossils. It is therefore of the highest importance in the examination of sedimentary rocks to be governed by three essential facts, which are:

1st. The lithological character.

2d. The order of the superposition.

3d. The contained characteristic fossils.

By an observance of such precepts geologists have been enabled to form a reliable and a systematic geological history, which is arranged into natural distinctions of ages, periods, epochs, and eras, with the capability to trace from one portion of country to another, through all intricate phases, types and characters, the rocks containing remains, images or casts of paleozoic life.

It is thus we determine the first appearance in the world's history of organized beings, as exemplified in the commencement of the Silurian age — usually termed the Lower Silurian, where by successive layers or strata of calcareous or siliceous sedimentary matter, we trace each order of life through distinctive periods, and epochs, until progressive organization culminated in the era of man.

The nomenclature adopted by tacit consent of paleontologists, to be applied to rocks, is that of the locality where the exposure of a specified rock exists in its best state of preservation and can be carefully examined and studied.

In this manner are the terms derived, Canadian, Trenton, Niagara, Salina, Lower and Upper Helderberg and Hamilton, with the subdivisions of Quebec, Galena, Waukesha, Racine and St. Claire.

But it is the three principal periods: the Trenton, Niagara and Salina which particularly interest a paleontologist when making collections of paleozoic remains from the eastern portions of Wisconsin, and therefore the foregoing explanatory observations seemed to be necessary to elucidate what seemed to befog or deter some of our leading state geologists in arriving at definite satisfactory conclusions.

For if you examine the strata of rocks, with their fossiliferous contents, as exhibited in various exposures by quarrying or from other causes in Milwaukee county within a radius of twenty miles, it is difficult to apply the foregoing mentioned, or geological axioms. In a single quarry containing a coralline limestone near Wauwatosa I have obtained several thousand specimens within the past twenty years, and from among them I can show you representative fossils delineated and described as belonging to the commencement of the primordial time or Lower Silurian age, intermingled with many fossils characteristic of the Upper Silurian, the Guelph and the beginning of the Devonian age. However, "Prof. Dana asserts that there is no evidence that a species existed in the latter half of the Upper Silurian, that was alive in the latter half of the Lower Silurian." The fossils of the Niagara fauna being mostly casts of the interior, it is more of an exception to find the shell or testaceous covering in a perfect state of preservation thereby making our investigations accompanied with many difficulties, nevertheless Eastern Wisconsin has a fauna which in variety, beauty, perfection and numbers cannot be excelled by a similar collection, within the same extent of country on either hemisphere.

Could the distinguished Prof. L. Aggasiz have examined our corals, Echinoderms, Brachiopoda, Lamellibranchs, Gasteropoda, Cephalopoda and Trilobita, no doubt he would have exclaimed, "why sir, the sight of this display would make an eastern naturalist crazy."

On one occasion after a recent excavation by blasting at Schoonmacker's quarry, I measured a coral disk about twenty feet in diameter, three feet in height, and more than sixty feet in circumference. The surface was made up of beautiful concentric layers, like the flattened whorls of a gasteropod, and were covered by very pretty Heleolites.

Cruising around such coral eminences, were the "lords of the invertebrates," the Orthoceratites, the straight variety of Cephalopoda, measuring over twelve feet in length and twenty inches in circumference, and having siphuncles so peculiar in shape and expansion, that Prof. H. A. Ward, notwithstanding his large experience and observation, declared these different from any species he had seen in the old or new world; because the pyrimidal-cone-shaped siphuncle of the base, or last chamber, resembled much the contour of a Belemnite.

Here also was the gigantic *Phragmoceras* having a base twenty one inches in circumference, six inches deep, and a seven inches latitudinal aperture, and extremely *macrochcilus* or long lip, for perfect specimens collected of five species of Phragmoceras make Prof. Hall's description of a single specimen of our species, comparatively a myth, and his *Phragmoceras nestor* is simply a description of a mutilated specimen of a *Phragmoceras macrocheilus.* Prof. Hall's *Gomphoceras septoris* has the curvilinear figure of a *Phragmoceras*, or *Cyrtoceras*, and in general aspect much resembles a *Phragmoceras callistoma* (Barrande), delineated in Woodward's Modern and Fossil Shells. Of the four varieties of *Gomphoceras*, one may prove to be *G. scrinium* or *G. Marcyi* of Winchell.

The gasteropoda of the Lower and Upper Silurian and Hamilton cement are found much larger and in a more perfect condition than those pictured and described in reports of previous geological surveys. A magnificent and perfect *Pleurotomaria perlata* five inches in diameter, found in the Niagara shale, and also in the Guelph or Gault, a *Trochoceras, Gebhardii*, six inches in diameter, from the cement rocks, besides many others, claim honorable mention. In no other place are such unique lamellibranchiata to be found, particularly the *Moceraunas* and *Amphicelia*, *Ambonychia*, and *Paleocardia.* I have quite a number of perfect specimens, retaining the whole or parts of their beautiful striated shells.

It is in Schoonmaker's Quarry that several distinct species of trilobites belong which are not found elsewhere—in any fossiliferous formation.

Prof. J. Hall, in his description of the fauna of Wisconsin, was often obliged to make use of imperfect material, and in resorting to the very unsatisfactory mode of delineating restored parts, or "supposed differences," he would naturally be much disappointed and mortified to find his opinions erroneous upon the subsequent discovery of perfect specimens, which were heretofore entirely new, or but little known. On this account it is questionable whether Hall's synonyms for fossils like the *Illœnus, Sphœrexochus, Phragmoceras,* et cetera, when perfect specimens prove them to be so radically different from Hall's descriptions, should be "saddled" with the names he intended should be applied to them, especially when his opinions are based upon a single part or fragment of a perfect specimen, and also when the synonym is foreign to the idea suggestive of its character. For example, the pygidium of the *Illœnus cuniculus* is confounded with the Bridgeport and Waukesha *Illœnus armatus*, which is probably an adult specimen of *Illœnus insignis*, or *Illœnus Worthmanus* of Winchell, or *Illoenus Springfieldensis*, of Meek. There are other species of the *Illœnus*, or *Asaphus*, to which the glabella has a slight resemblance to Hall's description, but otherwise are totally different.

The pygidium of Hall's *Sphoerexochus Romingeri* is simply a mutilated specimen of a pygidium of *S. mirus* of Beyrich. I am induced to make these assertions after a careful comparison with perfect specimens in my cabinet. Allow me, also, to state that I have never seen a single specimen of *Illoenus ioxus*, found in Schoonmaker's Quarry, notwithstanding Prof. Hall's mention that it is of frequent occurrence, and Prof. T. C. Chamberlaiu identifies it as belonging to this quarry.

A nearly perfect head and pygidium of an *Acidaspis Danai* make the specimen quite different from Winchell's *Acidaspis Ida.*

Extraordinary sized *Ceraurus insignis* are occasionally found and well marked parts of *Bronteus Acmas*, *Harpes*, *Lichas*, *Dalmania*, uew species of *Illœnus*, *Asaphus*, besides quite a number of as yet undetermined varieties of trilobites, which are "new or but little known."

Fine specimens of *Illoenus ioxus* are found in Waukesha and and Greenfield, but it is in the Racine quarries that the grand patriarchial *ioxus* assumed his supremacy. Specimens of heads over five inches wide and three inches deep, and joined to thoracic segments, and pygidium will make full-sized specimens, more than one foot in length. The *Acidaspis* and several other very remarkable varieties of trilobites are also found, beautiful as well as unique, and unsurpassed. But it is in the the Wauwatosa quarries that the best documents are produced to illustrate the comparative anatomy and physiology of the trilobite. A critical examination of fossil specimens of this invertebrate animal reveals a bundle of contradictions on account of its possessing many attributes belonging to several orders, which cause the trilobite to assume as uncertain a position among the invertebrates as a Cheiroptera does among vertebrates "which can claim a habitation neither with birds or beasts."

All the parts of the trilobite, as found at Wauwatosa, being "casts of the interior," reveal an internal mechanism which requires no more stretch of the imagination to localize and impute certain actions to different parts, than for an anatomist to explain definitely and intelligently the properties and powers pertaining to the skeleton of a vertebrate.

Precisely in similar manner do the casts of the trilobite illustrate its organism, habits and locomotion. Like some species of Entromostracans, it was capable of being dismembered into several parts and had the attributes of Crustaceans, Mollusks and Worms. Its ambulatory movements were performed in a similar manner to the larvæ of insects, but its exteiior covering of crustaceous segments, united by chitine, enabled it to move rapidly in the water similar to the molluscan *Chiton.* It also possessed the same natatory powers as the Crustacean Macrurans. or it could assume a spherical form like an Isopod, or lepidoptera hairy larva. By the action of its extension or flexor muscles, the trilobite was enabled to elongate or contract its size from several inches in length to one-third its longitudinal extension capacity, and did not possess a single attribute of an arachnoid. If a name were required for such an organization, it would be one suggestive of three orders of genera, combined in one, indicative of an annelid, a Mollusk, and a Crustacean. Such a proposition is the result of a careful examination of many thousand specimens of several genera and species of trilobites, and I am induced to believe that this peculiar invertebrate lived, at certain distinct periods of time, so well defined, as to indicate a sufficient reason for making a change in the ages of Geological History. For instead of classifying the Silurian age as one of Mollusks, and the Devonian as one of Fishes, substitute a Trilobite age. For Mollusks existed through all ages, and fishes first appeared in the later part of the Silurian, and assumed a prominence in subsequent ages, like the Devonian, Carboniferous, etcetera, but the Trilobite is identified at the commencement, and became extinct at the close of paleozoic life. In a paper like this, treating of a miscellaneous fauna, I can only thus give a brief synopsis of the component parts of Trilobite, which, like the Crustacea, by aid of muscular action could be "sessile or stalked eyed," and its having a chitine carapace nnited by sutures, was provided with processes, and sinuses for the attachment and action of muscles, and it could be readily dismembered at its dissolution into cheeks, glabellæ, hypostoma, thoracic segments and pygidium, that were held in proper position by a chitinous bond of union, which enabled the trilobite to perform its wormlike motions by expansion, adhesion and contractions, or to fold its extremities together as the caterpillar larva, or wood louse when alarmed, or if attacked as a means of defense, or could move swiftly through the water, like the Molluscous *Chiton* or Crustacean crawfish.

After many years of patient research and with the aid of largely magnifying optical instruments, I have been unable with the single exception of the seta filaments at the extremities of the thoracic segments of *Calymene* — to discover any apppearance having the slightest resemblance to the strong jointed legs; characteristic of the limulus group.

Since preparing this society paper, I have received from Mr. C. D. Wolcott, Curatór State Museum Natural History, Albany, N. Y., two pamphlets on the organism of the trilobite, entitled "a preliminary notice of the discovery of the natatory and branchial appendages of the trilobite," also an explanatory letter from the author respecting the uncertanty of his discoveries, but hopeful of a final satisfactory result.

A copy of the twenty-eighth Regents' New York Report by Prof. Hall, with reference to plate 34, fig. 14, illustrating points of attachment for supposed natatory organs, also fig. 13, which might be a sub-section in conjunction with other parts of a folded specimen, could be readily construed into a semblance of strong jointed legs, resembling the limuloid species. Mr. Wolcott's theories are formed from incised specimens of "casts of the exterior," while my conclusions are the result of examinations made of "casts of the interior."

In our investigations, Mr. Wolcott and myself may be in a chameleon sense, right or wrong, as to the opinions we may form, being largely influenced by the circumstances which govern our actions in a similar manner — as several years ago — a diversity of opinion existed between Professors Billings, Woodward, Verrill and Dana.

Permit me to simply state that I think I have conclusive evidence, that "trilobites did *not* swim on their backs," they did not have *stout jointed legs*, they did *not* rest with their dorsal surface downwards, and they did *not* belong to the higher order of entromostracans. But more extended and fully explanatory views concerning the trilobite, will appear in a work I am now preparing for the press.

But whatever the result may be of our persevering labors, natural science will no doubt be benefited by our efforts to solve what have been so long problematical statements.

It is said to be a trite saying of the Icelander, that the "sun shines on no country equal to his own." In like manner we may boast or as Virgil, "sing praises," not of "men and arms," but of the richness and variety of the "paleozoic treasures of Milwaukee County, and other counties contiguous thereto," for a naturalist will examine with ecstatic delight, the unexcelled crinoids, as found in the quarries of Racine, Waukesha, Bridgeport and Greenville. Probably in no other fossiliferous localities are there to be found such rich collections of Silurian echinodermata. Quite a number of them are delineated and described in part 3 of Hall's Paleontology of Wisconsin, 1871.

But since the publication of that work, more perfect specimens and new genera and species have been added to private collections, like that of our worthy president, Dr. P. R. Hoy.

If I claim to have unravelled some of the many perplexing and doubtful theories concerning the organism of the trilobite, President Hoy can claim equal success as regards the habits and internal structures of Wisconsin Niagara Echinoderms.

Although a large proportion of the crinoidea may be found at Racine, a majority of the Cystidea are found in Waukesha and Milwaukee counties.

For Racine, besides her unsurpassed Echinoderms, has a wonderful genera, and species of other paleozoic fossils, trilobite heads and pygidia, equal to the largest size yet published or described. Specimens are found of the very peculiar *Acidaspis*, *Dalmanites*, *Bronteus*, *Lichas*, *Sphæroxochus*, *Illænus*, *Calymene* and *Asaphus Harpes.*

Exquisitively beautiful is the internal structure of several varities of Cephalopods, that of the *Orthoceras abnorme*, with a siphuncle, having a central siphuncle, composed of minute cyclindrical ramifications which reach to the outer walls of the siphon. Also several varities of the *Orthocerta*, like the O. *angulatum*, O. *columnnre*, O. *crebescens*, O. *Laphami*, on account of their peculiarly constructed chambers, bases or siphuncles, have some resemblance to *Endoceras.*

Quite a number of the Gasteropods claim our attention, as the *Pleurotomaria occidens*, *Trochoceras costatum*, *Tremanotus*, *Tremanotus alphenus*, *Pleurotomarial Hoyi* and *P. Halli.*

Principal among the Brachiopods are the *Osotus conradi*, *Spirifer nobilis*, *Spirifer plicatella*, *Strophodonta paofunda*, *Pentamarella ventrecosus*, *Pentamarus oblongus*. In an inspection of the fossils of Eastern Wisconsin, it is naturally expected by every votary of natural science, that an identity of fossiliferous bearing rocks should be established with some age or period.

But it appears from the published expressed opinions of those appointed to execute the geological state surveys, that there are many complications and difficulties intervening, in localizing, in accordance with established rules and methods, definite ages and periods, for the strata of rocks as exhibited in Eastern Wisconsin.

In 1862, the first plausible or rational theories were published by Wisconsin legislative enactments concerning the parallelism of New York paleontology, with the same fossiliferous bearing rocks of the northwestern states, — more particularly the eastern portions of Wisconsin, — especially Milwaukee, Racine and Waukesha counties.

Notwithstanding the conclusions reached were far from satisfactory, still some system was established, which enabled the student of Paleontology to profit by his investigations, and may have been the means of stimulating such inquiries and experiments, as resulted in establishing a great commercial and profitable branch of industry, which may give to Milwaukee a reputation for hydraulic cement products, second to none in the Union, and eventually first in the world.

No doubt this most gratifying success was accomplished through the suggestions and persevering investigations of the late Dr. I. A. Lapham, one of the chief pioneers of natural history.

SCIENCE IN WISCONSIN.

Yet, a certain amount of credit is due to the Superintendent of the Geological Survey of Wisconsin (Prof. James Hall) of 1862, for the opinions he expressed in that work, and also for the theories similarly advanced in Vol. III, Paleontology of New York, and part 3d, Paleontology of Wisconsin, 171, in the introductory chapters, having reference to the hydraulic cement character, of the calciferous formations of the Upper Silurian age of rocks, as exhibited in the vicinity of Milwaukee.

Prof. Hall, also in his statements in Vol. I, Geology of Wisconsin, represents the strata of rocks lying above the Niagara, as the equivalent of the Salina or Onondaga Salt group of New York, or the Guelph, or Gault, of Canada, and the Le Claire, of Iowa. Notwithstanding, he was unable to trace the characteristic fossil, Eurypterus remipes of the Water-Lime Group. Similar views are expressed by him in his prefatory remarks in his paleontology of Wisconsin, also see Paleontology of New York, Vol. III. Likewise what are called, on page 72, Vol. I, Geology of Wisconsin, the upper Helderberg and Hamilton groups, have proved to be what is Geology of the Hamilton cement, of Devonian age, in Vol. II. of now termed Wisconsin.

An analytical examination of the expressed sentiments of the authors in Volumes first and second of Geology of Wisconsin, concerning the lithological character of the rocks containing the fauna of Wisconsin, especially its eastern portion, shows no very marked distinction or discrepancy, for their final summation respecting the area, the age, and periods, embracing the characteristic epochs, as generally admitted in American Geology.

To the general student of Natural History, the previous classification established by Hall, on 447 page, of Vol. I, of Geology of Wisconsin, comprehensively covers the synonymous terms of Mayville and Byron beds, and upper and lower coral beds, lying below the Waukesha limestone. For the Hamilton cement, the Le Claire, the Racine and Waukesha limestones, embrace all the fauna belonging to that portion of the Upper Silurian, equivalent to the Salina, Lower Helderberg and Hamilton.

Such an increase of synonyms has a tendency to embarrass the student in his study of pàleozoic life, notwithstanding. Prof. Chamberlin, while reiterating the ideas advanced by Prof. Hall, has invested them, in a fuller and more interesting phraseology. But some facts concerning the quarries in Milwaukee county do not substantiate the correctness of Prof. Chamberlin's views, that the three classes of limestone, Mayville, Waukesha and Racine, lying above the Trenton period of rocks, were formed simultaneously.

If we examine the lowest depths of the sole of Schoonmaker's quarry, we find the same characteristic rock, containing the *Terebratulous fossil*, *Gypidean occidentalis*, belonging to the Byron division of the Mayville bed. This formation was quarried to some extent, and formed dressed stones, for bases to grave-stones, and window caps and sills.

This stratum terminated abruptly in an ancient river bed, the bottom of which is smooth and polished, grooved and scratched by the drift of the glacial action or era, for huge granite boulders were excavated during the process of quarrying.

Above this stratum, are regular even layers of a glazed, compact, metalic ringing, cherty limestone, of several inches in thickness, which is quarried in regular rectangular forms, and is utilized as a durable pavement on the side walks, or macadamized streets of Milwaukee and Waukesha. This formation was covered with animal life, similar to that, so extensively intermixed in the strata or groups overlying it, and is well exhibited at every exposure of this rock, in all the quarries in Milwaukee, Racine and Waukesha counties. But the fauna which covered the surface of the Waukesha limestone, at Cook's, Hadfield's and Pelton's, in Waukesha county, or Trimbone's, Swan's, Busack's, Schwackhart's and Story's in Milwaukee county; or Ives', Horlick's and others, in Racine county; or Cook and Mc'Henry counties in Illinois, are in an exceedingly compressed stratum, and in many instances the fossils are in such a state as to be but little better defined, than well marked outlines of the original plant or invertebrate animal. In several of the quarries, as Story's, Schewickhart's, Busack's and Cook's, the Bryozoa, Cephalopoda, Gasteropoda, Brachiopoda and Crustacea, are so intensely compressed and distorted and glazened as often to give the appearance of different genera or species.

In seeking an elucidation of the age and character of the dolomitic formations in eastern Wisconsin, and in taking into consideration the totality of their surroundings, a plausible, perhaps a correct theory is established from these facts. Adopting the axioms, that the predominating fossil contents of rocks determine their age and character, we find lying above the regular stratified rocks of the Niagara period, and termed the Waukesha limestone, soft, porous, and in places, easily disintegrated coral formations, termed by Profs. Hall and Chamberlin, coral reefs, which were formed on the top of sedimentary rocks, less than one hundred feet deep, in an ancient sea.

That these coral reefs extended from the south of Kewaunee, Wisconsin, in a southerly direction, below Bridgport, Illinois; a distance of more than two hundred miles, and westerly, to Le Claire, Iowa.

That at certain points in Milwaukee, Waukesha, and Racine, these coral reefs became more prominent and formed, as termed by Prof. J. Dana, atolls, bordering on lagoons, which upon the receding of the ancient sea, formed the fiords vallies, now occupied by the numerous rivers of Wisconsin.

Subsequently in the vicinity or same direction of these fiord vallies, glacial vallies were formed at frequent intervals for long lines of granitic boulders, of the Archean age are found, some measuring many tons, in size and weight; they no doubt had an agency in producing the grooves, scratches and polished surface, exhibited on the tops and sides of the ledges of the compact and fine grained limestone. The compressed condition of the fossils appears to be due to an upward pressure from an upheaval at the era of Silurian eruption, from which the same cause may have changed portions of the sedimentary dolomitic strata, either by igneous action or by solution into metamorphic beautiful calcite, or strontianite. Such a theory would account for the extraordinary compressed condition of fossil Cephalopoda, and other genera, and calcite crystals in the Waukesha limestone, and at the quarries in Wauwatosa, Racine and elsewhere in the state. An equally plausible theory is, that by a gradual submergence, or subsidence; and also from erosion, by the waves and currents of the ancient sea upon portions of the foundation or base of the coral reefs, certain parts were undermined, causing the superior portion of the rocks to tilt over and slide down in huge blocks, which give the appearance, upon exposure by quarrying, of an upheaval of the strata. Such causes, explain somewhat, the deep vertical fissures and seams, which permeate every portion of the Wauwatosa reefs, and this situation is taken advantage of by workmen, in the process of quarrying, by blasting and excavating.

In certain parts of the reefs are coves, or pockets, which contain remains of distinct colonies of paleozoic life. For in one cove, you will chiefly find Foraminifera and Zoophyta. In another cove, the Brachiopoda; in another the Crustacea, and so on with each class and species of fossils. A similar state exists in other of the coral reefs; for the trilobites of Wauwatosa are not found at Waukesha. The magnificent and peculiar Echinoderms of Racine, are not found in other reef formations; and the trilobite species, *Illænus imperator*, *Illænus armatus*, are found in the southerly reefs of Burlington, Bridgeport and Algonquin.

From the foregoing considerations, aided by geological axioms and other published opinions of accepted paleontological authority, we offer these suggestions, as an effort to supply the "missing links" in our research, as to the age, period and epoch, wherein once lived, moved and had a being, "the fauna of Niagara and Upper Silurian rocks, as exhibited in Milwaukee county, Wisconsin, and in counties contiguous thereto."

DISCOVERIES ILLUSTRATING THE LITERATURE AND RELIGION OF THE MOUND BUILDERS.

BY EDMUND ANDREWS, A. M.. M. D.,

Prof. of Surgery in Chicago Medical College.

Looking back into the dawn of American history, we see certain figures stalking dim and phantom-like across the horizon. So unreal do they appear, that were it not for the massive earthworks they have left behind them, we might well disbelieve their existence.

Little by little we have gained information respecting them. They were miners and coppersmiths of considerable skill, but apparently wrought their metal solely by hammering, yet they occasionally had molten bronze chisels, which they probably imported from Mexico. They possessed shells from the sea, plates of mica from the Alleghanies, and Obsidian from the Rocky Mountains. They probably sent copper to Mexico, and in the graves of Yucatan have been found heads of their Lake Superior chlorastralite. They were farmers, and cultivated broad fields with hoes and spades made of flint and wood. They wove cloth, made pottery, and erected earthworks of such enormous size and number as to astonish even the white men who now occupy their deserted cities. Their skeletons often exceed six feet in height, their skulls, which are generally brachycephalic, are flattened at the occupit like those of the modern Indians, but enclosed a large sized brain. This comprises nearly all that we have hitherto known about the vanished races.

The exploration of the interiors of their mounds has generally been conducted in a very slovenly and inefficient way. It would seem that in sacrificial mounds, the builders were accustomed to deposit sacred records inscribed on stone, but so incomplete have been our examinations, that hitherto only a few of them have been disinterred, and these more by accident than by any real skill of the discoverers.

The first one that came to my knowledge was found in a township called Savannah, on the Tennessee river, in the state of Tennessee. A mound existed here so broad that a company of cavalry and all their horses, in the late war, encamped on its summit. Subsequently the men removed their tents from it and systematically dug away the whole structure. A small slab of stone was found with a drawing upon it representing an altar with the body of some animal upon it enveloped in flames, while the sun was depicted above. It evidently represented a sacrifice to the deity residing in that luminacy. I have not yet succeeded in securing a copy of this stone.

The second was near Rockford, Illinois. A large mound was examined there, and yielded a small stone of crystalline marble containing a figure of the sun supported as if on a pedestal, with a column of hieroglyphics on either side consisting of twelve characters, in all. A fac simile marked No. one, is transmitted with this paper. The left hand column shows at the top a segment of a circle. Next below is a triangle, next a snake, a lizard, and last a flower. The right hand column consists of a sigmoid line, a line like the letter U, a minute cross, head of a rabbit, two objects whose significance I am unable to make out, and a fish. The disk of the sun has a human face drawn on it, and on the forehead of the face is the disk of a crescent moon, with as much of an imitation of a face on the latter as there was room to portray. It may be remarked here that the Aztecs, according to Prescott, (Conquest of Mexico, vol. 1, p. 122), understood the agency of the moon in producing eclipses, and portrayed these events by drawing a moon on the disk of the sun. This stone, therefore, may be the record of an eclipse. It is not possible yet to translate the twelve hieroglyphic signs upon it.

The third discovery of this sort also occurred near Rockford. There were hieroglyphics found on some stones excavated from a mound, but I have not yet succeeded in obtaining a copy.

The fourth inscribed object was an ornament of shell found in a Mound Builder's grave, near East St. Louis. It contained only four characters.

The fifth discovery was made last month at Davenport, Iowa, by the Rev. Mr. Gass, a trustworthy Lutheran clergyman, with his friends. Fac similes ha e been sent me by Mr. Pratt, Secretary of the Davenport Academy of Sciences, and copies are sent herewith, numbered two, three and four. Numbers two and three are on opposite sides of the same stone. The drawing is excessively rude and far inferior to the work of some modern Indians. It is a sacrificial scene, taking place on the summit of a mound. At the bottom is the mound itself, on it blazes a large fire, and near it lie the bodies of three human victims. Around it stand a circle of worshipers clasping each others hands, while the smoke curls upward from the flame. Above at the right hand is the sun; at the left hand is the moon, with a human face portrayed on its disk, and between are the stars, over all arches the sky. On the upper part of the slab are about one hundred characters, which are evidently a record of something which we at present cannot read. (The irregular line from the top to the bottom represents only a fracture in the stone).

The opposite side of the same slab seems to be a rude representation of a wooded country, full of game of every description, which a few lucky hunters are killing with the greatest ease. There are deer, bears, buffaloes, fish, birds, and nondescript animals, possibly intended for a musk ox and a turtle. As the opposite side was a sacred scene, this side is probably a religious delineation also, and may, perhaps, represent the famous "happy hunting grounds" of departed souls. Two-thirds of the way up the slab, a line of hieroglyphics runs across it containing, like the Rockford stone, twelve characters, four of which are identical with those on the Rockford stone. It is to be observed, also, that the two lines of characters carried along the arch of the sky on the other side of the slab, each contain twice twelve characters, and in fac similie number four, we again find twelve hieroglyphics, so that this number seems to have some special significance in their system.

Number four shows a central round spot, surrounded by four concentric circles. Between the two outer circles are ranged very regularly the twelve hieroglyphic characters just mentioned. They are very hastily drawn as if the priests had long been familiar with them and only felt it necessary to slightly imitate the forms. Above are two round spots, intended, perhaps, to signify the sun and the moon. It seems difficult to avoid the impression that this inscription is some sort of a calendar. The stones lay one on the top of the other at the bottom of the mound, on the original surface of the ground, and were surrounded by a circle of small rounded stones, each about four inches in diameter.

No one can inspect these fac similies without the conviction that we have before us rude specimens of literature, which some future investigation may yet translate. Meantime the sacrificial mounds should be ransacked in every part, instead of being carelessly dug into, for the only hope of being able to translate these inscriptions rests on the discovery of more of them for comparison and study.

In concluding this paper I desire to call attention to some neglected evidences, which seem to indicate that the Mound Builders are not extinct, as popularly supposed, but still exist among our Indian tribes.

Squier, after investigating carefully the mounds of western New York, found himself driven very unexpectedly to the conclusion that "they were erected by the Iroquois, or their western neighbors."

Purchens, writing two hundred and fifty years ago, said "The Iroquois have no Townes: their dwellings and Forts are three or foure stories high, as in New Mexico."

Greenhalgh, one hundred years ago, made a statement about the commercial houses of the Senecas, which shows them to have been somewhat like those of New Mexico in plan.

Foster is of the opinion that the mounds thirty miles southwest of Natchez, were erected by the Natchez Indians, and states that the trees on them were younger than on the adjacent grounds.

Lasalle, nearly two hundred years ago, visited the Natchez Indians, and his companion, Touty, says their town was surrounded by a strong earthwork, defended by stakes, on which were stuck the skulls of enemies sacrificed to the sun. They also kept a perpetual fire burning on a mound forty-five feet high. They, therefore, made use of mounds and earth fortifications and sacrificed human victims to the sun, like the Mound Builders of Davenport. In fact they were Mound Builders themselves.

The Smithsonian Reports state that at the bottom of a mound, near Savannah, an iron sword was found with an oak handle, indicating communication with white men.

Bartram (Antiq. Southr. Indians, p. 131), says that in his day the Choctaws erected mounds over the collected bones of their dead, and that the chief, To-mo-chi-chi, pointed out the large mound in which were the bones of a chief who had entertained a great white man with a red beard, who came into Savannah river in a ship.

It is well proved that the southern Indians, like the Mound Builders, possessed the art of weaving cloth, which Foster erroneously attributes to the Mound Builders alone.

I have just received a letter from the Rev. A. L. Riggs, a missionary among the Nebraska Indians, respecting the use of earthworks among the western tribes. He says:

"Along the Missouri river, at least from Sioux City to its head, are many remains of villages and fortifications. They are all traceable to tribes now in existence, chiefly to Poncas, Rees, and Mandans, and were built within two hundred and fifty years. The large circular dirt houses still to be seen at Fort Berthold, among the Mandans and Gros-ventres, were once built by the Poncas, also.

"I remember the site of an old fort on the Minnesota river, near the Yellow Medicine. It was on the edge of the western bluffs. Three sides had been protected by a ditch, and probably by palisades. It enclosed, as I remember, an acre. This fort was said to have been built by the Pawnees, or else the Omahas. This was before the Dakotas occupied the country."

It appears, therefore, that a considerable number of tribes still exist, and some of them are now well civilized, who were Mound Builders when the white men first met them. These facts may destroy some of the poetry of the mounds, but we must look at things as they are. The theories of ethnology have grown too much under blue glass, swelling to an unhealthy size, which cannot be maintained under white sunlight. We shall get on faster, if we move slower.

The next grand effort should be to disinter more of this buried literature, and see whether by the study of it, some genuine knowledge of the past can be made to rise from these tombs. It is also necessary to make a thorough study of the dialects of those tribes, who seem to be descended from the Mound Builders, for they will furnish a necessary stepping stone to the interpretation of the inscriptions, just as the study of Coptic was an essential pre-requisite to the translation of the Egyptian hieroglyphics.

No. 6, Sixteenth street, Chicago, Feb. 8, 1877.

HOW DID THE ABORIGINES OF THIS COUNTRY FABRICATE COPPER IMPLEMENTS.

BY P. R. HOY, M. D., President Wisconsin Academy of Sciences.

I propose to consider the manner in which the ancient inhabitants of this country fabricated those curious copper implements which the plow and spade turn up all over Wisconsin and the adjacent states. These copper tools are objects of great interest to the archaeologist, and it is a matter of pride that the Wisconsin Historical Society has the largest and best collection to be found in any state.

A few of the specimens, upon a superficial examination, seem to be cast. This point will first be considered: Did these prehistoric people possess the skill and intelligence requisite to cast articles of pure copper?

Before a cast can be made, it is necessary to have an exact copy moulded, either in sand, plaster, clay, metal, or other suitable substance. The formation of sand moulds is by no means so simple an affair as it seems at first thought. It requires long practical experience to overcome the disadvantages attendant upon the materials used. The moulds must be sufficiently strong to withstand the action of the fluid metal perfectly, and at the same time to permit the egress of the gases formed by the action of the metal on the sand. If the material is air-tight, then danger would come from pressure, arising from the rapidity of the generating of the gases, and the casting would be spoiled, and probably the operator injured. If the gases are locked up within the mould, the general result is what moulders term *blown casting*, that is, the surface becomes filled with bubbles of air. The preparation of sand and loam used in forming the mould must be carefully considered. The greater the quantity of sand the more easily will the gases escape and the less liability is there of fracture of the casting. On the other hand, if the loam predominate, the impression of the pattern will be better, but a far greater liability of injury to the casting will be incurred from the impermeable nature of the moulding material. In moulding an accurate pattern must be made, generally in two or more parts. Pattern making involves much knowledge and skill.

I enumerate these difficulties in order to show that it was not likely that a rude people possessed that amount of knowledge and skill adequate to overcome these obstacles.

I pass over all other modes of forming moulds, and speak only of those formed in stone. Almost all savage tribes possess the skill to fashion stone into various tools, and we are forced to admire the workmanship displayed in working the hardest materials, such as flint, quartz, granite, greenstone, etc. In contemplating these evidences of patient toil, we are assured that they could readily work out suitable moulds in stone in which castings might be made.

Copper is a refractory metal, which melts at from 2200 to 2600 degrees, a temperature that can be reached only in a furnace, assisted by some form of coal and an artificial blast. We must have good evidence before we assert that these dwellers by the lake possessed these indispensable auxiliaries to successful working in metals. "Copper, when melted, is thick and pasty, and without the addition of some other metal, will not run into the cavities and sinuosities of the mould."

In consulting with an intelligent and skillful brass-founder, I was shown a hammer weighing three pounds, cast of pure copper, and was assured that this was the smallest casting he could make of this metal. The addition of one pound of zinc to ten of copper makes an alloy that will melt at less than half the temperature of copper, and will flow freely.

In casting in copper it is positively necessary to put the materials in a crucible, and that the surface of the melting mass be covered with a flux in order to effectually defend the melting metal from the action of the atmosphere.

A word about crucibles. The manufacturing of good crucibles, such as will withstand the heat necessary to melt the more refractory metals, involves such a degree of knowledge, that for many generations the entire civilized world was dependent on a small section of Germany; and even now Hessian crucibles are unsurpassed. In England there are now several manufactories which turn out excellent articles, one in London which makes the celebrated Plumbago crucible. It will sufficiently indicate the difficulties involved, when I state that America, to-day, is dependent upon Europe for the immense number of crucibles used in this country. I am aware there is a manufactory established in Connecticut, but the quality is so inferior that they are only used for the more easily fused metals. I experimented with fragments of pottery taken from the ancient mounds near Racine, in order to determine the degree of heat they would stand. The result was they were melted long before the copper was fused.

A majority of copper implements found have specks or points of pure silver scattered over their services. I am prepared to prove by the best authority in America, James C. Booth, and Thomas H. Garrett, U. S. assayers at Philadelphia, that one single speck of pure silver, visible even with the microscope, is positive evidence that the specimen was never melted.

Copper unites intimately with nearly all metals, thus forming homogeneous alloys — with zinc forming brass, with tin, bronze, and so on. The only apparent exception to this law is where large masses are fused and at rest for a long time. In these cases the heavier metals gravitate and separate more or less, but *never perfectly.* When large brass cannon are cast, in consequence of the great quantity of metal fused, together with the additional circumstance that the mould is made in the earth and hence requires days to cool, "blotches of lighter color are occasionally found on the surface of the guns, indicating a *segregation* of the metals. A fibrous texture is another evidence that these implements were hammered or rolled out. This fibrous quality is well exhibited by the action of strong acids on the specimens. On articles that are cast, the acid acts in a uniform manner, revealing no *striae* or hard bands. The absence of the slightest indication of a *sprue* — the opening where the metal is poured — is also, to say the least, suggestive. We certainly would expect to find indications of this necessary blemish in specimens so carelessly finished that the mould marks remain conspicuous. If these projections are the remains of the imprint of the mould, the specimen is of recent casting, for it is evident that these delicate marks would be the first to be corroded by the tooth of time.

I make a short extract from a paper entitled "The Ancient Men of the Great Lakes," read by Henry Gilman at the Detroit meeting of the American Association for the Advancement of Science. Mr. Gilman is a close observer, and an accomplished archaeologist, and has made the ancient mines of Lake Superior a specialty. He says: "I cannot close, however, without expressing my wondering admiration of a relic, which, taken in connection with our former discoveries, affords some of the most important evidences of the character of the ancient miners, the nature of their work, and the richness of the mineral field selected for their labors, at Isle Royale. On cleaning out of the pit the accumulated debris, this mass was found at the bottom, at the depth of sixteen and one-half feet. It is of a crescent-like shape and weighs nearly three tons, or exactly 5,720 pounds. Such a huge mass was evidently beyond the ability of those ancient men to remove. They could only deal with it as best they knew how. And as to their mode of procedure, the surroundings in the pit, and the corrugated surface of the mass itself, bear ample testimony. The large quantities of ashes and charcoal lying round it show that the action of fire had been brought to bear on it. A great number of the stone hammers, or mauls, were also found near by, many of them fractured from use. With these the surface of the mass had evidently been beaten up into projecting ridges and broken off. The entire upper face and sides of the relic present repeated instances of this; the depressions, several inches deep, and the intervening elevations with their fractured summits covering every foot of the exposed superficies. How much of the original mass was removed in the manner described, it is of course impossible to say. But from appearances, in all probability it had at least been one third larger. Innumerable fragments of *copper chips* lay strewn on all sides, and even the scales of fish, evidently the remnants of the meals of the miners, were recovered from the pit."

Mr. Gilman was asked if there were in or about any of these ancient mines any indications of the copper having been melted. He replied: "Not the least." And now, were not these innumerable copper chips that were strewn on every side additional evidence that these ancient men know nothing about casting in copper? Those fragments would have been the most suitable to melt, as in all metals the smaller the fragments the more easily they melt. It is evident that those chips, being too small to make any form of their implements, were abandoned as useless.

Finally, How were they made if not cast? I believe that I have the *key*, and can fabricate any form of these ancient implements so exactly as to deceive *even* my learned friend, Dr. Butler.* These ancient Indians, for I believe they were Indians, used fire in their mining operations. The vein-rock was made hot by building a fire on or against it; then, by dashing on water, the rock would not only be fractured, but the exposed pieces of copper be softened, so that it could be beaten into shape. Then the metal became hard, in consequence of its being pounded; it was again heated and plunged into cold water; for copper is, in this respect, the opposite of steel; the one is softened, while the other is rendered hard. In this way copper was fashioned simply by pounding.

In addition to the hammering process, cylindrical articles were evidently rolled between two flat rocks, which is the manner in which several of the articles in the historical collection might be made. Some of those implements that have been supposed to be cast, were, I think, swedged; that is, a matrix was excavated in stone, into which the rudely fashioned copper was placed, and then by repeated blows the article would be made to assume the exact shape of the mould. Nearly all those plano-convex articles could be made in this manner. Of twenty axes taken from mounds near Davenport nearly three-fourths were of this pattern. I will repeat a few lines of an interesting paper read at the Detroit meeting of the American Association, by R. H. Farquharson, on "Recent Explorations of Mounds near Davenport, Iowa."

"The Davenport collection of copper implements consists, at present, of twenty axes, six of which were more or less covered with cloth, four copper awls or borers, over one hundred beads, and a curiously spoon-shaped implement. The axes are all of two forms, one plano-convex, the other with flat sides. They are

*** Dr. Butler, who was present, has held strongly for the *casting* of these copper tools.— Ed**

all cold-wrought by hammering. Some retaining the original scales or lamina on the surface; none of them show signs of use, and are notably harder on the edge than elsewhere."

All of these interesting implements are figured in the proceedings of the American Association at the Detroit meeting, page 304.

We can learn more from this Davenport collection than from any other, because of the perfect condition of the specimens, being unused and in some degree protected by their coverings.

Besides this half swedging process, I am persuaded that, in a few instances at least, there was a complete mould worked out in halves, on the face of two flat stones, so that by placing a suitable piece of copper between them and giving it repeared heavy blows the copper was made to fill the mould accurately.

Last September, while watching some workmen engaged in filling the cribs of the harbor pier with stone, my attention was directed to a slight excavation on the face of a large granite boulder. On careful inspection I found that it was undoubtedly the work of man; although but a part of the excavation was left, the rock having suffered fractures, there was enough, nevertheless, to enable me to make out the original form. We attempted to chip off the specimen with a heavy stone hammer, but failed, as the cleavage was in the wrong direction, and the mould was obliterated. I however worked out a pattern as nearly accurate as I could, representing the excavation. I took this pattern to a stone cutter, for the purpose of having a mould cut in granite. Upon consultation it was decided that the mould would have to be cut in halves in large granite boulders in order to insure success, which would be costly and inconvenient, and for the purpose of illustrating the subject it would be as well to have a mould cast in iron. This was done, and a beautiful ax swedged out of cold native copper was the result. This cylindrical specimen* was made out of a piece of float copper, hammered with a stone ax into partial shape, and then finished by rolling between heavy flat stones.

(The author exhibited plain convex and double convex hatchets, as well as a long cylindrical implement tapering regularly from the centre to the point, that were fabricated by him in the manner stated). *The specimens referred to was exhibited to the Academy.

REMARKS ON THE DESCENT OF ANIMALS.

BY PROF. H. OLDENHAGE, MILWAUKEE.

Whether species are constant and have been created with the same specific characteristics they now possess, or whether they are variable and have desended from common ancestors, is the point at issue between the defendants of special creation and the evolutionists. Since Linne first introduced the idea of species into Botany and Zoology, many attempts have been made to define in an exact manner, what we are to understand by the term species; but when a systematizer underakes to apply these definitions, it is at once seen that they are either glittering generalities, or unmeaning phrases. Among the most recent, and no doubt the ablest of these attempts, is Agassiz's "Essay on Classification," the dogmatism and fulitity of which, Hæckel has so thoroughly exposed in his "Generelle Morphologie."

"Even before the appearance of Darwin's work on the 'Origin of Species,'" says Oscar Schmidt, "Carpenter, in the course of his researches on the Foraminifera, arrived at the conclusion, proved in special instances, that in this group of low organisms, which secrete the most delicate calcareous shells, there could be no question of "species," but only of "series of forms." Forms which the systematizer, had reduced to different genera and families, he beheld developing themselves from one another" (Descent and Darwinism., p. 92). But as these Foraminifera are "so simple in structure, and so little is known of their individual development, the defenders of the persistency of species might claim, that Carpenter's series of forms are mere varieties, and only prove that the true 'species' have not yet been found." To determine this point, however, the researches of Oscar Schmidt and Hæckel, on sponges, have been of the greatest importance. Oscar Schmidt shows, that "we arrive gradually at the conviction, that no reasonable dependence can be placed on any 'characteristic;' that with a certain constancy in microscopic constituents, the outward bodily form, with its coarser distinctive marks, varies beyond the limits of the so called species and genera; and that, with like external habits, the internal particles which we looked upon as specific, are transformed into others, as it were under our hands." "Any one," thus concludes this section of Schmidt's work on the Fauna of the Atlantic Sponges, "who with regard to sponges, makes his chief business the manufacture of species and genera, is reduced *ad absurdum*, as Hæckel has shown with exquisite irony in his Prodrome to the Monograph in the Calcareous Sponges."

"In my specific researches," continues Schmidt, "I confined myself essentially to the siliceous sponges, and by thousands of microscropic observations, by measurements, by drawings, by facts and inferences, have produced evidences, which acute opponents of the immutability of species had not brought forward before me, that in these sponges, species and genera, and consequently fixed systematic unities in general have no existence. The other division of the same class, the calcareous sponges, had been treated with unrivaled mastery by Haeckel in his monograph."

Hæckel was not only able to confirm Oscar Schmidt's statements, "but, owing to the smaller compass and the greater facility of observing the groups selected for study, to advance with more sequence and continuity, from the observation of details to the whole, to portray its morphology, physiology, and evolutionary history, with the utmost completeness." He sums up his conclusions as follows: (Preface to American Edition of History of Creation, p, 15.) "For five consecutive years I have investigated this small but highly instructive group of animals in all its forms in the most careful manner, and I venture to maintain that the monograph, which is the result of these studies, is the most complete and accurate morphological analysis of an entire organic group, which has up to this time been made. Provided with the whole of the material for study, as yet brought together, and assisted by numerous contributions from all parts of the world, I was able to work over the whole group of organic forms, known as the Calcareous Sponges, in the greatest possible degree of fullness, which appeared indispensable for the proof of the common origin of its species. This particular animal group is especially fitted for the analytical solution of the species problem, because it presents exceedingly simple conditions of organization; because in it, the morphological conditions possess a greatly superior, and the physiological conditions are inferior, in part, and because all species of the Calcispongiæ are remarkable for the fluidity and plasticity of their form. With a view to these facts, I made two journeys to the sea-coast (1869 to Norway; 1871 to Dalmatia), in order to study as large a number of individuals as possible, in their natural circumstances, and to collect specimens for comparisons. Of many species, I compared several hundred individuals in the most careful way. I examined with the microscope, and measured in the most accurate manner, the details of form of all the species. As the final result of these exhaustive and almost endless examinations and measurements, it appeared that 'good species,' in the ordinary dogmatic sense of the systematists, have no existence at all among the Calcareous Sponges; that the most different forms are connected, one with another, by numberless gradational transition forms; and that all the different species of Calcareous Sponges are derived from a single exceedingly simple ancestral form, the Olynthus. If we take for the limitation of genera and species, an average standard, derived from the actual practice of naturalists, and apply this to the whole of the Calcareous Sponges at present known, we can distinguish about 21 genera with 111 species. I have however, shown that we may draw up, in addition to this, another systematic arrangement, which gives 29 genera and 289 species. A systematist, who gives a more limited extension to the ideal species, might arrange the same series of forms in 43 genera, and 381 species, or even in 113 genera and 590 species; another systematist, on the other hand, who takes a wider limit for the abstract "species," would use in arranging the same series of forms, only 3 genera, with 21 species, or might even satisfy himself with 2 genera and 7 species. This appears to be so arbitrary a matter, on account of endless varieties and transitional forms in this group, that their number is entirely left to the subjective taste of the individual systematist."

