Vol 18

BULLETIN

OF THE

ESSEX INSTITUTE.

VOL. 18. SALEM: JAN., FEB., MAR., 1886. NOS. 1–3.

MR. TOPPAN'S NEW PROCESS FOR SCOURING WOOL.

JOHN RITCHIE, JR.

Read before the Essex Institute, March 15, 1886.

Ladies and Gentlemen, — Two years ago, almost to a day, I had the pleasure of discussing before you what was at that time a new process of bleaching cotton and cotton fabrics,—a process which, since that day, has been developed with steadily increasing value by a company doing business under Mr. Toppan's inventions. This evening [March 15] I desire your attention to a consideration of the effects of the same solvent principle upon that other great textile material, wool.

The lecture of two years ago was illustrated by the processes themselves, practically performed before your eyes. It is our intention this evening to follow out the same plan and to illustrate and, so far as may be, prove by experiment the statements which shall be made.

It is our intention to scour upon the platform various specimens of wool, and as well, to dye before you such colors as can be fixed within a time which shall not demand, upon your part, too much of that virtue, patient waiting.

Mr. Toppan, who needs no introduction to this audience, will undertake, later in the evening, the scouring of wool, and Mr. Frank Sherry, of Franklin, has kindly offered to assist in the work of dyeing. To those of you who are not familiar with the authorities in this country, in the work of dyeing, I need only say, that Mr. Sherry is an expert in his chosen business, and that his books are the standard in a majority of the mills in New England and in Canada. Inasmuch as the time necessary for dyeing is somewhat long, Mr. Sherry will begin at once, in order that his specimens may be ready for your inspection at the close of the lecture.

Before proceeding to the discussion of wool, allow me to refer briefly to the principal statements of the previous lecture, of which this is indeed but a continuation.

A reduction in the time necessary for bleaching was claimed. This claim has been substantiated in practice. The process will bleach the goods in one half the time of the next best practical process. As to color and quality, you can judge for yourselves. I have brought here bleached cottons in the piece for your inspection. A bleacher of my acquaintance, who has no interests at stake, being engaged in a specialty with which these goods do not compete, has assured me that he considers the Toppan bleached goods as fifteen to twenty per cent better in a monetary sense, than the same goods by the old process. The white proves to be permanent; and when it is question of sewing the material, I am assured by ladies, that the ease with which it can be sewed, both by hand and on the machine, pays many times over for the trouble it is to find the article, which, as yet, has not secured a universal distribution throughout the stores.

The position of opponents to the process has changed. After the previous lecture, I was many times assured that, while the results of experiments with small swatches of cloth were very good, yet, on a large scale, the method would fail. This feeling or opinion has disappeared before practical results, and the question of cost is now raised. This is a consideration which it is not at all my province to discuss, but I can say in passing, that the Canton Company will give the Toppan bleach at the same price per yard as do the bleachers by the old system.

It has been and will always be urged against new chemical processes in the arts, that practice in the mill does not follow closely enough the experiments in the laboratory; that a process which can easily be applied to a small quantity of material fails, through inability to use it on a large scale. This was the objection urged against the cotton bleach, and I should not be surprised if it were urged against the wool scour. There is this, however, to be considered: in the scouring of wool, the mill reproduces very closely the conditions of this platform, or the laboratory. Instead of handling goods by the ton, as in cotton bleaching, the wool is treated in lots of a few pounds each, and the care which the experiment here will of course receive, will not be so disproportionate as in other cases. The laboratory experiments on cotton have been confirmed in the mill, and by analogy we expect that, in the case of wool, the results will agree equally well.

The scour has been practically worked a number of times in establishments, some of which are to-day under contract to scour by this method, and it is from the lips of practical woolen men that I have evidence of the success of the scour on a large scale. When the date of this lecture was fixed, I hoped to be able to present to you the actual figures of several weeks' work, but the weather of the past two months, with the delay imposed by it upon transportation, has prevented the erection of the plant upon which I counted. The machinery is now set, but it is too early to give reports from it.

There is but little doubt that wool was in use before vegetable fibres, for the manufacture of fabrics, since it is, in its natural state, almost ready for the uses of a primitive people. It possesses fineness, flexibility, elasticity, — qualities not to be found in an equal degree in vegetable fibres in common use; and it is practically a process of little difficulty to render it fairly available for ordinary usages.