"In point of fact," he continues, "I have a right to expect of my opponents, that they shall carefully consider the exact 'empirical proof' here brought forward for them, as they have so eagerly demanded. May they, however, spare me the empty, though by even respectable naturalists the oft repeated phrase, that the monistic nature-philosophy, as expounded in the 'General Morphology,' and in the 'History of Creation,' is wanting in actual proof. Precisely that exact form of analytical proof, which the opponents of the direct theory demand is to be found, by anybody who wishes to find it, in the 'Monograph of the Calcareous Sponges.'" "This mutability of the Spongiadæ" adds Oscar Schmidt, "affords the extremely important evidence that, so to speak, an entire class has even now, not attained a state of comparative repose." But to prove the variability of species satisfactorily, "the transition of the forms succeeding one another historically in the strata of the earth" must be shown.

The researches of Waagen, Zittel, Neumayr and Würtenberger have proven, in the most conclusive manner, "at least with respect to the important division of the Ammonites, the utter impossibility of separating them into species." "Neumayr is such a cool and cautious observer, that he allows nothing to pass current, but that which is absolutely certain." It is true he holds it to be "extraordinarily probable, that in *all* forms these gradual transitions have taken place, yet in one case only does he demand unqualified assent; namely, that he has proven 'that Perisphinctes aurigerus of the Bathoniaus, and Perisphinctes curvirostris of the zone of the Cosmoceras Jason, are connected in such a manner by intermediate occurrences that it is impossible to draw a limit.'"

Würtenberger's studies were applied to thousands of specimens from the groups of the Planulate Ammonites, with ribbed shells, and of the Armate Ammonites with prickly shells. In summing up his results he says: "In groups of fossil organisms, in which, as in the present case, so many connecting links between the most extreme forms are actually before us, that the transition is regularly carried on, the species is far less susceptible of apprehension than in the organic forrus of the present world, which at least denote the existing limits of the great pedigree of the organic world.

With respect to these fossil forms, it is fundamentally indifferent whether a very short, or a somewhat longer portion of any branch be honored by a special name, and looked upon as a species. The prickly Ammonites, classified under the name Armata, are so intrinsically connected, that it becomes an impossibility to separate sharply, the accepted species from one another. The same observation applies also to the group of which the manifold forms are distinguished by their ribbed shells, and termed Planulata.

This is sufficient to show why modern inquiry "sets aside the phantom of 'species,' and to judge what series of observations are opposed to the assertion, that in no single case has evidence been given of the transition of one species into another." "The fact is," says Huxley, "that if the objections which are raised to the general doctrine of evolution were not theological objections, their utter childishness would be manifest even to the most childlike of believers.'"

"Scarcely a single fact," says that most careful observer Neumayr, "speaks more decisively in favor of the correctness of the theory of descent, than the existence of series of forms in the manner in which they have already been proved in many cases, and will, no doubt, be now found more frequently, since attention has been called to this point.'"

But it is not only among the lower animals that these transition forms have been found. Even among vertebrates, and what is the more important, between those classes, orders and families, which at present are separated very widely from one another, these connecting links multiply almost daily, bearing in mind, of course, the great imperfection of the geological record.

"The class of birds and reptiles as now living," says Prof. Marsh, of Yale College, to whom palæontology owes so many important discoveries, "are separated by a gulf so profound, that a few years since it was cited by the opponents of evolution as the most important break in the animal series, and one which that doctrine could not bridge over. Since then, as Huxley has clearly shown, this gap has been virtually filled by the discovery of bird-like reptiles and reptilian birds.'"

In 1860, shortly after the appearance of Darwin's "Origin of

Species," a remarkable bird was found in the lithographic slates of Solenhofen, Bavaria, the head of which was unfortunately crushed beyond recognition. Recently, however, another specimen has been found in the same formation, at Eichstadt, Bavaria, with a well preserved head. The celebrated comparative anatomist, Owen, of London, described this bird and called it Archaeopteryx. "There is this wonderful peculiarity about this creature, that so far as its feet are known, it has all the characters of a bird, all those peculiarities by which a bird is distinguished from a reptile. Nevertheless, in other respects, it is unlike a bird and like a reptile. There is a long series of caudal vertebrae. The wing differs in some very remarkable respects from the structure it presents in a true bird. In a true bird the wing answers to the thumb and two fingers of the hand, the metacarpal bones are pressed together into one mass, and the whole apparatus, except the thumb, is bound up in a sheath of integument, and the edge of the hand carries the principal quill feathers. It is in that way that the bird's wing becomes the instrument of flight. In the archaeopteryx, the upper arm bone is like that of a bird; the two forearm bones are more or less like those of a bird, but the fingers are not bound together — they are free, and they are all terminated by strong claws, not like such as are sometimes found in birds, but by such as reptiles possess; so that in the archaeopteryx we have an animal which, to a certain extent, occupies a place midway between a bird and a reptile. It is a bird so far as its foot and sundry other parts of its skeleton are concerned; it is essentially and thoroughly a bird, in the fact that it possesses feathers; but it is much more properly a reptile, in the fact that what represents the hand has separate bones resembling that which terminate the fore-limb of a reptile. Moreover, it had a long tail with a fringe of feathers on each side. From this description it is seen that the archaeopteryx is about three-fourths bird and one-fourth reptile."

Prof. Marsh has found during the last few years very remarkable forms of birds in the Chalk of Kansas. In the Hesperornis, "says Marsh," "we have a large aquatic bird, nearly six feet in length, with a strange combination of characters. The jaws are provided with teeth set in grooves; the wings were rudimentary and useless, while the legs were very similar to those of modern diving birds. Ichthyornis, a small flying bird, was stranger still, as the teeth were in sockets, and the vertebrae biconcave, as in fishes and a few reptiles."

"It is obvious," says Huxley, "that the contrast between the crocodile's leg on the one hand, and the bird's leg on the other, is very striking. But this interval is completely filled up when you study the character of the hinder extremities of those ancient reptiles which are called the Dinosauria. In some of these, the bones of the pelvis, and those of the hind limb, became extraordinarily similar to birds, especially to those of young or foetal birds. Furthermore, in some of these reptiles, the fore-limbs become smaller and smaller, and thus the suspicion naturally arises, that they may have assumed the erect position. That view was entertained by Mantel, and was also demonstrated to be probable by your own distinguished anatomist, Leidy, but the discoveries of late years show that in some of these forms the fact was actually so; that reptiles once existed which walked upon their hind-legs as birds now do. The Compsognathus longipes (Wagner) must assuredly have walked about upon its hind-legs, bird fashion. Add to this feathers, and the transition would be complete."

It is now generally admitted by biologists "who have made a study of the vertebrates," continues Marsh, "that birds have come down to us through the Dinosaurs, and the close affinity of the latter with recent struthious birds will hardly be questioned. The case amounts almost to a demonstration, if we compare with Dinosaurs, their contemporaries, the Mezozoic birds. Compsognathus and Archaeopteryx of the old world, and Ichthyornis and Hesperornis of the new, are the stepping-stones by which the evolutionist of to-day leads the doubting brother across the shallow remnant of the gulf, once thought impossible."

Although this kind of evidence is far weightier than that upon which men generally base their conclusions regarding important propositions, it is not that kind of evidence which might be called demonstrative. That is to say, it might be demanded "that we should find the series of gradations between one group of animals and another in such order as they must have followed if they had constituted a succession of stages, in time of the development of the form at which they ultimately arrive." In short, it would have to be shown, that, with reference to birds and reptiles, for instance, "that in some ancient formation reptiles alone should be found; in some later formations birds should first be met with; and in the intermediate strata we should discover in regular succession the forms which are intermediate between reptiles and birds."

Precisely this kind of evidence has of late years been accumulating rapidly respecting many groups of the animal kingdom. The development of the horse offers us, perhaps, the best illustration of this kind of evidence, and I give the substance of "these thoroughly and patiently worked-out investigations of Prof. Marsh," in his own words. He says: "I have unearthed with my own hands not less than thirty distinct species of the horse tribe, in the tertiary deposits of the west alone.

"The oldest representation of the horse at present known is the diminutive *Eohippus*, from the lower Eocene. Several species have been found, all about the size of a fox. Like most of the early mammals, the ungulates had forty-four teeth, the molars with short crowns, and quite distinct in form from the premolars. The ulna and the fibula were entire and distinct, and there were four well-developed toes, and the rudiment of another on the fore-feet, and three toes behind. In the structure of the feet and in the teeth, the Eohippus indicates unmistakably that the direct ancestral line to the modern horse has already separated from the other perissodactyles. In the next higher division of the Eocene, another genus (Orohippus) makes its appearance, replacing Eohippus, and showing a greater, although still distant, resemblance to the equine type. The rudimentary first digit of the fore-foot has disappeared, and the last premolar has gone over to the molar series. Orohippus was but little larger than Eohippus; in most other respects very similar. Near the base of the Miocene, we find a third closely allied species, Mesohippus, which is about as large as a sheep, and one stage nearer the horse. There are only three toes and a rudimentary splint bone on the fore-leg, and three toes behind. Two of the premolar teeth are quite like the molars. The ulna is no longer distinct, or the fibula entire, and other characters show clearly that the transition is advancing. In the upper Miocene Mesohippus is not found, but in its place a fourth form, Miohippus, continues the line. The three toes in each foot are more nearly of a size, and a rudiment of the fifth metacarpal bone is retained. All the known species of this genus are larger than those of Mesohippus, and none pass above the Miocene."

"The genus Protohippus of the lower Pliocene is far more equine, and some of its species equalled the ass in size. There are still three toes on each foot, but only the middle one, corresponding to the single toe of the horse, comes to the ground. In the Pliocene we have the last stage of the series before reaching the horse, in the genus Pliohippus, which has lost the small hooflets, and in other respects is very equine. Only in the upper Pliocene does the true Equus (horse) appear and complete the genealogy of the horse, which in the post-tertiary roamed over the whole of South and North America, and soon after became extinct. Besides the characters I have mentioned there are many others in the skeleton, skull, teeth, and brain of the forty or more intermediate species, which show that the transition from the Eocene Eohippus to the modern horse has taken place in the order indicated, and I believe the specimens now at New Haven will demonstrate the fact to any anatomist. They certainly carried prompt conviction to the first of anatomists (Huxley), whose genius had already indicated the later genealogy of the horse in Europe, and whose own researches so well qualified him to appreciate the evidence here laid before him."

Basing his conclusion on these facts, Huxley says: "The doctrine of Evolution at the present time rests upon exactly as secure a foundation as the Copernican theory of the motion of the heavenly bodies. In fact, the whole evidence is in favor of Evolution, and there is none against it."

Another class of facts, considered equally conclusive in favor of the Theory of Descent, are the results of Embryology.

Note.—Prof. Oldenhage had only written thus far when he was seized with an illness which speedily terminated a most promising life.

WHY ARE THERE NO UPPER INCISORS IN THE RUMINANTIA?

BY P. R. HOY, M. D., PREST. ACADEMY.

In studying the anatomy and physiology of animals, we become intensely interested in the various modifications of parts, so as to exactly fit them, to perform the office assigned them. In other words, the structures are so altered as to correspond to the mode of life which the animal pursues.

Perhaps no part of vertebrates is as significant as the apparatus of the mouth, for obvious reasons, as it performs an important part in nutrition, the function which strikes at the very foundation of life.

Every vertebrate has his *bill of fare* written in indelible characters on his teeth. They not only indicate the food on which the animal subsists, but with few exceptions, the mode of procuring that food, as well.

All those animals having no incisors in the upper jaw, and provided with eight placed obliquely outward in the lower jaw, have evenly divided hoofs, complicated stomachs, and chew the cud. I am satisfied that there is a deep meaning conveyed in the absence of upper incisors in ruminantia, if the fact is correctly interpreted.

In the first place, all true ruminants have a prehensile tongue. We will take one of the most familiar examples, the cow, and what is true of this domestic animal, will apply equally well, not only to the entire *boss family*, but with slight modification, to the entire ruminantia. The tongue is large and muscular, weighing from three to five pounds, the upper surface, *dorsum*, is covered with a dense, almost horny skin, especially at the point; the mucous coat, covering the tongue and lingual glands, pours out an abundance of mucus and saliva to keep the organ moist and pliable. It is capable of being thrust out beyond the lips to the distance of from six to eight inches. In protruding the tongue it is pressed firmly against the hardened gum of the upper jaw, then it is coiled around the morsel, the tongue curves upwards bringing the food into the mouth rasping, as it were, the upper jaw.

In grazing, the tongue is lapped around a wisp of grass, which is brought into the front of the mouth, and held in its grasp against the upper jaw, when by a quick motion of the head, the sharp chisel-teeth in the under jaw, clip off the herbage. In these motions we see the great advantage of the outer direction of the under incisors.

In studying these movements of the tongue, we become convinced that upper front teeth would not only seriously interfere with its motion in protrusion by lacerating its upper surface, but would positively arrest the morsel against the upper incisors, if there were any, and thus impose a barrier against the use of the tongue in prehension.

In the deer tribe, *cervidae*, the tongue is longer in proportion to its weight, than in the ox. Deer are mostly browsing animals, feeding on leaves and branches of shrubs and small trees; for this purpose the long flexible tongue is especially well adapted. Deer have the longest tongue of any of the ruminants, if we except the giraffe, whose tongue is simply enormous. With its extensive tongue, and long neck, this singular animal is enabled to reach branches of considerable elevation.

Antelopes, for the most part, have moderately sized tongues, yet not a few have the organ largely developed; in fact the tongues vary nearly as much as do these ill-assorted animals themselves. For the genus antelope is a kind of zoological retreat for the reception of those outcast hollow-horned ruminants which do not belong, either to the ox, sheep, or goat species.

Goats have a moderately developed tongue, fully capable, however, of procuring food in the same manner as the preceding tribes.

Sheep have this organ less developed than in any other of the true ruminants. It is capable of being protruded not over three inches beyond the lips. In grazing on short pasturage, the point of the tongue is only used to fix the short grass to the upper gum, while the under teeth are made to sever the herbage. In our wild sheep of the Rocky mountains, *ovis montana*, the tongue is more developed than in the domestic animal. Is it not more than probable that the domestic sheep, having been confined to short pasture for a long series of generations, have lost, in length, a portion of their tongues?

In the camels, including the lamas, there is a wide departure from the typical ruminants. In fact anatomically, the camel family show a marked affinity to the pachyderms. They stand on the border line of the ruminants where they join the pachydermata, possessing characteristics of each. Their lips are large and fleshy, the upper one cleft. Their dentition is peculiar, the young possessing a full set of incisors in the upper jaw, which fall out as the animal approaches maturity, save the two latter ones, which are permanent.

We have here perfect corresponding relations between the imperfect set of upper front-teeth and the partly prehensile tongue which they possess. The lips and tongue are nearly equally useful in seizing and conveying food to the mouth.

On the lowest round looking up towards the ruminants, stand the kangaroos. These herbivorous marsupials do chew the cud, though imperfectly, as they possess saculated stomachs approaching the multiple condition of the typical ruminants. It is interesting to find that these wonderful animals, of a wonderful country, do not possess a prehensile tongue, but have instead, a full, strong set of incisors in the upper jaw. Here we have then, one of the best proofs that the use of the tongue regulates the presence of incisors.

Insectivorous edentata, embracing the armadillos, and ant-eaters of South America, and the Panoglins and Ard-vark of India and Africa — in these quadrupeds, the tongue is long and cylindrical, and is protruded directly forwards, so that front teeth in either jaw, would interfere with the necessary rapid motions of the tongue in feeding. Hence, the total absence of front teeth in either jaw, and in fact the ant-eaters have no teeth whatever, being strictly edentate. These animals furnish us with another proof that prehensile tongues are antagonistic to front teeth.

If a prehensile tongue be cylindrical, then we will have a total absence of front teeth; if flat and coiled upward in using, then we will find incisors only in the under jaw.

May it not be true that the absence of upper incisors in the ruminants, and the total want of front teeth in the edentata, are the result of long ages of disuse, accompanied with the almost constant friction and presure against them, which might injure and ultimately destroy the germs of the useless teeth, until their absence becomes an hereditary peculiarity, as a final result?

BOILER EXPLOSIONS.

BY CHAS. I. KING,

Superintendent University Machine Shop.

In considering the subject of Boiler Explosions, I am aware that it has heretofore received the attention of many able theorists and mechanical engineers who do not agree in their conclusions. That such diversity of opinion exists, is natural from the various conditions of the matter discussed.

What is here prepared may not be new, but the subject is of such vast importance, that even repetition may be pardonable.

If we for a moment consider the field, we find that its extension precludes comprehending the whole in one short paper, which covers the subject proportionally, as the hand might cover a table. That the astonishing developments, attained by the use of steam in the various industries throughout the country, must be ascribed to its universal success as a moderately cheap prime mover none can deny; and the facility with which it can be employed in any section of the land enables the manufacturer to locate his mills wherever desirable, and then transport to them the mo tive power.

Without it, he must be content with the water courses wherever they may be found, and ever after transport the material of manufacture to and from the market.

Without it many of our large cities and manufacturing centers could not exist to-day. Only while it is considered less dangerous or less expensive than other agents, can steam maintain its now prominent position of principal motive power for nearly all branches of manufacture, transportation, etc.

There are considerations in connection with the present methods of utilizing steam, which, looked upon from every point, would indicate clearly that we are justified by no means in accepting it as the most economical prime mover obtainable. Many unsuccessful attempts have been made to discover a substitute for steam as a source of power, there always having been found insurmountable obstacles, inseparably connected with the use of all other agents; difficulties which science and the best mechanical skill have failed to overcome. Quite a number of years will probably yet elapse, ere these hindrances are pushed aside by the spirit of investigation and invention which pervades the age in all civilized countries. But supposing the successful employment of a more suitable and economical motor might be rendered practicable, during the coming week, month or year, the expense necessary to secure the change would preclude its rapid adoption by many using the present devices. It would in fact be so long before the present arrangements could be superseded that it must still be worth our time to strive for improvements in the manner of employing the power we now have, and to gain some knowledge in which direction, further improvement in its safe and economical use may tend.

Practical experience has taught us, in the past twenty-five years, that there was no economy in the "old time practice" of using steam at a low temperature and pressure for all purposes. The direct advantages accruing from its use at high pressure, securing high piston speeds, and expanding the steam to nearly zero, have been very large. This change came gradually. Many improvements were necessitated, but now the six to fifteen pound pressures of forty-five years ago, and large unsightly engines are supplanted by pressures of fifty to two hundred pounds, and engines of half the size which give the same equivalent of work. As the economy of the higher temperatures becomes generally appreciated, the greater the demand will be for them.

The principal impediment still existing to progress in this direction is due to the limited strength of the present forms of the steam generators. The boilers of the future must be improved so that safety may be insured, being either constructed in sections, or of material with greater strength, also not complicated in design and of moderate cost. That the most important of these requirements have not been realized, is only too apparent from the many accidents continually occurring in different sections of the country. That some boilers will explode is perhaps inevitable. The increase in the number of those accidents is, in a measure, owing to the increase of the number of boilers in use, and to the greater demand made of them in sustaining high pressure. The inference is plain, that improvements in manufacture have not kept pace with this demand. That all boiler explosions are due directly to the inability of the vessel to retain the enormous pressure generated just prior to the rupture, all will admit, but indirectly there are many primary causes traceable. Of the vast number of boilers in use, but comparatively few explode; fortunately they are the exceptions. Something certainly enters into the conditions where explosions occur different from those in which they do not. Boilers are in use under so many varying circumstances, that two explosions are seldom traceable to exactly the same causes. Instances are known where boilers have been in constant use tor twenty years, and almost without repairs, while others fail in as many weeks or months. This difference must be due to material, workmanship, quality of water, and the attention they receive. We know that certain causes produce certain effects, and that neglect and carelessness have no business in mechanical matters at all, much less should they be seen about our steam generators. It is simply astounding to know the extent to which ignorance and incapacity are placed in charge of these agents of the public service, which, in the hands of incompetent men, are about as dangerous as a package of dynamite. That all boiler explosions are due to carelessness and ignorance we do not mean to assert, but that about nine-tenths of them are, is beyond question.

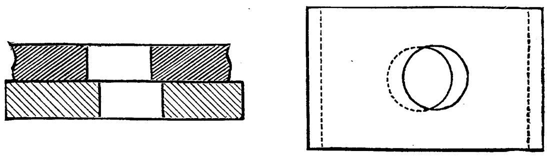
People are accustomed to think that any thing constructed of iron should "endure forever," merely because made of iron. Well, such an hypothesis may answer in some cases. Experience in the past year alone, however, has taught us, that it is an exceeding unsafe one in connection with steam boilers. That so many incompetent men are found in charge of so many boilers and engines, is principally owing to the fact that they are cheap. Cheapness seems to be the only required qualification. The scale balances up and down like the beam of a steelyard, intelligence and suitable compensation usually being found at the upper end. Possibly some employers prefer this class of help lest they might learn some disagreeable truths concerning their steam generators. There is, however, one very important point in this connection which is usually lost sight of. There seems to be an inexorable law in force in these cases as in many others. There is a minimum cost in the management of machinery, which cannot be reduced even by machinery. And if the steam user will employ incompetent labor because it is cheap, then the difference between its cost and that of a higher grade of intelligence must certainly be given to the boiler-maker and machinist by way of repairs, and to the coal dealer for extra fuel, as a skillful fireman will save from five to twenty per cent. over an untrained one. I call to mind a striking illustration of the case, that of a manufacturer in an eastern state, who, though a most successful business man otherwise, possessed a remarkable faculty for utilizing every piece of old iron he could obtain, and the extra work on which, in putting it in suitable condition, always cost him more than the new material. His annual loss from breakage and wear, making no account of time when the machinery was idle, due to the employing of a one dollar man where a two dollar one was required, was at least three times the difference in cost of one or two reliable men. A very common practice, and one most reprehensible withal, is that of employers compelling their engineers and firemen (often these consist of but one man) to do their legitimate work and that of two or three others, frequently being called to distant parts of the building. No man can attend to too many duties well; it is in the nature of things that some will be forgotten, and under these circumstances it is just as likely to be the most important as any other.

Boilers are constructed from a great variety of designs. Those found in more common use are of the locomotive type, and the plain cylinder with closed ends. The material usually is from 1-4 to 3-8 inches thick. As a conductor of heat, iron stands low in the scale, gold being as 1000, copper 898, and iron but 347. Now with iron but 1-4 inch in thickness, a great amount of heat is lost in boilers, owing to the inability to transfer all the heat produced to the water. Hence it is seen we cannot gain security by use of heavier material without a sacrifice of fuel. Small boilers, as a rule, are safer than large ones, if built in proportion, as they have a less number of square inches exposed to pressure. Taking a hasty glance at some of the practices in vogue in the construction of boilers, one of the most objectionable features in this as in many other things, is the too general tendency to obtain our goods at a price below a fair market value, and the custom of letting these contracts to the lowest bidder often works to the disadvantage of both parties. In this business, of all others, the custom should be discontinued. It is fair to assume that boiler makers are as fallible as any other class of business men. Men do not do business for nothing, as a rule, neither for pleasure. "Each trade has its trick," and the purchasing party who obtains his boiler for less than the market rate, may seek consolation in the fact that he has been "sold" somewhere in his purchase.

In my own experience, I have known boilers constructed under these conditions of so poor material, that the plates did not have the manufacturers' brand on their surface. It may not be out of place to add that the builders of those boilers have had no less than four explosions of boilers of their construction in the past five years. From the time the boiler material is placed in the hands of the workman, it is constantly growing weaker, until thrown aside as old iron. The width of the iron in common use is three feet. Along each edge and across the ends, holes are cut or punched for rivets, after which the sheets are rolled to an approximation of a cylinder. When these cylinders are slipped together, all of the rivet holes should coincide. That they do not is a source of much trouble. The positions of these holes are marked through a wooden templet, which will be about three inches wide by 1-2 in thickness, and of such length as each particular case may require. Along the edges of this templet holes are bored, one set answering for the inside cylinder and the other for the outside. In spacing these holes, about six times the thickness of iron is allowed for difference in length, and the same number of holes must appear in each sheet, only in the short ones they are nearer together. The operation of punching the holes is a rather haphazard one at best, so far as accuracy is concerned.

There are two chances for error by the time the plates are rolled. First. The holes will not all be made exactly where marked; if one whole is punched slightly one side of its mark, and the one which it should match the other way, the error is

Fig. 1.



multiplied. Moreover, it is quite impossible to produce these plates and have them perfectly homogeneous. There will be hard and soft places. The great pressure from the rolls in making the plates cylindrical will cause changes in distance between some of the holes, as the temper of the plate varies. When the cylinders are placed together for riveting, many holes will shut past

Fig. 2.

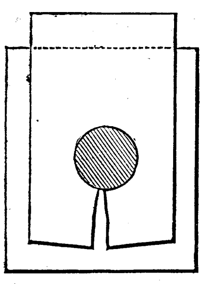


Fig. 3.

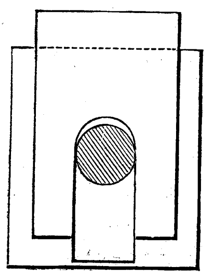
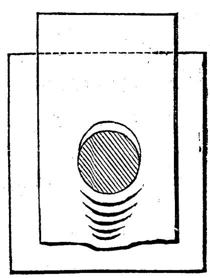


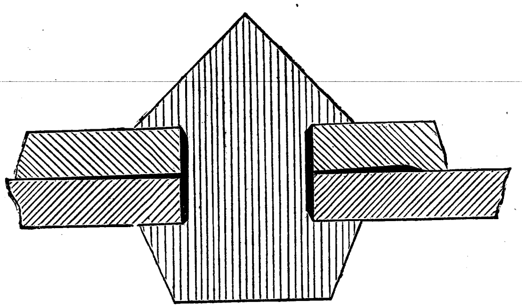
Fig. 4.



one another from 1-16 of an inch to 1-2 or 2-3 their diameter. This, in itself, is objectionable enough, but the case is aggravated. The overlapping metal should all be removed by the reamer and the hole filled by a suitable rivet. If the overlapping of the holes is not such as to compel the use of the reamer, a most objectionable resort is the tool known in shop parlance as a "drift pin," which is nothing more than a steel pin, slightly tapering, and when well oiled can be driven in with such force that the solid iron is often compressed and cracked, and pieces of the plate may be forced out. Fig. 1 is intended to illustrate the overlapping holes, and figs, 2, 3 and 4 the effects of the use of the "drift pin." Another difficulty here presents itself, arising chiefly from carelessness and poor workmanship. Often the sheets do not come in contact, and especially at the heads or ends of the boilers, on which the flanges are turned, is this the case, and also on internal fire-box work. When the rivets are driven, the iron acts as a spring, and vibrates back and forth from the blows of the hammer. The rivets too, will "upset" in between the plates if much apart.

Rivets driven in this way can never be made tight, neither will the caulking chisel remedy the defect, for when the caulking is done, the iron is driven back between the plates forming a thin narrow ridge under which the pressure will soon force the water or steam, Fig. 5, is a fair illustration of the case.

Fig. 5.



To this defect are due, many of the mysterious leaks in new boilers, when but a short time in use. Often rivets are improperly supported or "backed" when being riveted, which causes leaks; or riveted when too cold, causing crystalization to such an extent that often a slight jar will cause the heads to drop off. The outer corner of the outside cylinder must be chamfered to an angle of about fifteen degrees, thus leaving a sharp edge where the cylinders join, for caulking. In many large shops this is done by machinery before the plates are rolled, in others before the cylinders are placed together. In many, it is done after the riveting, and thus the lower sheet is more or less cut by the corner of the chisel, the greatest care cannot prevent it. With many boiler-makers, this is of minor consideration, but the fact that many exploded boilers have given way at this point should draw attention to it. The following account of an experiment made at the University machine shop shows well the effect of cutting through the outside of the iron. A piece of common five-eighths square iron was cut on the four sides with a cold chisel, so that it was well marked. A slight blow from the hammer caused it to break, the ends showing crystalization. A second piece was marked on but one side, which on being broken, was crystalized about half through, the rest showing the fibre undisturbed, and tearing out the iron for half an inch up the bar. It has been claimed that the principal strength of iron is destroyed by cutting through the "skin," yet, a piece of this same bar marked as in the first instance, was placed in the lathe and the marks turned out, after which it was bent to more than ninety degrees before breaking.

It is estimated that about forty-four per cent. of the original strength of the material has been destroyed by the time a boiler is ready for riveting. The axiom that the "strength of any structure must be estimated from the weakest point," is a good one. By these various operations, six per cent. more will be of questionable value. Repeat them at every joint in a boiler twelve to twenty-four feet long, and who will tell where the weakest point may be? Imagine if you can a boiler so constructed of any flexible material, it would contain more kinks and puckers and gathers than a fashionable dress. New boilers are often submitted to the hydraulic test, which consists of forcing in cold water to a certain pressure, and then assuming it safe to carry one-third or two-thirds as much steam pressure. I believe it a questionable method and an unsafe assumption. If there are blisters or imperfect welds in the plates it may develop them. A careful inspection would probably accomplish the same result. But in these tests the boiler is subjected to strains under conditions which do not occur in actual use. The water and iron are both cold, stay rods and braces are loosened which do not again come tight of their own accord. Further, most boiler iron, as demonstrated by the experiments of the Franklin Institute Committee and Fairbairn, a noted English mechanical engineer, has a greater tensile strength with an elevation of temperature, some proving stronger at 600 ° Fahrenheit, than at any lower point. Now it is quite certain that testing with cold water has not rendered the weakest point of the vessel much stronger.

As soon as a boiler is in use, the agents of destruction incident thereto begin their work. Probably chief among these, is the steam itself. The unit of elasticity, by which the expansive force of elastic fluids is measured, is for popular use, one pound on one square inch of surface. We glance at a steam guage and the little hand may indicate fifty. Let us ascertain what that means. If a boiler is twelve feet long and three feet in diameter (very common dimensions) and contains thirty-four three inch tubes, the two heads with tube surface deducted have remaining 1,864 square inches. The cylinder of the boiler contains 16,280, equaling in all 18,150 square inches which, multiplied by fifty pounds pressure, give a total of nearly one million pounds, or a fraction over 450 tons, continually tending to rend the cylinder. Boilers are made round or approximately so, for two reasons. It is the cheaper form and one naturally self-supporting. I say approximately round, for they are not a true circle and cannot be made so owing to the lap of the longitudinal seams. Now this enormous pressure, tends to force the shell of the boiler to a true circle. The pressure is never constant. Great and unequal strains are produced along the under edge of the lap, which vary from time to time according to the different degree of pressure. In effect it is similar to bending a piece of iron back and forth in the hands, only on a more minute scale. In time the same result will be effected, destruction of the fibre of the iron.

Many purchasers of these steam generators commit the serious mistake of selecting boilers of insufficient capacity, simply because one or two hundred dollars cheaper. In so doing, the door is opened through which many dollars will pass in the way of fuel without an adequate return. But when a boiler has just the capacity to supply the demand by forcing the fires, a nearly full opening of all passages to the engine will result. The steam flows rapidly through them, twice at every revolution of the engine, this flow is suddenly and positively checked. While so checked, there is a rapid accumulation of steam from the forced fires. The boiler expands to the greatest limit in retaining the increasing pressure. The opening of the passage way again affords a temporary relief. Thus the boiler dilates and contracts to such an extent that the movements are sometimes visible to the eye, and they have been compared to the breathing of some large animal.

With this slow and continuous change, there is no wonder that boilers eventually "give out." If there is any mystery in the case, it is that they last so long and serve so well as they do.

That steam and water in pipes not properly drained have great percussive action, may be readily seen from the jumping and snapping of the pipes under these conditions, and many serious accidents have occured from pipes and fittings bursting, even loss of life resulting in some cases. With these facts before us, great care should be exercised, not to open the steam passages from the boiler, too suddenly, on account of the danger arising from relieving the pressure on the water.

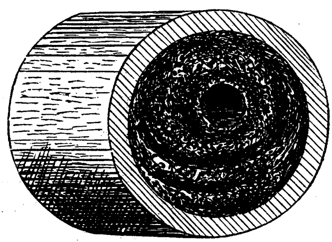
What effect might be caused by such lack of care, may be seen in the following deduction.

The heat required to raise one pound of water through one degree of temperature is termed a unit of heat, or its equivalent, 100 pounds of water through one-tenth of a degree, or one-tenth of a pound through 100 degrees. This quantity of heat possesses the same amount of power as would be required to raise 772 pounds, one foot, or one pound 772 feet. This is termed the mechanical equivalent of heat. Now if the addition of one degree of heat to one pound of water, be such an accession of force, the addition of 100 degrees to 500 pounds of water is an equivalent of a half million times that force. In practice, the combustion of a pound of coal imparts to the water in a good boiler about 10,000 units of heat, and evaporates eight or nine pounds of water of usual temperature. With all the losses and disadvantages considered, a pound of coal exerts about one-fourth of a horse power per hour, fifteen horse power for a minute or 900 for one second. The heat absorbed by 5,000 pounds of water in raising it through 100 degrees, is really twelve and a half horse power for an hour, 750 for a minute or 45,000 horse power for a second. The amount of heat absorbed by 5,000 pounds of water in raising it through 100 degrees, is but a small portion of the quantity in any boiler in common use, yet fifty pounds of coal are required to cause it, and the imparted heat is equal to the amount expended to convert about 430 pounds of water at common temperature to steam. By a too sudden release of pressure, this latent heat might all be released in one or two seconds, and thereby cause an explosion. The idea quite generally prevails that all boiler explosions are due to low water. That might cause such a disaster, but that alone I think seldom does. Often, no doubt, boilers are seriously injured by the plates being burned. Burned plates lose about one-half their strength. Repeat the operation often enough and it is only a question of time, and a rather limited time, too, when the boiler will be ruined.

Several years since, the United States government squandered about $100,000 at Sandy Hook and Pittsburg, trying to determine the cause of boiler explosions. The experiments were under conditions which were almost totally different from those under which boilers are used. Hence, practically, they were nearly failures. Two things were discovered, however; one, that a boiler will not explode when you want it to, and that water, pumped in on plates red hot, would all run out through the seams, which were caused to open from the rapid contraction, or else escape through the safety valve as steam. This operation was repeated three times to produce an explosion.

Boiler plates are burned oftener from incrustation than from low water. Wherever this formation is thick enough to prevent the water from coming in close contact with the iron, that must be the result, and if from this cause the plates when in use become sufficiently hot to weaken the tensile strength in a place of any large area, a rupture will surely follow. Fig. 6 shows a section of a feed pipe filled with lime in the short space of three months. A few years since I had an opportunity to examine a case of this kind. The boiler was of the locomotive type, and was not under cover. The plate over the fire had been forced

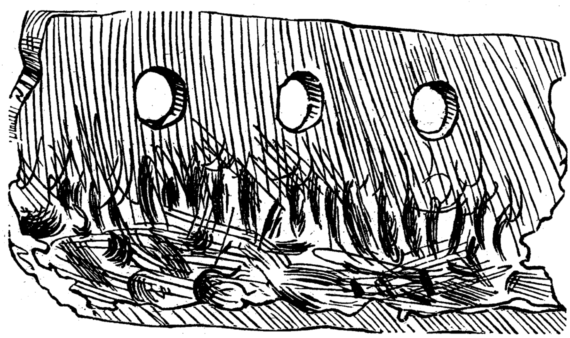
Fig. 6.



down gradually, and in shape like the bottom of a wash-bowl, becoming thinner at the lowest point until finally breaking open, it left rough, ragged edges and a hole about eight inches in diameter. The whole weight of three and a half tons was raised about thirty feet and thrown over back, striking the ground at an angle of about thirty degrees, and sliding along, tore off every particle of the engine.

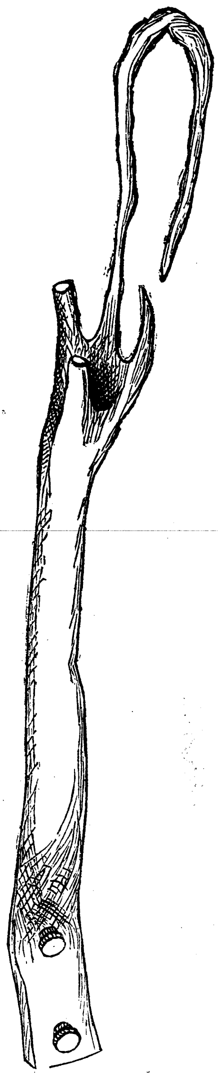
These deposits in boilers are the most difficult matters steam users have to contend with, but its formation to a dangerous thickness can be prevented by frequent cleaning out, also by frequently letting out a little water through the day when the boiler is under pressure. It is a bad practice, and, of course, a common one, to let the water all blow out of the boiler, after the fires are out and before sufficiently cooled. The heat retained in the metal and

Fig. 7.



surrounding walls will cause the deposit to bake to the iron so that nothing less than a hammer and chisel will remove it. Care should be exercised in setting boilers so that they may be examined at different times, and to keep them in places as dry as possible. Iron wastes away fast enough at best, and if leaks occur where the boiler is in contact with brick and mortar, corrosion goes on so rapidly that the best boilers may be rendered unsafe in a year or two. When leaks are discovered they should be considered signs of wearing out, and should receive attention at once. Usually, however, because it is small or does not let out the water faster than it can be replaced, it is allowed to go. It is treading on a dangerous path.

Fig. 8.



Often, when very impure water is used, boilers are attacked by internal corrosion. Usually it is found at the edge of the sheets, along the seams and around the rivet heads. Sometimes different plates in the boiler will be corroded, while others will be found in good condition.

With all this evidence of the dangerous processes going on both without and within a boiler, it seems very plainly indicated, that too much care and attention cannot be given them. Marine boilers are of the most dangerous class, but they seldom explode. The reason is evident. First-class men, and none others, are placed in charge of them. The statistics show that in the decade from 1865 to 1875, there was an average of about one explosion every three days, and it would seem that the public had the right to demand some system whereby a little higher grade of intelligence could be placed in charge of these, now, indispensable agents of the public service.

From the use of impure water results a process called "pitting." Small holes quite near together are eaten into the plates, and often a pitted plate and a sound one will be found side by side. This is probably due to a chemical difference in the iron, and the pitting may be caused by galvanic action. Pitted plates resemble very much the partly consumed zincs from a battery. Experiments were made with pieces of iron cut from pitted plates, and those which were not, taken from the same boiler and placed in a bath of acidulated water, when connected with a galvanometer, the pieces excited sufficient action to sensibly deflect the needle.

Fig. 7 * shows a case of pitting, and fig. 8 represents a corroded brace or stay rod, so much of which is destroyed that it became entirely useless.

*Figs. 7 and 8 are taken from Reports of Hartford Boiler Insurance Company.

MIND IN THE LOWER ANIMALS.

BY J. S. JEWELL, M. D.,

Professor of Mental and Nervous Diseases in the Chicago Medical College, and Corresponding Member of the Wisconsin Academy of Sciences, Arts and Letters.

My subject is that of "*the evidences of mind in the lower animals.*" The first thing to be done, in a case like the present, is to define the meaning of the leading terms. This is one of the golden rules of discussion. Then, what is mind? Before trying to answer this question, which, by the way, is not a new one, I should tell you that it was not my plan to determine, except in a superficial sort of way, what mind really is. It would require more than one lecture to deal adequately with that question. For my present purpose, it is sufficient to assume the existence of something, which may be called mind, whether motional or immotional, the presence and action of which is known usually by certain *signs*, by which beings possessed of mind are commonly distinguished from those that do not have it. It is with these *signs*, rather than the mind itself, that I am to deal. But once again, what is mind? It is much easier to ask this question than it is to answer it. You all know it has been, and at this hour it would be answered very differently by various persons, who have given themselves (following different methods) to its study.

But taking all these answers together, aside from unessential particulars, they may be divided into two principal classes, which are susceptible again of division into sub-classes. But I am to call your attention to the two principal classes mentioned. They may be described as follows:

In the one case, the phenomena called mental are not attributed to any other agent or source than the material organism itself. In this view there is no such being as a mind numerically different from the body of the animal, neither before nor after death. The word mind is simply a name for the aggregate of functions of the nervous system, at any rate of its higher functions. There is no actual proof of the existence of any such immaterial, immortal entity, as that usually designated by the terms, mind, soul, spirit. Mind is simply brain action. When the brain is disordered, mind is disordered. When the brain is healthy, the mind is healthy. When the brain is imperfect in its development and structure, as it is in idiots, then the action of the mind is hopelessly imperfect. But when, on the contrary, its development and structure are the most perfect, uniformly its action is the most perfect.

Moreover, when the brain perishes as it does after death, all mental action ceases, or at least all evidences of it. In short, all that we knew as mind before the death of the individual, perishes with the brain. Any opinion that there is a being so distinct from the body, as to continue to survive after its death, is a mere creation of the fancy, at the dictates of the baseless aspirations or traditions of mankind.

Mind is, hence, absolutely dependent on the body, and without it has no existence. It is simply a combination of physical forces, which return to their primitive condition after death, ready to enter into new combinations of any or all kinds. Such, in outline, is one class of opinions as to mind. They are what have been called *materialistic.* If this class of opinions were true, there could hardly be any difference among thinking people as to whether the lower animals are possessed of minds, as well as man. In point of fact, persons who hold to the view just described, generally admit that animals share in the possession of mind with men.

By the other class, mind is regarded as something substantially different from the physical organism, or body, though closely associated with it during the corporeal life of the individual, from which, however, it becomes separated in what is called death, of which this supposed separation is held to be the principal event. After this, the organization of the body indeed perishes, but not so the mind; for the latter is believed to continue to exist, as mind, in some other state. It is farther conceived, that the mind is an imperishable existence, possessed always of the same faculties of knowledge which distinguished it while yet connected with the body, but deprived, perhaps, of the means of mechanism furnished by the latter for obtaining a knowledge of the physical world, as well as for manifesting its own existence, or its invisible states or acts, as depicted or represented in the changes of the body. It is also held to be not simply *numerically* different from the body, but *radically* different in substance. The body is said to be material, the mind *immaterial.* It cannot, therefore, possess the properties of matter. If not, then it cannot, by the terms of the case, be madè cognizable by the senses, since they appear to be fitted to reach only to material impressions. Mind therefore, as mind, cannot be submitted to physical tests or examination, though the body can be. Its acts and states cannot be directly made known by such means. They can only be made known to other minds by certain signs, or in other words, certain acts and states of the body which is regarded in a certain sense as an instrument of the mind. But these signs would be without any significance whatever, if it was not for certain modes of interpretation possessed by animals, and in various degrees of perfection.

The only way, so far as is known, that they have for finding out the meaning of these signs, is by their own experience. They find by observation that the mutual acts and states are more or less invariably associated with certain states or acts of the body. So when they observe other animals in the same bodily states, or performing the same acts, they infer the corresponding *mutual* states that they have found connected therewith, in their own experience. In this indirect way alone can they discover the mental condition of other animals.

One mind cannot, so far as we know, commune directly, unless under rare circumstances, with another, during the continuance of physical life. But ordinarily, each individual mind may know directly, without the intervention of such signs, many, if not most, of its own states and acts. They take place in what is called *self-consciousness,* which is, in my opinion, the chief, if not the only kind of consciousness we have. These mutual states and acts then, though they cannot be directly reached by physical tests, and are not open to sense observations as physical objects are, may nevertheless be submitted to the tests of immediate self-observation. We can secretly know often what passes in our own minds, and with the utmost clearness, while the observer, who looks upon our bodies from without, cannot many times so much as suspect what is passing within us. There are two ways then of studying mind. One of them is applicable to ourselves alone, and is confined to the states and acts of our own mind. This is the method of introspection, or of looking within our own minds, to directly observe our own mental acts and states, and not the signs of them. The other method is also in a measure applicable to our own bodies. It is the objective method. It is from first to last directly compared with the *signs* of mental states and acts. It is the only method by which we can study the mental states and acts of other individuals, whether man or animals. And the only way in which we can make our observations useful or intelligible is, by a recurrence to our own internal experience, our self observations, which have taught us in various degrees of fullness and perfection, that certain internal, and hence invisible, mental states and acts, are either preceded or followed by certain bodily conditions and signs. The key of the interpretation lies within. If this is true, then it may happen that we would be liable to be deceived by persons who in some way exhibit the signs of thought or feeling, and yet do not truly experience the states or the mental acts, which in a truthful experience the signs represent. And this is sadly too true, as nearly all can testify. Hence, it happens that a mask, a statue, a picture, may exhibit the *signs* of feeling, for example, so perfectly as to excite the same state in ourselves, notwithstanding the object has *only* the signs, and not the fact of thought or feeling. This, I say, is the only method applicable directly to the study of the minds of other beings. It is the one that must therefore be applied to the study of animals. All we can do is to observe them, under varying conditions, and see how they act, or what they do, and then interpret their actions by appeals to our own personal experience in similar conditions. And this, as I have said, is the way in which one must study other men.

But to return from this partial discussion. By persons of this second class, mind is held to be the invisible, intelligent energy, with which, in connection with the body, we truly feel, will, and think, and which permeates the body, possibly only the brain, and uses it, for sake of illustration, as the invisible magnet force, which inheres in a visible portion of magnetic ore, or of steel, causes movements of the same. In short, mind is the immaterial, imperishable, sensitive, intelligent being, which feels, and wills, and thinks, suffers and enjoys, within the body, which though living, would be an unintelligent, or unthinking, possibly unfeeling organism without it.

Now in the sense that it is held and understood by this class, do the lower animals have minds? In relation to this question, and for various reasons, persons differ widely in opinion. Some think they have, others think they have not. And it is to the possession of mind, at any rate, or rather the signs of it in this sense, by the lower animals, that I wish to call your attention this evening.

I know as well as I can ever know, that it is a serious question with many, whether even man possesses mind in the sense just indicated. But I wish for the time, to assume without controversy, as a hypothesis, if you please, that they do, and my present inquiry, I repeat, is whether the lower animals show clear signs of having the same; and if this is refused, I wish to inquire what we are to include as to the mental natures of the lower animals, or how we can explain the phenomena which they present to any intelligent observer. By the phrase "lower animals" I should say, in passing, I mean the whole animal kingdom. I do not include simply the higher vertebrates, but the entire class. For, as we shall see perhaps, even the humbler types of the animal kingdom present us with striking exhibitions of intelligence.

In dealing with this matter, it might be expected that I would lay out some division of the faculties of the mind, as a scheme under which examples from among the lower animals might be ranged. But it is deemed the best way to proceed at once to adduce suitable and well authenticated instances of phenomena, which show in fair measure whether or not animals do possess minds. In doing this, the trouble is not to find such examples, but out of the mass of such cases to make a selection. I have collected from various works under my hands many hundreds, and I might truthfully say, thousands of cases of interest. I might occupy hours detailing and discussing my own personal observations. But I do not have time to do either the one or the other.

But to begin, take this case: A naturalist friend of mine was one day walking along a road, and saw as he walked one of those familar road beetles, rolling its ball of compost. He stopped and watched it for a few moments, and then with a pin, made the ball fast to the ground. The beetle seemed surprised at this turn in its affairs, but soon recovered itself, and endeavored as before to push its ball; but it was not able to do so. It crawled over and round it, and appeared to carefully inspect the situation, and at the same time made strenuous efforts from all points to move its ball: still it could not move it. It then climed up on its ball, and sat there for a few moments, quietly moving its antennæ as if in a sort of reverie, and then rose on its wings and flew away. The gentleman much interested in what he saw, thought he would tarry a while and see what would come to pass. He had not waited many minutes, until he heard the familiar hum of two beetles. They circled about, as is their custom, and finally they both alighted near the ball. One of them was recognized as being the same beetle that had been first observed. It was known by a speck on one of its wing cases. The two immediately went to the ball and united their efforts to move it, the one pushing, and the other pulling, But after various trials, they ceased, and literally putting *their heads* together, they *seemed* to be in consultation. During this time the gentleman quietly removed the pin and left the ball free. They at last went back to the ball, and tried to move it, and of course succeeded. Whereupon beetle number two rose up on its wings and disappeared, while beetle number one rolled its ball along without farther interruption. Now I am quite well aware that this is a simple story, but it is none the less interesting to one who will consent to think on it without prejudice. A hundred histories of this kind would really not be any better than one.

Let us examine this case a little more closely. It might be said, with more or less propriety, that the beetle formed its ball as a nidus for its young, and then sought a proper place in which to bury it away, guided solely by instinct. But I do not think it could be maintained successfully that many of the later performances of the creature were in the proper sense of the word instinctive. It *seemed* as if, when it found itself unable to move its ball, —I say it *seemed* to stop and deliberate as to what should be done. It *seemed* to have found a place of securing aid from some other beetle. For, after a short absence, it returned with a companion. It *seemed* to have gone purposely to find it. It *must* have communicated in some way a knowledge of its wants, for the other beetle seemed to understand the case. They had a common purpose, as was evidenced by their united action toward the same end. They *seemed* to consult, when they found themselves unable to move the ball. They seemed by common consent to conclude to make another effort. When the ball was found movable again, beetle number two *seemed* to know that it was needed no longer, and probably returned to its own occupations. Certainly this cannot have been all due to instinct. It has the plain mark of the presence and action of mind, no less so because the signs of purposive acts were done by beetles instead of men. The *signs* of mind are much the same as they would have been under similar circumstances among men.

As has been already intimated, one case well studied is as good as a hundred. But though this is so, I shall now proceed to advance other examples from the animal kingdom, apparently involving mental action.

For example, let us consider points in the history and doings of ants, as we have given much observation and study to these most singular little creatures. On one occasion, as I was passing along a road, my attention was attracted by a company of large, pale red ants hurrying across the way, the whole company following what seemed to be a leader, who was much in the advance. I stopped and followed them through the grass and weeds for full fifty yards, when they suddenly came to a halt, and collected in a circle in the space beneath the bending spires of grass. mmediately one of the ants disappeared in a hole in the ground, only to be followed with every appearance of precipitation by one after another of the company. At this moment a smaller ant, but of a similar color, entered on the scene, and rushed for the hole in the ground, but it was instantly seized by one of the marauders, and a fierce struggle ensued, which was not terminated while I watched them. But in a few seconds, as I watched the hole down which most of the company had disappeared one by one, I saw an ant come struggling out, in a state of great excitement. It was of a smaller kind than those which I had watched cross the road. Presently it was followed by another of the same kind, in (as I was about to say) much the same excited state, and as time passed on these two were joined by others. The place evidently belonged to them. They ran violently about the hole, and even up to the top of the blades of grass, and then jumped off to the ground in a distracted and reckless manner. At times two of them would meet and, *apparently*, stop for a hurried exchange of ideas, and then they would run about in the same frantic manner. Meantime all the larger ants had gone down into the hole. In a few moments, however, these latter ants began to reappear, one by one, each bearing a white egg not far from hatching, as the outline of the young ant could be seen through the cuticle. But no sooner had these latter ants reached the open day with their booty than they were ferociously attacked by the smaller ones, to whom the eggs properly belonged. And here began a series of struggles of the most animated and interesting character—one set of ants striving, by might and main, to get away with their booty, the other set striking for their altars and fires. But after some time had been spent in this way, the larger and stronger got away, each one, on his own hook, traveling with great speed, on the back track, bearing an egg in its jaws. But now began a scene of evident distress among the smaller ants whose home had just been robbed in so miserable a manner. They ran round and round, in helpless bewilderment, meeting and consulting (apparently) and passing each other, and diving into their den, and then out again. And in this distressing condition I left them. I followed on after the marauders, and found most of them already across the road. At last, fully sixty yards from the scene of the robbery, they came to their own den, and carried the eggs down into a special chamber, as I afterwards found. After the eggs had been deposited below, the ants of the expedition came up, and with a *seeming* air of satisfaction at their exploit, passed their time in rubbing off their bodies, cleaning and polishing their limbs and mandibles. This was an instance of the doings of slave-making ants.

In this case, there can be no reasonable doubt but that one of the party which composed the expedition had made a discovery of the colony that was to be raided. The ant returned to its companions, reported its discovery, a party was organized, led by the discoverer, the colony was robbed, a conflict ensued, and finally the spoils were carried home.

This whole performance looks very like what men have done in all ages. But when done by men such actions are not ascribed to instinct, but to mind. But let them be done by even one of the higher animals, not to say an ant, and they are loosely attributed to instinct. But why so, where the *signs* are essentially the same?

But I have not done with the history of the singular doings of ants, which seem to indicate the presence of mind. To do this fully would require several lectures. I have watched ants on the hunt for colonies of aphides or plant lice. I have watched them after discovering such a colony. They station guards over them, to dispute the entrance of any other ants, on their domain. They carefully tend the aphides, as a shepherd would his flock. If one of the clumsy creatures of their charge gets off its plumb, and is in danger of falling, a guardian ant takes and tenderly places it in position. The ants step around, among and over the members of their flock with every sign of care. But why? Let any one see. They do not do that to feed on them, but they use them in a sense as men use cows. An ant will stand astride of, or behind the plant louse, and with its pointed feet will seize the little *aphid* underneath the abdomen, and by a motion of combined pressure and tickling, induces it to issue amethystine drops from its back, from a little bag. The ant watches for this, and when it appears, stoops and drinks it with apparent gusto, and then goes his way. The only ants that have this privilege are those which belong to the colony — they alone have the passport.

Ants have armies, commanded, it seems, by officers who seemingly issue their orders, insist upon obedience, and will not permit any of the privates to stray from the ranks. There are some ants which till the ground, plant the particular grain on which they feed, cut it when ripe, and store it away in subterranean granaries. There are ants which bury their dead. There are ants who have slaves, as already intimated, and compel them to labor while their masters live on its proceeds, just as we have known of man. How can we attribute all these things to instinct? If so, let us call the whole thing instinct, and so end it.

Take the case of the bee. It has required a small volume in which to record the doings of these little creatures, which, to say the least, are curious. Take the case of weak hives, which on that account are liable to the incursions of more powerful neighbors, who are ever ready to appropriate the works of the thrift of their less powerful neighbors. In such cases, it has been frequently observed that the weaker colony casts up a cross within the entrance or hallyport to their hive, a wall of wax, etc., called, I believe, a *traverse*, in engineering parlance. Upon entering, the bee is at once confronted by this traverse, and is obliged to turn either to the right or left to enter the hive proper. But in so doing it must pass a very narrow way at either end of the traverse. By this means a few bees can defend a hive against the assault of a very large number of marauding bees. But all hives do not have this traverse, and why not? Is it made in obedience to a blind tendency, such as an instinct is ordinarily held to be? If so, why do not all hives have the traverse? It seems to me, the only natural way is to admit that such doings are an evidence of the possession of mind.

Sometime since a gentleman was struck by a happy thought, viz.: one in which he could utilize bees. He formed the design of exporting a number of hives to the island of Hawaii, where there are flowers all the year round. His thought appears to have been that, as bees gather honey guided solely by a blind tendency or an instinct, that they would work all the year round, and hence make honey all the year, and if so, become a source of no small profit. If they gathered honey wholly from a mere blind impulse, his expectations would have been fulfilled. But in the course of a few years the bees learned somehow that it was unnecessary to lay up honey as in climates where flowering plants exist only a part of the year, and they became valueless from an economical point of view. Was this due to instinct, or to education? If to the latter, is mind involved in the case? I must confess, it seems so to me.

Take the following anecdote from many hundreds of others of various kinds, in respect to dogs:

"There is a water mill on the Tweed in Scotland called Maxwellhaugh, by the road between Kelso and Trovist. It is driven by a sluice of water from the Trovist, just before it joins the Tweed, and consists of two flats. The upper flat, or story, is on a level with the public road, and is called the "upper mill," while entrance to the lower story was reached by a lath road descending from the highway. The first thing the miller did in the morning was to unchain the dog. The dog immediately placed himself across the upper doorway, while the miller proceeded with his work in the lower mill. As soon as the miller had finished his work there, and removed to the upper mill, the dog, without being told, set off to the miller's house, and in two journeys brought his master's breakfast, — namely, milk in a pitcher and porridge in a 'bicker,' tied up in a towel.

"On one occasion, when the Trovist and the Tweed were in a flood, a little dog ventured incautiously into the Tweed, and was carried rapidly down the stream, struggling and yelping as it was hurried along. It so happened that the miller's dog, while carrying his master's breakfast to him, saw the little dog in distress. He immediately put down his burden, and set off at full gallop down the stream. When he had got well below the drowning dog, he sprung into the river, swam across, and so exactly had he calculated the rapidity of the river and his own speed, that he intercepted the little dog as it was being helplessly swept down the current, and brought it safely to land.

"When he got his burden safely on shore, the dog, instead of displaying the least affection for it, cuffed it, first with one paw and then with the other, and returned to the spot where he had deposited his master's breakfast and carried it to him, as usual.

"How is it possible," says the author of the anecdote, to 're-fer the proceedings of this animal to mere instinct? Had a negro slave performed them, we should have used them (and with perfect justice) as arguments, that so intellectual and trustworthy a man ought not to be the property of an irresponsible master.'

"The whole behavior of the dog is exactly like that of a burly, kindly and rugged barger, possessed of cool judgment and rapid action, willing to risk his life for another, and then to make light of the whole business.

"The process of reasoning that took place in the dog's mind is as evident as if the brain had been that of a man and not a dog. The animal exhibited self-denial, presence of mind, and forethought. Had he jumped into the water at once, he could not have caught the little dog; but by galloping down the stream, getting ahead of the drowning animal, and then stemming the current until it was swept within his reach, he made sure of his object; and no man could have done better if he had tried to save a drowning child?"

There are hundreds of cases, from among not only the almost innumerable species of lower animals, but also, so to speak, of the higher, such as birds of many kinds, cats, dogs, horses, elephants, and monkeys. But, manifestly, I cannot refer to them to-night; nor, indeed, is it necessary to do so after what has been said, and when it is remembered that it is probably true that there is not one person present but has had opportunities for making interesting personal observations bearing on this question.

Contenting myself, therefore, I will pass at once to a discussion of the subject in various of its aspects. For my own part, I am led to hold to the position provisionally, that the lower animals are possessed of minds, the same in kind as those of men. I have said, this is my *provisional* opinion, for it has become, after much endeavor, a habit of mine to adopt opinions with care, and if not well founded, to try and *remember* that they are not well founded. Such opinions I try to be ready to drop at the first occasion which seems truly to require me to do so, even if I am left without opinions, as, indeed, I have come to be, in relation to many things. I will now proceed to give you some of the reasons which seem to me to justify me in adopting the opinion to which I have here given expression.

1. One strong proof of this position is to be gained from such facts as I have been relating in your hearing. An unprejudiced and attentive examination of the mental phenomena of lower animals, shows them to have in some measure most, if not all, the mental capacities or faculties which distinguish men. But let us for a moment go even back of this. The nervous system, the admitted instrument of mind, in its intimate structure, is essentially the same; even the *brain* of man and the lower animals agree so closely as to render all but futile the elaborate attempt of Prof. Owen to establish a separate class, the *archencephale*, of which man is held to be the sole member. The agreements in general, and even in details, are surprisingly close, whether in gross form or in minute texture, between the brains of men and the anthropoid apes. Then the lower animals have the same extrinsic means for acquiring a knowledge of the outer world that man has. But why have they the sense apparatuses of vision, hearing, touch, taste, smell, the muscular sense, etc., unless for the same purposes that they subserve in men? But to come nearer. The lower animals experience sensations both agreeable and the contrary, they enjoy sense-perception, and in many cases far beyond what is true for man. They have frequently as perfect, and often a more elaborate muscular system than man, which is exercised and controlled by means of the same kind of nervous mechanism, and is devoted to similar purposes. They have often well marked and very tenacious memories, so far as we can tell, the same as that which belongs to man. They can reason also, or compare the perceptions they have or have had, and many times in a surprising degree. They have most certainly a will, and hence power to choose from among alternatives, the story of Buridan's ass to the contrary notwithstanding. They display all the principal qualities and passions which belong to man, such as parental affection, jealousy, anger, fear, courage, constancy, fidelity, friendship, ill-temper, hope, despair (for animals have been known to commit suicide), pride, self-importance, caution, trickery, maliciousness, etc. examples of all of which it would be easy to give and of many

of them to multiply. They can certainly *learn* and improve, even in many such actions as have been called instructive. They even show abuse of humor and fun, some appreciation of the beautiful, and would appear in some instances to have a knowledge of right and wrong. It is admitted that the moral sense, if developed at all in the lower animals, is very rudimentary. But the same may be said with some degree of seriousness of many human beings, especially of young children and idiots. A young child, if arrested in its moral development at an early period, would, so far as signs can show, be a mere human animal, not equal perhaps to an intelligent monkey. It might be expected *a priori*, that if the lower animals should fail anywhere in a comparison with man, it would be in respect to the higher faculties. And this is found to be actually true. But if the lower animals show but little, if any evidence of possessing a moral and especially a religious sense and capacity, let it be remembered, as already said, that some time elapses in the human being before the conscience is developed so as to beget what is called *accountability*. A young child is not held to be accountable for its acts, when they lead to bad consequences, any more than is a mere animal. So after all, it would seem from the confessedly superficial view of the case, we cannot refuse to admit that the lower animals have minds similar to men, at least in *kind*, on the score of radical difference in their mental phenomena.

2. Then to what shall we ascribe the mental phenomena exhibited by the lower animals, if not to mind? It has been the custom to refer them to what has been called *instinct*. But what is instinct? When an act is performed by an animal without having *learned* to perform it, as when a bird builds a nest without ever having *learned* to do it, or when a bee builds its cell of a certain geometrical figure without any previous instruction or demonstrable plan to follow, or when a pig will begin twenty-four hours before an approaching storm to gather materials for a bed, and in making which, it will heap them up on the side from which the storm is to approach, etc., such actions are called *instinctive* or *automatic*. The animal does them *without purpose or design*. Many such actions are performed like the leaping of a headless

frog, when, according to ordinary experience, the mind would seem to have been removed. But take the case of a bird building its nest. This is said to be instinctive. If this means anything, it means that the animal is fitted prior to experience, and independently of all knowledge, to build its nest. It is created from the start with a nest-building tendency, which is the soul so to speak, of a nest-building mechanism, which at some peculiar conjunction in its affairs impels and guides the bird, it knows not how or why, to build the nest, which it is under the necessity of building on account of the fixed conditions and modes of action of its nest-building apparatus, and in a certain way and none other. Hence the individual members of the same species will build their nests after a peculiar pattern or of peculiar materials, so much so, that it is enough for the observant naturalist simply to see the nest, in many cases, to name the bird. But the case is, or seems to be different, with the architect who plans and builds a house, as every one knows. But let us look more closely at this instinctive act of nest building. One thing is certain, there must be a *plan* somewhere, consciously or unconsciously followed, for the nests of the same species are made alike, or after a common type or plan. The only possible places (so to speak) in which the plan can inhere, are either just in the mechanism or organism of the bird itself, in which case it would have to be assumed that it was constructed to work of itself, in the absence of a mind. It would work then, for example, like a watch, or better yet, if you please, like a pin or match machine, which is fitted to take the raw material at one end, and give out at the other the finished product. It cannot in the nature of its case make anything but tacks. *Any* power which can set it in motion, no matter from what source, may, through the agency of the mechanism, bring about the result; or the plan may inhere in the mind of the animal, as well as the apparatus to which the mechanism corresponds. Why should we deny the presence of mind, in a given case, because it works through an apparatus, even if the latter is automatically perfect from the outset? Can *mind* not work through such mechanism as well as through one which for certain reasons is imperfect at the start, and has to be developed by purposive use? In the latter case the evidence of mind may be clearer, but in the other, is it absent? Or, finally, the act called instinctive may be attributed to the immediate presence and action of the Divine mind. But in some form or other, mind must be present, and we cannot escape it, as some seem to imagine they do by calling certain cases in which it seems to be present, *instinctive.* The bird must *choose* a place in which to build her nest. Is this instinctive? Think of it a moment. How should a bird be *prearranged* to select, from thousands of places in which her nest might be securely built, the one she does select? Does she not look about, and after considerable search and consideration, at last fix upon the spot which, upon the whole, she *likes* best. Then again, is her search for and choice of materials a blind one, in which she follows, mechanically, the unvarying conditions of a fated or at any rate a fixed mechanism? No, it must be that however perfectly the material organism is prearranged for action, under favoring conditions, that it has within it a mind, which, it is true, has a less sphere of spontaneity than belongs to man, and which works therefore under more rigid conditions than in man; but still mind is there. By the limitations of its automatic organism, it is made unnecessary for it to go the round of experience to learn, for it begins where man ends, or tends to end; that is, with an organism, embodying an organized experience prior to the fact. By this means, the lower animals whose lives are short, are enabled to begin their life-work at once, and from the first to avoid mistakes as a rule. But coupled with this freedom from errors in their acts, is the corresponding inability to perceive or correct them when they have been made. Just in proportion as automatic action prevails, does spontaneity and inventive capacity and adaptability disappear. Hence, these latter elements are found in the greatest measure in man, and in the least in the lower animals. But this is to be remembered, that by attributing the actions of the lower animals to instinct, we do not therefore exclude the mind, though this is commonly supposed to have been done in such a case. Even in view of those actions, then, which are most clearly automatic, mind is probably present, and hence by this mode of reasoning we cannot exclude the lower animals from participating in it, in common with man.

Then again there is the question of the *immortality* of the minds of the lower animals. It has been thought if the admission is made that the lower animals have minds, that this will oblige us to concede to them immortality, equally with man. But why not do this? What harm could come of such an admission? What forbids it? Would it be contrary to scripture, to reason, to the true interests of men present or to come, or would it conflict with any well authenticated facts? Would it be degrading to men, or cheapen future existence? But if we refuse it, what shall we do with the intelligent principle, whatever it may be, which feels, and thinks, and wills, and suffers, and enjoys, and remembers, in the lower animals? What is it in them that appeals in hunger and distress, or is the spring of pride or joy, or satisfaction, or fidelity, that devises expedients, draws conclusions, etc.? If it perishes with the body, on what logical grounds can we refuse to surrender the mind of man to a similar fate? If we can do all the things done by the animals by means of a perishable combination of physical and vital forces, why not join in with the so-called materialists, and do the same for mind in man? If not, why not?

But suppose the ground is taken, that we must attribute all the phenomena bearing the marks of mind exhibited by the lower animals to the immediate presence and action of the Divine mind, how shall we reclaim the human mind from being swallowed up in the Divine mind, thus destroying all except the shadow or pretense of individuality? Hence, on such grounds as these, it seems hardly possible to refuse to the lower animals the possession of mind in the same sense, but not necessarily in the same degree as in man.

Of course there are many other reasons which may be used in support of the position that the lower animals have minds, but I cannot refer to all of them, or indeed to any, except in a brief way.

But I will call your attention to two or three of the stronger reasons that may be urged against this view. I will state and briefly discuss them before I close.

One of the objections which may be raised is to this effect:

1. That there is no real proof that animals possess immortal spirits, or minds. Without a revelation we could not really know, except on the grounds of a frail inference, that the mind of ani-

mals survives the destruction of their bodies. But we have no clear revelation on this subject. The Bible, the only pretended source of authority on such subjects, so far as revelation is concerned in them, makes no statement bearing on it, at least none equaling in clearness those made in respect to the future existence of the spirits of men. It would seem not unreasonable, that if the spirits or minds of the lower animals are endowed with immortality, that it would have been for some *purpose*, probably a moral one. And since men and the lower animals sustain to each other such close relations in this life, the purpose in conferring immortality on the souls of the beasts would probably have some relation to man, and hence, would naturally find some expression in the Bible, which has so much to say of the hereafter of men. But no such statements occur. By a mere observation of animals, and a simple scientific study of the phenomena they present, it is not possible to arrive at clear and logical conclusions on this subject, unless, perhaps of a kind unfavorable to the view which affirms their immortality. It is true, such modes of reasoning do not prove that animals do not have immortal souls, but it at least raises a reasonable presumption against such a view.

2. Again it is said, that the mental phenomena of lower animals do not require the agency of mind to explain them, for they have been referred almost by common consent, from the earliest times, to *instinct*. Men and animals differ, as regards their actions and their knowledge, chiefly in this: Animals do not as a rule *learn* to do, or to know what their modes of existence require them to know, or do what they need to do, and their actions therefore are usually as well performed at first as at last. Their actions are automatic, or they are done without purpose or *foresight* of the animal. It is thus with the walking of animals when first born, with their breathing or their sucking. A chicken, not yet out of its shell, will peck at, and swallow a fly; a serpent, when it first escapes from its egg, will on the instant, seek a retreat under a stone, or stick, or clod, if there is any show of violence or danger.

The bee builds its cell, the bird its nest, the spider weaves its web, just as perfectly at first as at last. All these things and thousands more are done by these and other animals prior to experience. They were never learned. In one sense the animal does not *know* how to do them, viz.: in the sense of having *learned* to do them. It does them moved by an *impulse*, rather than determinate thought. It obeys a mere blind, but cogent *propensity*, rather than a rational conclusion, viz.: one deduced by logical processes from ascertained and definite premises. These mere propensities arise in, and then reach on, are apparatus, or mechanism, which is often perfect at birth, or before it. In such cases as those, in which the animal does not begin the performance of certain acts or to manifest certain tendencies until late in life, the reason is to be found in the lateness of development of the appropriate mechanism through which the acts in question are accomplished. The case is in nowise different from that in which the apparatus is perfect at birth. No matter how late in life it is that the animal begins to do what it does, this much is clear, that the apparatus was not developed by *educative* processes, as is so generally the case in man. To all appearances the development is spontaneous. The animal seems to acquiesce, without purpose, and hence unconsciously its capacities to do. It does whatever it does as a rule, from the first, with automatic precision. But while this is the rule with the lower animals, the contrary is true of man. He has the smallest possible stock of instinctive or automatic acts to begin with, and those few of the lowest and simplest kind. Whatever *he* does or knows he has to *learn* to do or know as a rule, by or through slow, *educative processes.*

The point in this case is as follows: As respects the lower animals, they are provided by their Creator from the first with complete mechanisms, fitted to reach in a determinate way to various stimuli, external and internal, while the development and perfection in structure and working of the nervous mechanisms in man are conditional on their *determinate purposive use* or *education.* If not so used, or, in other words, *educated*, they are never developed. Hence we may have ignorant and incapable men, as compared with each other, but not ignorant and incapable animals, as compared with their kind. Hence arises a *duty* on the part of men to *develop themselves*, and if they do not discharge that duty we *blame* them, as in the scripture parable of the talents. But not so in the lower animals. But why these remarkable differences between men and animals if they both have minds of the same kind? The only way in which they may be explained is to admit that in the one case there is a *rational mind or spirit*, which can feel and know, and can use the mechanisms with which it stands connected, so as to lead to their development in many ways and degrees, and in varying propertions to each other, while in the lower animals, the nervous and other mechanisms are developed as a rule in some other way than by their *use*. They are devel oped prior to or *independently of use*, but not so in man, as a rule. In the one case there is a mind to use the imperfect apparatus, and, according to the degree and kind of the use, to develop it in various ways and degrees; but in beasts this is not so, only in a low degree. Hence animals of the same kind are more nearly equal in their development, and men less so. Hence man is in a measure the master of his own higher development, and is, therefore, charged with a duty in this connection; but not so the animals below him. Out of such considerations, if time permitted, it would seem that quite a presumption could be raised up in favor of the view that the lower animals do not have minds as men do. But to pass on, it may be urged,

3. That any necessity which might seem to arise for admitting the lower animals to have mind with man, may be met, or at least justly avoided, by certain distinctions which have been long recognized by many writers. It has been maintained by many, from the time of Aristotle, that in man we may discern at least two forms of mind. The one is conveyed with the objects of sense, and our relations in space and time. To it belongs the sense of perception, the capacity for comparing sense perceptions, or to think on them, and also our nerve propensities, and certain emotions not ordinarily classed with propensities or appetites. This, it is admitted, is possessed in kind by animals as well as men. It has been called the *psyche*. The other is superior to the *psyche*, and has relations not only to the *psyche*, but also to the body. It is that form of mind by which we become related to God, and which is the seat of conscience. By it we are enabled to discern right from wrong, good from evil, the beautiful from its contrary, and by this

we obtain motives to action, not only for the present but the distant future, not only in accordance with, but often in opposition to the mere teachings of sense, or the mere impulses of appetite or of the bodily passions, in obedience to which the lower animals act. This is the home of the reason, of even the "Pure Reason" of Kant, of the *moral sense*, and the true seat of the religious life, to all of which the lower animals are strangers. This form or part of mind is called the *pneuma*. It is the possession of this part which chiefly distinguishes men from the lower animals. It is this part which it may be most truly offered is immortal, without contesting for the immortality of the *psyche*, which the lower animals possess in common with man. This latter part may perish possibly, and if so, we need not trouble ourselves about the question as to whether the mind of animals may continue to survive after the death of their bodies. But that these two forms of mind may be separable from each other would seem to be possible from the fact, as they may be assumed to be, that the lower animals have what corresponds to the *psyche* without the *pneuma* in man, and from the fact, that forms of mind seem to relate to wholly different objects, and from the further fact, as it seems to be in the moral and religious history of mankind, that the *pneuma* may be either dead or alive to the proper moral and spiritual objects and relations, without involving any corresponding or other change in the *psyche*. This is the part of a man's nature which seems of all others the most susceptible of cultivation and expansion, and which the advance of age, which seems to involve so seriously the *body* and the *psyche*, does not often affect. It is *par excellence*, the *progressive* part of man, the most human-like, nay, God-like, part of man; that it is within its domain that these aspirations take their origin, which at once imply and demand a life hereafter, as the only one which does not mark them, and in which alone it would seem possible for them to find satisfying objects. By making some such distinction as has been hinted at, it would seem possible to admit a form of mind as common to man and animals, the admission of which would be perfectly compatible with a denial of its immortality, or at least with a doubt on this subject, and also with a claim for man of a form of mind which, so far as the signs go, may be denied to the lower animals.

4. But finally, it may objected that it cannot be sustained on the score of *utility.* Of what use would a hereafter be to creatures who do not show any signs of needing or wanting it, and who show so little capacity for improving it, to be of any good end? Notwithstanding the acknowledged possibility of educating certain animals, yet the great fact remains, that the lives of all the lower animals are almost wholly automatic. Their lives are not spent in struggles after the practical attainments of ideals, and in an apparent sacrifice of the present for the future, in a purposive exercise of will, to the end of the chastening and subjection of their sensual natures, and the elevation, expansion, unlimited refinement and development of their higher faculties— faculties which, indeed, they do not have as compared with men—in the pursuit of moral and esthetic good, which often have their final object concealed, either in the immediate future or even in another state of existence, and in a rational sacrifice of self for others. I say the great fact remains, that the lives of beasts are not open to any such way, but in following out the dictates of mere propensities, and these are usually, though not always, selfish. Their lives and faculties are developed for them, rather than by them. Of what use would a future life be to such creatures? It is true there may be a use for them hereafter which we do know of, but we are not permitted to go outside of our knowledge for positive purposes. We should never permit ourselves to use a mere negation in a positive manner; we cannot properly use our ignorance as against our knowledge, however imperfect that knowledge may be. We do not know, as compared with men, that the lower animals show no *signs* of desiring a future life, only at best a desire for a continuance of the present one, and they do not show any considerable capacities for improvement or rational enjoyment. But it has been and is different with men in all ages. We all have, I hope, a desire to live hereafter, that is, after death; and as a rule men have in their average estate shown capacities for the acquisition and use of knowledge and for enjoyment which are too vast for the short and uncertain measure of this life.

But why, if there is no hereafter? This desire which men have for immortality, which is shown in so many ways, and which must have an object somewhere, has its birth in the *pneuma* rather than the *psyche*; and hence, if the distinction between these two forms of mind is admissible, and men and animals participate in the *psyche*, but not in the *pneuma*, we can see why animals should not have this desire.

Such are a few among the many reasons which may be offered for refusing to admit the view that the lower animals have minds the same in kind as men, differing only in degree of development.

The reasons that have been given have been selected rather than others, because it was supposed their discussion would prove the most *suggestive*. I say *suggestive*, because my opinion is, that if what is said on such an occasion as this is said only to convey mere information, rather than to provoke and direct thought, we come together for little purpose.

But it is impossible in one short discourse to adequately state, much less discuss, in a satisfactory manner, such a theme as this.

As a result of my studies, which have been long turned in this direction, I have been led to admit that the lower animals, even the lowest, have minds generally the same in *kind* as men, but with important differences.

In the lower animals, the mental faculties involved in perception and memory, and the instincts and propensities, and the lower phases of moral sentiment, may be compared with men, in the natural state, viz.: with the savages. But in the higher provinces of mind, especially those which are the seats of the esthetic, moral and religious activities, the lower animals are separated from man by a vast difference in degree of development, if not of kind. It is on these latter grounds that the distinction is the most profound as between men and the lower animals when compared mutually.

Why should we deny that animals have minds? Why deny that they are immortal? By admitting these positions no harm is done, so far as I can see, and we avoid thereby a host of uncomfortable questions and inferences, which we can neither answer nor parry in a rational manner, and many of which strike at the heart of the immortality of the human soul. Whether the spirits of animals, if they are immortal, will be with us hereafter as at present, or will be somewhere else, is a question about which no one knows anything, and about which no one need concern himself. It may be that the old and yet living doctrine of the transmigration of the spirits of animals points to the true solution of this question.

THE ANTIQUITIES AND PLATYCNEMISM OF THE MOUND BUILDERS OF WISCONSIN.

BY J. M. DE HART, M. D.

The vast difference that has been found to exist between the mounds of Wisconsin and those of other parts of the United States, both in their form and variety of structure, have led many archæologists to infer that they were constructed by a different race; but such eminent authority as the late Dr. Lapham, has dispelled these views, and finds in them sufficient evidence to prove that they are of a common origin. The animal mounds, located a few miles west of the four lakes, near Madison, were first described by Squier and Davis, in their contributions to the Smithsonian Institution, in 1848, and also by R. C. Taylor, in Silliman's Journal.

Dr. Locke, in the Geological Report of Iowa and Wisconsin, furnished information which greatly increased our knowledge of these structures; but Dr. Lapham, in his contributions to the Smithsonian Institution and American Antiquarian Society, has done more than any other writer, in furnishing evidence of their conformation and general character.

Most of these mounds consist of imitations, on a gigantic scale, of animate objects, which were characteristic of the region, such as the bear, buffalo and deer, among the mammals; of the turtle and lizard, among the reptiles, and the night hawk and eagle, among the birds; and, in a few instances, of the human form. The animal mounds seldom exceed five feet in height, while some of them were only one or two feet high, above the surrounding ground. From the fact that the mounds were nearly always located near the great rivers, and in the vicinity of the lakes, we are led to infer that the mound-builders availed themselves of the natural advantages of the country — ready access to living water, natural highways, streams abounding with fish, and the adjacent forests with game.

Many of the mounds are built on high bluffs, from which an extensive view may be obtained of the surrounding country, diversified by wooded steeps and rolling prairies, with, in many instances, a broad river meandering through the landscape, or a beautiful lake, with its placid waters ever abounding with fish in great quantity.

Peschel of Leipsic, in his "Races of Man," says that in North America the aborigines made dome shaped tumuli, round, flat topped mounds and circular earth works; some of them contain graves and covered passages. These are very scarce in the New England states, and are rarely found west of the Mississippi, but extend from the upper course of the Missouri and the great lakes, to the south, on both slopes of the Alleghanies, as far as Florida. Most archæologists have ascribed them to an extinct race of Mound-builders, who are supposed to have migrated from Mexico. The builders of these mounds were, therefore, the predecessors of the Indians, and these latter were supplanted by Europeans. Wisconsin furnishes many evidences of the existence upon its soil of a prehistoric race, known as the Mound-builder. Along the northern shore of Lake Mendota, many mounds may be found. The animal mounds found in this vicinity represent a bear, deer, squirrel, and other mammals now extinct; while a few of the mounds are made in the form of birds, some of which are very large, and three of them are located in close proximity to one another, and resemble

Fig. 1.

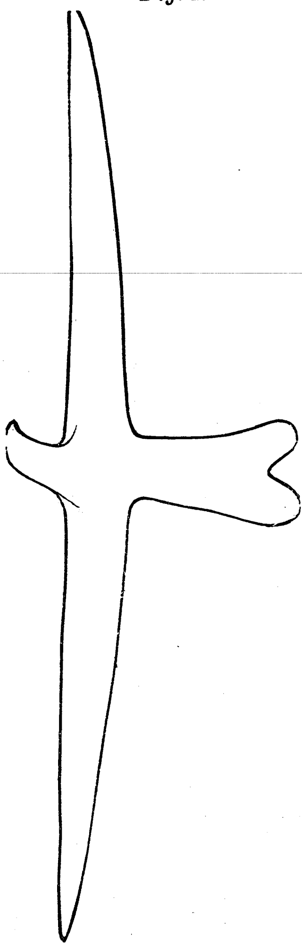


Fig. I represents an eagle, with a body 100 ft. long, and wings expanded 300 ft. on either side of it. It has a well-defined beak, and a tail 40 ft. wide.

an eagle with expanded wings. The largest of these birds has a body 100 ft. long, whose expanded wings measure 300 feet on either side of his body, while the tail is 40 ft. wide. The head is quite perfectly formed, so that the outline of the beak is 15 ft. in length. [*Fig.* 1.] The form of a deer, about three feet high, is found near the left wing of the gigantic bird. The body of the deer measures 65 ft. and the legs are 14 ft. long; the head measures 12 ft. from the tip of the nose to the origin of the antlers. These latter are each 10 ft long, and have a branch extending at right angles from their center. [*Fig.* 2.] Near the left wing of the other bird there is the form of a bear, with a well defined body, head and legs. [*Fig.* 3–4.]

Fig. 2.

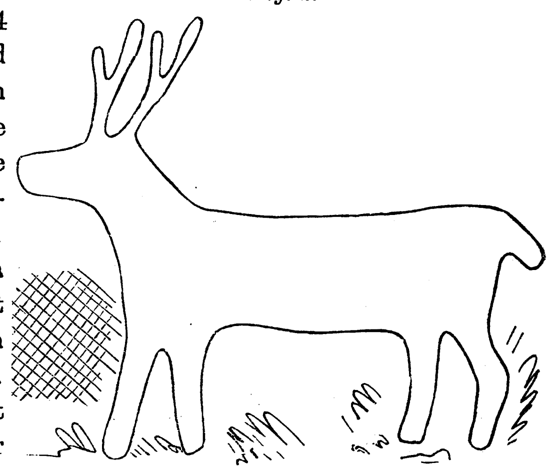
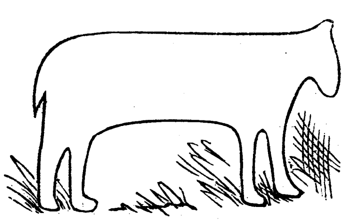


Fig. 2. represents a deer, whose body measures 65 ft., with legs 14 ft. long. The antlers are each 10 ft. long, with branches from each.

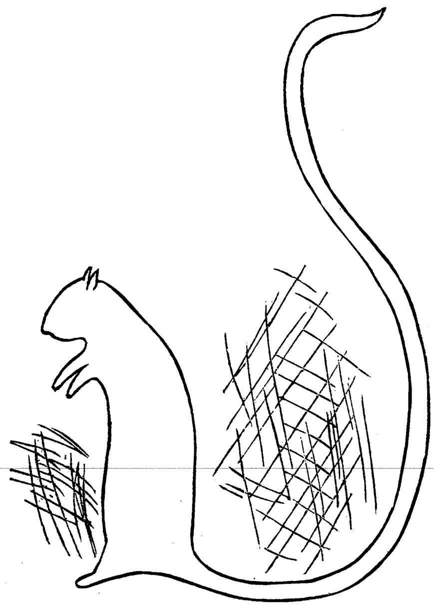
Fig. 3.



Near Grand river, in Green Lake county, there is a collection of about one hundred mounds, mostly of a conical or circular form. One of these resembles the form of a man, with arms of an unequal length. The head points to the south, and towards a high hill, called Mt. Moriah. As these mounds are composed of a sandy soil, they do not preserve their form as well as the mounds in other localities, which are composed of adjacent soil and clay.

In the vicinity of Fox river there are several mounds, some of which resemble racoons and bears, while the remainder are oblong and circular mounds. One mound in this vicinity represents an animal whose genus and species could not be ascertained.

Fig. 4.



While many animal mounds are found near Lake Mendota, there are also circular and oblong mounds. On the following page there is a diagram showing the location and elevation of eight ancient mounds on the northern shores of this lake. Their elevation varies from 93 to 96 feet above the lake, and on some of them trees are growing, measuring five and a half feet in circumference. [*Fig.* 5.] The largest circular mound of this group measures 188 feet in circumference, and 35 feet from the base to its summit. It is the highest mound in this group, and from its elevated position, could have been used for observation, and as a means of communication by signal with other mounds in the adjacent country. From its summit you have an extended view of the surrounding country for many miles in all directions.

This mound was the first one of the series explored, and on the following page a diagram of the manner of exploration is given, together with the location of the skeletons and other relics found therein. [*Fig.* 6.]

In commencing the work, it was thought best to sink a perpendicular shaft, about six feet square, through the centre of the mound, from the apex to the bottom of the tumulus. After removing the surface, a black earth, similar to what is found on the shore of the lake when muck accumulates, or on the prairie bottom, was removed to the depth of five feet. At this depth, and on the western side of the shaft, a group of stones, consisting of magnesia limestone, yellow and red sandstone were found. Some of these stones were flat, while others were irregular in shape, and bear indications of having been obtained from the limestone quarry along the shore of the lake, where the water had worn away portions of them. Underneath this course of earth there was a layer of yellow clay, about four feet in depth, through which a similar course of stones, arranged in a semi-circular manner, and passing off to the opposite side of the shaft, were encountered. Another layer of black earth was found underneath this course of yellow clay, about five and a half feet in depth, after removing two feet of this deposit, ashes, charcoal, and decayed wood, with small pieces of flint were discovered. A few stones were removed directly below these, and the earth underneath was so hard and dry, that it had the appearance of having been baked, another foot of earth was then removed, when the skeleton of an adult mound-builder was discovered in a sitting posture, at the southeastern corner of the shaft, several pieces of the cranium, vertebra, the body of the inferior maxillary, with the alveolar process quite complete, ribs, and bones of the extremeties were found, but none of them were wholly perfect.

Where the cranium had lain, there was a perfectly formed mould, but only a few pieces of the bones were found. Had I thought to measure this mould I could have obtained some idea of the dimensions of the skull. The vertebra were very large and indicated the existence of a race larger than the Indian; of the bones of the upper extremity that were found, that of the humerus presented a feature which is regarded as characteristic of the ancient Mound-builder. There was a perforation through its inferior extremity, as shown in the accompanying illustration. In all instances where the inferior extremity of the humerus has been found in mounds, this perforation has been observed to exist, and hence it may be called a natural communication existing between the olecranon depression on the one side and the coronal and radial depression on the opposite side,. in the humerus of the Mound-builder. This perforation is found to exist in the chimpanzee, ape and other animals, who go about on all four of their extremities.

As shown in the accompanying illustration, the specimen found

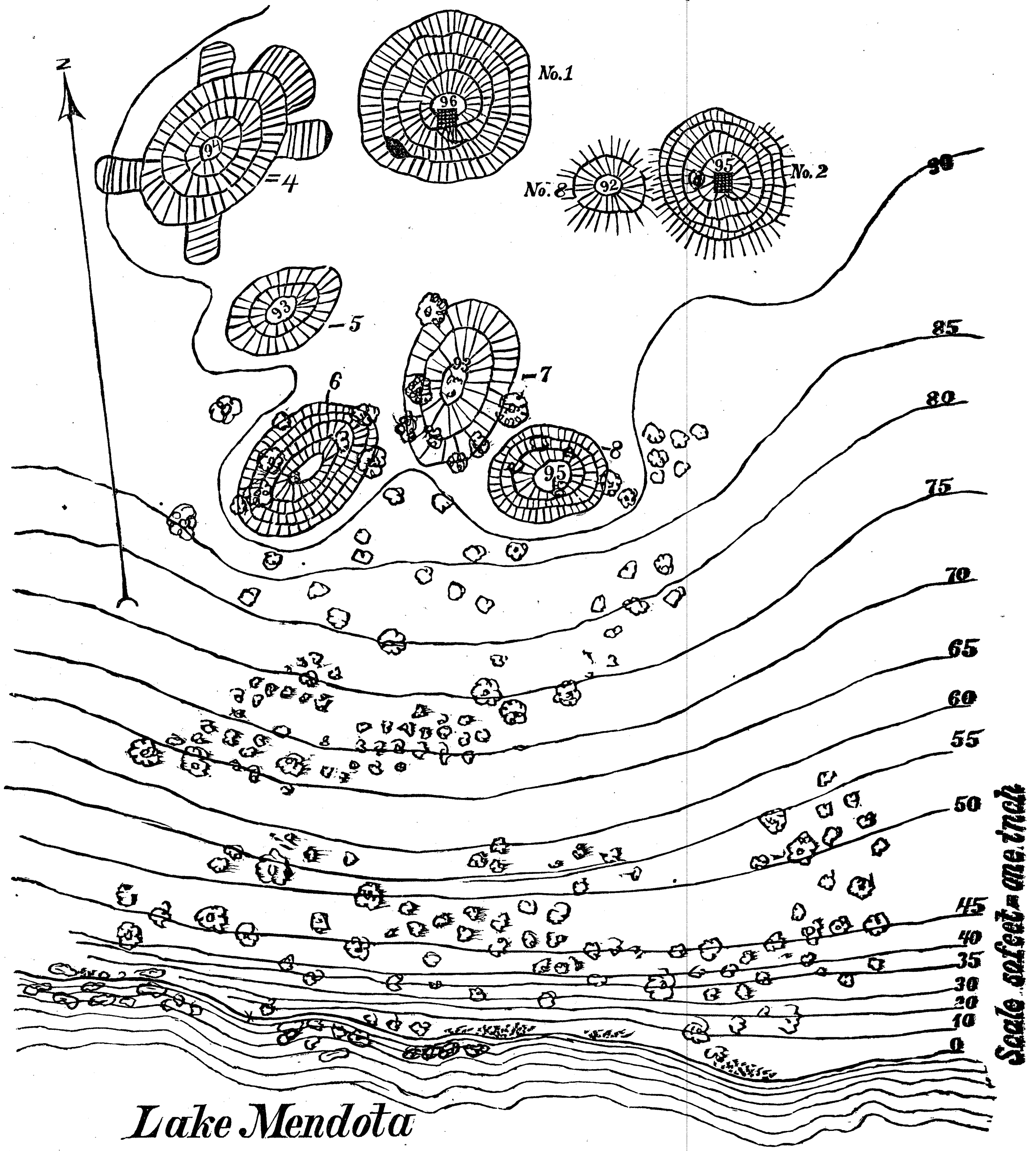
Fig. 5.

DIAGRAM

SHOWING THE

LOCATION AND ELEVATION OF THE MOUNDS AND THEIR ELEVATION ABOVE LAKE.

No. 1. The Mound first examined × 96 above the Lake.
No. 2. The second Mound examined × 95 above the Lake.
The other six Mounds have not been examined.
No. 4. Represents an animal of some kind, probably a Turtle.



Represent Magnesian Limestone.

Represent a bed of gravel.

Represent a few trees on the Mounds and bottom. No Mounds and Lake.

These marks the elevation above the Lake.

Fig. 6.

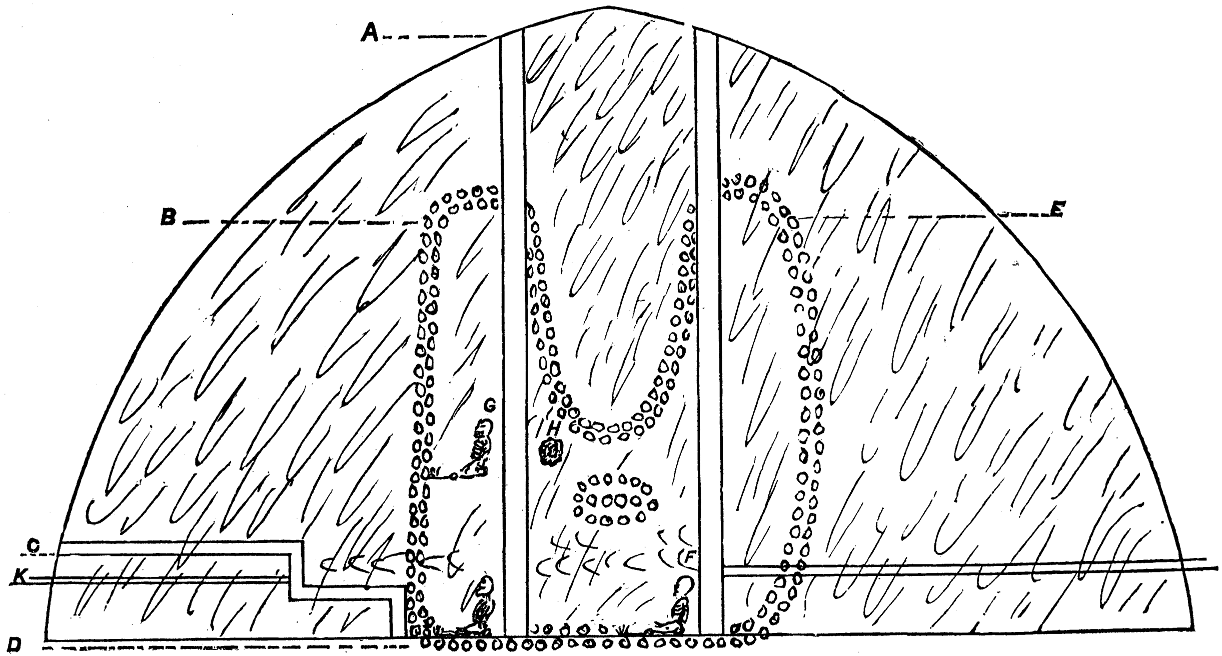
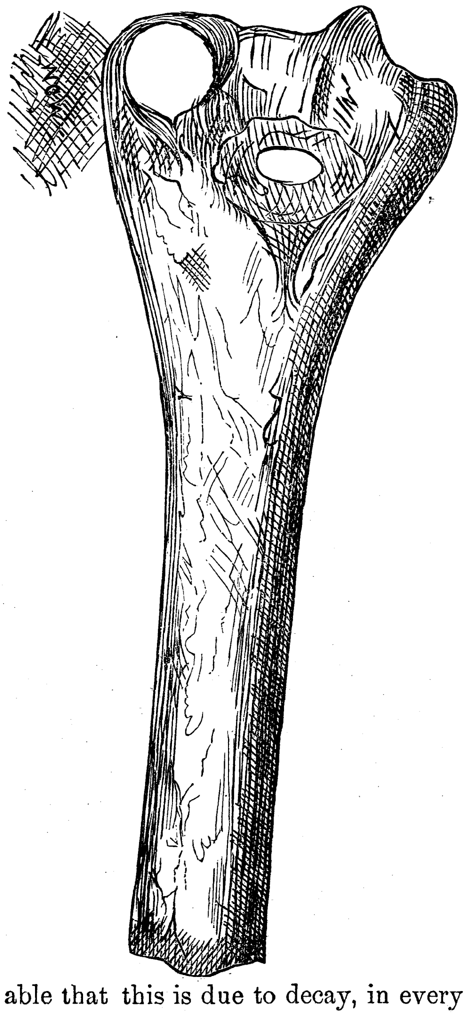


Fig. 7.



in this mound, presents on its anterior surface a perforation, which is surrounded by a gradually receding margin, which is not so great as that surrounding the perforation on the opposite or posterior surface, of the same bone. In the human subject, the anterior surface of the inferior extremity of the humerus presents a ridge of bones, which separates the coronal and radial depressions.

This bone is, no doubt, of great antiquity and was very much decayed, the superior extremity having disappeared. In no case did I find any of the long bones of the extremities wholly perfect, but all of them were broken near the center of the shaft, the other extremity not being found. It is hardly probable that this is due to decay, in every instance, but it may point to some superstitious rite or custom, connected with the sepulture of the dead, among the ancient Mound-builders.

This was the only humerus found, with either extremity nearly perfect.

The shafts of two tibias, found in this mound presented another characteristic of the Mound-builder. They were both remarkably flat, and this peculiarity is termed Platycnemism. In the Smithsonian Annual Report of 1873, Mr. H. Gilman, of Michigan, furnishes six comparative tables, which give the dimensions of some forty specimens of Platycnemism, and in these tables the tibias found in the mound near Rogue river, Michigan, present the greatest amount of flatness. In comparing the specimens found in this mound near Lake Mendota, with those reported by Mr. Gilman, I find that while his measure forty-eighth one hundredths of an inch in comparing their antero-posterior diameter with the transverse diameter, my specimens measure fifty-two one-hundredths and fifty-four one-hundredths of an inch respectively, in comparing the same diameters. This flatness of the tibia has been recognized in the skeletons found in many ancient mounds, not only in this country but also in England and Wales, and might, therefore, be justly regarded as another characteristic feature of the osteology of the Mound-builder.

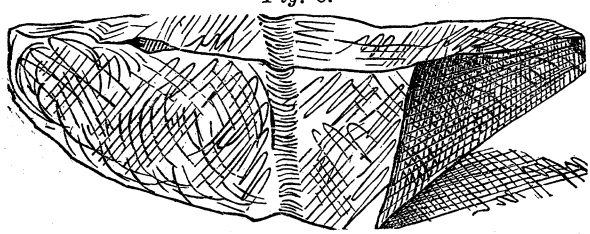
Prof. Buck regards Platycnemism as being characteristic of remote antiquity.

Prof. Gilman says further, that it is impossible to give the correct age of the mounds in Michigan, but from an examination of the trees growing on them, it was evident that they were either planted, or had taken root there, from 750 to 1,000 years ago. It was, therefore, beyond his observation to give anything like an aproximate age of the mounds, because they existed before the trees grew.

Beneath the skeleton of this Mound-builder, there was a few inches of earth, and then a course of stones similar to those previously described, resting upon a bed of yellow clay. As there were no evidences that this had ever been disturbed, and it being one and a half feet below the level of the surface, it was not thought best to sink the shaft any deeper.

As shown in fig. 6, a drift was then made into the side of this mound, three feet above the level of the surface, and about eight feet wide. After the removal of several feet of earth, a similar course of stones, was found, which could be traced to the group of stones on the west side of the shaft. These were removed, and large quantities of ashes, charcoal, and pieces of flint were found near them. On continuing the drift towards the center of the tumulus, and near the shaft, the skeleton of a young Mound-builder, was discovered in a sitting posture. He was probably not more than six years of age, judging from the condition of the bones, a few pieces of the cranium, several vertebra, portions of the long bones of the extremities, and the superior and inferior maxillary were removed; several teeth were still in the alercolar process of the superior maxillary, several pieces of flintshell beads, two large teeth, of some animal, and small arrow heads were found in close proximity. Quite near these remains, three pieces of ancient pottery were discovered; the largest piece measuring four and a half or five and a half inches, and about a quarter of an inch in thickness. It was smooth on its internal surface, and marked externally by raised lines running obliquely across it, such as are frequently seen upon ancient pottery found in mounds. I give an illustration of this piece of pottery, together with a stone implement, resembling a hammer, found in this mound.

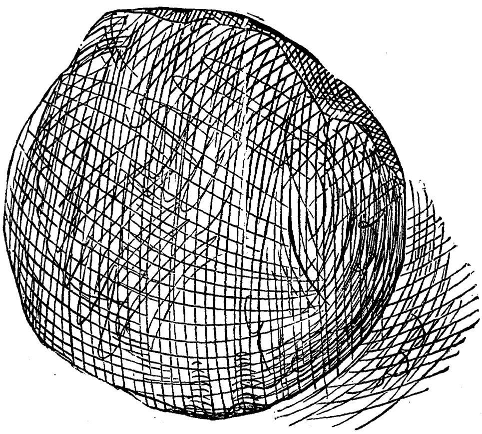
Fig. 8.



The drift was carried forward as far as the shaft, and then downwards to the natural bed of yellow clay. Just before striking the shaft, and near the bottom of the tumulus, the skeleton of a second adult was found, only a very few pieces of the cranium and two pieces of the femur were discovered. After removing some very dry and hard earth another course of stones were removed, which bore evidences of having been exposed to fire. Ashes, charcoal, and decayed wood in quite large pieces, one foot long by four inches thick, and plants were found quite near the stones. Many of the stones crumbled to pieces on handling. On removing the pillar of earth formed by the junction of the drift with the perpendicular shaft, a flat disc of stone, quarter of an inch in thickness and four inches in diameter was, found. Similar stone dics were found by Squier and Davis, and were called by them discoidal stones. They have been found in the other parts of the northwest, and were supposed by them to have been used by the Mound-builders in playing games.

Another mound circular in form, and located a few yards from number one, and marked number two in the diagram, on page 7, was that examined. This mound was about five feet high and 125 feet in circumference. A drift was made into the side of this mound on a level with the surrounding ground, and six feet in width. A section of this mound, with the mode of exploration is given on the opposite page. After removing the surface a layer of gravel one foot in depth, and on the summit a course of sand dipping downwards into the layer of earth beneath it, was found. The layer of black earth was three feet deep, and this was followed by another course of gravel and then a layer of earth one foot deep. A thin stratum of gravel was removed, which was followed by finding ashes, charcoal, decayed wood, and flint. These lay upon an altar of stones, composed of limestone, yellow and red sandstone, resting upon a bed of yellow clay. This altar was about one and a half feet below the surrounding surface, and measured three and a half feet in length by one and a half feet in height and two feet in width. The excavation was continued downwards to the depth of three feet, but nothing was found.

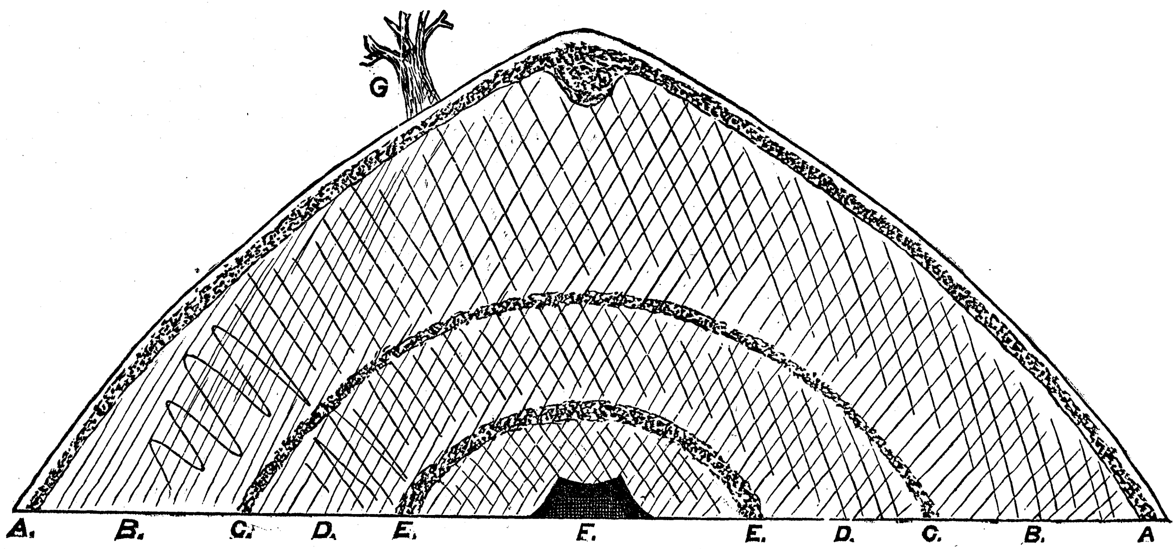
Fig. 9.



Two feet from the summit of this mound, there was a tree growing which measured five feet in circumference. In the side of this tree, and fastened in the back, was a stone pestle, which had undoubtedly been carried upward through the mound, during the growth of this tree. This pestle was composed of granite, with a layer of quartz running through it. It measured six by eight inches.

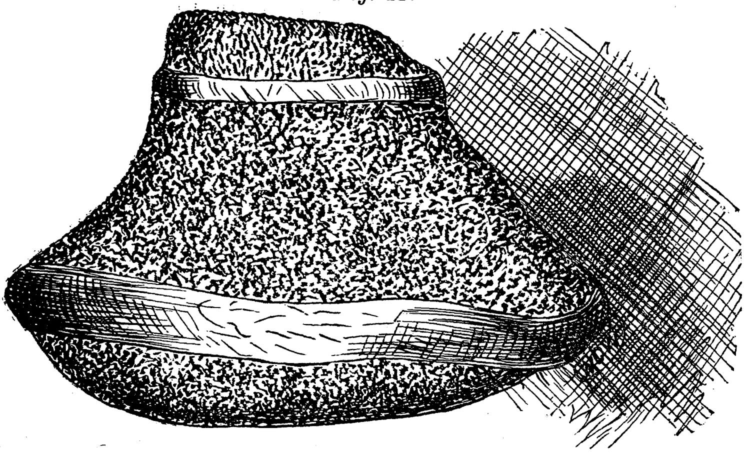
Owing to the approach of winter no further explorations were made of these mounds, but next spring it is my intention to con-

Fig. 10.



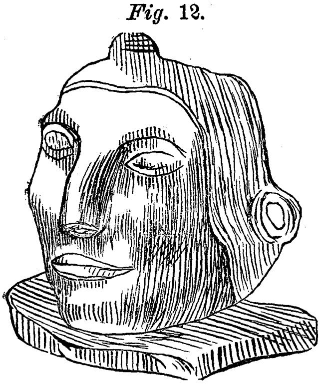
tinue the examination of them, and hope to find on them more evidences of the Prehistoric race, known as the Mound-builder.

Fig. 11.



The question has, no doubt, occurred to many archæologists and antiquarians, who have examined these ancient land-marks, as to who were the people, or what race, built them; but, so far, no possible knowledge has been obtained as to their origin. The Indian tribes, who have lived in the vicinity of them for the past few centuries, know nothing of them.

Fig. 12.



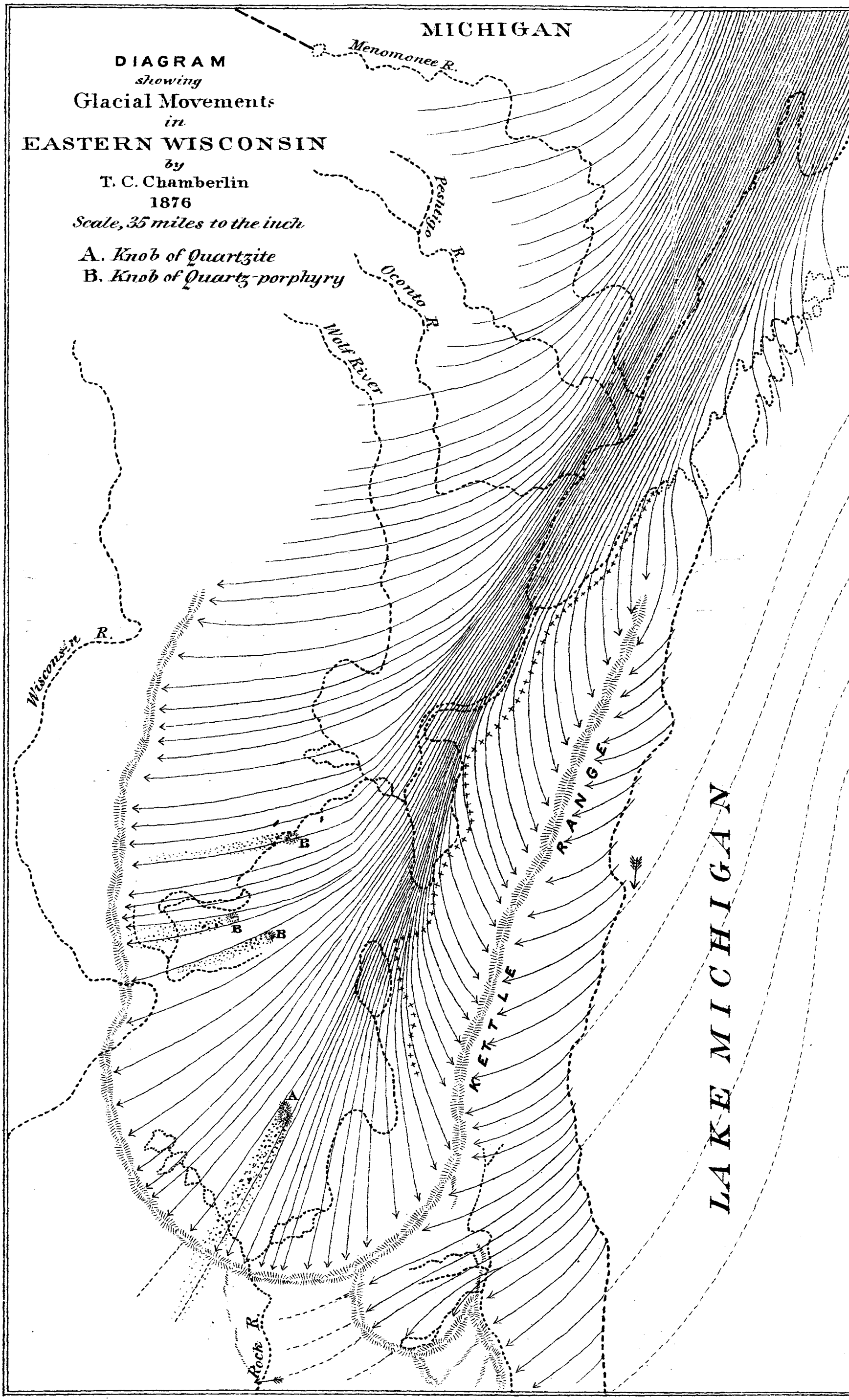
The Winnebagos, who were the last Indian occupants of the Ancient Works at Aztalan, in Jefferson county, would always answer in the negative by a significant shake of the head, when asked if they could tell who erected them.

While Nott and Glidden, in their work, the "Indigenous Races of the Earth," refer to the Mound-builders, as belonging to a race far higher in civilization than the hunting tribes of America." They call them Mound-builders, from the regular fortifications, which they have erected, in several of the Western and Southern States. The Natchez, destroyed by the French of Louisiana, in the last century, seem, in fact, to have belonged to them.

Among the many relics of this ancient race, which were found by Squier, during his explorations of the valley of the Mississippi, was a most characteristic head, made of red pipe clay, the workmanship of these unknown builders, which exhibits the peculiar Indian features.

He says further, "that this discovery proves that these 'Mound-builders' were American Indians, or type; that time has not changed the type of this indigenous group of races; and that the 'Mound-builders' were probably acquainted with no other race, but themselves. In every way proving the views of author of Crania Americans."

Fig. 12 represents above overturned head, formed by squares.



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DEPARTMENT

OF THE MATHEMATICAL AND PHYSICAL SCIENCES.

ON THE EXTENT AND SIGNIFICANCE OF THE WISCONSIN KETTLE MORAINE.

By T. C. CHAMBERLIN, A. M.,

State Geologist, and Professor of Geology in Beloit College.[1]

At the meeting of the Academy, three years since, I took the liberty of occupying the attention of the members by the presentation of some observations and conclusions in reference to a peculiar series of drift hills and ridges in eastern Wisconsin, known as the Kettle range, and the views then advanced afterwards found a place in my report on the geology of eastern Wisconsin.[2] Similar observations were subsequently made by Professor Roland D. Irving, of the Wisconsin survey, and his conclusions are in perfect agreement with my own.[3]

In neither case, however, was any attempt made to show the full extent of the formation outside of the districts reported upon, or to point out its theoretical significance, the chapters being intended only as contributions to local geology, made under somewhat severe limitations as to space.

It is not now possible to map, or even safely conjecture, the complete extent and limitations of the formation; but it is the purpose of this article to add such trustworthy observations as have since been made, and to gather such evidence as may justify a provisional mapping of the range, where it has not been actually

[1] I have taken advantage of the interval between the date of reading and the printing to introduce new matter. T. C. C.

[2] Geology of Wis., Vol. II, 1877 (revised edition 1878), pp. 205-215.

[3] Geology of Wis., Vol. II, 1877 (revised edition 1878), pp. 608-635.

traced. A portion of the paper will, therefore, relate to well ascertained facts, while other portions will be in various degrees hypothetical. If care is taken to distinguish between these portions, no harm can arise from their association; while the provisional mapping will, it is hoped, prove of service in both stimulating and guiding further investigation. The extent of the range is likely to prove too great for the immediate time and means of a single observer; while the broad and irregular, and sometimes obscure, character of the belt is such that it is likely to be overlooked, as a continuous range, as experience has shown, unless attention be called to it, or the observer be keenly alive to distinctions in drift topography. It is believed, therefore, that the presentation of some things that are only probable, not certain, will not be without value.

It will be advisable to consider first, somewhat critically, the character of the formation. The following description, which is based upon careful observation, relates more specifically to the moraine in Wisconsin, where it is usually well developed, and may require some modification in its application to the range where sub-aqueous deposits overlap or encroach upon it, and in other special situations.

Surface Features.— The superficial aspect of the formation is that of an irregular, intricate series of drift ridges and hills of rapidly, but often very gracefully, undulating contour, consisting of rounded domes, conical peaks, winding and, occasionally, geniculated ridges, short, sharp spurs, mounds, knolls and hummocks, promiscuously arranged, accompanied by corresponding depressions, that are even more striking in character. These depressions, which, to casual observation, constitute the most peculiar and obtrusive feature of the range, and give rise to its descriptive name in Wisconsin, are variously known as "Potash kettles," "Pot holes," "Pots and kettles," "Sinks," etc. Those that have most arrested popular attention are circular in outline and symmetrical in form, not unlike the homely utensils that have given them names. But it is important to observe that the most of these depressions are not so symmetrical as to merit the application of these terms. Occasionally, they approach the form of a funnel, or of an inverted bell, while the shallow ones are mere saucer-like hollows, and others are rudely oval, oblong, elliptical, or are extended into trough-like, or even winding hollows, while irregular departures from all these forms are most common. In depth, these cavities vary from the merest indentation of the surface to bowls sixty feet or more deep, while in the irregular forms the descent is not unfrequently one hundred feet or more. The slope of the sides varies greatly, but in the deeper ones it very often reaches an angle of 30° or 35° with the horizon, or, in other words, is about as steep as the material will lie. In horizontal dimensions, those that are popularly recognized as "kettles" seldom exceed 500 feet in diameter, but, structurally considered, they cannot be limited to this dimension, and it may be difficult to assign definite limits to them. One of the peculiarities of the range is the large number of small lakes, without inlet or outlet, that dot its course. Some of these are mere ponds of water at the bottom of typical kettles, and, from this, they graduate by imperceptible degrees into lakes of two or three miles in diameter. These are simply kettles on a large scale.

Next to the depressions themselves, the most striking feature of this singular formation is their counterpart in the form of rounded hills and hillocks, that may, not inaptly, be styled inverted kettles. These give to the surface an irregularity sometimes fittingly designated "knobby drift." The trough-like, winding hollows have their correlatives in sharp serpentine ridges. The combined effect of these elevations and depressions is to give to the surface an entirely distinctive character.

These features may be regarded, however, as subordinate elements of the main range, since these hillocks and hollows are variously distributed over its surface. They are usually most abundant upon the more abrupt face of the range, but occur, in greater or less degree, on all sides of it, and in various situations. Not unfrequently, they occur distributed over comparatively level areas, adjacent to the range. Sometimes the kettles prevail in the valleys, the adjacent ridges being free from them; and, again, the reverse is the case, or they are promiscuously distributed over both. These facts are important in considering the question of their origin.

The range itself is of composite character, being made up of a series of rudely parallel ridges, that unite, interlock, separate, appear and disappear in an eccentric and intricate manner. Several of these subordinate ridges are often clearly discernible. It is usually between the component ridges, and occupying depressions, evidently caused by their divergence, that most of the larger lakes associated with the range are found. Ridges, running across the trend of the range, as well as traverse spurs extending out from it, are not uncommon features. The component ridges are themselves exceedingly irregular in height and breadth, being often much broken and interrupted. The united effect of all the foregoing features is to give to the formation a strikingly irregular and complicated aspect.

This peculiar topography, however, finds a miniature representative in the terminal moraines of certain Alpine glaciers. Most of the glaciers of Switzerland, at present, terminate in narrow valleys, on very steep slopes, and leave their debris in the form of lateral ridges, or a torrentially washed valley deposit. A portion of them, however, in their recently advanced state, descended into comparatively open valleys of gentle decline, and left typical, terminal moraines, *formed from the ground moraines of the glaciers*, and only slightly obscured by the medial and lateral morainic products, which have little or no representative in the Quaternary formations. The Rhone glacier has left three such ridges, separated by a few rods interval, that are strikingly similar in topographical eccentricities to the formation under discussion, save in their diminutive size. The two outer ones have been modified by the action of the elements, and covered by grass and shrubs, while the inner one remains still largely bare, and, as they have been cut across by the outflowing glacial streams, they are exceedingly instructive as to glacial action under these circumstances. The inner one graduates in an interesting way into the widespread ground moraine, which occupies the interval between it and the retreating glacier, where not swept by floods, and which presents a different surface contour, illustrative of Till topography. The two Grindelwald glaciers have left similar moraines; those of the upper one, being the more massive, and being driven closer together, present an almost perfect analogy to the Kettle ranges.

The Glacier du Bois, the terminal portion of the Mer de Glace, the Argentière, and, less obviously, the Findelen, and others, so far as their situation favored, have developed similar moraines, and indicate that this is the usual method of deposit under these conditions. Reference is here made *only* to the terminal deposit of the *ground moraine*, eliminating, as it is quite possible to do, for the most part, the material borne on the surface of the glacier.

The Material of the Formation.—This topic, which is one of primary importance in determining the origin of the deposit, readily divides itself into three subordinate ones, all of which need discriminative attention; (1) the *form* of the constituents, (2) their *arrangement* as deposited, and (3) their *source*.

(1) Premising that the Kames, and those deposits which have been associated with them in the literature of the subject, are described as composed mainly of sand and gravel, it is to be remarked, in distinction, that *all* the four forms of material common to drift, viz.: clay, sand, gravel, and boulders, enter largely into the constitution of the Kettle range, in its typical development. Of these, gravel is the most conspicuous element, *exposed to observation*. This qualification is an important one in forming an adequate conception of the true structure of the formation. It is to be noticed that the belt, at many points, exhibits two distinct formations. The uppermost—*but not occupying the heights of the range*—consists almost wholly of sand and gravel, and lies, like an irregular, undulating sheet, over portions of the true original deposit. This superficial formation is confined mainly to the slopes and flanks of the range, and to depressed areas between its constituent ridges; though, when the whole belt is low, it often spreads extensively over it, so as sometimes to be quite deceptive. But, where the range is developed in force, this superficial deposit is so limited and interrupted, as to be quite insignificant, and not at all misleading; and, at some points, where it is more widely developed, excavations reveal unequivocally its relationship to the subjacent accumulations. In such cases, the lower formation shows a more uneven surface than the upper one, indicating that the effect of the latter is to mask the irregular contour of the lower and main formation. Notwithstanding this, the upper

sands and gravels are often undulatory, and even strongly billowy, and the bowls and basins in it commonly have more than usual symmetry. A not uncommon arrangement of this stratum is found in an undulating margin on the flank of a ridge of the main formation, from which it stretches away into a sand flat or a gravel plain.

Setting aside this, which is manifestly a secondary formation, it is still true that gravel forms a large constituent of the formation. Some of the minor knolls and ridges are almost wholly composed of sand and gravel, the elements of which are usually very irregular in size, frequently including many boulders. But, notwithstanding these qualifications, *the great core of the range*, as shown by the deeper excavations, and by the prominent hills and ridges, that have not been masked by superficial modifications, *consists of a confused commingling of clay, sand, gravel, and boulders, of the most pronounced type.* There is every gradation of material, from boulders several feet in diameter, down to the finest rock flour. The erratics present all degrees of angularity, from those that are scarcely abraded at all, to thoroughly rounded boulders. The cobble stones are spherically rounded, rather than flat, as is common with beach gravel, where the attrition is produced largely by sliding, rather than rolling.

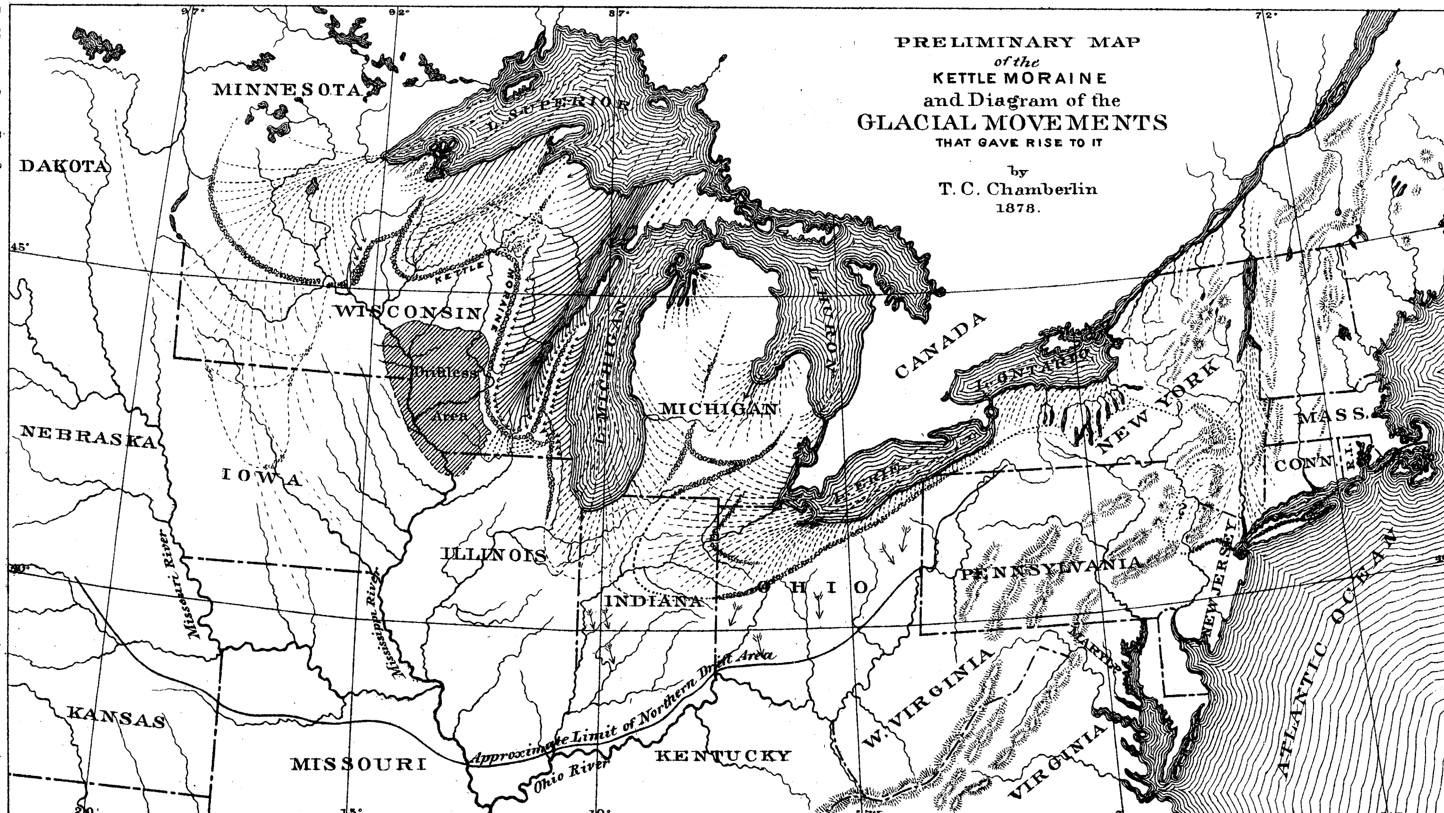
Stratification. — As indicated above, the heart of the range is essentially unstratified. There is, however, much stratified material intimately associated with it, a part of which, if my discriminations are correct, was formed simultaneously with the production of the unstratified portion, and the rest is due to subsequent modification. The local overlying beds, previously mentioned, are obviously stratified, the bedding lines being often inclined, rather than horizontal, and frequently discordant, undulatory or irregular.

The Source of the Material. — This, so far as the range in Wisconsin is concerned, admits of the most unequivocal demonstration. The large amount of coarse rock present renders identification easy, and the average abrasion that has been suffered indicates, measurably, the relative distance that has been traveled. The range winds over the rock formations in a peculiar manner, so as to furnish fine opportunities for decisive investigation. Of the many details collected, there is room here for a single illustrative case only. The Green Bay loop of the range surrounds on all sides, save the north, several scattered knobs of quartzite, porphyry and granite, that protrude through the prevailing limestones and sandstones of the region. These make their several contributions to the material of the range, *but only to a limited section of it, and that invariably in the direction of glacial striation.* Any given segment of the range shows a notable proportion of material derived from the formation adjacent to it, in the direction of striation; and a less proportion, generally speaking, from the succeeding formations that lie beyond it, backward along the line of glacial movement for three hundred miles or more. It is undeniable, that *the agency, which produced the range, gathered its material all along its course for at least three hundred miles to the northward, and its largest accumulations were in the immediate vicinity of the deposit.* For this reason, as the range is traced along its course, its material is found to change, both lithologically and physically, corresponding to the formation from which it was derived.

These facts find ample parallel in the moraines of Switzerland. The marginal portion of the great moraine of the ancient expanded glaciers, on the flanks of the Juras, is composed, very largely, of boulder clay, derived from the limestones that lie in its vicinity, while the quantity of material derived from the more distant formations of the Alps is quite subordinate. Of the more recently formed moraines, those derived from the Bois, Viesch, Rhone, Aar, and other glaciers, which pass over granitic rocks, consist quite largely of sand, gravel, and boulders, clay being subordinate, while those glaciers of the Zermatt region, that pass mainly over schistose rocks, and the Grindelwald glaciers, that, in the lower part of their course, traverse limestone, give rise to a decided amount of clay. The moraines, previously referred to as miniature kettle ridges, are composed of commingled unstratified debris, in the main, but there are instances of assorted and stratified material. The inner moraine of the upper Grindelwald glacier presents much fine assorted gravel and coarse sand, heaped up, very curiously, into peaks and ridges, in various attitudes on the summit and sides of the moraine.

Relations to Drift Movements. — This is manifestly of most vital consideration. The course of drift movement may be determined, (1) by the grooving of the rock surface, (2) by the direction in which the material has been transported, (3) by the abrasion which rock prominences have suffered, (4) by the trend of elongated domes of polished rock, and, (5) less decisively, by the arrangement of the deposited material and the resulting topography. Recourse has been had to all these means of determination, in that portion of the range that has been carefully investigated, and their individual testimony is entirely harmonious, and their combined force is overwhelming. Exceptional opportunity for positive determination is afforded by the protruding knobs of Archæan rocks before alluded to, from which trains of erratics stretch away in definite lines, continuous with the striation on the parent knobs, and parallel to that of the region, as well as concordant with the general system. The united import of all observations, in eastern Wisconsin, testifies to the following remarkable movements, which may be taken as typical, and which are here given, because they have been determined with much care. Between Lake Michigan and the adjacent Kettle range, the direction was obliquely up the slope, as now situated, southwestward, towards the range. On the opposite side, between the Green Bay valley and the range, the course was, after surmounting the cliff bordering the valley, obliquely down the slope, southeastward, toward the range. In the Green Bay trough, the ice stream moved up the valley to its watershed, and then descended divergingly the Rock river valley. Between the Green Bay valley and the Kettle belt on the west, the course was up the slope, westward, or southwestward, according to position. These movements, which are imperfectly shown on the diagram, exhibit a remarkable divergence from the main channel toward the margin of the striated area, marked by the Kettle range.

Much of the data relating to the movements, outside of Wisconsin, has been derived from a study of publications relating to the geology of the several states, to whose authors I am indebted,



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but who should not be held responsible for the special collocation presented in the accompanying diagram, which, in some of its details, may prudently be held as somewhat tentative, until more rigorously verified. But the grand features of these movements, which may be confidently accepted, are very striking, and are very singularly related to the great basins of the lake region. The three main channels were the troughs of the great lakes, Superior, Michigan, and the couplet, Erie and Ontario, while between these lay three subordinate ones in the basins of the great bays, Saginaw, Green and Keweenaw.

The divergence of the striations from the main channels toward the range, in the case of the Green Bay valley, and, so far as the evidence goes, in other troughs, was an unexpected result, developed by combining individual observations; but, when the method of wasting and disappearance of a glacier is studiously considered, appears not only intelligible, but a necessary result, and one which finds partial illustration among existing glaciers.

Topographical Relations and Distribution.—The topographical relations of the formation are an essential consideration, but may be best apprehended in connection with its geographical extension, which now claims our attention. If we start with the northern extremity of the long known Potash Kettle Range, in Wisconsin, we find ourselves about midway between the southern extremity of Green Bay and Lake Michigan, and on an eastward sloping, rocky incline. The base of the range is here less than 200 feet above Lake Michigan, and is flanked on either side by the lacustrine red clays of the region; and seems, in some measure, to be obscured by them. From this point, it stretches away in a general south-southwestward direction, for about 135 miles, ascending gradually, and obliquely, the rocky slope, until it rests directly on its crest.

When within about twenty miles of the Illinois line, *it divides*, one portion passing southward into that state, and the other, which we will follow, curves to the westward, and crosses the Rock river valley. A profile of the rock surface across this valley, beneath the range, would show a downward curve of more than 300 feet. The range should not, perhaps, be regarded as sagging more than half that amount, however, in crossing the valley, as the canon-like channel of the pre-glacial river, seems to have been filled without much affecting the surface contour of the drift. But the fact of undulation to conform to an irregular surface, produced by erosion, and not by flexure of the strata, is a point to be noted, as it is a serious obstacle in the way of any explanation that is only applicable on the supposition that the formation was in a horizontal position when formed, as the view that it was produced by beach action, or the stranding of icebergs.

After crossing Rock river, the range curves gradually to the northward, passing over the watershed between the Rock and Wisconsin rivers, "descends abruptly 200 feet into the low ground of the valley of the Wisconsin,"[1] crosses the great bend of the river, sweeping directly over the quartzite ranges, according to Prof. Irving, with a vertical undulation of over 700 feet, after which it gradually ascends the watershed between the Mississippi and St. Lawrence drainage systems, until its base reaches an estimated elevation of 700 to 800 feet above Lake Michigan. From thence it has been traced across the headwaters of the Wisconsin river, by Mr. A. Clark, under my direction.[2]

Within the Chippewa valley, it has been observed by Prof. F. H. King, of the Wisconsin Survey, and I have observed it in the vicinity of the Wisconsin Central railroad. This region is covered by an immense forest, mainly unsettled and untraversed, even by foot paths, so that geological exploration is difficult and expensive, and, as no industrial importance attaches to it, and the rock below is deeply concealed by it, I have not deemed it sufficiently important to trace the belt continuously to justify the large expenditure of time and means requisite, especially as I entertain no serious doubts as to its continuity and general position. The observations made, indicate that it descends obliquely the east-

[1] Prof. Irving, Geol. of Wis., Vol. II, 1877, page 616.

[2] To the eastward of the range, as thus traced, Col. Whittlesey describes (Smithsonian Contributions, 1866) a similar formation in Oconto county. I have observed the same at several points. Mr. E. E. Breed informs me that it occurs on the watershed between the Wolf and Oconto rivers, but it has not yet been traced through the wilderness, to any connection with the main range, and it is uncertain whether it is so connected or constitutes a later formation, as such later moraines have been observed at other points.

ern slope of the Chippewa valley, and crosses the river below the great bend (T 32, R. 6 and 7), near which the Flambeau, Jump, and several smaller streams gather themselves together, in a manner very similar to that of the branches of the Rock and Upper Wisconsin rivers, just above the point where they are crossed by the range. From this point the belt appears to curve rapidly to the northward, forming the western watershed of the Chippewa. It is joined in eastern Burnett county by a portion of the range coming up from the southwest, the two uniting to form a common range, analogous to that of eastern Wisconsin. The conjoint range thus formed, extends along the watershed of the Chippewa and Nemakagon rivers, to the vicinity of Long and Nemakagon lakes, on the watershed of Lake Superior. This part is given mainly on the authority of Mr. D. A. Caneday, who visited a portion of the formation with me, and whose discrimination can, I think, be trusted. Mr. E. T. Sweet, of the Wisconsin Survey, describes[1] a kettle range as lying along the axis of the Bayfield peninsula, but it has not been ascertained that this is connected with the belt under consideration.

Returning to the junction of the two ranges in eastern Burnett county, I have traced the belt thence southwestward through Polk and St. Croix counties to St. Croix lake, on the boundary of the state. The lower portion of this has also been studied by Prof. L. C. Wooster, of the Wisconsin Survey. The southeastern range of the belt may be conveniently seen on the North Wisconsin railroad, near Deer Park, and on the Chicago, St. Paul & Minneapolis line, to the west of the station Turner, but only in moderate force.

If a good surface map of Minnesota be consulted, it will be seen that there lies along the watershed, between the Upper Mississippi and the conjoint valleys of the Minnesota and Red rivers, a remarkable curving belt of small lakes. Along this line, lies a chain of drift hills, known in its northwestern extension as the Leaf hills. In the Sixth Annual Report of the Geological Survey of Minnesota, received just as this article is going to the printer,

[1] Manuscript report on Douglas and Bayfield counties, to form a part of Vol. III, Geol. of Wis.

Prof. N. H. Winchell, speaking of the great moraines of the northwest, says: "There are two such that cross Minnesota, the older being the Coteau and the younger, the Leaf hills. Corresponding to the latter, the Kettle Range in Wisconsin seems a parallel phenomenon."[1] I have seen this belt, west of Minneapolis, and concur in Prof. Winchell's opinion. I have also observed, hastily, what I regard as portions of it — dissevered by the river channels — on the peninsula formed by the bend of the Mississippi and the Minnesota, south of St. Paul, and on the similar peninsula between the Mississippi and Lake St. Croix; and this seems to be the line of connection between the Wisconsin and Minnesota ranges. It appears to me, therefore, well nigh certain, that the Leaf hills of Minnesota are not only analogous to the Wisconsin Kettle range, but are portions of the same linear formation.

The multitude of small lakes, found in Wisconsin, lie almost exclusively either along the Kettle belt itself, or in the area within, or north of it. The surface outside has a much more perfect system of drainage, and is almost entirely free from lakelets. The Kettle range constitutes the margin of the lake district. But in Minnesota, south of the Leaf hills, there is an extensive lake region stretching southward in a broad tongue, nearly to the center of Iowa, though the lakes are not very numerous in the latter state. The question naturally arises, whether this lake district is likewise bordered by similar drift accumulations, and this question, though not essential to the present discussion, has much interest in connection with it. In respect to this, I can only give some detached observations and quotations. As already stated, accumulations of this character occur south of St. Paul. Still further to the southward, in the town of Aurora, Steel county, there is a moderate exhibition of gravelly boulder-bearing hillocks and ridges, accompanied by shallow basins and irregular marshes, much after the manner of the formation in question. From the descriptions of Prof. Harrington,[2] these features appear

[1] Sixth Annual Rept. Geol. & Nat. Hist. Sur. Minn., p. 106. The R. R. profiles crossing this belt furnish valuable data. See Ann. Rept. for 1872, pp. 53 and 57, and Sixth Ann. Rept., pp. 47 and 156.

[2] Geol. and Nat. Hist. Sur. Minn., Ann. Rept. 1875, pp. 103 *et seq.*

to characterize the county somewhat widely, especially in the southern part. Near Albert Lea, in the adjoining county, on the south, and only a few miles from the Iowa line, there is a more prominent development of similar features, the ridges having a southwestward trend. Dr. C. A. White, in the Geology of Iowa, describes a terrace in the northern part of the state, which, in its eastern extension, " becomes broken up into a well marked strip of 'knobby country.' Here it consists of elevated knobs and short ridges, wholly composed of drift, and usually containing more than an average proportion of gravel and boulders. Interspersed among these knobs and ridges, are many of the peat marshes of the region."[1] One knob he estimates as rising 300 feet above the stream at its base. This area lies in the line of the preceding localities, and near the Minnesota border. Between this "knobby country" and the Algoma branch of the C., M. & St. P. R. R., and stretching southwestward from the latter, there is a broad belt of low mounds and ridges, some of which show the structure and composition common to the Kettle moraine, while others present externally only a pebble clay, similar to that which characterizes the level country to the west of it. The whole presents the appearance of a low range modified by lacustrine deposits.

Near the center of the state, Dr. White describes a second range under the name of "Mineral Ridge,"[2] as consisting, "to a considerable extent, of a collection of slightly raised ridges and knolls, sometimes interspersed with small, shallow ponds, the whole having an elevation, probably, nowhere exceeding 50 feet above the general surface, but, being in an open prairie region, it attracts attention at a considerable distance." Both these ridges, Dr. White classes as probable moraines.

This Mineral ridge lies south of the lake district, and may be regarded as forming its margin in that direction. On the western border, Dr. White describes "knobby drift," in Dickinson county, which, however, is "without perceptible order or system of arrangement."[3] To the northwest from this, we soon encounter the

[1] Geol. of Iowa, 1870, p. 99. [2] Loc. cit. [3] Geol. of Iowa, Vol. II, p. 221.

morainic accumulations of the "Coteac de Prairie,"[1] and the "Cobble Knolls" and "Antelope Hills."

These observations do not indicate a continuous, well defined range, but seem rather to point to a half-buried moraine, that only here and there, along its course, protrudes conspicuously, and this is the impression gained from an inspection of the formation. It is to be noted, as supporting this view, that, at least so far as the eastern side is concerned, this supposed moraine is flanked on the *exterior* by level plains, of smooth surface, often underlaid by sand and gravel, that seemingly owe their origin to broad rivers or lakes that fringed the border of the glacier, in its advanced state, when it probably discharged its waters over the moraine at numerous points, rather than at one, or a few, selected points, as would more likely be the case during its retreat, when accumulations of water could gather along its foot, within the moraine, and large areas be discharged at some single favorable point. But on the inner side of the moraine, the surface, although nearly level, in its general aspect, undulates in minor swells and sags, and the drainage is imperfect. The substratum, instead of being gravel, sand, or laminated clay, is generally a pebble or boulder clay. *Outside* of the moraine, the existing surface contour was formed in the presence, and, to some extent, under the modifying influence, of a fairly established drainage system. But on the *interior*, the drainage system has not, even yet, become fully established, much less impressed itself upon the surface configuration, except in the vicinity of the main rivers.

The terrace-like ridge mentioned by Dr. White, and some of the lines of hills described by Prof. Winchell in Minnesota, as running in a similar direction, may be perhaps regarded as minor morainic lines, stretching across the glacial pathway and marking oscillations in its retreat, analogous to some quite clearly made out in Wisconsin.[2]

This southern morainic loop is, of course, presumed to be older than the Kettle range, and is here discussed because of the inter-

[1] See note of Prof. Mather, Nat. Hist. Sur. 1st Dist. N. Y., p. 193. See also 2d Annual Report Geol. and Nat. His. Sur. Minnesota, by N. H. Winchell, pp. 193 to 195; also *loc cit.*, *ante.*

[2] Geol. of Wis., Vol. II, 1876, p. 215 *et seq.*

esting way in which it is associated with the latter formation, and the suggestions it may contribute to the final solution of the main problem, to which the special one under discussion is only a tributary, viz.: the definite history of the Quatenary formations.

Returning to the branching of the range in southeastern Wisconsin, we find the left arm, or that nearest Lake Michigan, striking southward into Illinois. If we lay before us Prof. Worthen's geological map of that state, and attentively observe its topographical features and its drainage systems, it will be observed that nearly all the lakelets, the greater part of the marshes, and most of the region of abnormal drainage may be included in a curving line, rudely concentric with the shore of Lake Michigan, starting near the center of McHenry county, on the Wisconsin line, and ending in Vermillion county, on the Indiana border. It may also be observed, on a similar inspection of Indiana, that nearly all the lake district lies north of the Wabash.

In Wisconsin, as already stated, we have found this area bordered by the Kettle range, which is itself notably lake-bearing. The range continues to sustain this relationship in Illinois, so far as I know it to be directly continuous. It exhibits a progressive broadening, and flattening, as it enters upon the level country that encompasses the head of Lake Michigan. The pebble clay deposit — not coarse boulder clay — that characterizes the flat country, and which, to the north, has been separated from the range by a belt of coarse boulder clay, here approaches, and appears, to some extent, to overlap the range, and to be one cause of its less conspicuous character. From what I have seen of the region south of Lake Michigan, and from all I can find in geological reports relating to the region, I gather that the range, so far as it escaped the destructive action of the floods issuing from the Lake Michigan basin, both while occupied by ice, and subsequently, is, to a large extent, buried beneath later deposits, or so modified as to be inconspicuous. Whatever the correct interpretation, it remains a fact beyond question, that the belt becomes very obscure, compared with its development to the northward. Dr. E. Andrews says: "As we trace it southward, the material becomes finer, and the hills lower, until they shade off imperceptibly into the drift clay, of the Illinois prairies."[1] The members of the geological corps of Illinois did not recognize it distinctively, in the sense in which it is now considered, but Dr. Bannister, in his report on Lake county, says: "In the western part of the county, near the Fox river, we find the ridges, in some places, to be largely composed of rolled limestone boulders. The same character has been observed further south along the same stream and remarked upon in the chapter on Cook county."[2] In respect to McHenry county he says: "In the vicinity of the Fox river, the same kind of gravel ridges are met with as those which have been described as occurring in the western part of Lake county."[3] This lies in the belt identified by me, from personal observation, as belonging to the Kettle range.

Concerning the district farther south, he says: "Boulders of granite, quartzite, greenstone, and various other rocks are abundant in various localities on the surface of the ground, and are frequently met with in excavations for wells, etc., and large deposits of rolled boulders, chiefly of limestone from the underlying Niagara beds, similar to those already described in the report on Cook county, occur in the drift deposits of the adjoining portions of Kane and Du Page counties."[4] Concerning the topography, the same writer says: "Along some of the principal streams, and especially the Fox river in Kane county, the country is more roughly broken, and can, in some parts, even be called hilly, although the more abrupt elevations seldom exceed eighty or one hundred feet above their immediate base."[5] This broken country, if we may judge from what is true of the rough country along the same river to the north of this, it not due so much to the drainage erosion of the river as to the original deposition of the drift. The same features are said to continue into Kendall county, next south, which brings us to the vicinity of the ancient outlet of Lake Michigan, where, of course, the moraine is locally swept away. Still farther south, in Livingston county, Mr. H. C. Freeman mentions a ridge running southeast-

[1] On Western Boulder Drift, Am. Jour. Sci., Sept., 1869, p. 176.

[2] Geol. Sur. of Ill., Vol. IV, p. 130.

[3] Loc. cit., p. 131.

[4] Geol. Surv. of Ill., Part IV, p. 113.

[5] Geol. Surv. of Ill., Part IV, p. 112.

erly from a point in La Salle county, to near Chatsworth, a distance of about forty miles. "This is gravelly and sandy, giving it a distinctive character as compared with the adjacent prairie."[1] This is quite too meager to base an identification upon, but I have thought it worthy of quotation here. At Odell, which lies near this ridge, the drift is said to be 350 feet deep.[2]

On the railroad line from Chicago to Kankakee, there is no recognizable indication of the formation under consideration. Southwestward from Kankakee, on the line to La Fayette, Ind., there are a few mounds and ridges that bear a somewhat morainic aspect, but they are isolated in a generally level tract of lacustrine, rather than glacial, topography. They are, perhaps, remnants of a formation that has been largely eroded or buried. Near Fowler, in Benton county, Indiana, there is a belt of low mounds and ridges, accompanied by shallow depressions, that quite closely resemble the Kettle range in its more modified phases. Boulders appear upon the surface, and, in the more immediate vicinity of the village, are large and numerous. This is probably a portion of the "stream of boulders two miles wide," which Mr. F. H. Bradley mentions as extending through the eastern part of Iroquois county, Illinois, and the central part of Benton county, Indiana,[3] and which he attributes to floating ice. He does not, however, mention the associated topography or underlying drift formation. South of this low range, the country again becomes level, or gently undulating, as far as the Wabash."

The Indiana geologists have not yet critically examined the heavy drift region in the northern part of the state, through which the moraine might be supposed to pass, but in such preliminary inspection as has been made, they have not recognized any prominent moraine-like accumulation. The superficial expression of the region is quite monotonous, and presents to view deposits of sand, gravel, lacustrine or pebble clays, but more rarely the coarse boulder clay or mixed material, that I regard as the unmodified ground moraine. The modifying agencies which produced this phase of the deposits, would be antagonistic to

[1] Geol. Surv. of Ill., Vol. IV, p. 227. [2] Geol. Surv. of Ill., Vol. VI, p. 237.
[3] Geol. Surv of Ill., Vol. VI, p. 236.

ridge-like morainic accumulations, and their presence, in sharp outline, is not to be expected. In the vicinity of Ligonier, in Noble county, there is a feeble, but somewhat characteristic development of some of the features of the formation. So also, in the vicinity of Rome and La Grange to the northeast. Between La Port and Otis there is a kindred, though somewhat peculiar formation, but I am in doubt as to its true character.

On entering Michigan, we find the formation more unequivocally developed. Just north of Sturgis, which is near the southern line of the state, the formation appears in marked development. It does not attain a great altitude, but presents the peculiar strongly undulating and hummocky contour, and the coarse, mingled material, characteristic of the deposit. It may be seen to advantage on the line of the Grand Rapids & Indiana R. R. To the northeast in the vicinity of Albion, it may be seen from Springport on the north, to Condit on the south. It is here broad and flat, and superficially composed of gravel, for the greater part, but some of the deeper excavations reveal the characteristic coarser material. On the Michigan Central R. R., the formation may be observed between Jackson and Dexter, the most prominent portion being between the stations Francisco and Chelsea. It is not very prominent on the immediate line of the road, which was doubtless selected to avoid it, but in the vicinity it rises into prominent hills and ridges. Some of these, on the north, are conspicuous objects at considerable distances. Still farther to the northeast, my friend, Dr. D. F. Boughton, whose identifications I have elsewhere verified, informs me that the range is well developed in Oakland county, and is finely exhibited near the line of the Flint & Pere Marquette R. R., between Plymouth and Holly. Still farther to the northeast, it may be seen at great convenience and advantage, along the Detroit & Milwaukee R. R. from Birmingham, below Pontiac, to Holly. On the flanks, its features are subdued, the hills and ridges being rather low, with more or less level surface between them, and the superficial sands and gravels are prevalent; but from Waterford to beyond Clarkston, the range has a fine, though irregular development. The hills rise with characteristic contours, to an estimated altitude of 200 feet or more above the surface of the beautiful lakelets embosomed at their base. The deep cuts near the latter station, amply exhibit the coarse, commingled material, characteristic of the core of the range.

Putting the foregoing observations together, they seem to establish beyond reasonable doubt the existence of a broad, massive belt stretching northeastward on the highland between the Saginaw and Erie basins.

If we return again to the southwestern part of the state, we are informed by Dr. Boughton that we shall find a similar accumulation at, and in the vicinity of, Kalamazoo. To the north-northeast, in Barry county, the Thorn Apple river cuts across this range between Sheridan and Middleville. This belt here, though broad, presents a more prominent and ridge-like aspect, with better defined limits than elsewhere observed in Michigan. To the north of this, opposite Saginaw bay, there occurs, near Farwell, broken, rough country and abundant coarse drift, that probably belongs to the belt in question, but my opportunity for observation was unsatisfactory. Beyond this point, I have no definite information, but I deem it highly probable that the moraine will be found extending some distance farther, on the highlands of the Peninsula.

The lake survey charts show that Grand Traverse bay has the remarkable depth of over 600 feet. This great depth, together with its linear character, and the form and arrangement of the associated inlets and lakes, has suggested that it may have been the channel of a separate minor glacier, analogous to that of Green Bay on the opposite side of the great lake, but I have no direct evidence that such was the fact.

In the reports of the geological survey of Ohio, a formation of nearly, or quite, identical characteristics is carefully described by the several writers whose districts embraced it. In the second volume,[1] Dr. Newberry gives, under the name of "Kames," an excellent summary of its leading features. These harmonize very nearly with those of the Kettle belt. The main points of differ-

[1] Pages 41-47. See also "Surface Geology of Northwestern Ohio," Proc. Am. Assoc. Ad. Sci., 1872, by Prof. N. H. Winchell, under heads of St. Johns and Wabash Ridges.

ence are the less conspicuous character and massiveness of the Ohio range, and the greater prevalence of assorted and stratified material; in other words, its features are the same that the Kettle range presents in its more subdued aspects, especially where it is formed in a comparatively smooth country, and is flanked by pebble clays, with level surface, instead of coarse boulder clay, with ridged, or mammillary, contour. I cannot turn aside, here, to define, with sufficient circumspection, the distinction between these clays, further than to indicate my belief that the former are sub-aqueous, and the latter sub-ærial, or, if you please, sub-glacial, deposits.[1]

Where I have seen the Ohio formation, it presents almost precisely the characteristics that are exhibited by the Kettle range in northern Illinois, where it is similarly related to plane topography and pebble clays, and it is also very similar to the same formation opposite Green Bay, where it is bordered on both sides by red lacustrine clays of later date. Dr. Newberry quite clearly recognizes the parallelism, but perhaps not the identity, of the formations.[2] Col. C. Whittlesey, in his article on the "Fresh Water Glacial Drift of the Northwestern States,"[3] classes the formations together as identical in character, though he does not seem to have considered them members of a continuous formation, and could not well do so with the prevalent view, which he somewhat emphasizes, that it is peculiarly a *summit* formation. It very often does occupy the summit of a rock terrane, and it sometimes *forms* a watershed by its own massiveness, but it likewise occupies slopes and crosses valleys, as shown in detail in the Wisconsin report. Prof. Andrews of the Ohio survey, in a personal communication, adds his conviction that the Ohio and Wisconsin deposits are parallel formations. It would seem, then, that the only question relates to the *continuity* of the belts. Unfortunately there intervenes the Wabash valley, the ancient drainage channel

[1] I have mapped these formations separately in Eastern Wisconsin. See Atlas accompanying Vol. II, Geol. of Wis., 1877, Plate III, Map of Quaternary formations. See, also, p. 225 of the volume.

[2] Geol. Surv. of Ohio, Vol. II, pp. 4, 5, and 43. Dr. Newberry's views as to the origin of the Ohio "Kame" belt are at variance with those here presented.

[3] Smithsonian Contributions, 1866.

of the Erie basin. Absolute continuity undoubtedly does not exist. If my views are correct, this was the great — not exclusive — channel of discharge of the glacial floods, at the very time the moraine was being formed, where it could be formed, and, for that reason, the debris was swept away or leveled. In addition to this, the region has been subjected to the vicissitudes of erosion, of a reversal of drainage systems, and of lacustrine and fluviatile accumulation. It is to be presumed, therefore, that a portion of the range, where once formed, has been lost, leveled, or buried. Some remnant indications of the range, on the upper slopes, might, however, rationally be presumed to exist. But, awaiting a critical examination of the region, we must confess a want of direct evidence. The belt stretches entirely across Ohio and enters Indiana, but has not been traced farther.

In the line of indirect testimony, however, some facts may be noticed. Prof. N. H. Winchell describes in the Ohio reports[1] six ridges running parallel to Lake Erie, and Mr. G. K. Gilbert has described that portion of these which lie in the more immediate Maumee valley.[2] Two of the inner ones are conceded to be lake beaches. The two outer ones are members of the "Kame," or Kettle belt, according to Dr. Newberry.[3] The one next within, the St. Mary's ridge, Prof. Newberry distinguishes, apparently, with justness, from both the other classes. Mr. Gilbert gives a clear and discriminating description of this, and expresses the conviction that it is "the superficial representation of a terminal glacial moraine, that rests directly on the rock bed and is covered by a heavy sheet of Erie clay, a subsequent aqueous and iceberg deposit."[4] The views of Professors Newberry and Winchell, while they each differ somewhat, agree with this in the only point essential to the present discussion, viz.: *that this ridge represents the margin of the glacier at the time it was formed.* This shows the glacier to havebeen a tongue or lobe of ice, differentiated from the supposed continental glacier, and having its axis coincident with the Maumee valley, and, withal, capable of forming a morainic accumulation on both sides. The St. Mary's ridge crosses the

[1] See also Proc. Am. Assoc. Ad. Sci., 1872.
[2] Geol. Surv. Ohio, Vol. I, pp. 537 *et seq.*
[3] Geol. Sur. Ohio, Vol. II, pp. 56 and 57.
[4] Loc. cit.

Maumee - Wabash valley — the glacial trough — and, recurving upon itself, bears away to the northeast, approximately parallel to the Kettle belt already described in southeastern Michigan. This wing of the St. Mary's ridge bears the same relation to the Kettle belt bordering the Erie basin on the Michigan side, that the opposite wing does to the "Kame" belt on the south side. The force of this relationship is not easily escaped.

If my views are correct, that this Michigan belt was formed along the right hand margin of the Erie glacier (conjointly with the Saginaw glacier), just as the "Kame" belt was formed on the left hand margin, then its composition should give evidence of the fact. In the case of the Green Bay glacier, I have shown that the lines of striation and transportation diverge from the main axis toward the margin,[1] and, so far as the paths of other glaciers lie within Wisconsin, the observations made upon them, imply the same method of movement, and this habit finds partial exemplification among the glaciers of the Alps — partial, because their contracted valleys and steep slopes afford little opportunity to deploy in this fashion. If this manner of movement holds true with the Erie glacier, material from its trough will be found to have been transported westward and northwestward toward the moraine. Thirteen years ago, in an article in the American Journal of Science, entitled, "Some Indications of a Northward Transportation of Drift Material in the Lower Peninsular of Michigan,"[2] Professor Alexander Winchell called attention, with much detail and precision, to a large mass of evidence, which finds, for the first time, so far as I am aware, satisfactory explanation in the view now presented, and, in return, has the force of confirmatory evidence. It appears that immense, and often but slightly eroded masses of Corniferous limestone, have been borne in the direction indicated, and scattered over the areas of the Hamilton group, the Marshall sandstone, and the Subcarboniferous limestone; that similar blocks of Hamilton rock have been deposited over the two last named formations and even beyond; that the Marshall sandstone has likewise been borne on to the Carboniferous limestone, and that this transportation has

[1] Geol. of Wis., Vol. II, pp. 199 *et seq.*

[2] Am. Jour. of Sci., Vol. XL, Nov., 1865.

been from lower to higher levels, as the strata now lie, and are presumed to have lain, since the basin is one of excavation and not of flexure. These phenomena, in all their details, are precisely what we should expect from the action of a glacier advancing through the Erie valley, and moving in a manner analogous to that of the Green Bay glacier. That a glacier moved through this valley has been abundantly shown by the Ohio geologists. The only labor of this article is to show that it was an individualized stream, forming the Ohio "Kame" belt on one side, and the Michigan on the other, simultaneously, and that they are collateral members of a common moraine.

Eastward from Ohio, there has been, so far as I am aware, no definite attempt to trace out the extent of the belt. In western New York, Prof. Hall mentions, as one of the three general aspects of the superficial deposits, a surface "broken into irregular hills or ridges, with deep bowl-shaped depressions, or long valleys, which often communicate in more extensive ones, or are enclosed on all sides by drift,"[1] but he does not definitely locate the formation, or indicate whether it assumes the form of a belt, or otherwise. In central New York, Prof. Vanuxem says: "There is another class of deposits, well defined as to position, but irregular as to composition, which are worthy of note. They occur in the north and south valleys, which are on the south of the Mohawk river, or the great level." "The whole of these deposits have a common character. They are in short hills, quite high for their base and are usually in considerable numbers." "They consist of gravel, of stones also of greater size, sand and earth."[2] These, he says, greatly resemble the "deluvial elevations" noticed in the survey of Massachusetts,[3] the description of which is perfectly applicable to the formation under consideration. Furthermore, Prof. F. H. King, of the Wisconsin survey, has examined the same deposits in the vicinity of Ithaca, and recognizes their identity in kind. Neither of these observers, however, discern a definite belt, although Prof. Vanuxem destroys the force of his apparent limitation of the formation to the valleys, by stat-

[1] Nat. Hist. Surv. 4th Dist., Geol., Pt. IV, pp. 320, 321.

[2] Nat. Hist. Surv. N. Y., 3d Dist., p. 218. [3] Geol. of Mass., E. Hitchcock, 1833, p. 144.

ing that there are numerous points where it has formed over the hill sides, and by associating in mention with it accumulations on the "heights, apparently in no regular order."[1] As these are deep, canon-like valleys, they would probably modify in some degree, the comparatively thin margin of the glacier, giving it a somewhat digitate outline, and the greatest accumulations would take place near the extremities of the tongues, in the valleys, so far as drainage permitted; while the connecting chains would form retreating lines, and be less conspicuous, and might, therefore, escape observation not definitely turned to the subject. This, at least, is suggested by some observations of my own in similar situations. Such valley accumulations, however, do occur at the extremities of linear glacial lakes that are unconnected with a definite belt, as in the case of Green Lake, Wisconsin.[2]

On the line of the Erie R. R., along the small tributary of the Delaware river that is followed up, westward, from Deposit, I have observed winding Osar-like ridges, parallel to the valley, and Kame-like hills upon the slope, up to the watershed of the Delaware and Susquehanna; likewise in the valley of the latter, at and near the village of Susquehanna, but I have no knowledge of their intimate structure, extent, or relations.

In the southeastern district of New York, Prof. Mather recognizes the distinctive aspect of this class of accumulations.[3] He cites several instances of its occurrence on the east side of the Hudson, leaving the impression that they are local features. But on Long Island, it forms "an elevated ridge, called by some, 'Green Mountains,' and by others, the 'Backbone' of the island."[4]

This he describes in detail and maps, showing that it branches at the east, one chain extending along the southern peninsula to Montauk Point, and the other, along the northern to its extremity, and, theoretically, to the islands beyond.

Professors Cook and Smock have recently examined this, and have shown its connection with a similar moraine, that stretches across the northern part of New Jersey, from Perth Amboy to

[1] Loc. cit., p. 219.
[2] Geol. of Wis., 1877, Vol. II, p. 138.
[3] Nat. Hist. Surv. N. Y., 1st Dist., Pt. IV, p. 212.
[4] Loc. cit., p. 161.

the Delaware river, below Belvidere.[1] The descriptions of this range tally quite perfectly with that of the Kettle moraine. This range, however, lies on the margin of the area of northern drift, while the western one is medial in position, and at some points is quite distant from the margin. It will be observed, nevertheless, that this distance is greatest, in general, at the west, and that in Ohio it becomes very greatly reduced, so that the fact of coincidence on the Atlantic coast, presents no reason for supposing the ranges to be distinct. But, whether distinct or not, is a matter to be settled by observation, and it is to be hoped that it will not long remain undecided for want of it. The extension of the New Jersey moraine westward has not, so far as I can learn, yet been traced, but the survey of Pennsylvania, in progress, will, doubtless, soon leave nothing to be desired, so far as that State is involved.

To the eastward, Mr. Warren Upham has recently been engaged in studying its probable continuation in southeastern Massachusetts. In a personal communication he writes: "A very clear line of terminal moraine extends along the chain of the Elizabeth islands southeast of Buzzard's Bay; thence it bends to the northeast and north as far as to North Sandwich, when *it turns at a right angle* to the east, and extends through Barnstable and other towns to Orleans, running along the east and west portion of Cape Cod, and terminating at its east shore." "This terminal moraine, like the 'Kettle moraine', is not at the outmost limit reached by the ice-sheet; for hills, in series nearly parallel to the moraine already described, and similarly composed of glacial drift with many boulders, occur on Martha's Vineyard and Nantucket islands, corresponding, perhaps, to the terminal moraine which forms the 'backbone' of Long Island. * * The moraine of the Elizabeth islands and Cape Cod has a length of about 65 miles." It may be suggested that the range along the Elizabeth islands may correspond to the northern branch of the Long Island moraine described by Prof. Mather, and that, as Mr. Upham suggests, that of Martha's Vineyard and Nantucket corresponds to the southern.

[1] Ann. Rept. of State Geologist, N. J., 1877, pp. 9 *et seq.*

Dr. E. Hitchcock refers to these accumulations in his report on the geology of Massachusetts,[1] and classes with them "diluvial elevations and depressions," occurring at other points in that and adjoining States. It would appear, from the geological reports of the Eastern States that analogous, though not certainly identical formations, occur locally, more frequently than in the interior, and this, from the mountainous nature of the country, is not strange; but no continuous massive range seems to have been discerned, except the southern one already described.

In the interior, so far as yet ascertained, the drift limit is not marked by any such persistent ridge-like accumulation, but gradually dies away or is buried by later deposits, so that the precise limit of glacial advance is not easily determined. The only approach to an exception to this, known to me, is the case of the Kettle moraine in Central Wisconsin, where it lies near the border of the driftless area. Elsewhere around that area, the drift thins out very gradually, so as to render the mapping of its margin a work of close inspection; and, as the region presents no evidence of subsequent submersion, or any other special modifying agency, except the usual meteorological forces, this would seem to represent approximately the original form of deposit.

It is evident from the foregoing sketch that much observation remains to be made before the complete geography of this formation is determined. The conjectural lines on the map are only theoretical suggestions, preliminary to observation.

Summary.— It may be helpful at this point to summarize, and bring into close juxtaposition, in thought, the leading characteristics of this remarkable formation.

1. Its linear extent is very great, whatever its final limits may be found to be.

2. It has a width of from one to thirty miles.

3. Its average vertical thickness can only be very roughly estimated, but may, very prudently, be placed at 200 or 300 feet.

4. Its surface configuration is peculiarly irregular, and denotes an extraordinary origin.

[1] Geol. of Mass. 1833, pp. 144 *et seq.*

5. It is a complex range, the component ridges being often arranged in rude parallelism.

6. A distinction is usually to be observed between the superficial and lateral portions of the deposit on the one hand, and the central, underlying one on the other, the former being chiefly sand and gravel, the latter complex commingled debris.

7. The superficial sands and gravels are usually stratified in various attitudes, but the core of the range is mainly unstratified.

8. The irregularities of the range are most conspicuous where the superficial sands and gravels are least abundant.

9. The material was derived, in part, conspicuously so, from the vicinity of the range, and, in part, from the formations lying backward along the line of drift movement for at least 300 miles.

10. A portion of the material is spherically rounded, a part is scratched and polished, and some is little affected, though sometimes soft or friable, the latter being usually from adjacent formations.

11. The range is tortuous in its course, but sustains a remarkable and significant relationship to the great lake basins.

12. It undulates over the face of the country, varying at least 800 feet in its vertical oscillations.

13. It does not sustain any uniform relation to present, or what are presumed to have been, preglacial drainage systems in their details. In some portions, it occupies water-partings; in others, lies on slopes; and in still others, stretches across valleys.

14. It crosses, in its course, all the indurated formations, from the Laurentian to the Coal measures, but exhibits no specific relation to their strike or dip.

15. It sustains a definite and most important relationship to the lines of general drift movement.

16. The range is frequently flanked on its southern, or outer edge, by level areas of sand and gravel, of greater or less extent. These also occur between the component ridges of the belt, and on the inner flank, but less frequently.

17. The surface contour of the adjacent region within, or north of, the belt, usually, though not invariably, has a less perfect drainage system, and exhibits less noticeably the effects of superficial modification, than the outer side.

Origin.— Waiving, for the present, some further generalizations, it is thought that the foregoing phenomena present a *specific combination* which points unequivocally to a morainic origin. To the writer, familiar with the multitudinous details, that cannot here find a place, and having studied recent moraines with special reference to this formation, they have a force little less then demonstrative. The range is confidently regarded as a moraine formed at the margin of a group of glaciers — which may be regarded as a single lobate one — and marking a definite stage of their history. A more vivid and graphic view of the outline and movements of these glaciers, than can be given in words, may be obtained from the accompanying map, from which it will appear that through each of the great lake troughs there poured an ice stream, attended by minor currents through the lesser channels.

Its Medial Position.— It has already been remarked that, in the interior, this moraine does not mark the extreme limit of glacial advance. Numerous striations, and other evidences of glaciation, occur on the south side of it. A line has been drawn on the map intended to indicate the approximate limit of northern drift, based on several authorities.[1] How nearly this shows the limit of actual glacial progress, in distinction from other means of transportation, is not, I think, as yet definitely ascertained, but the general fact of progress, to a considerable distance beyond the Kettle moraine, is sufficiently established. The moraine was, therefore, formed *after the retreat of the glacier had commenced, and marks a certain stage of its subsequent history.*

Glacial Movements before the Formation of the Moraine.—It becomes an interesting question to ascertain whether the glacial movements were the same before the formation of the moraine, as afterwards. Fortunately, in southern Wisconsin, we have very definite and specific evidence bearing on this question. In the towns of Portland and Waterloo, which lie within the area of the Green Bay glacier, and from twenty-five to thirty miles distant from the moraine, there are several domes of quartzite that rise through the horizontal sandstones and limestones, which occupy the surrounding region. These domes are glacially abraded and grooved in a direction S. 30° W., and trains of quartzite boulders

[1] Tesley, Newberry, Cox, and assistants, Worthen, Swallow, and Mudge.

stretch away in that direction to the moraine, and, mingling with it, pass onward to an equal distance beyond. At the same time there is abundant evidence from the material of the drift, from the surface contour and from striation, recently observed by Mr. I. M. Buell, that the westerly movement of the Lake Michigan glacier, near the Illinois line, extended to the west side of Rock River, and that the line of junction of the two glaciers was on the west side of that stream. It appears then, that in this region, the movements were in the same general direction before and after the formation of the moraine, but that there were changes in the details, and that the relative size and position of the glaciers were somewhat different, the Green Bay glacier being relatively smaller in the earlier epoch. Testimony of similar general import, but less specific, may be gleamed from the reports of the other states involved.

Method of Formation.— If, then, the glacial movements were the same, in general, before and after the formation of the moraine, and yet the minor movements and relative size of the glaciers somewhat different, how was the moraine formed? A halt in the retreat of the glaciers, by which their confluent margin should remain stationary for a period, would doubtless cause an unusual accumulation of debris, but this would fail to account for the varying width or irregularities of the moraine. The structure of the range seems to indicate an alternating retreat and advance of the ice mass. During the former, debris was thrust out at the foot of the melting mass, which, when the glacier advanced, was plowed up into immense ridges. If this process be repeated several times paralled ranges will be accounted for, and the irregularities incident to such advance and retreat will explain the complexity of the range. Where the later advances were equal to the earlier ones, the accumulation of drift material would be forced into a single massive ridge. Where any advance failed to equal a former one, an interval between the accumulations of the two would result, giving rise to a depression whose form would depend upon the relations of the two accumulations, but would in general be more or less trough-like in character. Where tongues of ice were thrust into the accumulated material an irregular or broken outline would be the result. If masses of the ice became incorporated in the drift, as has been suggested, their melting would give rise to depressions, constituting one form of the kettles that characterize the range. The suggestion just made, with reference to the irregular advance of the ice mass, accounts for other forms, and, at the same time, for the irregular hills, mounds, and hillocks. Certain of the kettles may be due to underdrainage, through the action of strong underground streams that occasionally flow, as full brooklets, from its base. The drainage of the glacier, while it was advancing and pushing the debris before it, was probably quite general and promiscuous *over* the moraine, and this would give rise to the stratified sands or gravels, and other evidences of the action of water, among which may perhaps, be reckoned some of the minor mounds, ridges and depressions. The changing attitudes, which the debris would be likely to assume, as it was forced along, would, perhaps, give peculiar force to torrential effects.

The gaps in the range, attended by plains, or long streams of gravel and sand, appear to represent the more considerable points of discharge of the glacial floods. When the surface about the margin of the glacier permitted the accumulation of water, the moraine would doubtless be much modified by it and present a subdued aspect.

The Alpine moraines, above referred to, are regarded as miniature exemplifications of the process by which the Kettle moraine was formed.

But, in addition to the structure of the range, the change in the relative position of the Green Bay and Lake Michigan glaciers, already alluded to, affords evidence of an exceedingly interesting character, which has a significance much beyond what can be here indicated. It appears that the junction between the Green Bay and Lake Michigan glaciers at the last observable stage, preceding the formation of the Kettle moraine, was about twenty-five miles farther west, than at the time of the latter's formation, or, in other words, there is an abrupt easterly shift of the line of junction. It appears, also, that the width of the ante-morainic Green Bay glacier, measured just south of the Kettle moraine, was only half that of the post-morainic glacier, north of it, measured at a distance just far enough to escape the terminal curvature. An inspection of the outline of the Green Bay glacier shows that this eastward shift of the junction of the two glaciers was not due simply to encroachment on the Lake Michigan stream, nor to a common movement of both in that direction, for the opposite margin of the Green Bay glacier lay close upon the borders of the driftless region, demonstrating that there was no eastward swaying on that side. Indeed, the indenture of the outline of the driftless area strongly suggests actual encroachment on that side also, and this view is not without independent support.

In harmony with these phenomena are the fiords of the Green Bay peninsula, which indicate that the Green Bay ice stream overflowed into the basin of Lake Michigan. These facts, taken altogether, seem to warrant the belief that both glaciers retreated sufficiently far to the northward, and within their respective basins, to allow time and opportunity for the change in the relative size and position of the two ice streams, and that, under slightly changed conditions that favored the Green Bay glacier, they advanced to the position of the Kettle moraine, and, after a series of oscillations, retreated permanently. This view seems also to be demanded by certain details in the distribution of the drift material that are otherwise enigmatical, but whose discussion would too much extend this article.

Significance.—As forty-five years have passed since Dr. Hitchcock called attention to some of the phenomena under consideration, or, at least, to some distinctly related to it, and yet, the matter has received so little consideration, that our present knowledge is limited to such a degree, that I lay myself liable to the charge of undue temerity in attempting to correlate the observations, I may be pardoned in attempting to indicate, briefly, something of the significance and importance the foregoing conclusions, if sustained, have in relation to the Quaternary history of the region involved. The moraine constitutes *a definite historical datum line*, in the midst of the glacial epoch, and becomes a basis of reference and correlation for adjacent formations. It is an historical rampart, outlining the great dynamic agency of the period, at an important stage of its activity, and separating the formations on either hand by a chronological barrier. It is manifest that the true Boulder Clay, or ground moraine, south of the belt, must have been formed earlier than that north of it, and that the two portions are not at all synchronous. In sedimentary formations synchronism is found in horizontal strata, but in glacial deposits it is to be sought in linear belts, concentric with the margin of the glacier. This fact finds illustration, and emphasis, in the demarcation introduced by this singular corrugation of the wide-spread glacial sheet. It is difficult to limit the value of such a determinate line, in the midst of the complex drift formations, if fully established, and should similar belts be found to mark other stages of glaciation, there would be opened a definite line of investigation that promises much assistance in unraveling the gnarled skein of Quaternary history.

While it does not follow, necessarily, that all formations overlaying the true glacial clay, south of the Kettle moraine, are older than those occupying similar relations to the newer Till, north of it, it is clear, that similarity of stratigraphical sequence is not, by any means, sufficient ground for assuming chronological equivalence. It is evident, that all endeavors at correlation between the superficial deposits, on the opposite sides of the moraine, should be attempted with much circumspection.

These suggestions have especial application to the discussion of the vegetal deposits, so frequently found in the later Quaternary formations. By many writers, the various deposits of this kind, in the Mississippi basin, have been, very naturally, in the present state of our knowledge, grouped together without reference to the necessary discriminations above indicated, and, as a result, beds of diverse age are referred to a common stratum. A general discussion of these deposits is not sufficiently germane to our subject to be fittingly introduced here, but it is appropriate to point out the fact that some of the vegetal strata sustain such a relation to the Kettle moraine, that they must be widely separated from others, in the date of their accumulation and burial. Some of these organic strata lie at the immediate foot of the moraine, beneath fluviatile and lacustrine deposits that, I am confident, began to be accumulated during the accumulation of the moraine, and through the agency of glacial floods; while it is even more certain, that other vegetal deposits accumulated much subsequently, as those found in the red clays of Wisconsin, which are lacustrine deposits of the great lakes formed after the recession of the glacier. It would be too much to assume that all plant remains, found south of the moraine, antedate its formation, but it is safe to affirm that, with only phenomenal exceptions, e. g., such as escaped glacial abrasion, all north of it are more recent.

The bearing of these definite determinations of the glacial outlines and movements upon the question of the origin of the remarkable driftless area of Wisconsin, Minnesota, Iowa and Illinois (see map) was early perceived, and it was clearly foreseen that this line of investigation promised a *demonstrative* solution of the problem. The driftless area manifestly owes its origin to the divergence of the glaciers through the Lake Superior channel, on the one hand, and that of Green Bay and Lake Michigan, on the other, and to the obstacle presented by the highlands of northern Wisconsin and Michigan. This obstacle the glacier surmounted, and passed some distance down the southern slope, but apparently not in sufficient thickness to overcome the melting and wasting to which it was subjected, and so it terminated midway the slope. But the deep, massive ice currents of the great channels pushed far on to the south, converging toward each other; and, if they did not actually unite, at least commingled their debris south of the driftless area.[1] An instance closely similar to this, considered from a dynamical point of view, may be seen, at the present termination of the Viesch glacier, and illustrations of the general principles involved in the explanation may be seen in connection with several other Alpine glaciers.

If the evidence adduced to show that the Kettle moraine was due to an advance of the glaciers be trustworthy, then, to the extent of that advance, whether much or little, the moraine marks a secondary period of glaciation, with an interval of deglaciation

[1] Compare N. H. Winchell in An. Rep., Geol. of Minn., 1876, and R. D. Irving, Geol. of Wis., Vol. II, 1877, whose views are closely analogous to the above and each to the other but are not strictly identical. See, also, J. D. Dana, Am. Jour. Sci., April, 1878.

between it and the epoch of extreme advance. Its great extent indicates that whatever agency caused the advance was very wide spread, if not continental in its influence. The moraine, therefore, may be worthy of study in its bearings upon the interesting question of glacial and interglacial periods.

It will also furnish definite data bearing upon the somewhat mooted question of the origin of the Great Lakes, as well as other questions involving both perglacial and postglacial topography.

DEPARTMENT

OF THE

MATHEMATICAL AND PHYSICAL SCIENCES.

ROTATION AS A FACTOR OF MOTION.

By Professor J. G. McMurphy, Kenosha.

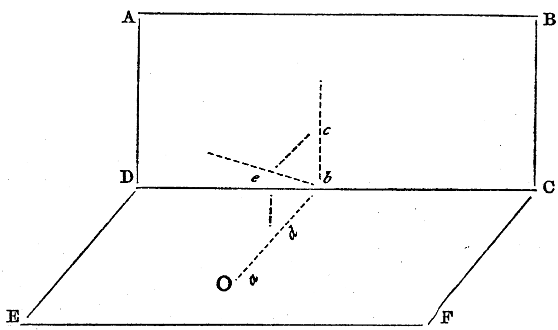
When an elastic ball is thrown against a plane surface it rebounds from that surface according to certain fixed laws. Its position at any moment will depend on certain conditions. The elasticity of the ball, the angle of projection, the rotation of the ball on its own axis, the velocity, will all of them affect the rebounding of the ball. Velocity and elasticity affect the distance to which it will rebound; the angle of projection and angular motion will affect the direction of rebounding.

A ball projected perpendicularly against a plane surface will rebound in the same line, making due allowance for the attraction of gravitation, which finally comes and controls its motion. The resistance of the air is no inconsiderable factor. (In point of fact, it is the latter only which is opposed to the force with which the ball rebounds, for gravity acts at right angles to this force and is not opposed to it.)

If the ball, without rotation, is projected against the plane surface at any angle, excepting ninety degrees, it will rebound so that the angle of reflection shall be equal to the angle of incidence; modified, of course, by gravitation and the resistance of the air.

Let us add another factor and examine the result. Given a horizontal plane surface in front of the vertical plane. Let the ball be placed upon it and propelled perpendicularly against the vertrical plane by a blow, which takes effect above its center of gravity. Such a blow will impart to the ball a rotary motion, together with an onward motion or translation. When the ball reaches the vertical plane its *rebounding force*, due to translation, will tend to make it retrace its path, while the force due to its rotation will tend to make it climb the vertical plane. It is actuated by the resultant of these two forces, and rebounds through the air, in the plane of those forces following the diagonal of the *rectangle* of forces.

The following diagram* may serve to make the explanation more apparent: Let A, B, C, D, be the vertical plane; C, D, E, F, the horizontal plane; Let *a* be the point from which the ball *d* is propelled on *a-b*; the ball having a forward rotary motion; *b-d* the distance the ball would rebound by virtue



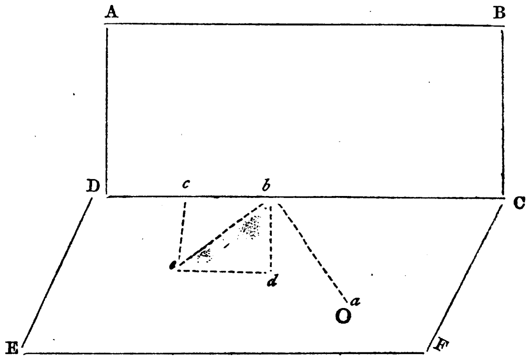
of its rectilinear motion; *b-c* the distance it would climb by virtue ot its angular motion. Then will it be found somewhere on the line *b-e*. Being a rectangle of forces, the resultant may be expressed by the formula $b\text{-}e = \sqrt{(b\text{-}c)^2 + (b\text{-}d)^2}$.

If the ball is propelled from a point to the right of its center of gravity, and constrained to keep the same perpendicular course, it will have a negative or left-hand rotation; when it strikes the vertical plane it will not return in the same path, but will be reflected to the right, so that the angle of reflection is not equal to the angle of incidence. But just as before, the path of the returning ball is the resultant of two forces acting at right angles to each other. If the angular velocity is very great, compared

*No cuts having been furnished by the author, the printer has been obliged to construct the accompanying figures, which are necessarily very imperfect.

with the velocity of translation the deflection from a perpendicular will be very great and vice versa.

When the ball is propelled against the vertical plane at any other angle than a right angle with a rotary motion besides, the problem becomes somewhat more complicated. Let the ball be propelled from *a* with a positive rotation. By its motion of translation it ought to rebound in the path which makes the angle of reflection, equal to the angle of incidence But by its rotation



against the fixed point, *b*, it would tend toward *c*; hence it will take the direction *b-e*, and be measured by the diagonal parallelogram of forces, represented by *b-a* and *b-c*. Here it is plain that the angle of reflection is much less than the angle of incidence. If the rotation be a negative or left-hand rotation from the same point, *a*, following the same path, *a-b*, the resultant will be nearer a perpendicular — that is, the angle of reflection will be greater than the angle of incidence.

If a ball be thrown perpendicularly against a vertical plane surface with a positive rotation it will rebound to the left, if the rotation be negative it will rebound to the right, if the rotation be forward the ball will rise, if backward it will fall. If the ball be thrown obliquely to the left, with positive rotation, the angle of reflection will be less than that of incidence. If thrown obliquely to the right, with same rotation, the angle of reflection will be greater than that of incidence. The combinations are almost infinite, and afford a variety of valuable observations.

There are some very curious and interesting experiments in compound direct motion. If a ball lying upon a plane surface be struck by a mallet so as to produce translation with forward rotation on its horizontal transverse axis, and at the same time a rotation about a vertical axis, the ball will neither rotate upon the one nor the other, but upon a new axis intermediate between the vertical and horizontal axes, pointed out by the resultant of the parallelogram of angular forces. This is the principle illustrated by the Gyroscope. The ball will describe a curve upon the plane in the same way that a truck rolled upon the ground when the axes cease to be level, begins to curve its path ; of course the two cases are quite different, because the curve made by a ball is much less marked than that made by a truck or wheel.

There is something of a similar nature seen when a ball is projected from a gun or cast from the hand. Since the middle of the sixteenth century, it has been known that the path of a projectile is a parabola, if no account is taken of the resistance of the air. *Templehoff* was the first to take into consideration this element in calculating for projectiles. The resistance of the air increases with the square of the velocity until the velocity exceeds 1,300 feet per second, when the resistance is much greater.

In experimenting with smooth-bored guns, it was found that rotation had much to do with the motion of the projectile from the muzzle. The only rotation which aided in aiming the gun, and in making calculations reliable, was the axial rotation, which was attained by grooving the interior of the barrel.

In the practice of gunnery with a smooth-bored gun there was allowed enough space around the ball for free and easy motion. It was called windage. This windage allowed the ball to ballot slightly from side to side as it passed through the barrel. At each point of balloting the ball received a rotary motion by being retarded on that side next the tangent barrel. The last touch imparted the final rotation, or that which continued through the space traversed by the ball. If the last ballot was upon the right side of the barrel the ball received a right hand rotation. It also received an impulse toward the left of the mark aimed at by the touch on the right side. But while the left side of the ball is moving forward at a much greater velocity than the center on account of the right hand rotation, the right side is moving much slower than the center on account of the same rotation. The left side, therefore, encounters a greater resistance than the right side. The air in front and to the left is compressed, and accumulated resistance finally throws the ball to the right. If the ball had balloted on the left side last, in leaving the muzzle, it would have been deflected to the right by touch and afterwards to the left by resistance and reaction of the compressed air. Thus it is possible with a smooth-bored gun to "shoot round" a nearer object in direct line and hit a more remote object behind it.

I wish to give but one more instance of the effect of rotation on direct motion. It is vulgarly called "curved ball." It may be witnessed in any good base-ball match. The pitcher desires to elude the strokes of the batter; after delivering a few balls in simple parabolic curves or with axial rotations, he will deliver the ball from the hand in such a way that when the ball leaves the hand the fingers touch it from below, causing the underside to be retarded while the upperside moves forward. Then the ball rotates upon a horizontal transverse axis, relative to its motion of translation. The greatest resistance from compressed air is in front and above the moving ball. The ball seeks a path of less resistance, preserving its plane of rotation and drops enough to form a depressed curve. By a skillful adjustment of rotation and translation, the pitcher is able to produce about such a curve as he wishes. To the batter the ball seems coming toward a point it is destined to fall short of. Again, by delivering the ball from the hand with the fingers touching above, a backward rotation is produced on the top of the ball and a forward motion to the under side. Such a ball continues its course until accumulated resistance of air from ahead and below throws it upward. So the batter sees the ball coming toward a point it is destined to pass clearly above. By skillful manipulation the right side of the deliverer the ball may be retarded, and the ball will curve to the right, and by retarding the left side it will curve to the left. The amount of curvature is variously estimated by different persons. With the rotation or twist of the best pitcher, it is no uncommon thing to make a ball curve a yard from its direct path, while many cannot effect any curve.

This purports to be only the outline of a subject worthy of much greater investigation, in its relation to great scientific problems.

Mr. President, members of the academy and others, my subject does not admit of a brilliant introduction nor of a grand peroration. It is the simple statement of the effect of rotation as an element of curvelinear and rectilinear motion.

REPORT ON RECENT PROGRESS IN THEORETICAL PHYSICS.

By J. E. DAVIES, A. M., M. D.,
Professor of Physics in the University of Wisconsin.

Part II.

THE MAGNETIC ROTATORY POLARIZATION OF LIGHT.

It is a well known fact that a ray of plane polarized light, vibrating in any azimuth, will, on passing through a lamina of quartz, have the azimuth of that vibration changed by an amount depending upon the thickness of the lamina, and the wave length of the particular kind of light employed. The direction, right or left, of this rotation of the plane of vibration depends upon the

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Note to Previous Paper on "Vortex Motion."

For the production of large-sized vortex rings, the device shown in Fig. 1 is used by Prof. Tait. It is an ordinary wooden box, with a large circular hole cut out of one end, and the other covered tightly with elastic cloth. It can be filled with smoke from a couple of retorts, one containing Ammonia and the other Hydrochloric Acid. This will give copious clouds of chloride of Ammonium, which are driven out]in vortex rings, on striking the elastic cloth. It has been objected that the rings thus produced do not behave as Helmholtz' mathematical results imply. It is not to be expected that they should; for Helmholtz' investigation upon vortex motion expressly assumes that the medium in which the rings are formed is a *frictionless* fluid, which air is not. The rings are truly air rings, the accompanying smoke merely serving to make them visible. This is finely shown by sending air rings from a second box against the smoke rings already formed. The invisible air rings are made manifest by the jostling of the smoke rings as they are struck by them. The suddenness of this movement is often very striking.

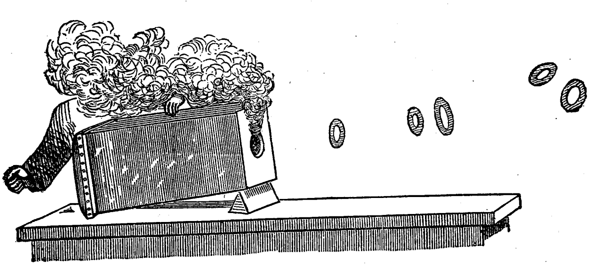

Fig. 1

quartz employed, some being right-handed and some left-handed. Certain substances such as quinine, turpentine, tartaric acid, cane

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Fig. 2, shows the direction of the motion at each point around and close to the core, or circular axis of a vortex ring. Fig. 3, shows the relation between the direction of motion of the entire ring and the direction of rotation around the core. It is seen to be in a direction "perpendicular to the plane of the ring, *towards* the side towards which the rotatory motion carries the *inner* parts of the ring." The *direction* of the motion of the fluid in which the vortex ring exists, at different distances from the *axis of the ring*, both within the ring and without it, corresponds to the *direction* of the lines of magnetic force around a circular conductor in which an electrical current is maintained, (like the ring of a tangent galvanometer, for example,) and the *velocities* of the fluid in various parts, will be in proportion to the *intensities* of the magnetic forces around this circular conductor, in various parts of the magnetic field, which is due to the electric current passing through the conductor.

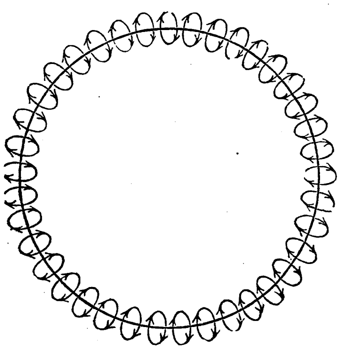

Fig. 2.

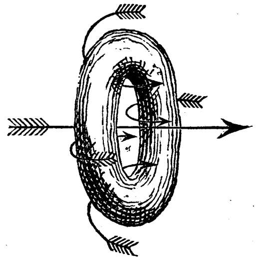

Fig. 3.

The directions of these lines of magnetic force, surrounding a circular conductor are shown in Fig. 4, taken from Prof. Clerk Maxwell's admirable treatise upon Electricity and Magnetism. The small circle represents a section of the circular conductor conveying the electric current, while the oval lines represent the lines of magnetic force surrounding it. Were the conductor merely a straight wire, the lines of magnetic force would be circles surrounding it.

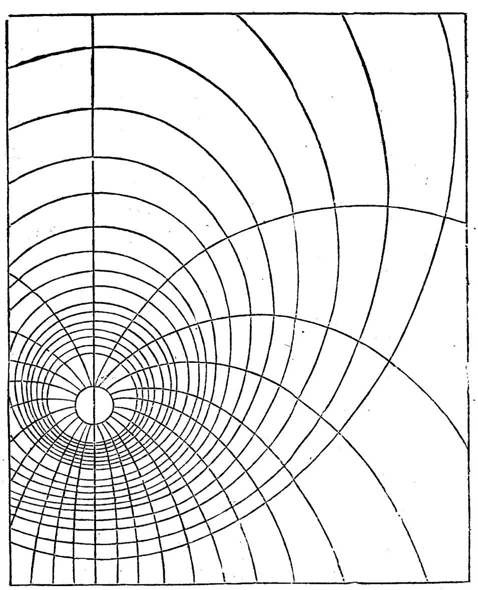

Fig. 4.

and other sugars, are also known to possess this property to a greater or less degree.

Here the conductor is supposed to be bent in a ring placed vertically, and the plane of the paper, a section through it. The section and lines of one side only are shown. These lines would therefore represent the directions of the lines of flow in the fluid surrounding a vortex ring of which the small circle is a section of the core. The intensity of the magnetic force at any point of one of these lines would also be proportional to the velocity of the fluid at a corresponding point around the vortex.

Perhaps Figs. 5 and 6 will help to a better under standing of the relations contemplated.

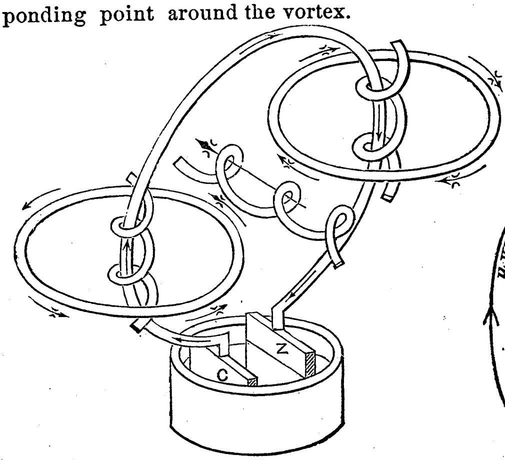

Fig. 5.

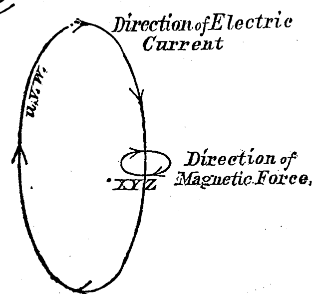

Fig. 6

The behaviour of two vortex rings gyrating in the same or in opposite directions, in a frictionless fluid, are shown for rings gyrating in the *same* direction by Nos. 1, 2, 3 and 4 of Fig. 7;

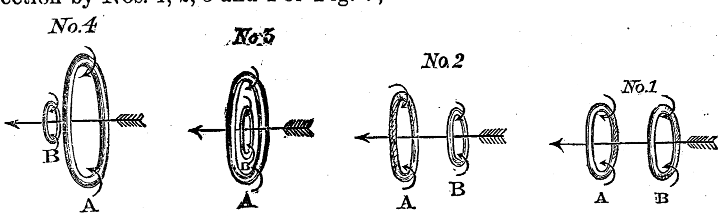

Fig. 7.

and for rings gyrating in *opposite* directions by Nos. 1, 2 and 3 of Fig. 8.

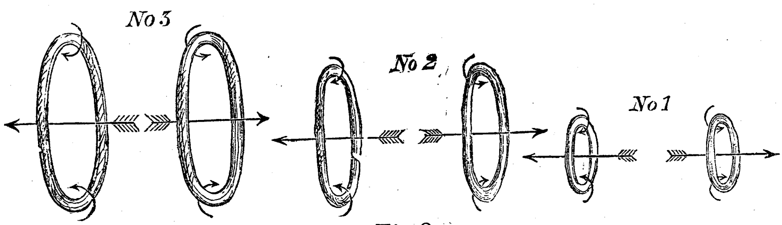

Fig. 8.

Faraday, in 1845, showed that this rotation of the azimuth of vibration could also be produced in substances not otherwise possessing it, by subjecting them to strong electro-magnetic influence, something after the manner shown in Fig. 9, where N is the polar-

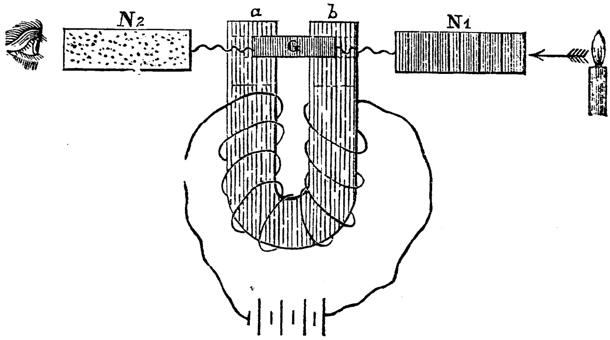

Fig. 9.

izer which reduces the vibrations to a definite azimuth; G is the substance subjected to electro-magnetic strain; *a* and *b* are the

"Where the rings have equal radii and equal and opposite angular velocities, they will approach each other and widen one another; so that finally when they are very near each other, their velocity of approach becomes continually smaller and smaller, and their rates of widening faster and faster. If they are perfectly symmetrical, the velocity of fluid elements midway between them, parallel to the axis, is zero, and here we might imagine a rigid plane to be inserted, which would not disturb the motion, and so obtain the case of a vortex ring which encounters a fixed obstacle. If the rings have the same direction of rotation, they travel in the same direction; the foremost widens and travels more slowly, the pursuer shrinks and travels faster, till finally, if their velocities are not too different, it overtakes the first and penetrates it. So the rings pass through each other alternately."

In Fig. 7, No. 1 represents the rings rotating in the same direction at starting; No. 2 shows the forward ring, *A*, slackening its speed and dilating; No. 3, the *B* ring contracting, accelerating its speed and passing through. Ring *B* then slackens its speed, and dilates in turn, while *A* contracts.

In Fig. 8, the gradual approach of the rings gyrating oppositely is not well shown. The long arrows are intended to show the direction in which the rings *would* move, in virtue of their respective rotations, *were they not influenced by each other.*

The motions of the fluids at various points surrounding a vortex filament in the shape of a ring, are best traced by means of Elliptic Integrals of the two poles of the electro-magnet, bored through for the reception of the substance and the passage of the light, and N_2 is the analyzer by which the position of the azimuth of the light reaching it is determined. When G is a determinate length of "heavy glass" (a silico-borate of lead), the analyzer requires a rotation of 6° on producing the electro-magnetism, in order to be placed in the same relation to the azimuth of vibration of the light reaching it, as it was in, before the circuit was closed. That is, if the position of the analyzer is such before the electro-magnetic circuit is closed, that the field is dark, on closing the circuit, and thus placing the glass in a strong field of magnetic force, the azimuth of the polarized light is so changed that a perceptible amount gets through, and the analyzer must be rotated 6° in order to again cut it off and render the field dark as before. This angle through which the light is turned, is, however, in addition to the length of the stratum of the medium through which it is compelled to pass, directly proportional to the strength of the current producing the magnetism (or rather to that resolved part of the magnetic force produced by the current, which is in the direction of the ray). The amount of the rotation also depends upon the refractive energy of the medium subjected to the magnetic strain. The relation is sometimes stated thus: "The angular rotation of the plane of polarization is numerically equal to the amount by which the magnetic potential increases from the point at which the ray enters the medium to that at which it leaves it, multiplied by a coëfficient, which, for diamagnetic media (like glass), is generally positive."— Maxwell.

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first and second kind. An elementary discussion of the principal features of vortex motion, involving only the simplest Quarternion notions, is given in Prof. Clifford's recently published "Elements of Dynamics — Part I," page 191, *et seq.* Sir Wm. Thompson has also published an extensive paper in the Trans. of the Royal Soc., Edin. Vol. 8 for 1869, in which many new theories are established and many illustrations of vortex motions in fluids are given, by means of real or or ideal electro-magnets variously arranged. A summary of several of these theories and analogies will be found in Thompson's "Reprint of Papers on Electro-statics, and Magnetism."—London, 1872. An earlier paper, suggesting the idea of *vortex atoms*, was published in Vol. 34, p. 15, of the Phil. Mag., 1867. London, Dublin and Edinburgh.

Under the same circumstances, where "heavy glass" would produce a rotation of 6°, Bisulphide of Carbon would produce a rotation of 3°; flint glass, 2° 8′; rock salt, 2° 2′; water, 1°.

The behavior of a large number of substances under the simultaneous influence of magnetism and circularly polarized light of different colors was examined by Verdet in 1863. He found the results of his experiment to agree very well with the formula:

$$\theta = mc\gamma \frac{i^2}{\lambda^2}\left(i - \lambda \frac{di}{d\lambda}\right) \ldots\ldots\ldots (1.)$$

where θ is the angular rotation of the plane of polarization; m a constant (the coëfficient of *magnetic* rotation of the medium); γ the intensity of the magnetic force resolved in the direction of the ray; c the length of the ray within the medium; λ the wave length in air, of the particular kind of light employed; i its index of refraction in the medium.

For Creosote there was considerable deviation from the formula. On account of the mixed nature of Creosote, being an aggregate of Carbolic Acid and several other substances, this might have been expected, even if the above were the true formula representing the relation between the rotation, magnetic force, wave length, and refractive index.

Verdet has summed up his results as follows:

1st. "The magnetic rotations of the planes of polarization for light of different colors are approximately as the inverse square of the wave length of the light employed.

2nd. "The *exact* law is that the product of the rotation of the square of the wave length, increases from the least refrangible to the most refrangible end of the spectrum."

3rd. "The substances for which this increase is most sensible are also those which have the greatest dispersive power."

The formula (1) may be derived from the following more general formula

$$\theta = - c\gamma \frac{dq}{d\gamma} = \frac{4\pi C}{v\rho} c \sqrt{\frac{i^2}{\lambda^2}} \left(i - \lambda \frac{di}{d\lambda}\right) \frac{1}{1 - 2\pi C\gamma \dfrac{i^2}{v\rho\lambda}} \ldots (2.)$$

which Prof. Clerk Maxwell has shown to be a consequence of Sir Wm. Thompson's assumption that the only dynamical explanation possible for the magnetic rotation of the plane of polarized light is that, in magnetization there must be molecular electrical currents, and that the components of these currents can be dynamically compounded with the angular velocity acquired by an element of the medium, during the passage through it of a ray of circularly-polarized light.

On making in formula (2), $m = \frac{4\pi C}{v\rho}$, and neglecting $2\pi C\gamma \frac{i^2}{v\rho\lambda}$,

because it is very small, being essentially the amount of the rotation of the plane of polarization after passing through a thickness of the medium only equal to half a wave length of the light employed, we have formula (1).

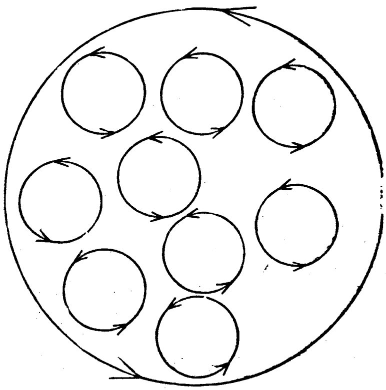
Before showing the manner in which formula (2) is derived by Maxwell, from Thompson's explanation of the magnetic rotation of the plane of polarized light, it may be best to recall one or two elementary propositions relating to polarized light, and also to circular motion. In the first place, *experiment* shows that two rays of light circularly polarized in opposite directions, and of the same intensity, become, when united, a plane polarized ray, the plane of polarization of which will depend upon whether the periods of the component circular vibrations are the same or not. If, from any cause, the phase of one of the circularly-polarized rays is accelerated, then the plane of polarization of the resultant ray, is turned round through an angle equal to half the angle of acceleration of the phase.

So also in certain cases, such as reflection from metallic surfaces, or total reflection in glass at certain angles, as in Fresnel's rhombs, or in the passage of light through thin laminæ of double refracting crystals, as in quarter-wave laminæ of mica, two plane vibrations may give rise to one circular one, right handed or left-handed, according as one or the other plane component is advanced in phase by a quarter of a complete oscillation.

This is only what might be expected from the well-known theorem in pure motion, that "two uniform circular vibrations of the same amplitude, having the same periodic time and in the same plane, but revolving in opposite directions, are equivalent, when compounded together, to a rectilinear vibration. The periodic time of this plane vibration is equal to that of the circular vibrations, its amplitude is double, and its direction is in the line joining the points at which two particles describing the circular vibrations, in opposite directions round the same circle, would meet."

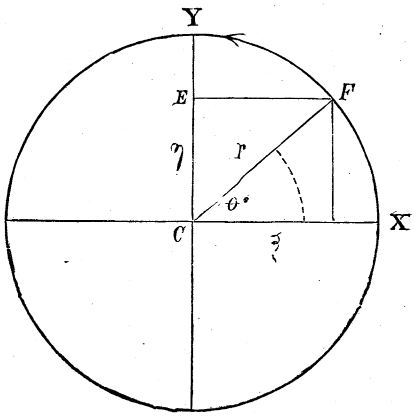
The theorem may be illustrated as follows:

Fig. 10.



If, in any space like that represented in Fig. 10, we have a great number of *spins*, more or less completely filling the space enclosed by the larger circle, and about axes perpendicular to the plane of the paper, the resultant will be equivalent to a spin of definite magnitude about some single axis likewise perpendicular to the to the plane of the paper; the magnitude of this *resultant spin* being determined by the intensity, relative distances, and number, of the component spins which go to make it up. Regarding this resultant spin only, the velocity of a particle at any distance from the axis can be decomposed into component velocities, as in Fig. 11, where the uniform circular motion of F, from X to Y, can be decomposed into $\xi = r. \cos \theta$ and $\eta = r. \sin \theta$, in such a manner that the motion of D, to and fro on the line X, and the motion of E to and fro on on the line Y, correspond constantly in position to the motion of F around the circle. In such a case, we say that the *circular* harmonic motion of F is compounded of two *rectilinear* harmonic motions along X and Y, of equal periods and amplitude, but differing by

Fig. 11.



a quarter of a complete oscillation. If there be two equal and opposite tendencies operating upon F, one to carry it toward Y, and the other toward X, the result will be, that the tangential tendencies at F will neutralize each other, while the normal components will coincide and carry the particle towards C along r (Fig. 11), and a rectilinear motion will be the result, as in Fig. 12 or Fig. 13. Thus two tendencies to gyrate in opposite directions may result in mere rectilinear vibrations. If one of these tendencies be stronger than the other, so that of itself it would produce a more rapid rotation in *its* direction, than the other component in its, then the motion will be elliptical in an orbit of which the major axis changes at each complete oscillation by some angle θ, the magnitude of which will depend upon the excess of velocity in one direction over that in the opposite. This is easily seen by reference to Figs. 14 or 15, where the motion would be along *ab*, were both circular components equal, whereas the

Fig. 13.

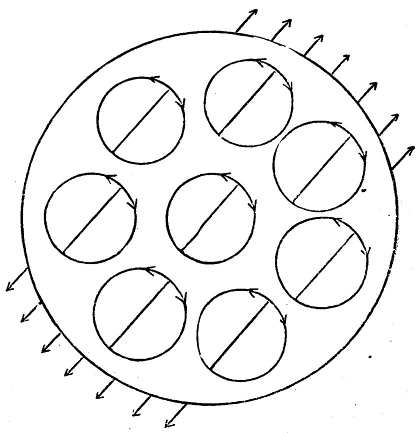


Fig. 12.

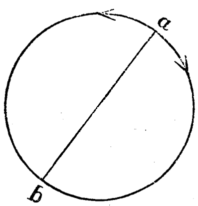


Fig. 15.[1]

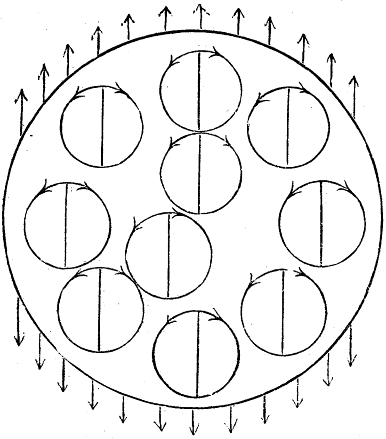
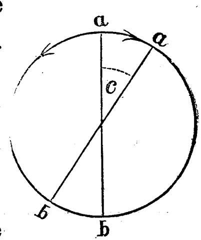


Fig. 14.[2]



[1] The engraver has very imperfectly copied the original drawings for this as for some of the other figures.

[2] For *c* in the figure, read θ, and for *a* and *b* at the extremities of one of the diameters, read *a'* and *b'*, respectively.

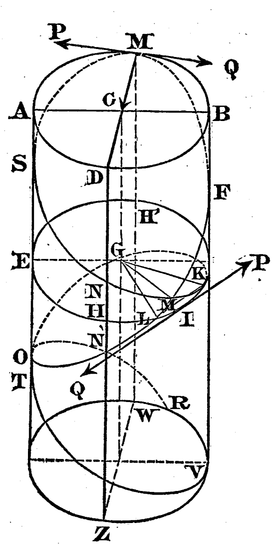
excess of that towards a' carries towards a' during the first part of the virtual motion along ab, and towards b' during the part from θ to b; that is, on account of the shorter time required to complete an oscillation in the direction from a' to b', around the circle, than in the opposite direction, there is an acceleration of phase in that direction. Hence, as long as the tendency to increased rapidity of one component over that of the other continues, so long will there be a change in the position of the line ab.

The application of these principles to the rotation of the plane of polarization as it occurs in quartz, will be clearly shown by the following extract and diagram, taken from Prest. Barnard's excellent "Lectures on the Undulatory Theory of Light," Smithsonian Annual Report for 1862.

After a general discussion of circular and elliptical polarization *by reflection*, Prest. Barnard says:

"We are now perhaps prepared to understand the reason of the rotation of the plane of polarization of a ray transmitted along the axis of a crystal of quartz. We have seen that Fresnel, by an ingenious combination of prisms, succeeded in demonstrating the existence within the crystal of two circularly polarized rays, gyrating in opposite directions. And we have seen that the resultant effect of two opposite gyrations, is to produce a movement in a plane. The gyratory movements within the crystal are then not *actual* but *virtual*—in other words, there are forces constantly tending to produce these gyrations, which hold each other *in equilibrio*, or at least nearly so. We must consider these forces as successively traversing all azimuths within the length of each undulation. If the wave were of the same length in both gyrations, the forces being presumed equal, the molecular movement would be constantly rectilinear, and the plane of polarization would not change. But, as the plane does in fact change, we are led to infer

Fig. 16.



that the undulation lengths for the two rays are *not* equal. The annexed figure may serve to illustrate the mutual action of these rays. Suppose M A D B, to be the orbit in which a force P tends to urge a molecule M, to revolve around the center C, to which it is drawn by the force M C. Suppose the equal force Q to urge the same molecule to describe the same orbit in the opposite direction. These forces holding each other *in equilibrio*, the molecule will follow the direction of the third force, M C.

Now suppose the force Q suspended, the molecule will take the direction of the circle A D B, and will continue to revolve in it so long as the force P (supposed always tangential) continues to act. But its movemehts will impart to the molecule next below it a similar motion, and that to the next, and so on; so that, as these successive molecules take up their movements later and later, there will be a series in different degrees of advancement in their several circles, forming a spiral; and when the molecule M shall have returned to its original position, the series will occupy a position like the curve M F L N′ O R. If, now, P be supposed to be in turn suspended, while the force Q continues to act, the effect of Q will be to produce a contrary spiral, which may be represented by M S K T V. If M D be a diameter of the circle M A D B, drawn from M, and D H N′ be a line parallel to the axis C G of the cylindrical surface, which is the locus of the spirals, then, if the undulating lengths are the same for both movements, the two spirals will intersect D H in the same point, the intersection marking the completions of a half undulation for each. But if these lengths be unequal, the intersection with D H will take place at different points as N and N′.

Let now a plane intersect the cylinder at any distance below M A D B, as at E, parallel to M A D B. It is conceivable that this plane may be made to pass through the point where the spirals intersect each other. If I mark the point of intersection, and we draw the tangents I P′ and I Q′ in the plane of the circle E H I, then there will be a molecule at the point I which will be in the circumstances of the molecule in [Fig. 12 at the point *a*] — that is to say, solicited by three forces, of which two, I P′ and I Q′ are equal and opposite, and the third is directed in the line I G towards the center. The molecule will, therefore move in this line, and not in a circle; and if the plane of the circle E H I H′ be the bounding surface of the crystal, or the surface of emergence of the light, I G will mark the azimuth of the molecular movements of the emergent ray.

But if the planes of E H I H′ do not pass through the point of intersection of the spirals it must cut each spiral in a different point. The figure is drawn to represent this more general case, the points of intersection with the spirals being severally L and K.

By joining L K and drawing the radius G I perpendicular to it, G I will bisect the angle G L K and M′, at the intersection of G I and L K will be the position of the molecule in the plane E H L I K, which, if the tangential force P only were acting, would be at L, and if the tangential force Q only were acting, would be at K. The tangential forces acting at the moment on this molecule will not be represented by I P′ and I Q′, but will be tangents at K and L.

Now, as D H, the distance between the planes A D B and E H I, is a larger part of the length of an entire turn of the spiral M S N K than of the spiral M F L N′, the line G I will fall on the right of G H, the position it would occupy if the two undulations were equal in length. We may therefore say, as before, that if the plane E H I were the surface of emergence of a ray from a crystal, in which it had been subject to the action of the forces supposed, its plane of polarization, G I, would be turned towards the right from its original azimuth. The plane of polarization turns, therefore, in the direction of the *winding* of the closest spiral, or of the ray of shortest undulation; but it turns in the direc tion of the *gyration* of the ray of longest undulation.

This rotation of the plane, thus demonstrates that the two rays advance with unequal velocities in the axis of quartz — a remarkable fact which is not true of any crystal which produces plane polarization only. It also enables us to determine the relative velocities, or to ascertain the *index* of rotatory polarization. For since G I bisects the angle between the points K and L, which mark the relative degrees of advancement of the two rays in their respective rotations, if we take a thickness θ, which produces a rotation of 90°, we know that the difference of phase is then one-half an undulation. If λ denote the length of the longer undulation, and λ', that of the shorter, then —

$$\theta = m\lambda = (m + \tfrac{1}{2})\lambda'; \text{ or } \frac{\lambda}{\lambda'} = \frac{m + \frac{1}{2}}{m} = \frac{2m+1}{2m}$$

As $\frac{\theta}{\lambda} = m$, and λ may be determined by experiments in refraction, the value of m is known when θ is measured. By pursuing this method, Mr. Babinet found the value of $\frac{\lambda'}{\lambda} = 1.00003$; a value which, small as it is, is the largest known for [non-magnetic] rotatory polarization."

The first mathematical explanation of rotatory polarization as it occurs in quartz, appears to have been given by MacCullagh, in 1836 (Trans. R. Irish Acad., XVII). He succeeded perfectly in explaining the phenomena as they occur in uniaxial crystals, by introducing into the ordinary equations of vibratory motion in fluids, terms of the form $c\,\frac{d^3\eta}{dz^3}$. So that the equations become:

$$\frac{d^2\xi}{dt^2} = b^2\,\frac{d^2\xi}{dz^2} + c\,\frac{d^3\eta}{dz^3}$$

$$\frac{d^2\eta}{dt^2} = b^2\,\frac{d^2\eta}{dz^2} - c\,\frac{d^3\xi}{dz^3}$$

Cauchy also appears to have furnished similar equations to M. Jamin, at the request of the latter, who compared them carefully with experiments, and found a perfect agreement so far as uniaxial crystals are concerned (Verdet–Lecons D'Optique Physique, Vol. II, p. 323). For biaxial crystals Verdet says: "*La methode de MacCullagh est tres remarquable : c'est un bel exemple de ce qu' on peut faire quand on est réduit à de simples conjectures.*"

The matter has since been treated by M. Briot in an "*Essai sur la theorie mathematique de la lumiere.*" He supposes a forced distribution of the ether in rotatory crystals, so that the lines of ethereal molecules are arranged in elliptic helices. This supposition introduces into the differential equations of vibratory movement, differential coefficients of odd orders, the presence of which indicates the rotatory power.

Airy has suggested similar equations for the rotation produced by *magnetism*, "not as giving a *mechanical explanation* of the phenomena, but as showing that the phenomena may be explained by equations, which equations appear to be such as might possibly be deduced from some plausible mechanical assumption, although no such assumption has been made."

This explanation of what rotatory polarization is, as it occurs in bodies which of themselves rotate the plane of polarization, may help to an understanding of the manner in which an electric current, circulating around a medium through which circularly polarized light is passing, may possibly affect the velocity of either circular component of the polarized light, and thus, according as the direction of the current is *with* a circular component, as in Fig. 16, or *against* it, as in Fig. 17, produce a right-handed or a left-handed rotation, according to the direction in which the current circulates around the medium.

Fig. 16.

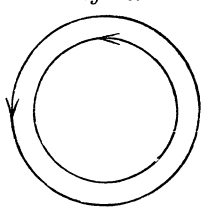
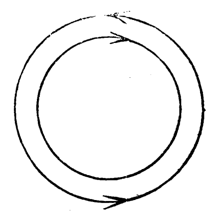


Fig. 17.



Of this latter, Sir Wm. Thompson, in 1856, made the important observation,[1] which Prof. Clerk Maxwell has elaborated into the

[1] "The magnetic influence on light, discovered by Faraday, depends on the direction of motion of moving particles. For instance, in a medium possessing it, particles in a straight line parallel to the lines of magnetic force, displaced to a helix round this line as axis, and then projected tangentially with such velocities as to describe circles, will have different velocities, according as their motions are round in one direction (the same as the nominal direction of the galvanic current in the magnetizing coil) or in the contrary direction. But the elastic reaction of the medium must be the same for the same displacements, whatever be the velocities and directions of the particles; that is to say, the forces which are balanced by centrifugal force of the circular motions are equal, while the luminiferous motions are unequal. The absolute circular motions being therefore either equal or such as to transmit equal centrifugal forces to the particles initially considered, it follows that the luminiferous motions are only components of the whole motion; and that a less luminiferous component in one direction, compounded with a motion existing in the medium when transmitting no light, gives an equal resultant to that of a greater luminiferous motion in the contrary direction compounded with the same non-luminous motion. I think it is not only impossible to conceive any other than this dynamical explanation of the fact that circularly-

fundamental equation with which we began this article, and which the experiments of Verdet so remarkably corroborate.

"The disturbance which constitutes light, whatever its physical nature may be, is of the nature of a vector, perpendicular to the direction of the ray. This is proved from the fact of the interference of two rays of light, which, under certain conditions, produces darkness, combined with the fact of the non-interference of two rays polarized in planes perpendicular to to each other. For, since the interference depends on the angular position of the planes of polarization, the disturbance must be a directed quantity or vector, and since the interference ceases when the planes of polarization are at right angles, the vector representing the disturbance must be perpendicular to the line of intersection of these planes, that is, to the direction of the ray.

The disturbance, being a vector, can be resolved into components parallel to x and y, the axis of z being parallel to the direction of the ray. Let ξ and η be these components; then, in the case of a ray of homogeneous circularly-polarized light,

$$\xi = r\cos\theta, \qquad \eta = r\sin\theta, \tag{1}$$

where

$$\theta = nt - qz + a. \tag{2}$$

In these expressions, r denotes the magnitude of the vector, and θ the angle which it makes with the direction of the axis of x.

The periodic time, τ, of the disturbance is such that

$$n\tau = 2\pi. \tag{3}$$

The wave-length, λ, of the disturbance is such that

$$q\lambda = 2\pi. \tag{4}$$

The velocity of propagation is $\dfrac{n}{q}$.

The phase of the disturbance when t and z are both zero is a.

The circularly-polarized light is right-handed or left-handed according as q is negative or positive.

---

polarized light transmitted through magnetized glass, parallel to the lines of magnetizing force, with the same quality, right-handed always or left-handed always, is propagated at different rates, according as its course is in the direction or is contrary to the direction in which a north magnetic pole is drawn; but I believe it can be demonstrated that no other explanation of that fact is possible. Hence it appears that Faraday's optical discovery affords a demonstration of the reality of Ampere's explanation of the ultimate nature of magnetism." — Sir Wm. Thompson.

Its vibrations are in the positive or the negative direction of rotation in the plane of (x, y), according as n is positive or negative.

The light is propagated in the positive or the negative direction of the axis of z, according as n and q are of the same or of opposite signs.

In all media n varies when q varies, and $\frac{dn}{dq}$ is always of the same sign with $\frac{n}{q}$.

Hence, if for a given numerical value of n, the value of $\frac{n}{q}$ is greater when n is positive than when n is negative, it follows that for a given value of q, given both in magnitude and sign, the positive value of n will be greater than the negative value.

Now this is what is observed in a diamagnetic medium, acted on by a magnetic force, γ, in the direction of z. Of the two circularly-polarized rays of a given period, that is accelerated of which the direction of rotation in the plane of (x, y) is positive. Hence, of two circularly polarized rays, both left-handed, whose wave-length within the medium is the same, that has the shortest period whose direction of rotation in the plane of (x, y) is positive, that is, the ray which is propagated in the positive direction of z from south to north. We have, therefore, to account for the fact that when in the equations of the system q and r are given, two values of n will satisfy the equations, one positive and the other negative, the positive value being numerically greater than the negative.

We may obtain the equations of motion from a consideration of the potential and kinetic energies of the medium. The potential energy, V, of the system, depends on its configuration, that is, on the relative position of its parts. In so far as it depends on the disturbance due to circularly-polarized light, it must be a a function of r, the amplitude, and q, the coefficient of torsion, only. It may be different for positive and negative values of q of equal numerical value, and it probably is so in the case of media, which of themselves rotate the plane of polarization.

The kinetic energy, T, of the system, is a homogeneous function of the second degree of the velocities of the system, the coefficients of the different terms being functions of the coordinates.

Let us consider the dynamical condition that the ray may be of constant intensity, that is, that r may be constant.

Lagrange's equation for the force in r becomes

$$\frac{d}{dt}\left(\frac{dT}{dr}\right) - \frac{dT}{dr} + \frac{dV}{dr} = 0. \qquad (5)$$

Since r is constant the first term vanishes. We have therefore the equation

$$-\frac{dT}{dr} + \frac{dV}{dr} = 0. \qquad (6)$$

in which q is supposed to be given, and we are to determine the value of the angular velocity θ, which we may denote by its actual value, n.

The kinetic energy, T, contains one term involving n^2; other terms may contain products of n with other velocities, and the rest of the terms are independent of n. The potential energy, V, is entirely independent of n. The equation is, therefore of the form

$$An^2 + Bn + C = 0. \qquad (7)$$

This being a quadratic equation, gives two values of n. It appears from experiment that both values are real, that one is positive and the other negative, and that the positive value is numerically the greater. Hence, if A is positive, both B and C are negative; for, if n_1 and n_2 are the roots of the equation,

$$A\,(n_1 + n_2) + B = 0. \qquad (8)$$

The coefficient B, therefore, is not zero, at least when magnetic force acts on the medium. We have, therefore, to consider the expression Bn, which is the part of the kinetic energy involving the first power of n, the angular velocity of the disturbance.

Every term of T is of two dimensions as regards velocity. Hence the terms involving n must involve some other velocity. This velocity cannot be r or q, because, in the case we consider, r and q are constant. Hence it is a velocity which exists in the medium independently of that motion which constitutes light. It must also be a velocity related to n in such way that when it is multiplied by n the result is a scalar quantity, for only scalar quantities can occur as terms in the value of T, which is itself scalar. Hence this velocity must be in the same direction as n, or in the opposite direction, that is, it must be an *angular velocity* about the axis of z.

Again, this velocity cannot be independent of the magnetic force, for if it were related to a direction fixed in the medium, the phenomenon would be different if we turned the medium end for end, which is not the case.

We are therefore led to the conclusion that this velocity is an invariable accompaniment of the magnetic force in those media which exhibit the magnetic rotation of the plane of polarization.

We have been hitherto obliged to use language which is, perhaps, too suggestive of the ordinary hypothesis of motion in the undulatory theory. It is easy, however, to state our result in a form free from this hypothesis.

Whatever light is, at each point of space there is something going on, whether displacement or rotation, or something not yet imagined, which is certainly of the nature of a vector or directed quantity, the direction of which is normal to the direction of the ray. This is completely proved by the phenomenon of interference.

In the case of circularly-polarized light, the magnitude of this vector remains always the same, but its direction rotates round the direction of the ray so as to complete a revolution in the periodic time of the wave. The uncertainty which exists as to whether this vector is in the plane of polarization or perpendicular to it, does not extend to our knowledge of the direction in which it rotates in right handed and left handed circularly-polarized light respectively. The direction and the angular velocity of this vector are perfectly known, though the physical nature of the vector and its absolute direction at a given instant are uncertain.

When a ray of circularly-polarized light falls on a medium under the action of magnetic force, its propagation within the medium is affected by the relation of the direction of rotation of the light to the direction of the magnetic force. From this we conclude that in the medium, when under the action of magnetic force, some rotatory motion is going on, the axis of rotation being in the direction of the magnetic forces; and that the rate of propagation of circularly-polarized light, when the direction of its vibratory rotation and the direction of the magnetic rotation of the medium are the same, is different from the rate of propagation when these direc tions are opposite.

The only resemblance which we can trace between a medium through which circularly-polarized light is propagated, and a medium through which lines of magnetic force pass, is that in both there is a motion of rotation about an axis. But here the resemblance stops, for the rotation in the optical phenomenon is that of the vector which represents the disturbance. This vector is always perpendicular to the direction of the ray, and rotates about it a known number of times in a second. In the magnetic phenomenon, that which rotates has no properties by which its sides can be distinguished, so that we cannot determine how many times it rotates in a second.

There is nothing, therefore, in the magnetic phenomenon which corresponds to the wave-length and the wave-propagation in the optical phenomenon. A medium in which a constant magnetic force is acting, is not, in consequence of that force, filled with waves traveling in one direction, as when light is propagated through it.

The only resemblance between the optical and the magnetic phenomenon is, that at each point of the medium something exists of the nature of an angular velocity about an axis in the direction of the magnetic force.

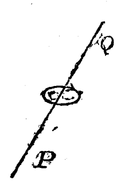
ON THE HYPOTHESIS OF MOLECULAR VORTICES.

The consideration of the action of magnetism upon polarized light leads, as we have seen, to the conclusion that in a medium under the action of magnetic force something belonging to the same mathematical class as an angular velocity, whose axis is in the direction of the magnetic force, forms a part of the phenomenon.

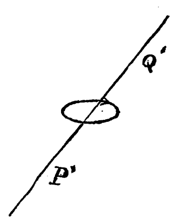
This angular velocity cannot be that of any portion of the medium of sensible dimensions rotating as a whole. We must, therefore, conceive the rotation to be that of very small portions of the medium, each rotating on its own axis. This is the hypothesis of molecular vortices.

The motion of these vortices, though, as we have shown, it does not sensibly affect the visible motions of large bodies, may be such as to affect that vibratory motion on which the propagation of light, according to the undulatory theory, depends. The displacements of the medium, during the propagation of light, will produce a disturbance of the vortices, and the vortices, when so disturbed, may re-act on the medium so as to affect the mode of propagation of the ray.

It is impossible, in our present state of ignorance as to the nature of the vortices, to assign the form of the law which connects the displacement of the medium with the variation of the vortices. We shall therefore assume that the variation of the vortices, caused by the displacement of the medium, is subject to the same conditions which Helmholtz, in his great memoir on Vortex-motion, has shown to regulate the variation of the vortices of a perfect liquid.



Helmholtz's law may be stated as follows: — Let P and Q be two neighboring particles in the axis of a vortex, then, if in consequence of the motion of the fluid these particles arrive at the points P' Q', the line P' Q' will represent the new direction of the axis of the vortex, and its strength will be altered in the ratio of P' Q' to P Q.



Hence if α, β, γ denote the components of the strength of the vortex, and if ξ, η, ζ denote the displacements of the medium, the value of α will become

$$\left.\begin{aligned} \alpha' &= \alpha + \alpha \frac{d\xi}{dx} + \beta \frac{d\xi}{dy} + \gamma \frac{d\xi}{dz} \\ \beta' &= \beta + \alpha \frac{d\eta}{dx} + \beta \frac{d\eta}{dy} + \gamma \frac{d\eta}{dz} \\ \gamma' &= \gamma + \alpha \frac{d\zeta}{dx} + \beta \frac{d\zeta}{dy} + \gamma \frac{d\zeta}{dz} \end{aligned}\right\} \qquad (1)$$

We now assume that the same condition is satisfied during the small displacements of a medium in which α, β, γ represent, not the components of the strength of an ordinary vortex, but the components of magnetic force.

The components of the angular velocity of an element of the medium are

$$\left.\begin{aligned} \omega_1 &= \tfrac{1}{2}\frac{d}{dt}\left(\frac{d\zeta}{dy}-\frac{d\eta}{dz}\right),\\ \omega_2 &= \tfrac{1}{2}\frac{d}{dt}\left(\frac{d\xi}{dz}-\frac{d\zeta}{dx}\right),\\ \omega_3 &= \tfrac{1}{2}\frac{d}{dt}\left(\frac{d\eta}{dx}-\frac{d\xi}{dy}\right). \end{aligned}\right\} \qquad (2)$$

The next step in our hypothesis is the assumption that the kinetic energy of the medium contains a term of the form:

$$2\,C\,(a\omega_1 + \beta\omega_2 + \gamma\omega_3). \qquad (3)$$

This is equivalent to supposing that the angular velocity acquired by the element of the medium during the propagation of light is a quantity which may enter into combination with that motion by which magnetic phenomena are explained.

In order to form the equations of motion of the medium, we must express its kinetic energy in terms of the velocity of its parts, the components of which are $\frac{d\xi}{dt}, \frac{d\eta}{dt}, \frac{d\zeta}{dt}$. We therefore integrate by parts, and find

$$2\,C\iiint(a\omega_1 + \beta\omega_2 + \gamma\omega_3)\,dx\,dy\,dz$$

$$= C\iint\left(\gamma\frac{d\eta}{dt}-\beta\frac{d\zeta}{dt}\right)dy\,dz + C\iint\left(a\frac{d\zeta}{dt}-\gamma\frac{d\xi}{dt}\right)dz\,dx$$

$$+ C\iint\left(\beta\frac{d\xi}{dt}-a\frac{d\eta}{dt}\right)dx\,dy + C\iiint\left\{\frac{d\xi}{dt}\left(\frac{d\gamma}{dy}-\frac{d\beta}{dz}\right)\right.$$

$$\left.+\frac{d\eta}{dt}\left(\frac{da}{dz}-\frac{d\gamma}{dx}\right)+\frac{d\zeta}{dt}\left(\frac{d\beta}{dx}-\frac{da}{dy}\right)\right\}dx\,dy\,dz. \qquad (4)$$

The double integrals refer to the bounding surface, which may be supposed at an infinite distance. We may, therefore, while investigating what takes p'ace in the interior of the medium, confine our attention to the triple integral.

The part of the kinetic energy in unit of volume, expressed by this triple integral, may be written

$$4\pi C\left(\frac{d\xi}{dt}u+\frac{d\eta}{dt}v+\frac{d\zeta}{dt}w\right),\tag{5}$$

where u, v, w are the components of the electric current.

It appears from this that our hypothesis is equivalent to the assumption that the velocity of the particle of the medium whose components are $\frac{d\xi}{dt}$, $\frac{d\eta}{dt}$, $\frac{d\zeta}{dt}$, is a quantity which may enter into combination with the electric current whose components are u, v, w.

Returning to the expression under the sign of triple integration in (4), substituting for the value of α, β, γ, those of α', β', γ', as given by equation (1), and writing

$$\frac{d}{dh}\text{ for }\alpha\frac{d}{dx}+\beta\frac{d}{dy}+\gamma\frac{d}{dz};\tag{6}$$

the expression under the sign of integration becomes

$$C\left\{\frac{d\xi}{dt}\frac{d}{dh}\left(\frac{d\zeta}{dy}-\frac{d\eta}{dz}\right)+\frac{d\eta}{dt}\frac{d}{dh}\left(\frac{d\xi}{dz}-\frac{d\zeta}{dx}\right)+\frac{d\zeta}{dt}\frac{d}{dh}\left(\frac{d\eta}{dx}-\frac{d\xi}{dy}\right)\right\}\tag{7}$$

In the case of waves in planes normal to the axis of z the displacements are functions of z and t only so that $\frac{d}{dh}=\gamma\frac{d}{dz}$, and this expression is reduced to

$$C\gamma\left\{\frac{d^2\xi}{dz^2}\frac{d\eta}{dt}-\frac{d^2\eta}{dz^2}\frac{d\xi}{dt}\right\}\tag{8}$$

The kinetic energy per unit of volume, so far as it depends on the velocities of displacement, may now be written

$$T=\tfrac{1}{2}\rho\left\{\frac{d\xi}{dt}+\eta^2+\zeta^2\right\}+C\gamma\left\{\frac{d^2\xi}{dz^2}\frac{d\eta}{dt}-\frac{d^2\eta}{dz^2}\frac{d\xi}{dt}\right\},\tag{9}$$

where ρ is the density of the medium.

The components, X and Y, of the impressed force, referred to unit of volume, may be deduced from this by Lagrange's equations

$$X=\rho\frac{d^2\xi}{dt^2}-C\gamma\frac{d^3\eta}{dz^2dt},\tag{10}$$

$$Y=\rho\frac{d^2\eta}{dt^2}-C\gamma\frac{d^3\xi}{dz^2dt},\tag{11}$$

These forces arise from the action of the remainder of the medium on the element under consideration, and must in the case of an isotropic medium be of the form indicated by Cauchy,

$$X = A_0 \frac{d^2\xi}{dz^2} + A_1 \frac{d^4\xi}{dz^4} + \text{etc.} \qquad (12)$$

$$Y = A_0 \frac{d^2\eta}{dz^2} + A_1 \frac{d^4\eta}{dz^4} + \text{etc.,} \qquad (13)$$

If we now take the case of a circularly-polarized ray for which

$$\xi = r\cos(nt - qz), \qquad \eta = r\sin(nt - qz), \qquad (14)$$

we find for the kinetic energy in unit of volume

$$T = \tfrac{1}{2}\rho r^2 n^2 - C\gamma r^2 q^2 n; \qquad (15)$$

and for the potential energy in unit of volume

$$V = r^2(A_0 q^2 - A_1 q^4 + \text{etc.}) = r^2 Q, \qquad (16)$$

where Q is a function of q^2.

The condition of free propagation of the ray given in equation (6), is

$$\frac{dT}{dr} = \frac{dV}{dr} \qquad (17)$$

which gives

$$\rho n^2 - 2C\gamma q^2 n = Q, \qquad (18)$$

whence the value of n may be found in terms of q.

But in the case of a ray of given wave-period, acted on by magnetic force, what we want to determine is the value of $\frac{dq}{d\gamma}$ when n is constant, in terms of $\frac{dq}{dn}$, when γ is constant. Differentiating (18)

$$(2\rho n - 2C\gamma q^2)\, dn - \left\{ \frac{dQ}{dq} + 4C\gamma qn \right\} dq - 2Cq^2 n\, d\gamma = 0. \qquad (19)$$

We thus find $\frac{dq}{d\gamma} = -\frac{Cq^2 n}{\rho n - C\gamma q^2} \frac{dq}{dn}$. (20)

If λ is the wave-length in air, and i the corresponding index of refraction in the medium

$$q\lambda = 2\pi i. \qquad n\lambda = 2\pi v.$$

The change in the value of q, due to magnetic action is in every case an exceedingly small fraction of its own value, so that we may write

$$q = q_0 + \frac{dq}{d\gamma}\gamma,$$

where q_0 is the value of q when the magetic force is zero. The angle, θ, through which the plane of polarization is turned in passing through a thickness, c, of the medium, is half the sum of the positive and negative values of q c, the sign of the result being changed, because the sign of q is negative in equations (14). We thus obtain

$$\theta = -c\gamma \frac{dq}{d\gamma} = \frac{4\pi C}{v\rho} c\gamma \frac{i^2}{\lambda^2} \left\{ i - \lambda \frac{di}{d\lambda} \right\} \frac{1}{1 - 2\pi C\gamma \frac{i^2}{v\rho\lambda}}$$

which is the complete form of the equation for determining the angle, through which the plane of polarization has been turned by the magnetic force while passing through a thickness of the medium equal to c, and is, in its modified form the one with which Verdet's results have been compared. From this comparison of the consequences of assuming the motions of light to be capable of composition with the motions caused by electric currents, with what experiment shows to be true of bodies conveying circularly polarized light when also placed under magnetic strain, we have probably good evidence for the opinion that some phenomenon of rotation is going on in the magnetic field, that this rotation is performed by a great number of very small portions of matter each rotating on its own axis, this axis being parallel to the direction of the magnetic force, and that the rotations of these different vortices are made to depend on one another by means of some kind of mechanism connecting them. The problem of determining the mechanism required to establish a given species of connection between the motions of the parts of a system always admits of an infinite number of solutions. Of these some may be more clumsy than others, but all must satisfy the conditions of mechanism in general."— MAXWELL — *Electricity and Magnetism*, Chap. xxi.

NOTE.— On page 246 the radical sign ($\surd$) should be the Greek letter gamma (γ), in formula No. (2).

PROCEEDINGS OF THE ACADEMY

SINCE FEBRUARY, 1876.

REPORT OF THE PRESIDENT.

To His Excellency, WILLIAM E. SMITH,

Governor of the State of Wisconsin:

SIR:—It affords me great pleasure to be able to report that the Wisconsin Academy of Sciences, Arts, and Letters is in a flourishing condition, steadily gaining in membership and usefulness.

Every college and educational institution of high grade in the state is now represented in the Academy; thus bringing together many of the ablest men in science, literature and art. The summer meetings held in Racine and Milwaukee were well attended and were instrumental in exciting a lively interest in the society and its aims. We are satisfied that in inaugurating this summer migratory meeting, the society acted wisely, and that these sessions will be productive of good.

At the Milwaukee meeting, a number of ladies were elected members, several of whom are not unknown to science and literature. In electing these ladies, the Academy has gained valuable working members and has added not a little to its well-being, intellectually as well as socially. The society acted on the broad principle that science and letters, have neither country, color or sex. The straight-jacket of superstition and bigotry no longer cramps and cripples investigation in any department of knowledge.

The report of the librarian shows the extent and value of our exchanges from this and foreign countries.

We have already formed the nucleus of a valuable library. The finances are in a healthy condition, the funds are not large, but sufficient for the workings of the society, aside from the publishing of the proceedings, which is justly done by the state.

We are in need of suitable rooms to accommodate the society, We want space sufficient to display and securely keep a cabinet such as will certainly come into our possession as soon as we have permanent accommodations.

The usefulness of the Academy will be greatly enhanced by the possession of suitable rooms for cabinet and library.

Very respectfully,

P. R. HOY, *President.*

PROCEEDINGS OF THE ACADEMY.

[Since February, 1876.]

REPORT OF THE SECRETARY.

ROOMS OF WISCONSIN ACADEMY OF SCIENCE, ARTS AND LETTERS,
CAPITOL, MADISON, WISCONSIN.

SEVENTH ANNUAL MEETING.

Held at Madison, Wisconsin.

FIRST SESSION.

February 13, 1877.

Academy met at 7:30 P. M. Usual routine of business. Prof. Davies, General Secretary, called attention to the many valuable exchanges received from foreign and American societies, and the urgent necessity of providing proper rooms and cases for them. Prof. Allen, Prof. Chamberlin and Gen. Delaplaine were appointed a committee for such purpose.

Remarks were made by Prof. Carpenter upon the death of Prof. J. H. Eaton, of Beloit, and a committee consisting of Dr. Chapin, Prof. Chamberlin, of Beloit and Dr. S. H. Carpenter, of Madison, were appointed to draw up an account of the life and work of Prof. Eaton.

A very interesting paper on a mode of illustrating Phylotaxis, by means of a model, was read by E. A. Birge, Esq., of the University of Wisconsin.

Dr. P. R. Hoy, President of the Academy, read a paper upon an elephant's tooth containing an iron bullet. He explained how the bullet sank into the pulp and appeared in another part of the tooth three feet off.

Profs. Chamberlin and Allen, and Gen. Delaplaine were appointed a committee to memorialize the Governor in regard to more ample room for the accommodation of the books and specimens of the Academy.

SECOND SESSION.

February 14, 1877.

Academy met at 9:30 A. M., President Hoy in the chair. On account of the unavoidable absence of the secretary, Hon. E. E. Woodman, of Baraboo, was chosen Secretary *pro tem.*

On motion of Prof. Davies, the following gentlemen were chosen annual members:

Dr. Clark Gapen, of Madison, Wis.
Mr. W. A. P. Morris, of Madison, Wis.
Dr. E. W. Bartlett, of Milwaukee, Wis.

W. F. Bundy, Esq., of Sauk City, read a paper on the "Crustacea of Wisconsin." Mr. James R. Stuart, of Madison, read a paper on "Art Instruction."

Prof. Davies showed the "Application of Fourier's Theorem to the Phenomena of Composite Sounds."

Adjournment, to meet at 2:30 P. M.

THIRD SESSION.

February 14, 2:30 P. M.

Gen. Ed. E. Bryant read a paper on the "Cost of Government." Dr. Clark Gapen read one on "Hereditary Insanity," which was discussed at great length by President Bascom, Prof. S. H. Carpenter and Dr. Gapen.

Prof. Wright, of Fox Lake, read a paper on "The Philosophy of History."

FOURTH SESSION.

7:30 P. M.

Mr. E. A. Birge read a finely illustrated paper upon the the habits and structure of the "Cladocera, a minute crustacean of our fresh water lakes." Many points of its structure were shown to be exceedingly curious.

Hon. E. E. Woodman, of Baraboo, read a valuable paper on "The Pipestone of Devil's Lake."

Dr. E. Andrews being detained at Chicago by important surgical cases, his paper was read by Prof. Davies. It gave a history of the present descendants of the mound-builders, considering the latter as still *not entirely extinct.* The paper elicited a great deal of discussion by Dr. Hoy, Prof. Butler, Mr. Woodman *et al.*

FIFTH SESSION.

February 15, 9:30 A. M.

Mr. E. T. Sweet read a valuable paper containing results of analysis of the Milwaukee brick clay.

The following business was then transacted: First, the summer meeting for July, 1877, was appointed to be held at Racine on the third Tuesday of July; the autumn meeting being entirely set aside for the future.

F. H. Day, M. D., of Wauwatosa, Wis.
Prof. George W. Peckham, of Milwaukee,
Prof. W. Bundy, of Sauk City,
Hon. W. C. Allen, of Racine,
Rev. H. M. Simmons, of Kenosha,

were elected as annual members.

John W. Barrow, of No. 313 E. Seventeenth street New York city was elected a corresponding member.

The following amendments to the By-laws were offered for one year's consideration, according to the provisions of the constitution. By-law No. II to be amended so as to read as follows: "The regular annual meeting to take place hereafter on the last Wednesday and Thursday of December, at Madison and the summer annual meeting to be held on the third Tuesday in July, at such place as shall be fixed upon at the regular annual meeting in December.

Special meetings may be called by the President at his discretion, or by request of any five members of the council.

By-law, Art. I, sec. 7, to be amended to make the fee of annual members three dollars in place of two.

The resignation of the Librarian was accepted, and the Secretary was requested to act as Librarian until the next election of officers.

The Department of Fine Arts was regularly organized.

Hon. Joseph Hamilton, of Milwaukee, was elected an Honorary member of the Academy. Hon. J. C. Ford, of Madison, an annual member.

The report of the treasurer was then read as follows:

WISCONSIN ACADEMY OF SCIENCE, ARTS AND LETTERS,
TREASURER'S OFFICE, *Madison*, Dec. 13, 1877.

Hon. P. R. HOY, President:

I have the honor to report the financial condition of the Academy as follows:

Total amount of fees and dues received from 58 members........	$778 25
Total fees received from 10 life members........................	1,000 00
Interest on loan	370 00
Total amount disbursed in payment of warrants, to date..........	777 97
Balance in treasury	1,370 28

Signed, GEORGE P. DELAPLAINE,
Treasurer.

The Academy then adjourned. to meet at Racine upon the 10th of July following.

FIRST SUMMER MEETING.

Held at Racine, Wisconsin.

FIRST SEMI-ANNUAL MEETING.
July 10, 11 and 12, 1877.

W. A. Germain, Acting Secretary.

FIRST SESSION.

Racine, July 10, 7:30 P. M.

The Academy met at 7:30, P M., President Hoy in the chair.

Dr. Meachem, mayor of the city, delivered an address of welcome. Rev Dr. Steele, of Appleton, responded.

Prof. Chamberlin then read a Eulogy on the late Prof. James Eaton, of Beloit, which was ordered printed in the transactions.

Rev. Dr. James DeKoven, Pres't Racine College, then read a paper on "Religion as an Element in Education."

The Academy adjourned to meet next morning at nine o'clock.

SECOND SESSION.

July 11, 9:00 A. M.

Academy met pursuant to adjournment. Minutes of the last annual meeting read.

Prof. Butler called attention to the fact that notice of Prof. Wright's paper on "Philosophy of History," had been omitted. Correction was made by the Acting Secretary.

Attention was called by President Hoy to the amendments offered at the last regular meeting.

To amend sec. 3 of the by-laws so as to read:

1. The regular annual meeting to take place on the last Wednesday and Thursday of December, at Madison, and the summer annual meeting to be held on the third Tuesday of July at such place as shall be fixed at the regular annual meeting in December.

2. Special meetings may be called by the President at his discretion, or by the request of any five members of the council.

3. Article I of sec. 7 of the constitution to be amended to make the fee of annual members three dollars in place of two dollars.

Prof. Allen moved the adoption of the amendments.

Dr. Steele moved to amend so as to read, in place of "the regular annual meeting shall take place, etc.," the following:

"The regular annual meeting shall take place during the last week of December, the days to be appointed by the council."

Amendment carried.

The resolutions were then adopted unanimously as amendments to the by-laws.

The following persons were then elected as annual members:

Rev. J. L. Jones, Janesville, Wis.
Rev. S. A. Griffith, Milwaukee.
Rev. A. P. Meade, Racine.
Rev. Dr. James DeKoven, Racine.
Prof. J. J. Elmendorf, Racine.
Prof. H. F. Oldenbage, Milwaukee.
Prof. F. W. Falk, Ph. D., Racine.
Dr. E. H. Merrell, Ripon.
Rev. G. E. Gordon, Milwaukee.
Hon. Edward Martin, Kenosha.
Prof. G. D. Swezey, A. M., Beloit.
Prof. Peter Henrickson, Beloit.
Prof. G. R. Kleeberger, Whitewater.
R. W. Reynolds, La Crosse
W. A. Germain, Delafield.
Prof. C. A. Kenaston, Ripon.
Prof. W. M. Hailman, Milwaukee.
Prof. G. W. Gerry, Ripon.
Prof. J. McMurphy, Kenosha.
Frank Head, Esq., Kenosha.
Prof. J. P. Marriett, Kenosha.
Hon. J. H. Howe, Kenosha.
Dr. J. G. Meachem, Racine.
Dr. J. G. Meachem, Jr., Racine.

As Corresponding members:

Dr. C. C. Abbott, Trenton, New Jersey.
Alford Paine, S. T. D., of Hinsdale, Ill.

As Honorary member,

Prof. Spencer Baird, M. D., LL. D., of Washington, D. C.

Prof. Allen, chairman of the committee appointed to see about securing rooms for the Academy, reported that the rooms of the Railroad Commissioners could be secured in December. The report accepted, and the committee continued. Prof. Allen then read a paper on "Early Form of Land Tenure."

Dr. Falk made extended remarks on Prof. Allen's paper, and gave a review of the feudal relations in Germany.

Prof. McMurphy read a paper on "Rotation as a Factor of Motion."

The President then read the following communication from Captain Nader, C. E., on "The Balloon in Meteorology."

MADISON, Wis., June 20, 1877.

DR. P. R. HOY, Racine, Wis.:

DEAR AND RESPECTED SIR: Your very kind note of invitation of the 7th instant was duly received, and while I regret very much that I shall be unable to partake of the proffered hospitality of the people of Racine, I feel very thankful for your kind remembrance.

My duties here render my time uncertain, and occupy my attention so much that I shall not be able to attend the meeting, which no doubt will be pleasant and instructive. I shall be unable to produce anything in time. I was preparing a letter to you, when I received your note, on a subject which may be interesting, and which I will now give you as briefly as possible.

It is but a short time since an idea occurred to me which I believe to be novel, and perhaps of scientific import, and should you consider it of sufficient importance, I beg you would please present the same for discussion at the meeting.

The object is to explore the atmosphere, so far as may be practicable, without the risk of life and limb. This I propose to do in the following manner: In the first place, I resort to a gas balloon to carry up my apparatus, and since there is no danger of any irreparable damage, the same may be constructed as light as possible, even frail, I may say; and since the charge is not required to endure very long, small leaks need not be noticed, and I believe such a balloon may be constructed at a nominal cost.

Each cubic foot of gas of specific gravity, say 0.6, will displace about 530 grains of air, and deducting its weight, 32 grains, will support a weight of 498 grains, so that 1,000 cubic feet will carry about 70 pounds weight, which is the displacement of a balloon of less than 13 feet diameter.

The balloon is allowed to rise at pleasure by means of a cord of sufficient strength to support considerable more than its own weight, of the desired length or height. The lateral motion, while rising, will indicate the direction of the currents; the height is computed at any time by its position.

The principal apparatus will be that for recording the temperature and barometrical changes. This is done by a clock-work arrangement carrying a strip of highly sensitised paper, with a regular motion, so that the condition of both instruments is photographed at each instant of time. The observation having commenced, it is only necessary to note the time and corresponding altitude, and obtain the corresponding phenomena when the apparatus is recovered. Under favorable circumstances, the balloon may be brought to rest at different altitudes, in order to give the instruments time to assume local conditions. To the apparatus is attached a parachute, so that the same may be recovered in case of collapse or other accident. I have thought some of adding a magnetic apparatus, but have not had time to develop the idea.

This might possibly throw some light on the possibility of aerial navigation, and also be worthy of consideration in other respects.

Hoping you will have an interesting and pleasant meeting, I remain, most respectfully, your obedient servant,

JOHN NADER.

THIRD SESSION.

July 11, 2.30 P. M.

Rev. H. M. Simmons read a paper on "The Social Organism."

Prof. Hailman delivered a lecture on "The Kindergartens"

Judge Allen then read a paper prepared by Dr. Mason, on the "Duty of the State to its Unfortunate Classes."

Prof. Butler read a paper on "American Pre-Revolutionary Bibliography."

FOURTH SESSION.

7.30 P. M.

Prof. Jewell, of Chicago, read a paper on "Mind in the Inferior Animals."

Academy adjourned to attend a reception given by Mayor Meacham in honor of the members.

FIFTH SESSION.

9:30 A. M.

The Academy met pursuant to adjournment.

Prof. Luther, of Racine, was elected an annual member.

Dr. Hoy, President of the Academy, delivered a lecture on the "Disappearance of Large Animals in Wisconsin."

Rev. C. Caverno read a paper on "Abolition of the Jury System."

Dr. Elmendorf read a paper on "Nature and Freedom."

SIXTH SESSION.

2:30 P. M.

Prof. Stuart read a paper on "Harmonic Method in Greek Art."

Prof. Butler then read a paper on "The Mosque of Omar at Jerusalem."

Mr. A. Paine, read a paper on "Art as Education."

The following resolutions were then proposed by Prof. Butler, and seconded by Prof. Caverno, and unanimously adopted:

"*Resolved*, That the Wisconsin Academy of Sciences, Arts and Letters begs to tender its grateful acknowledgments to the mayor of Racine for his cordial greeting in the Court House, and reception at his mansion, as well as to the citizens of the city for their generous hospitalities, and for their attendance on the sessions.

"*Resolved*, That the Wisconsin Central, and Western Union railroads, which have facilitated our convening in the interest of science, are hereby thanked for their kind courtesies.

"*Resolved*, That the sheriff and county commissioners, by placing at our disposal their new and noble court house, have done a service to science and shall be remembered by us with gratitude.

"*Resolved*, That the hearty thanks of the Academy are hereby presented to Dr. DeKoven, as well as the Professors of Racine College and other gentlemen for their able lectures, with which they have honored, entertained and instructed our Association.

"*Resolved*, That these resolutions be presented to the newspapers of this city for publication."

Prof. Perkins, in behalf of the Association, expressed the sincere thanks of the Academy to Dr. Hoy, President, for his earnest efforts to promote its interests.

The Academy then adjourned to meet in Madison on the 26th of December following, according to the change in the by-law regulating the time of the Regular Annual Meetings.

EIGHTH REGULAR ANNUAL MEETING,

Held at Madison, Wisconsin, December 26th, 27th and 28th, 1877.

WEDNESDAY, Dec. 16, 1877.

The Eighth Regular Annual Meeting was opened at 2:30 P. M., there being a large attendance.

Dr. Hoy, President of the Academy, in the chair.

The minutes of the Racine Semi-annual Meeting were read, and the amendments to the Constitution and the By-laws then made, commented upon and formally ratified.

The Secretary gave notice that a complete catalogue of all books and pamphlets thus far received by the Academy was completed, and would be published in the forthcoming Vol. IV of the Transactions.

The Treasurer made the following report:

TREASURER'S OFFICE,
Wisconsin Academy of Sciencies, Arts and Letters,
MADISON, Dec. 26, 1877.

P. R. HOY, M. D., *President of the Wisconsin Academy of Sciences, Arts and Letters:*

I have the honor to report the financial condition of the Academy, as follows:

Total amount of fees and dues from 62 members................	$817 25
Total fees from 10 life members..................................	1,000 00
Total interest on loan..	440 00
	$2,259 25
Total amount disbursed in payment of warrants to date..........	$855 17
Balance in treasury..	$1,402 08

(Signed) G. P. DELAPLAINE, *Treasurer.*

The Treasurer urged greater promptitude on the part of members in the payment of their dues. Only 62 members out of about 200 have paid any dues whatsoever thus far.

The following papers were read and dicussed during the session:

How Did the Aborigines of this Country Fabricate the Copper Implements? By P. R. Hoy, M. D., President of the Academy.

Some Remarks on the Descent of Animals. By Prof. Oldenhage, of Milwaukee.

Why Have the Ruminants no Upper Incisors. By P. R. Hoy, M. D., President of the Academy.

Boiler Explosions. By Chas. I. King, Superintendent University Machine Shop.

Antiquities and Platycnemism of the Mound Builders. By J. N. De Hart M. D.

Extent and Significance of the Wisconsin Kettle Moraine. By T. C. Chamberlin, A. M., State Geologist.

The German, French, English and American Press. By Hon. Joseph Hamilton, of Milwaukee, Honorary Member of the Academy.

The Ethical Bearings of the Doctrine of Evolution. By Rev. Jenk. Ll. Jones.

Mr. C. H. Haskins, of Milwaukee, gave a very interesting description of the Bell Speaking Telephone, illustrating his remarks by experimental demonstrations.

A paper on the Fauna of the Niagara and Upper Silurian rocks in Milwaukee county, by F. H. Day, M. D., was read by title only, not being received in time to be read in full.

The death of Prof. Oldenhage of Milwaukee was announced and his paper read by Prof. Peckham.

Profs. Peckham, Rogers and McAllister, of Milwaukee, were appointed a committee to present a memoir of Prof. Oldenhage, for publication in Vol. IV of the Transactions of the Academy.

The following gentlemen and ladies were elected annual members of the Academy:

J. S. Westcott, Superintendent of City Schools, Racine.
J. T. Lovewell, Female College, Milwaukee.
Albert Hardy, Principal High School, Milwaukee.
Rufus B. Smith, Madison.
Willett S. Main, Madison.
Geo. B. Smith, Madison.
P. B. Parsons, Madison.
B. E. Hutchinson, Madison.
Mrs. S. F. Dean, Madison.
Mrs. H. M. Lewis, Madison.
Miss Ella Giles, Madison.
J. N. DeHart, M. D., Madison.

J. J. Saylor of Cleveland, Ohio, was elected a corresponding member of the Academy.

Academy adjourned to meet in Milwaukee, at a time to be specified by the President of the Academy after consultation with the officers of the Scientific Club.

SECOND SEMI-ANNUAL MEETING.

Held at Milwaukee, Wisconsin.

FEMALE COLLEGE,
MILWAUKEE, July 23, 1878.

Pursuant to a notice given by the Milwaukee Scientific Club, the second semi-annual (or summer) meeting of the Wisconsin Academy of Science, Arts and Letters was convened in the Female College, Milwaukee, at 7:30 o'clock, P. M. President P. R. Hoy, of Racine, in the chair. Hon. Harrison C. Hobart, acting mayor of the city of Milwaukee, delivered an address of welcome. P. R. Hoy responded.

Prof. J. J. Elmendorf, S. T. D., of Racine, then read a paper on the "Popular Epics of the Middle Ages as Aids to Historic Study."

THURSDAY, July 24, 1878.

Academy met at 9 o'clock A. M. President P. R. Hoy in the chair, Prof. J. E. Davies, acting as Recording Secretary.

The following persons were elected annual members of the Academy. The president of the academy prefacing the ballot with the remark that "science knows no distinction of race, color, or sex:"

Mrs. Laura J. Wolcott, M. D., 471 Milwaukee St., Milwaukee, Wis.
Mrs. Charles Farrar, 614 Milwaukee St., Milwaukee, Wis.
Miss Brooks, 614 Milwaukee St., Milwaukee, Wis.
Miss Marion Stewart, 469 Marshall St., Milwaukee, Wis.
Mrs. Emery McClintock, 507 Astor St., Milwaukee, Wis.
Mrs. George Gordon, Humboldt Av., Milwaukee, Wis.
Miss Frank Whitnall, Humbolt Av., Milwaukee, Wis.
Mrs. A. M. Thomson, 459 Cass St., Milwaukee, Wis.
Mrs. A. W. Bate, 320 Terrace Av., Milwaukee, Wis.
Mrs. Celia C. Wooley, Sec. Philosophical Society, Chicago, Ill.
Mrs. P. Abbott, cor. Jackson and Division Sts., Milwaukee, Wis.
Mrs. Lewis Sherman, 171 Wisconsin St., Milwaukee, Wis.
Mrs. Dr. Marks, Prospect Av., Milwaukee, Wis.
Mrs. Carl Dœrflinger, 707 Jefferson St., Milwaukee, Wis.
Mrs. Matilda F. Anneke, 269 Ninth St., Milwaukee, Wis.
Mrs. Julia Ford, 375 Greenbush St., Milwaukee, Wis.
Mrs. N. H. Adsit, 268 Knapp St., Milwaukee, Wis.
Mrs. R. C. Spencer, 275 Prospect Av., Milwaukee, Wis.
Mrs. Edward P. Allis, 381 Prospect Av., Milwaukee, Wis.
Mrs. D. A. Olin, Racine, Wis.
Mrs. Frackleton, 469 Marshall St., Milwaukee, Wis.
Mrs. Olympia Brown Willis, Racine, Wis.
Mrs. J. G. McMurphy, Racine, Wis.
Mi s Jenny Hoy, Racine, Wis.
Miss Mary J. Lapham, Summit, Wis.
Prof. Robert C. Hindley, Racine College, Wis.
Mr. Eugene B. Winship, Racine College, Wis.
Mr. Charles Mann, Milwaukee, Wis.
Mr. Wm. P. Merrill, Milwaukee, Wis.
Dr. G. A. Stark, Milwaukee, Wis.
Mr. James S. Buck, Milwaukee, Wis.
Mr. George Gordon, Milwaukee, Wis.
Dr. Thomas A. Green, 146 Martin St., Milwaukee, Wis.
Prof. Charles A. Farrar, Milwaukee College, Wis.
Mr. H. S. Durand, Racine, Wis.
Mrs. H. S. Durand, Racine, Wis.
Miss Frankie Durand, Racine, Wis.
Rev. F. S. Luther, Racine College, Wis.
Dr. R. M. Byraness, Cincinnati, O., was elected corresponding member.

At the suggestion of Prof. J. J. Elmendorf, a resolution was framed and adopted to the effect, that all books that are now in the possession of the Academy, may be loaned, for one year, to any of the members desiring them.

A request was also made by Prof. J. E. Davies, that all members contemplating reading papers notify him of the same, for the purpose of facilitating the arrangement for the annual meeting.

An invitation was received from Dr. Day, soliciting the members to visit his cabinet at Wauwatosa.

A committee, consisting of Prof. S. H. Carpenter, Prof. Allen, and Prof. J. E. Davies, was appointed, to report, at the next meeting, a suitable memoir of the late Dr. Feuling.

Judge W. C. Allen, of Racine, then read a paper entitled, "The Accountability of Public Officials."

President Chapin, of Beloit College, read a paper on the "Nature and Functions of Credit."

This was followed by an extempore history of credit in Wisconsin, by Mr. Chapman.

At the afternoon session, the following papers were read:

"Drinking Water," by Dr J. G. Meacham, of Racine.
"Mental Hospitality," by Miss Ella Giles, of Madison.
"Scientific Housekeeping," by Mrs. A. W. Bate, of Milwaukee.
"The Origin of Certain Constellations," by the Rev. H. M. Simmons, of Kenosha.

The Academy then adjourned to attend at the invitation of the resident members and committee of arrangements, a banquet given in the evening at the Plankington House.

The following account of the banquet is taken from the Milwaukee News, of Thursday, July 25th, 1878:

"By invitation of the committee of arrangements, W. P. McLaren acted as President of the evening. At his right, sat President Chapin, of Beloit College, and at his left Dr. Hoy, president of the Academy. President Chapin asked Divine blessing on the gathering, after which an unusually long time was spent in disposing of the long and palatable list of dishes on the bill of fare. Mr. McLaren finally called the gathering to order and, in a neat and well-timed speech, introduced the first sentiment on the programme, "The State of Wisconsin." It was expected that the Hon. George H. Paul would respond to this, but, in Mr. Paul's absence, Judge Allen, of Racine, was called. The Judge gave a highly interesting account of the growth and progress of the state from the small beginnings of forty years ago, when he first came into this section of the country.

To the second toast, "The City of Milwaukee," the Hon. E. D. Holton responded, drawing parallels from history and from the present condition of cities in other parts of the world, to show the great advantages which Milwaukee possesses and the magnificent promises of the future. Dr. Hoy responded for "The Wisconsin Academy of Sciences, Art and Letters," very briefly sketching the objects and work of the society. To the fifth sentiment, "American Science," it was expected that Dr. Kempster would respond. But that gentleman was not present, and Prof. Davies, of our State University was called upon. Prof. Davies' speech was short, but full of the most interesting matter, and clothed in well-chosen words.

One of the best speeches of the evening was that of ex-Superintendent MacAllister, who answered for "Our Public Schools." President Chapin responded in an eloquent and logical manner to the seventh toast, "Arts and Letters." M. Almy Aldrich spoke for "The Press," and the regular sentiments closed with "Our New Associate Members," to which Mrs. Amelia Bate responded in a manner that elicited the heartiest applause and warmest commendations on all sides. Brief speeches followed by the Rev. Messrs. Gordon and Livermore, Dr. Wight, Dr. Elmendorf, Mr. Buck and others; and the gathering broke up about 11 o'clock.

Fourth Session, JULY 25, 1878.

Academy met at 9 o'clock A. M. President P. R. Hoy in the chair, Dr. J. E. Davies acting as recording secretary.

A resolution offered by Prof. Elmendorf, that in the appendix of the transactions shall be printed a list of the public and private collections of books within the state, as available for the use of members, to aid in the work of the society, was referred to Prof. Elmendorf and Prof. W. C. Allen, for further consideration.

A motion made by Mr. Peckham, that the secretary of the society be allowed to expend one hundred dollars ($100) for binding pamphlets belonging to the academy, was unanimously carried.

Dr. J. N. De Hart, of Madison insane asylum, then read a paper on the "Microscope and its Benefits to Science."

Rev. C. Caverno, of Lombard, Ill., read a paper entitled "Savings Banks and the Industrial Classes."

A paper entitled "The Relics of a Prehistoric Race," prepared by Dr. De Hart, was read by Rev. G. E. Gordon, as Dr. De Hart was suffering from a severe cold.

Mr. A. R. Sprague, of Evansville, Wisconsin.
Mr. W. P. McLaren, Milwaukee, Wisconsin.
Dr. D. W. Perkins, Milwaukee, Wisconsin,

Were elected annual members of the Academy.

After the morning session the members adjourned to meet at the Plankington House at 3 o'clock P. M., where the resident members of the Academy and citizens of Milwaukee had provided carriages for a drive around the city. The members were taken through the handsomest residence streets of Milwaukee, were shown the elegant grounds and conservatory of Mr. Alex. Mitchell, and then taken to the National Soldier's Home near the city, where they were introduced to Genl. E. W. Hincks, commandant of the Home, who gave them a most cordial welcome. They were then returned to the Plankington House, having spent a most enjoyable afternoon.

Academy adjourned, to meet in Madison on the 26th and 27th of December, 1878.

J. E. DAVIES,
General Secretary.

REPORT OF THE LIBRARIAN.

To the President of the Wisconsin Academy of Sciences, Arts and Letters:

SIR: At the suggestion of the General Secretary, Dr. Davies, I have made a complete revision of the library of the Academy. This work has been of considerable difficulty, owing to the fact that the bulk of the library consists of pamphlets, and the unbound publications of the various scientific associations in our own and foreign countries. Many of these are exceedingly valuable. Many of them contain the summation of the life-long investigations of specialists in their particular department of the vast field of science. Owing to their not being sufficiently well bound, few of these are at present available to the members of the Academy — a thing to be deeply regretted, since these publications are to be found in no other library of the State, that of the Academy filling a distinct and separate purpose, being, to a large extent, supplementary to the State Historical Library. Taking these things into consideration, it seems advisable that a certain sum should be set aside annually for the purpose of preserving these various publications in a more substantial binding.

The library of the Academy contains seven hundred and forty-four volumes, including pamphlets. Under the present system of exchange, it is rapidly growing. I herewith transmit a complete catalogue, embracing all publications received up to the present time (June 15th, 1878). The greater part of those from foreign societies have been forwarded by the courtesy of the Smithsonian Institute, at Washington, D. C.

W. A. GERMAIN, *Acting Librarian.*

PUBLICATIONS OF LEARNED SOCIETIES.

Now in the library of the Wisconsin Academy of Sciences, Arts and Letters.

EUROPEAN.

BELGIUM,

Musee Teyler — Archives —

Vol. I, Pts. 1, 2, 3 and 4.
Vol II, Pts. 1, 2, 3 and 4.
Vol. III, Pts. 1, 2, 3 and 4.
Vol. IV, Pts. 1 and 2.

Hainaut Academy of Science, Arts and Letters —

Memoirs for 1871, 1872, 1873, 1874, 1875, 1876 and 1877.

FRANCE.

National Academy of Caen,—
Memoirs, Vols. I, II, III, IV, V, VI and VII — 1871-6.

Academy of Bordeaux —
Acts de L'Academie, 3d Series, 1872-3.
Acts de L'Academie, 3d Series, 1873.

Academy of Lyons —
Memoirs, Vols. XV, XVI, XVIII, XIX — 1870-75.

Academy of Metz —
Memoirs — 1871-2, 1872-3, 1874-5, 1875-6.
Tables Generales de l' Academie, 1819-71.

Montpellier Academy of Science, Arts and Letters —
Transactions, Vols. IV, V, VI, VII and VIII — 1868-76.

Agricultural and Scientific Society of the Sarthe —
Bulletins, Vol. XIII, Parts 1, 2 and 3, 1871-2.
" " XIV, 1872-3.
" " XV, 1875.
" " XVI, 1876-7.

Amiens Linnean Society of the North of France —
Monthly Bulletins, from May, 1875, to December, 1877.

ITALY.

Royal Institute of Lombardy —
Transactions for 1873, Vol. VI; 1874, Vol. VII; 1875, Vol. VIII; Memoirs, Vols. XIII, XIV and XV.

Academy of Modena —
Memoirs, Vol. XVI.

Royal Geological Commission of Italy —
Bulletines, Nos. 1 to 12, 1874.
Publication of 1875.

NETHERLANDS.

Nederlandsch Meteorologroca.
id Jaarboeck, 1868.
id Jaarboeck, 1871.

Royal Academy of Amsterdam —
Transactions, Vol. I, P'ts 1, 2, 3 and 4, 1865-7; Vol. II, P'ts 1, 2 and 3, 1867-8; Vol. III, P'ts 1, 2 and 3, 1868-9; Vol. IV, P'ts 1, 2 and 3, 1869-70; Vol. V, 1871; Vol. VI, 1871-2; Vol. VII, 1873; Vol. VIII, 1874; Vol. IX, 1875; Vol. XIII, 1874; Vol. XIV, 1875; Vol. XV, 1875.
Year Book, 1873 and 1874.
Catalogue of the library of the Academy, 1877.

Netherland Society for the Encouragement of Industry —
Records, 1873, 1874, 1875 and 1876.
Proceedings, 1874, 1875 and 1876.

Amsterdam Royal Society of Physical Science —
Transactions, Vols. I, II, III, IV, V, VI, VII, VIII, IX, 1868–76.

Holland Society of Science —
Transactions, 1873, 1874, 1875, 1876 and 1877.
Catalogue of members, 1877.

Provincial Society of Arts and Sciences —
Publications, 1872, 1873, 1874, 1875 and 1876.

Royal Netherland Meteorological Institute —
Meteorological Observations, 1873.
Year Books for 1868, 1871 and 1874.

RUSSIA.

Royal Academy of Sciences of St. Petersburgh —
Repertorium of Meteorology, 1874, 1875 and 1876.

Royal Academy of Finland —
Natur och Folk, 1871, 1872, 1873, 1874 and 1875.

Imperial Physical Observatory —
Dorput Publications, Vols. I, II and III.
Annalen, 1875 and 1876.

SWEDEN AND NORWAY.

Kongliga Swenska Vetanschaps Academensis.

The Royal Swedish Academy —
Transactions, Vol. III, 1874.
Memoirs, 1875, 1876 and 1877.

University of Upsala —
Meteorological Observations, Vols. IV, V and VI.

Royal Society of Upsala —
Transactions for 1874, 1875 and 1876.

Royal Academy of Science of Christiana —
Enumeratio Insectorium Norvyicorum, 1874, 1875, 1876 and 1877.

University of Christiana —
Publications for 1873, 1874, 1875 and 1876.
Physiological Studies, by J. W. Muller.
Researches in Egyptian Chronology.
Official Statistics of Norway, 1870, 1871, 1872.

GERMANY.

Academy of Natural Sciences of Munich —
Transactions for 1871, 1872, 1873, 1874, 1875 and 1876.

Gottingen Royal Society —
Transactions for 1875, 1876 and 1877.

Royal Observatory, near Munich —
Annals, XX. Vol.

Mannheim Academy of Natural Sciences —
Transactions for 1870, 1871, 1872, 1873 and 1874.

Academy of Sciences of Heidelberg —
Transactions for 1874, 1875, 1876 and 1877.

Silesian Society, Breslau —
Transactions for 1873 and 1874.
51st Annual Report, 1873.
52d Annual Report, 1874.
53d Annual Report, 1875.
54th Annual Report, 1876.

Academy of Natural Science — Bremen —
Transactions for 1872–1873 and 1874.
Tables, etc., 1873, Parts I and II; 1874, Parts I and II, Vol. IV. Proceedings, Part I, 1876.
Supplement to same, 1876.

Rhenish Prussia and Westphalia Society of Sciences —
Transactions — 9th year, 1872.
" 10th " Part I, 1873; Part II, 1873.
" Part I, 1874; Part II, 1874.
" Part I, 1875; Part II, 1875.
" Part I, 1876.

Giessen Society of Science, Arts and Letters —
Transactions for 1876 and 1877.

Halle Journal of Natural Science — Berlin —
Transactions — Vols. IX to XIV, 1874-5 and 6.

Natural History Society of Dresden —
Transactions for 1876.

Isis Academy of Natural Science — Dresden —
Transactions for 1874, 1875, 1876 and 1877.

Polytechnic School at Hanover —
Programme for 1874, 1875, 1876 and 1877.

Natural Science Society of Freiburg —
Transactions, 1874, 1875 and 1876.

Academy of Eldena —
Transactions for 1870.

Royal Phys.-Econ. Society of Konigsberg —
Publications for 1873, 1874, 1875 and 1876.

Natural Science Society of Gorlitz —
Transactions, XV. Vol., 1875.

Society of Naturalists, Dantzig—
Publications for 1872, 1873, 1874, 1875 and 1876.

Munich Royal Bavarian Academy of Science —
Transactions for 1875, Parts I and II.; 1876, Part I.

SWITZERLAND.

Zurich Academy of Natural Science —
Transactions for 1873–1874, and 1875.

St. Galle Natural Science Society —
Transactions for 1874 and 1875.

Natural Science Society of Basel—
Transactions for 1874, 1875, 1876, 1877 and 1878.

Natural Science Society, Neuchatel —
Transactions for 1875, 1876 and 1877.

Natural Science Society of Berne —
Transactions for 1873, 1874, 1875, 1876 and 1877.

Natural Science Society of Schaffenhausen —
Transactions for 1872 and 1873.

Natural Science Society of Chur —
Transactions for 1873 and 1874.

Natural Science Society of Luzerne —
Transactions for 1876.

Academy of Vaudoise —
Transactions, Vols. XIV and XV, 1877–8.
Bulletin for 1877.

ENGLAND.

Philosophical Society of Manchester —
Memoirs, Vols. XII, XIII, XIN, XV — 1872–6.
Catalogue, 1875.

London Royal Society — *Proceedings* —
Vol. XXII, Nos. 153–155; Vol. XXIII, Nos. 156-163; Vol. XXIV, Nos. 164–170; Vol. XXV, Nos. 171–179; Vol. XXVI, Nos. 179–183.

DENMARK.

Royal Society of Denmark —
Transactions for 1874, 1875, 1876 and 1877.
Bulletin for 1877, No. I.

Royal Academy of Copenhagen —
Bulletins foı 1876, Nos. I and II.

AUSTRALIA.

Public Library of Melbourne —
Mines and Min. Statistics of New South Wales.
Treatise on New South Wales.
Nat. Industrial Resources of New South Wales.
Ann. Rept. of the Dept. of Mines.

MEXICO.

Natural Museum of Mexico —
Annals, Vol. I, 1877.

SPAIN AND PORTUGAL.

Royal Academy of Lisbon —
Transactions for 1875.

SOUTH AMERICA.

Venezuela Monthly Gazette for 1877 and 1878.

ISLAND OF MAURITIUS.

Academy of Mauritius —
Transactions, Vol. IX, 1876.

IRELAND.

Royal Dublin Society —
Journal for 1870–1875.

AUSTRIA.

Academy of Natural Sciences of Vienna —
Transactions, 1872, 1873, 1874, 1875 and 1876.

Royal Zoological and Botanical Society of Vienna —
Publications, 1872, 1873, 1874, 1875, 1876 and 1877.

Emden Natural-Philosophy Society —
Transactions for 1872, 1873, 1874, 1875, 1876 and 1877.

Society of Natural History, Brunn —
Transactions, Vols. XII and XIII, 1873.
Catalogue of the Library, 1874.

AMERICAN SOCIETIES.

Boston Society of Natural History —
Proceedings — Vol. 17, Parts II, III and IV, 1874.
Vol. 18, Parts I, II, III and IV, 1875-6.
Vol. 19, Parts I and II, 1877.

Buffalo Academy of Natural Science —
Bulletin — Vol. I, No. I, 1873.
Vol. I, Nos. II, III and IV, 1874.
Vol. II, Nos. I, II and III, 1874.

Museum of Comparative Zoölogy — Harvard University —
Bulletin — Vol. II, Nos. 1-10, 1876.
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Annual Report of Trustees, 1874.
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St. Louis Academy of Science —
Vol. III. Nos. I, II, III, IV, 1873-1875-1876-1878.

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For 1874, 1875 and 1876.

Philadelphia Academy of Natural Science —
Proceedings. Parts I and II, 1877.

New York State Museum of Natural History —
Twenty-fifth Annual Report of Regents.

American Academy of Science — Proceedings —
Vol. IV, from May, 1876, to May, 1877.

Kansas Academy of Science —
Vol. IV, 1875.
Vol. V, 1876, Birds of Kansas (Snow), 1875.

American Association for the Advancement of Scieace — Proceedings —
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Cleveland Academy of Science —
Proceeedings, 1845-1859.

BOUND VOLUMES AND MISCELLANEOUS PAMPHLETS.

Wells, Walter, Water Power of Maine.
Durrie, D. S., Cat. State Hist. Society, Vol. I, 1873.
Durrie, D. S., Cat. State Hist. Society, Vol. II, 1873.
Driunellette, P. S., Epistola.
Museum of Natural History of New York.
Munsel, J., Chronology of Paper Making.
Dudley Observatory, Annals of, Vol. II .
Cabinet of Natural History, New York.
Munsel, J. Manual of the Lutheran Church.
University of the State of New York, 85th Rep't, 1872.
Noye, W. Maxims of the Laws of England.
Ill. R. R. Commissioner's Rep't, 1871.
Department of Agriculture, Washington, Report, 1871.
Smithsonian Report, 1871.
Land Office Report, 1870.
DeCosta, B. F., Hudson's Sailing Directions.
Tophographic Survey of Adriondic Wilderness.
Natural History and Geology of Maine for 1863.
University of State of New York, 1873.
R. R. Commissioner's Report, Ill., 1872.
Same for 1873.
Transactions of the Wisconsin Agricu'tural Society, 1869.
Transactions of the Wisconsin Agricultural Society, 1870.
Transactions of the Wisconsin Agricultural Society, 1871.
Transactions of the Wisconsin Agricultural Society, 1872–3.
Transactions of the Wisconsin Agricultural Society, 1873–4.
Transactions of the Wisconsin Agricultural Society, 1874–5.
Transactions of the Wisconsin Agricultural Society, 1875–6.
Public Libraries of the United States, Part I, 1876.
Report Speciale Sur l'Immigration, 1872.
Raymond — Min. Resources West of the Rocky Mountains, 1872.
Raymond — Min. Resources West of the Rocky Mountains, 1873.
Finance Report of 1876.
Compendium of the United States Census, 1870.
Memoirs Manchester Phil. Society, Vol. V.
Mines and River Resources of New South Wales, 1875.
Report of the Chief of Statistics, Washington, 1876.
Commerce and Navigation, Washington, 1876.

Wisconsin Agriculture, 1876-7.
Hayden — U. S. Geological Survey, Washington, 1877.
Birds of the Northwest — *Coues.*
Museum of Natural History, New York, 1872.
New York State Library, 57th Report.
Patent Office Report, Vol. I, 1869.
Patent Office Report, Vol. II, 1869.
Patent Office Report, Vol III, 1869.
Report of Commissioner of Education, Washington, 1871.
Explorations in Nevada and Arizona.
Ninth Census of the U. S.
Hayden, F. V., Geological Survey, Vol. II, 1875.
Hayden, F. V., Geological Survey, 1867-8-9.
Hayden, F. V., Geological Survey, 1870.
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Hayden, F. V., Geological Survey, 1873.
Hayden, F. V., Geological Survey, 1874.
International Exhibition, London, 1862
Powell. B P., Geology of the Uinta Mts.
Hayden., U. S. Geol. Survey, 1874.
Hayden, U. S Geol. Survey, 1876.
Hayden, U. S. Geol. Survey, 1876.
Powell, B. P., Colorado River Exploraitions, 1873.
Memoriam — Increase A. Lapham.
New England and the English Commowealth.
Fur-bearing Animals of the Northwest — *Coues.*
Powell, J. W., American Ethnology.
Hayden, F. V., U. S. Geol. Survey, Vol. XI.
Hayden, F. V., U. S. Geol. Survey of 1875.
Memoirs, Vol. I, 1875.
Memoirs, Vol. II, 1875.
U. S. Geol. Exploration of 9th Par., C. King, 1875.
Department of Agriculture, 1875.
Department of Agriculture, 1876.
Commercial Relations, 1875.
Messages and Documents U. S., 1871.
Commerce and Navigation, Part I, 1876.
Commerce and Navigation, Part II, 1876.
The Electoral Count of 1876.
Leading Cases in International Law (Digest).
Western Review of Science and Industry. Theo. S. Case, Kansas City, Mo. Vols. I and II.
Medical Investigator, 1873 to 1878.

REPORT OF THE COUNCIL.

Since the last report of the Council, on February 13, 1876, the Academy has lost by death the following members:

James H. Eaton, Ph. D., for many years Professor of Chemistry in Beloit College, and one of the most valuable contributors to the Transactions of the Wisconsin Academy of Sciences, Arts and Letters. A memoir of Professor Eaton, contributed by his colleague, Professor T. C. Chamberlin, will be found at the end of this volume.

H. E. Copeland, A. M., Professor of Natural Sciences in the Whitewater State Normal School. No memoir of Professor Copeland has yet been presented.

John B. Feuling, Ph. D., Professor of Comparative Philology and Modern Languages in the University of Wisconsin, a memoir of whom, by his colleague, Professor S. H. Carpenter, will be found at the end of this volume.

Stephen H. Carpenter, LL. D., Professor of Logic and English Literature in the University of Wisconsin, whose sudden death has taken place while the last pages of this volume were in press. A brief sketch of his life, taken from the Wisconsin State Journal, will be found at the end of this volume.

J. E. DAVIES,
General Secretary.

LIST OF OFFICERS AND MEMBERS

OF THE

ACADEMY, 1878.

GENERAL OFFICERS OF THE ACADEMY.

(Term expires Dec. 27, 1878.)

PRESIDENT:

DR. P. R. HOY, RACINE.

VICE-PRESIDENTS:

DR. S. H. CARPENTER, - - - - - - MADISON.
PROF. T. C. CHAMBERLIN, - - - - BELOIT.
REV. G. M. STEELE, D. D., - - - - APPLETON.
HON. J. I. CASE, - - - - - RACINE.
REV. A. L. CHAPIN, D. D., - - - - BELOIT.
DR. J. W. HOYT, - - - - - MADISON.

GENERAL SECRETARY:

PROF. J. E. DAVIES, M. D., UNIVERSITY OF WISCONSIN.

TREASURER:

GEO. P. DELAPLAINE, ESQ., MADISON.

DIRECTOR OF THE MUSEUM:

——— ———

LIBRARIAN:

——— ———

MEMBERS OF THE COMMITTEE EX-OFFICIO:

HIS EXCELLENCY THE GOVERNOR OF THE STATE.
THE LIEUTENANT GOVERNOR.
THE SUPERINTENDENT OF PUBLIC INSTRUCTION.
THE PRESIDENT OF THE STATE UNIVERSITY.
THE PRESIDENT OF THE STATE AGRICULTURAL SOCIETY.
THE SECRETARY OF THE STATE AGRICULTURAL SOCIETY.
THE PRESIDENT OF THE STATE HISTORICAL SOCIETY.
THE SECRETARY OF THE STATE HISTORICAL SOCIETY.

GENERAL OFFICERS OF THE ACADEMY.

* Term expires Dec. 27, 1881.

PRESIDENT:

A. L. CHAPIN, Beloit.

VICE PRESIDENTS:

Prof. R. D. IRVING, A. M., M. E.,	Madison.
Hon. G. H. PAUL,	Milwaukee.
G. M. STEELE, D. D.,	Appleton.

GENERAL SECRETARY:

Prof. J. E. DAVIES, A. M., M. D.,
University of Wisconsin.

TREASURER:

Hon. S. D. HASTINGS, Madison.

DIRECTOR OF THE MUSEUM:

Prof. G. W. PECKHAM, M. D., Milwaukee.

LIBRARIAN:

E. A. BIRGE, Ph. D., Madison.

* Owing to the unusual delay in the publication of the present volume of Transactions, it was thought advisable to print the above list of General Officers of the Academy, who were elected at the Regular Annual Meeting, held at Madison, Dec. 27, 1878.

OFFICERS OF THE DEPARTMENTS.

Department of Speculative Philosophy.

President Ex-Officio — THE PRESIDENT OF THE ACADEMY.
Vice-President — S. H. CARPENTER, LL. D., *State University.*
Secretary — REV. F. M. HOLLAND, *Baraboo*
Counselors — PRESIDENT BASCOM, *State University*, PROF. O. AREY, *Whitewater*, and REV. A. O. WRIGHT, *Fox Lake.*

Department of the Natural Sciences.

President Ex-Officio — THE PRESIDENT OF THE ACADEMY.
Vice-President — PROF. T. C. CHAMBERLIN, *Beloit.*
Secretary — PROF. J. H. EATON, *Beloit.*
Counselors — PROF. W. W. DANIELLS, *State University*, PROF. J. C. FOYE, *Appleton*, and PROF. THURE KUMLEIN, *Albion College.*

Department of the Social and Political Sciences.

President Ex-Officio — THE PRESIDENT OF THE ACADEMY.
Vice-President — REV. G. M. STEELE, *Appleton.*
Secretary — E. R. LELAND, *Eau Claire.*
Counselors — DR. E. B. WOLCOTT, *Milwaukee*, REV. CHAS. CAVERNO, *Lombard, Ill.*, and PROF. J. B. PARKINSON, *Madison.*

Department of the Mechanic Arts.

President Ex-Officio — THE PRESIDENT OF THE ACADEMY,
Vice-President — J. I. CASE, *Racine.*
Secretary — PROF. W. J. L. NICODEMUS, *State University.*
Counselors — CHAS. H. HASKINS, *Milwaukee*, HON. J. L. MITCHELL, *Milwaukee*, and CAPT. JOHN NADER, *Madison.*

Department of Letters.

President Ex-Officio — THE PRESIDENT OF THE ACADEMY.
Vice-President — REV. A. L. CHAPIN, D. D., *Beloit.*
Secretary — PROF. J. B. FEULING. *State University.*
Counselors — PROF. W. F. ALLEN, *Madison*, PROF. EMERSON, *Beloit*, and HON. L. C. DRAPER, *Madison.*

Department of the Fine Arts.

President Ex-Officio — THE PRESIDENT OF THE ACADEMY.
Vice-President — DR. J. W. HOYT, *Madison.*
Secretary — HON. J. E. THOMAS, *Sheboygan.*
Counselors — J. R. STUART, MRS. S. F. DEAN, and MRS. H. M. LEWIS, *Madison.*

MEMBERS OF THE ACADEMY.

LIFE MEMBERS.

Case, J. I., Hon., Racine, Wis.
Dewey, Nelson, Ex-Governor of Wisconsin, Madison, Wis.
Hagerman, J. J., Esq., Milwaukee, Wis.
Hoyt, J. W., M. D., Governor of Wyoming Territory.
Lawler, John, Esq., Prairie du Chien, Wis.
Mitchell, J. L., Hon., Milwaukee, Wis.
Noonan, J. A., Esq., Milwaukee, Wis.
Paul, G. H., Hon., Milwaukee, Wis.
Thomas, J. E., Hon., Sheboygan Falls, Wis.
Thorpe, J. G., Hon., Eau Claire, Wis.
White, S. A., Hon., Whitewater, Wis.

ANNUAL MEMBERS.

Adsit, N. H., Mrs., Milwaukee, Wis.
Allen, W. C., Hon., Racine, Wis.
Allen, W. F., A. M., Professor of Latin and History in the University of Wisconsin.
Bartlett, E. W., M. D., Milwaukee, Wis.
Bascom, John, LL. D., President of the University of Wisconsin.
Bashford, R. M., A. M., Madison, Wis.
Bate, A. W., Mrs., Milwaukee, Wis.
Birge, E. A., Ph. D., Instructor in Zoology in the University of Wisconsin.
Bryant, Ed. E., Hon., Madison, Wis.
Buck, James S., Milwaukee, Wis.
Bundy, W. F., A. M., Sauk City, Wis.
Butler, J. D., LL. D., Madison, Wis.
Cass, Josiah E., Eau Claire, Wis.
Caverno, Chas., Rev., Lombard, Ill.
Chamberlin, T. C., A. M., Professor of Natural History in Beloit College, and Director of the Geological Survey of Wisconsin.
Chapin, A. L., D. D., President of Beloit College, Beloit, Wis.
Conover, O. M., A. M., Madison Wis.
Daniells, W. W., M. S., Professor of Chemistry in the University of Wisconsin.

Davies, J. E., A. M., M. D., Professor of Physics in the University of Wisconsin.
Day, F. H., M. D., Wauwatosa, Wis.
Dean, S. F., Mrs., Madison. Wis.
DeHart, J. N., M D., Madison, Wis.
De Koven, James, Rev. Dr., Racine, Wis.
De La Matyr, W. A., Spring Green, Wis.
Delaplaine, Geo. P., Madison, Wis.
Doerflinger, Carl, Mrs., Milwaukee, Wis.
Doyle, Peter, Hon., Secretary of State of Wisconsin.
Draper, L. C., Hon., Madison, Wis.
Dudley, Wm., Madison, Wis.
Durand, H. S., Racine, Wis.
Durand, H. S., Mrs., Racine, Wis.
Durand, Frankie, Miss, Racine, Wis.
Durrie, D. S., Librarian Wisconsin State Historical Society, Madison, Wis.
Elmendorf, J. J., S. T. D., Professor in Racine College.
Emerson, Prof., Beloit College, Wis.
Falk, F. W., Ph. D., Professor in Racine College, Racine, Wis.
Farrar, Chas. A., Prest. Milwaukee College, Milwaukee Wis.
Farrar, Chas., Mrs., Milwaukee, Wis.
Ford, J. C., Hon., Madison, Wis.
Ford, Julia, Mrs., Milwaukee, Wis.
Foye, J. C., A. M., Professor of Physics in Lawrence University, Appleton, Wis.
Frackleton, Mrs., Milwaukee, Wis.
Gapen, Clark, M. D., Madison, Wis.
Germain, W. A., Delafield, Wis.
Giles, Ella, Miss, Madison, Wis.
Gordon, Geo., Milwaukee, Wis.
Gordon, Geo., Mrs., Milwaukee, Wis.
Gordon, G. E., Rev., Milwaukee, Wis.
Gregory, Chas. N., A. M., Madison, Wis.
Hailman, W. M., Milwaukee, Wis.
Hardy, Albert, Principal High School, Milwaukee, Wis.
Haskins, C. H., General Superintendent Northwestern Telegraph Company, Milwaukee, Wis.
Hastings, S. D., Hon., Madison, Wis.
Hawley, C. T., Milwaukee, Wis.
Henrickson, Peter, Prof., Beloit College, Beloit, Wis.
Holland, F. M., Rev., A. M., Baraboo, Wis.
Holton, E. D., Hon., Milwaukee, Wis.
Hoy, P. R., M. D., Racine, Wis.
Hoy, Jenny, Miss, Racine, Wis.
Hutchinson, B. E., Hon., Madison, Wis.
Irving, R. D., A. M., M. E., Professor of Geology and Mining Engineering in the University of Wisconsin.

Jones, Jenk. Ll., Rev., Janesville, Wis.
Kenaston, C. A., Ripon, Wis.
Kerr, Alex., A. M., Professor of Greek in the University of Wisconsin.
King, Chas. I., Superintendent Machine Shop, University of Wisconsin.
Kingston, J. P., Necedah, Wis.
Kleeberger, G. R., Whitewater, Wis.
Kumlein, Thure, Prof., Albion College, Albany, Wis.
Lapham, Mary J., Miss, Summit, Wis.
Lapham, S. G., Milwaukee, Wis.
Leland, E. R., Eau Claire, Wis.
Lewis, H. M., Mrs., Madison, Wis.
Lovewell, J. T., Professor in Female College, Milwaukee, Wis.
Luther, F. S., Rev., Racine College, Racine, Wis.
Mann, Chas., Milwaukee, Wis.
Marks, Solon, M. D., Milwaukee, Wis.
Mason, R. Z., LL. D., Appleton, Wis.
McLaren, W. P., Milwaukee, Wis.
McMurphy, J. G., Prof., Racine, Wis.
Meacham, J. G., M. D., Racine, Wis.
Meacham, J. G., Jr., M. D., Racine, Wis.
Merrill, Wm. P., Hon., Milwaukee, Wis.
Morris, W. A. P., Hon., Madison, Wis.
Nader, John, C. E., Madison, Wis.
Nicodemus, W. J. L., A. M., C. E., Professor of Civil and Mechanical Engineering in the University of Wisconsin.
Olin, D. A., Mrs., Racine, Wis.
Orton, Harlow S., Hon., Judge of Supreme Court of Wisconsin, Madison, Wis.
Parkinson, J. B., A. M., Professor of Civil Polity and Political Economy in the University of Wisconsin.
Parsons, P. B,, Madison, Wis.
Peckham, Geo. W., Professor of Natural Science in the Milwaukee High School, Milwaukee, Wis.
Perkins, D. W., M. D., Milwaukee, Wis.
Pinney, S. U., Hon., Madison, Wis.
Pradt, J. B., Rev., A. M., Madison, Wis.
Preusser, Chas., President of Natural History Society, Milwaukee, Wis.
Sawyer, W. C., Professor, in Lawrence University, Appleton, Wis.
Shaw, Samuel, A. M., Principal High School, and City Superintendent of Public Schools, Madison, Wis.
Shipman, S. V., Chicago, Ill.
Simmons, H. M., Rev., Kenosha, Wis.
Sloan, I. C., Hon., Madison, Wis.
Smith, R. B., Attorney at Law, Madison, Wis.
Smith, Wm. E., Governor of Wisconsin.
Sprague, A. R., Evansville, Wis.
Stark, G. A., M. D., Milwaukee, Wis.

Steele, Geo. M., Rev., D. D., President of Lawrence University, Appleton, Wis.

Stuart, J. R., A. M., Madison, Wis.

Swezey, G. D., A. M., Professor in Beloit College, Beloit, Wis.

Whitford, W. C., A. M., Superintendent of Public Instruction of the State of Wisconsin.

Wilkinson, John, Rev., A. M., Madison, Wis.

Willis, Olympia Brown, Mrs., Racine, Wis.

Winship, Eugene B., Racine College, Racine, Wis.

Wolcott, E. B., M. D., Milwaukee, Wis.

Wolcott, Laura J., Mrs., Milwaukee, Wis.

Wood, J. W., Baraboo, Wis.

Woodman, E. E., Baraboo, Wis.

Wright, A. O., Rev., Fox Lake, Wis.

CORRESPONDING MEMBERS.

Abbott, C. C., M. D., Trenton, New Jersey.

Andrews, Edmund, A. M., M. D., Professor in Chicago Medical College, Chicago, Ill.

Barrow, John W., No. 313 East Seventeenth street, New York city.

Bridge, Norman, M. D., Chicago, Ill.

Brinton, J. G., M. D., Philadelphia, Pa.

Buchanan, Joseph, M. D., Louisville, Ky.

Burnham, S. W., F. R. A. S., Chicago, Ill.

Byrness, R. M., M. D., Cincinnati, Ohio.

Carr, E. S., M. D., Superintendent Public Instruction, California.

Ebener, F., Ph. D., Baltimore, Md.

Gatchell, H. P., M. D., Kenosha, Wis.

Gill, Theo., M. D., Smithsonian Institute, Washington, D. C.

Gilman, D. C., President John Hopkins' University.

Haldeman, S. S., LL. D., Professor in University of Pennsylvania, Chickis, Penn.

Harris, W. T., LL. D., St. Louis, Mo.

Hopkins, F. V., M. D., Baton Rouge, La.

Horr, Asa, M. D., President Iowa Institute of Arts and Sciences, Dubuque, Iowa.

Hubbell, H. P., Winona, Minn.

Jewell, J. S., A. M., M. D., Professor in Chicago Medical College, Chicago, Ill.

Le Barron, Wm., State Entomologist, Geneva, New York.

Marcy, Oliver, LL. D., Prof., Northwestern University, Evanston, Ill.

Morgan, L. H., LL. D., Rochester, Ill.

Newberry, J. S., LL. D., Prof., Columbia College, New York.

Orton, E., A. M,, President Antioch College, Yellow Springs, Ohio.

Paine, Alford, S. T. D., Hinsdale, Ill.

Porter, W. B., Prof., St. Louis,Mo.

Safford, T. H., Director of the Astronomical Observatory of Williams College, Williamstown, Mass.

Schele, De Vere M., L. L. D., Prof. University of Viriginia, Charlotteville, Va.

Shaler, N. S., A. M., Prof. Harvard University, Cambridge, Mass.

Trumbull, J. H., LL. D., Hartford, Conn.

Verrill, A. E., A. M., Prof. Yale College, New Haven, Conn.

Van DeWarker, Eli, M. D., Syracuse, New York.

Watson, James C., A. M., Director of the Washburn Astronomical Observatory at Madison, Wis.

Whitney, W. D., Prof. Yale College, New Haven, Conn.

Winchell, Alex., LL. D., Chancelor of Syracuse University, Syracuse, N. Y.

HONORARY MEMBERS.

Baird, Spencer, F. M. D., LL. D., Washington, D. C.

Hamilton, Joseph, Hon., Milwaukee, Wis.

NOTE — Members of the Academy will confer a favor upon the secretary by communicating to him their full postoffice address, and by giving him timely notice of any permanent change of residence on their part; also by pointing out any corrections needed in the foregoing lists of members.

MEMBERS DECEASED

Since the Organization of the Academy in 1870.

Wm. Stimpson, M. D., Late Secretary Chicago Academy of Sciences, Chicago, Ill.

J. W. Foster, LL. D., late Professor in the University of Chicago, Chicago Ill. Died June 29, 1873.

Rt. Rev. Wm. E. Armitage, S. T. D., Bishop of Wisconsin, and for a term Vice President of the Academy of Sciences. Died Dec. 7, 1873.

Hon. John Y. Smith, Madison, Wis. Died May 5, 1874.

Prof. Peter Englemann, Milwaukee, Wis. Died May 17, 1874.

I. A. Lapham, LL. D., Milwaukee, Wis. First Secretary of the Wisconsin Academy of Sciences, Arts and Letters. Died Sept. 14, 1875.

Hon. A. S. McDill, M. D., Madison, Wis. Died Nov. 12, 1875.

Prof. H. E. Copeland, Whitewater State Normal School, Whitewater, Wis.

James H. Eaton, late Professor of Chemistry in Beloit College, Beloit, Wis. Died Jan. 5, 1877.

J. C. Freer, late President Rush Medical College, Chicago, Ill. Died April 12, 1877.

Thos. Blossom, M. E., School of Mines, Columbia College, New York. Corresponding member of the Academy.

Prof. H. F. Oldenhage, Milwaukee High School, Milwaukee, Wis.

J. B. Feuling, Ph. D., late Professor of Modern Languages and Comparative Philology in the University of Wisconsin. Died March 10, 1878.

J. Wingate Thornton, Boston, Mass. Corresponding member of the Academy. Died June 6, 1878.

S. H. Carpenter, LL. D., late Professor of Logic and English Literature in the University of Wisconsin. Died Dec. 7, 1878.

COMMITTEES OF THE ACADEMY.

By-law No. 5, states that there shall be the following Standing Committees, to consist of three members each, when no other number is specified:

1. On Nominations.
2. On Papers presented to the Academy.
3. On Finance.
4. On the Museum.
5. On the Library.
6. On the Scientific Survey of the State; which committee shall consist of the Governor, the President of the State University, and the President of this Academy.
7. On Publication; which committee shall consist of the President of the Academy, the Vice-Presidents, and the General Secretary.

Under this by-law it has been customary to appoint, on the first committee, three members of the Academy present at the beginning of the regular meeting, at which the nominations are made.

The President and General Secretary of the Academy constitute the second.

The committee on Finance, to whom is referred the report of the Treasurer, consists of three members of the Academy, appointed by the President at the regular annual meeting in February or December.

The committee on the Museum at present consists of Professors T. C. Chamberlin, R. D. Irving and J. C. Foye.

The committee on the Library consists of Prof. W. F. Allen, Gen. Geo. B. Delaplaine and Gen. Ed. E. Bryant.

CHARTER, CONSTITUTION AND BY-LAWS

OF THE

ACADEMY OF

SCIENCES, ARTS, AND LETTERS,

OF WISCONSIN

With the Amendments thereto, up to February, 1878.

CHARTER.

AN ACT TO INCORPORATE THE "WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS.

The people of the State of Wisconsin, represented in Senate and Assembly, do enact as follows:

SECTION 1. Lucius Fairchild, Nelson Dewey, John W. Hoyt, Increase A. Lapham, Alexander Mitchell, Wm. Pitt Lynde, Joseph Hobbins, E. B. Wolcott, Solon Marks, R. Z. Mason, G. M. Steele, T. C. Chamberlin, James H. Eaton, A. L. Chapin, Samuel Fallows, Charles Preuser, Wm. E. Smith, J. C. Foye, Wm. Dudley, P. Englemann, A. S. McDill, John Murrish, Geo. P. Delaplaine, J. G. Knapp, S. V. Shipman, Edward D. Holton, P. R. Hoy, Thaddeus C. Pound, Charles E. Bross, Lyman C. Draper, John A. Byrne, O. R. Smith, J. M. Bingham, Henry Bætz, Ll. Breese, Thos. S. Allen, S. S. Barlow, Chas. R. Gill, C. L. Harris, George Reed, J. G. Thorp, William Wilson, Samuel D. Hastings, and D. A. Baldwin, at present being members and officers of an association known as "The Wisconsin Academy of Sciences, Arts and Letters," located at the city of Madison, together with their future associates and successors forever, are hereby created a body corporate by the name and style of "The Wisconsin Academy of Sciences, Arts and Letters," and by that name shall have perpetual succession; shall be capable in law of contracting and being contracted with, of suing and being sued, of pleading and being impleaded in all courts of competent jurisdiction; and may do and perform such acts as are usually performed by like corporate bodies.

SECTION 2. The general objects of the Academy shall be to encourage investigation and disseminate correct views in the various departments of science, literature and the arts. Among the specific objects of the academy shall be embraced the following:

1. Researches and investigations in the various departments of the material, metaphysical, ethical, ethnological and social science.
2. A progressive and thorough scientific survey of the state, with a view of determining its mineral, agricultural and other resources.
3. The advancement of the useful arts, through the applications of science, and by the encouragement of original invention.
4. The encouragement of the fine arts, by means of honors and prizes awarded to artists for original works of superior merit.
5. The formation of scientific, economical and art museums.
6. The encouragement of philological and historical research, the collection and preservation of historic records, and the formation of a general library.

SECTION 3. Said Academy may have a common seal and alter the same at pleasure; may ordain and enforce such constitution, regulations and by-laws as may be necessary, and alter the same at pleasure; may receive and hold real and personal property, and may use and dispose of the same at pleasure; *provided*, that it shall not divert any donation or bequest from the uses and objects proposed by the donor, and that none of the property acquired by it shall, in any manner, be alienated other than in the way of an exchange of duplicate specimens, books, and other effects, with similar institutions and in the manner specified in the next section of this act, without the consent of the legislature.

SECTION 4. It shall be the duty of said Academy, so far as the same may be done without detriment to its own collections, to furnish, at the discretion of its officers, duplicate typical specimens of its objects in natural history to the University of Wisconsin, and to the other schools and colleges of the state.

SECTION 5. It shall be the duty of said Academy to keep a careful record of all its financial and other transactions, and, at the close of each fiscal year, the president thereof shall report the same to the governor of the state, to be by him laid before the legislature.

SECTION 6. The constitution and by-laws of said Academy now in force shall govern the corporation hereby created, until regularly altered or repealed; and the present officers of said Academy shall be officers of the corporation hereby created until their respective terms of office shall regularly expire, or until their places shall be otherwise vacated.

SECTION 7. Any existing society or institution having like objects embraced by said Academy, may be constituted a department thereof, or be otherwise connected therewith, on terms mutually satisfactory to the governing bodies of the said Academy and such other society or institution.

SECTION 8. For the proper preservation of such scientific specimens, books and other collections as said Academy may make, the governor shall prepare such apartment or apartments in the capitol as may be so occupied without inconvenience to the state.

SECTION 9. This act shall take effect and be in force from and after its passage.

Approved March 16, 1870.

CONSTITUTION.

NAME AND LOCATION.

SECTION 1. This association shall be called "The Wisconsin Academy of Sciences, Arts and Letters," and shall be located at the city of Madison.

GENERAL OBJECTS.

SECTION 2. The general object of the Academy shall be to encourage investigations and disseminate correct views in the various departments of Science, Literature and the Arts.

DEPARTMENTS.

SECTION 3. The Academy shall comprise separate Departments, not less than three in number, of which those first organized shall be:

1st. *The Department of Speculative Philosphy* —

Embracing:
Metaphysics;
Ethics.

2d. *The Department of the Social and Political Sciences* —

Embracing:
Jurisprudence;
Political Science;
Education;
Public Health;
Social Economy.

3d. *The Department of Natural Sciences* —

Embracing:
The Mathematical and Physical Sciences;
Natural History;
The Anthropological and Ethnological Sciences.

4th. *The Department of Arts* —

Embracing:
The Practical Arts;
The Fine Arts.

5th. *The Department of Letters* —

Embracing:
Language;
Literature;
Criticism;
History.

SECTION 4. Any branch of these Departments may be constituted a section; and any section or group of sections may be expanded into a full Department, whenever such expansion shall be deemed important.

SECTION 6. Any existing society or institution mey be constituted a Department, on terms approved by two-thirds of the voting members present at two successive regular meetings of the Academy.

SPECIAL OBJECTS OF THE DEPARTMENTS.

SECTION 6. The specific objects of the Department of Sciences shall be:

1. General Scientific Research.
2. A progressive and thorough Scientific Survey of the State, under the direction of the Officers of the Academy.
3. The formation of a Scientific Museum.
4. The Diffusion of Knowledge by the publication of Original Contributions to Science.

The object of the Department of the Arts shall be:

1. The Advancement of the Useful Arts, through the Application of Science and the Encouragement of Original Invention.
2. The Encouragement of the Fine Arts and the Improvement of the Public Taste, by means of Honors and Prizes awarded to Works of Superior Merit, by Original Contributions to Art, and the Formation of an Art Museum.

The objects of the Department of Letters, shall be:

1. The Encouragement of Philological and Historical Research.
2. The Improvement of the English Language.
3. The Collection and Preservation of Historic Records.
4. The Formation of a General Library.

MEMBERSHIP.

SECTION 7. The Academy shall embrace four classes of governing members who shall be admitted by vote of the Academy, in the manner to be prescribed in the By-Laws:

1st. Annual Members, who shall pay an initiation fee of five dollars, and thereafter an annual fee of two dollars.

2d. Members for Life, who shall pay a fee of one hundred dollars.

3d. Patrons, whose contributions shall not be less than five hundred dollars.

4th. Founders, whose contributions shall not be less than the sum of one thousand dollars.

Provisions may also be made for the election of honorary and corresponding members, as may be directed by the by-laws of the Academy.

MANAGEMENT.

SECTION 8. The management of the Academy shall be intrusted to a general council; the immediate control of each Department to a Department Council. The General Council shall consist of the officers of the Academy, the officers of the Departments, the Governor and Lieutenant Governor, the Superintendent of Public Instruction, and the President of the State University, the President and Secretary of the State Agricultural Society, the President and Secretary of the State Historical Society. Counselors *ex-officiis*, and three Counselors to be elected for each Department. The Department Councils shall consist of the President and Secretary of the Academy, the officers of the Department, and three Counselors to be chosen by the Department.

OFFICERS.

SECTION 9. The officers of the Academy shall be: a President, who shall be *ex-officio* President of each of the Departments; one Vice-President for each Department; a General Secretary; a General Treasurer; a Director of the Museum, and a General Librarian.

SECTION 10. The officers of each Department shall be a Vice-President, who shall be *ex-officio* a Vice-President of the Academy; a Secretary and such other officers as may be created by the General Council.

SECTION 11. The officers of the Academy and the Departments shall hold their respective offices for the term of three years and until their successors are elected.

SECTION 12. The first election of officers under this Constitution shall be by its members at the first meeting of the Academy.

SECTION 13. The duties of the officers and the mode of their election, after the first election, as likewise the frequency, place and date of all meetings, shall be prescribed in the By-Laws of the Academy, which shall be framed and adopted by the General Council.

SECTION 14. No compensation shall be paid to any person whatever, and no expenses incurred for any person or object whatever, except under the authority of the Council.

RELATING TO AMENDMENTS.

SECTION 15. Every proposition to alter or amend this constitution shall be submitted in writing at a regular meeting; and if two-thirds of the members present at the next regular meeting vote in the affirmative, it shall be adopted.

AMENDMENTS TO THE CONSTITUTION.

Amendment to Section 3: "The Department of the Arts shall be hereafter divided into the Department of the Mechanic Arts and the Department of the Fine Arts." Passed February 14, 1876.

BY-LAWS.

ELECTION OF MEMBERS.

1. Candidates for membership must be proposed in writing, by a member, to the General Council and referred to the committee on Nominations, which committee may nominate to the Academy. A majority vote shall elect. Honorary and corresponding members must be persons who have rendered some marked service to Science, the Arts, or Letters, or to the Academy.

ELECTION OF OFFICERS.

2. All officers of the Academy shall be elected by ballot.

MEETINGS.

3. The regular meetings of the Academy shall be as follows:

On the 2d Tuesday in February, at the seat of the Academy; and in July, at such place and exact date as shall be fixed by the Council; the first named to be the Annual Meeting. The hour shall be designated by the Secretary in the notice of the meeting. At any regular meeting, ten members shall constitute a quorum for the transaction of business. Special meetings may be called by the President at his discretion, or by request of any five members of the General Council.

Amended at Racine, July 10, 1878, as follows:

The regular *Annual* Meeting of the Academy, shall be held as follows:

On the last Wednesday and Thursday in December, at the seat of the Academy; and the regular *Semi-annual* Meeting shall be held in July, at such time and place as shall be determined upon at the previous regular Annual Meeting in December. The hour shall be designated by the Secretary in the notice of the meeting.

Special meetings may be called by the President or the General Secretary, at their discretion or by request of any five members of the General Council.

DUTIES OF OFFICERS.

4. The President, Vice-President, Secretaries, Treasurer, Director of the Museum and Librarian shall perform the duties usually appertaining to their respective offices, or such as shall be required by the Council. The Treasurer shall give such security as shall be satisfactory to the Council, and pay such rate of interest on funds held by him as the Council shall determine. Five members of the General Council shall constitute a quorum.

COMMITTEES.

5, There shall be the following Standing Committees, to consist of three members each, when no other number is specified:

On Nominations.
On Papers presented to the Academy.
On Finance.

On the Museum.
On the Library.
On the Scientific Survey of the State; which Committee shall consist of the Governor, the President of the State University and the President of this Academy.
On Publication; which Committee shall consist of the President of the Academy, the Vice-Presidents, and the General Secretary.

MUSEUM AND LIBRARY.

6. No books shall be taken from the Library, or works or specimens from the Museum, except by authority of the General Council; but it shall be the duty of said Council, to provide for the distribution to the State University and to the Colleges and public Schools of the State, of such duplicates of typical specimens in Natural History as the Academy may be able to supply without detriment to its collections.

ORDER OF BUSINESS.

7. The order of business at all regular meetings of the Academy or of any Department, shall be as follows:

Reading minutes of previous meeting.
Reception of donations.
Reports of officers and committees.
Deferred business.
New business.
Reading and discussion of papers.

SUSPENSION AND AMENDMENT OF BY-LAWS.

8. The By-Laws may be suspended by a unanimous vote, and in case of the order of business a majority may suspend. They may be amended in the same manner as is provided for in the Constitution, for its amendment.

IN MEMORIAM.

IN MEMORIAM.

PROF. JAMES. H. EATON, PH. D.

Late Professor of Chemistry and Physics in Beloit College.

BY T. C. CHAMBERLIN.

Once and again, a seventh time and an eighth, has our Society been called upon to lament the departure of an esteemed and honored member.

An Armitage, an Engleman, a Foster, a Lapham, a Stimpson, a Smith, and a McDill have passed in turn from our number and have left vacancies we may not hope to fill, losses we may not hope to repair. Esteemed and mourned, as these have been, the more esteemed and the more lamented as we have known them the more intimately, our sorrow is no less profound, our bereavement is even yet sadder, as we realize the loss of a younger and no less earnest co-laborer, the devoted Eaton.

The 21st of June, 1842, marked the beginning, and the morning of the 5th of January, 1877, beheld the close of the life of Prof. James H. Eaton, a span of thirty-four years — twenty-five years of preparation, nine years of work.

To his father, at once a scholar, a teacher and an author, he owed much of that firm intellectual foundation upon which he erected so true and trustworthy a scholarship. His early training was received in earth's best and truest university, the home, a cultured, Christian home. To this was added the vigorous discipline of Phillip's Academy, the wider culture of Amherst College and the technical training of Göttingen University. The fruitage of these rare opportunities was everywhere manifest in the mental acquisitions of Prof. Eaton. His academic scholarship was thorough and accurate, firm and solid. There was no weakness or unsoundness in the foundation. We could admire the symmetrical shaft, the ornate capital, and the chaste entablature of the intellectual column, with no misgiving lest a weak or crumbling pedestal should work its ruin.

His culture was broad and catholic. Because he was a chemist, he did not find it necessary to despise the linguist. Because he traced and taught the history of an atom, he did not deprecate the merits of those who taught the history of man, or of his institutions. Because he could give visible demonstration of the laws of the physical elements, he did not disparage the more occult sanctions of civil, moral and religious laws. Because he dealt with the material, he did not scorn the spiritual.

While not an omniverous student, the bounds of his special investigations did not constitute for him the horizon of truth. He believed in the rotundity of the intellectual world; that, to whatever eminence, as an explorer of truth, he might climb, and however much his vision might thereby be amplified, there was yet beyond a wider circumference, and, however antipodal some phenomena might seem, they were still embraced in the sphericity of truth. How often in our judgment of truth do we forget that the completeness and perfection of the whole involves contrast and antagonism of the parts.

These enlarged views found expression in the opinions and efforts of Prof. Eaton as an educator. While an enthusiastic devotee of science, thoroughly impressed with its value as an educational agency, he at the same time fully recognized the importance of co-ordinate literary, ethical, and æsthetical culture. He extended neither sympathy nor fellowship toward the educational one-ideaism that finds expression in the average scientific course. It was largely due to his influence that the so-called Scientific course of Beloit College was abolished, while he gave a hearty support to the broader and more symmetrical Philosophical course, which is producing so much richer fruit. As an educator he despised narrowness, whether it were vertical or horizontal whether it arose from building upon a constricted foundation or from the tenuity of superficial diffuseness, and so he stood opposed alike to efforts to confine education to a single or a few lines of thought, on the one hand, and attempts, on the other hand, to spread the curriculum over the whole surface of knowledge without giving thorough or adequate instruction in any department of it.

One of the most prominent characteristics of Prof. Eaton, as a scientist and as a man, was his perfect sincerity and scrupulous conscientiousness. A worshiper of the truth, he spurned hypocrisy. A firm believer in the potency and permanence of truth, he scorned to erect a fabric of fallacy for personal or politic purposes. If error marked his views, it was the error of mistake, and not the aberration of guile. If, as all original investigators do, he gathered misconceptions, mingled with his gathering of facts, they were no sooner discovered than cast aside, however much they may have been interwoven with the fabric of his thought, and however much his personal feelings may have been involved by their publication. It requires courage and a conscience to do this.

His mental vision was marked by clearness and accuracy, the outgrowth in part of native endowments, and in no small part, we judge, of that conscientiousness we so much admired. How easy it is to deflect our intellectual sight and warp the native integrity of our judgment. The rays of truth have come to few through purer and clearer lens or one kept more perfect by conscientious care.

Patient industry marked all his endeavors and secured for him honors as a student, respect and confidence as a teacher, and esteem as a scientist. Painstaking preparation for every undertaking was a conspicuous trait. The summation of his life is but a type of his daily habit — twenty-five years of preparation, nine years of work.

To these mental and moral characters there was added religious belief and religious culture. He seemed to us to exemplify in an eminent degree the true attitude of faith and science. They appeared the right hand and the left hand of his being; set over against each other, indeed, antagonizing each other's action in a sense, yet both working together in mutual confidence and love for the good of the whole being.

His religious views never seemed to hamper his scientific conceptions, nor his science circumscribe the domain of his faith. He never seemed to hope or fear that his crucible would analyze the human soul, but in quiet and courageous trust he lived a true scientist and a true Christian.

His scientific labors have been so interwoven with the history of this Society that they do not need formal memorial here. We but repeat the spontaneous judgment of those most intimately associated with his investigations, as well as those who have listened to his productions, when we characterize them in terms of high esteem and admiration.

JOHN BAPTIST FEULING, PH. D.

BY STEPHEN H. CARPENTER, LL. D.

Professor of Logn and English Literature in the University of Wisconsin.

Dr. John Baptist Feuling, Professor of Modern Languages and Comparative Philology in the University of Wisconsin, died at Fayette, Iowa, March 10, 1878, after a lingering illness of more than six months.

Dr. Feuling was born in the classic city of Worms, Germany, February 12th, 1838. He attended the public school until his tenth year. In 1848 he entered the Gymnasium, from which he graduated nine years after, in 1857, with a first degree, and entered the University at Giessen to study Philology. His studies at the University were interrupted by being called to serve in the army, but after two months' service, he returned, and passed his public examination in 1860. While at the University he gave private instruction, and after leaving, he accepted a position in the Institute of St. Gowishausen, on the Rhine, as teacher of Latin and Greek. During 1861 he spent six months at the Bibliotheque Imperiale, at Paris, mainly in the study of Philology, and in acquiring a conversational mastery of the French language.

He came to this country in 1865, landing at Portland, Maine, April 14th. He went directly to New York, where he remained some time. He then spent a year at Toledo, Ohio, where he opened a French and German Academy. Not succeeding in this enterprise, he came west, and was employed for a time at Racine College in giving instruction in the classic languages, from which place he was called by President Chadbourne to the chair of Modern Languages and Comparative Philology, at the University of Wisconsin, in the spring of 1868 — which position he filled at the time of his death. Shortly after his accession to his professorship here, he was invited to the Professorship of Ancient Languages in the University of Louisiana, at Baton Rouge, and visited that place on a tour of inspection. The position was held open for him one year, when he finally declined it, preferring to remain here, although his preference was for the chair of Ancient Languages.

Dr. Fueling was married November 21st, 1868, to Miss Laura H. Aldrich, whose care and devotion have smoothed his dying pillow, and ministered to every want.

In 1876 he visited his old world home on a brief tour, but returned heartily in sympathy with American ways, and our systems of education, after having had the opportunity of comparing the two systems with his matured judgment. Indeed, he remarked to the writer of this sketch that his views as to the expediency of adopting the German method in this country had undergone a complete change — that while the German system carried a few students further, the American system carried the mass of students to a practical education unknown to the German system. The word "university" not designating the same grade of institution here as in Germany, it took him some time to adjust himself to the wants of the students that he here met, but during the last years of his life he was thoroughly in sympathy with his work and with the students under his charge.

The published works of Dr. Feuling are few. Shortly after coming to Madison he published an edition of the *Poema Admonitorium* of Phocylides, prefacing the Greek text with an introduction written in fluent Latin. This was dedicated to the American Philological Association, of which he was an active member, and before which he read several papers. He was also a member of the Wisconsin Academy of Sciences, Arts and Letters, and contributed several philological papers to its transactions. He has left several works in manuscript — "The Homeric Hymns," with notes; Montesquieu's "Considerations," with notes and a glossary, intended as a French Reading Book, which is nearly ready for the press; also "An Historical Outline of Germanic Accidence," which was nearly completed at his death. All these works show on every page his profound and thorough scholarship, and leave no room for doubt that had he lived he would have gained a lasting reputation in his chosen field of study. With him, teaching was not a drudgery; he felt proud of his profession, and discharged his duty with a conscientious fidelity.

As a man, he was genial, companionable and trustful. With an ardent temperament, his likes and dislikes were strong, and sometimes strongly expressed, but withal, he was free from baseless prejudices. He was as prompt to acknowledge a fault as to forgive a wrong. He had warm friends, and this is one of the best tests of manhood.

As a Christian, he kept the faith. He was brought up in the Roman Catholic Church, but on coming to this country he identified himself with the Episcopal Church, of which he was a constant communicant until his death. He died in Christian charity towards all, and let the living exercise the same charity towards whatever faults in human fraility he may have had. He died in the Christian's hope of a blessed immortality.

In the summer of 1877 he felt the premonitions of the fatal disease to which he finally succumbed. It appeared first as a paralysis of the right hand, which he naturally attributed to excessive use of his arm in writing, but the steady advance of the paralysis soon left no doubt that the disease was seated in the brain, and that no human agency could arrest its progress. For some three weeks he attempted to carry on his work, but was then forced to cease his labor in the hope that rest and quiet would restore his health; but disease had too firm a hold upon his system, and he steadily failed. In January he was removed to Fayette, Iowa, the residence of his wife's parents, in the faint hope that a removal from the scene of his labor would lessen the irritation that a man of his active temperament must have felt at being laid aside from duty; and, that care and quiet and the constant medical attendance of his wife's father might have a beneficial effect. But all was in vain, he failed; struggled with disease, and rallied, only to fall back beaten by his powerful antagonist. The disease of the brain steadily progressed, extinguishing one after another of his faculties; his speech gradually failed; then his sight; and at last he gave no signs of consciousness; and so life ebbed away, and death baffled all human effort. Love could not hold him, but Love can cherish the memory of his life.

His remains were brought for interment to Madison, where he wished to be buried. On a bright spring-like day a large concourse of mourners, composed of the Faculty and students of the University, and a large number of personal friends, gathered at his late residence, and followed his remains to the Episcopal church, where the solemn but hopeful and impressive service of the churce he so loved was held by Rev. Mr. Wilkinson, assisted by Rev. J. B. Pradt, after which his body was laid to rest in Forest Hill Cemetery, in sight of the city that he loved as his earthly home, and of the University, the scene of the labors of his active life; and there he rests, awaiting the resurrection of the just. *Requiescat in pace!*

NOTE. — It was Prof. Carpenter's intention to have completely re-written and extended the above notice of the life and death of Dr. Feuling, and he had promised the Secretary of the Academy to do so, only a few days before he was himself seized with the illness which so suddenly terminated his own life. "In the midst of life we are in death."

DEATH OF PROFESSOR S. H. CARPENTER.

[*From the State Journal (Madison) of Dec.* 7, 1878.]

Professor Stephen Haskins Carpenter, of the University of Wisconsin, died at half-past five o'clock on the morning of December 7, 1878, at Geneva, N. Y., of diphtheria, which had already proved fatal to his brother and nephew, a few days before.

Professor Carpenter's death is one of the saddest events we have ever been called on to chronicle. He was widely and favorably known, not only in this state, where he had devoted the best part of his life to the State University, but throughout the literary and educational circles of the country. As an educator he stood among the foremost, and in all matters pertaining to that avocation, his large experience and sound judgment stamped his opinions with unquestioned authority. He was devoted to the University, and rejected many tempting offers from other colleges, that he might retain his chair in her Faculty and continue to labor for her. He had seen the University grow from a mere academy to a great and prosperous institution, and this growth was due in a large part to his devotion to her, and to his zeal in her behalf. The institution with which he, with others, had so long been identified, is a memorial of his and their services and devotion. In every-day life, Professor Carpenter took a busy part; his acquaintance was large, and he was connected with other interests than the University. He was esteemed by all who met and knew him in these outside interests. But by the hundreds of students whom he has taught for so many years past, he was peculiarly loved. His associates have not failed to receive the respect of the students, but perhaps none have ever attained that position in their affection which Professor Carpenter has always held; and the announcement of his sudden death was received with exquisite sorrow by the *alumni* of the University, who had learned to love him while under his instruction, and by the undergraduate students from whom he parted but a week before his death.

Professor Carpenter was born August 7, 1831, at Little Falls, Herkimer county, N. Y., and his early education was obtained at his own home, his preparation for college being obtained at Munro Academy, Elbridge, N. Y. In 1848, he entered the Freshman class of the Madison University, at Hamilton, N. Y., where he remained two years, when he entered the University of Rochester, from which he took the degree of A. B. in 1852; A. M. in 1855, and in 1872, the degree of LL. D. was conferred upon him by his *alma mater*. He came to Wisconsin in 1852, and held the office of tutor for two years in its University. From 1858 to 1860 he was Assistant Superintendent of Public Instruction, and did much towards systematizing that office. In 1860, he was elected Professor of Ancient Languages in St. Paul's College, Palmyra, Mo., which position he held until the rebellion broke up the institution. He then returned north, taught select school one winter, and afterward worked at the printer's trade, devoting his spare time to literary pursuits. He held the office of city clerk of Madison from 1864 to 1868, but was all the time engaged in educational enterprises, as County Superintendent of Schools and member of the City Board of Education. In 1866, he was appointed by the Regents of the University to the chair vacated by Prof. Read, who had been called to the presidency of the Missouri University; in 1868, he was elected Professor of Rhetoric and English Literature, since which time his connection with the University has been continuous, but the title of his professorship was changed to that of Logic and English Literature. In 1875, he was elected President of Kansas University, but declined.

As a writer, he has contributed very largely to the religious and educational periodicals of the country. Ten of his educational addresses have been published and highly commended by literary authorities. His lectures, twelve in number, on the evidence of Christianity, were published a few years since, and have been well received. He has also been quite a translator from the French language, of which he was master. His articles on metaphysical subjects published in the Transactions of the Wisconsin Academy of Sciences, Arts and Letters, have attracted a good deal of attention, and been favorably reviewed in the periodical reviews of the country. But what has contributed most to his fame as a scholar and an educationist, is his proficiency in the Anglo-Saxon and early English languages. In 1872, he published a book, entitled "English of the Fourteenth Century," containing a critical examination of the English of Chaucer. In 1875, he published "An Introduction to the Study of the Anglo-Saxon," as a text-book, which has passed through several editions, and which the London School Board *Chronicle* has noticed in the most complimentary terms. His "Elements of English Analysis," published in 1877, is already in its second edition. His literary and scholarly abilities were of constant growth, and his fame was far from having reached its zenith.

The loss to the Wisconsin University, in his death, is an irreparable one, and the world of letters has been bereft of one of its most brilliant writers and thinkers. No words are adequate to offer solace to the bereaved wife — the balm of a religious hope, the consolations of a gospel, which he sincerely believed and ably defended, and the hope of a blessed reunion in n brighter and better world, must supply what nothing earthly can do.

ERRATA.

Page 188, for "J. M. De Hart," read "J. N. De Hart."
190, 14th line from bottom, for "[*Fig.* 3–4]" read "[*Fig.* 3.]"
193, under the figure insert:
A. Shaft six feet square.
B. E. Groups of stones.
C. Drift into side of the tumulus.
D. Bottom of tumulus.
F. Skeletons of adults.
G. Skeleton of child.
H. Fragment of pottery.
K. Surface of adjoining ground.
196, 5th line from top, for "alercolar" read "alveolar."
196, 5th line from bottom, for "dics" read "discs."
197, 2d–3d line from top, for "on page 7" read "opposite page 192."
197, 3d line from top, for "that" read "then."
197, 3rd line from bottom, after "inches," insert "(*Fig.* 11)."
198, under the figure insert:
A. Layer of gravel one foot thick.
B. Course of dark loam three feet thick.
C. Layer of gravel.
D. Loam.
E. Gravel.
F. Stone altar three feet high.
G. Tree growing from the mound.
200, 2d line from bottom, for "Americans" read "Americana."
200, last line, for "above overturned" read "cast of," and for "formed by squares" read "found by Squier."
201, heading—"Department of the Mathematical and Physical Sciences,"—should be omitted.
235, after name of author, for "Kenosha" read "Racine."
246, 7th line from top, for "experiment" read "experiments."