Its great difference, from a bleacher's point of view, lies in its susceptibility to heat, and the workman is, therefore, not able to apply to it the hot, lengthy processes which are used to whiten cotton. The strong caustics weaken the wool, and chlorine attacks it at the ordinary temperature, turning it a permanent yellow. These are the bleaching agents for cotton, and they cannot be used.

Wool is full of that grease and oil which serve to protect sheep against the weather, and usually bears with it quantities of dirt which mere washing fails to carry away.

The work of the bleach, or scour, as it is termed when it is question of wool, has varied little since its invention, and the industry was, in all probability, known to the Romans, who brought into England, at the time of their invasion, the art of working wool, their establishments being located where Winchester now is.

Wool scouring is simply a repetition of gentle treatment with soaps and lukewarm alkaline baths, and does not require a great length of time. The object of the process is to produce the whitest wool possible without loss of its elastic quality, or loftiness, as it is termed. At its best, the process of scouring, as practised to-day in our scouring mills, does not produce white wool, and furthermore, the scoured wools gradually yellow. When the wool is to be used for dyed goods in dark colors, the white may not be considered the most important requirement; but when white goods are desired, the additional and disagreeable operation of sulphuring becomes necessary.

Mr. Toppan's method of scouring involves the use of two preparations: first, the compound; and second, the anti-compound, or as it has been termed, the S liquor. The compound is made from petroleum products, and is closely allied to the cotton bleach. This is a perfect solvent for the oil and fatty matter, and softens and disengages the dirt. The S liquor is a solvent for the compound and washes it out of the wool. A simple wash in cold water completes the process, which does not vary much from that in use to-day.

The scouring of wool (differing from the bleaching of cotton) is the first step in its manufacture, and in his work the scourer must have consideration for the succeeding operations. The better the condition of the wool for spinning, weaving, dyeing, the more successful the scour.

Mr. Toppan's scour is of such nature, that the succeeding processes in manufacture are prepared for in a remarkable degree.

We will consider first the process itself, then the advantages in the after-processes.

In the regular course of work at one of our woolen mills, I noted some time since a series of scours at about twenty minutes to the scour. This was said to be quick work, and the operator said that the stock (Cal. spring clip) was needed at once. The scour was, even to the inexperienced eye, somewhat imperfect. It was evident that the process had not been carried far enough to fully cleanse the wool, and sticking as it did to the squeeze rolls, it gave evidence of the presence of oil and gum.

The usual time for scouring is, I am informed, not far from half an hour, varying of course with the nature of the wool. With heat, and with strong alkali, the process may be shortened in point of time, but attempts to economize in this way are dangerous.

This I can illustrate experimentally, and the experiment is of interest to housekeepers, as well as to wool men. It is one of the first points which should be appreciated by wool scourers. I am rather loath to believe the statement which I have clipped from a trade paper:—

"It is a fact not generally appreciated by wool washers, that wool can be dissolved until nothing is left visible. Hot water alone will not do this, wool may be boiled without being dissolved; but put a little caustic potash, or anything of similar nature, into the water, even if it be far from boiling, and the wool will rapidly disappear: the hotter the water, the more quickly it will melt."

This melting of wool is, indeed, an instructive experiment, and is of sufficient character to be shown, even upon the platform. It will require two or three minutes only, and I have prepared it for your instruction.

I have here an alkaline solution of twenty degrees Baumé. This little instrument measures the specific gravity of liquids, and is the common way of testing their strength. The alkali stands at twenty, Baumé, its temperature is 170, quite a little less than boiling. Water at this temperature is rather hot to hold one's hands in, but is not hot enough to really scald them. Into this liquid I drop a quantity of wool. In a short time the wool will be dissolved. Three minutes have sufficed in previous experiments, and I think it will be time enough in this instance. The wool disappears in the liquid, just as sugar does in your coffee. I pour this mixture through a glass funnel — you see that there are no lumps of wool in it. I pass it through a cold metal strainer, an operation that will show what has been done. The meshes have caught a white substance, which is a soap of wool. All fibre, or fibrous appearance, has disappeared.

The experiment is by no means a new one. Elwell, in his modern chemistry, published in 1806, speaks of a process which Chaptal had lately invented, whereby wool, instead of oil, was to be combined with an alkali to produce soap. The object was probably commercial manufacture of soap.

Now, in order to economize time, I have dissolved the wool in *strong* alkali. Other experiments, made especially for this occasion, give the following results: —

20 degrees	3 minutes.
15 "	3 minutes.
10 "	5 minutes.
5 "	25 minutes.

In these experiments there has been a considerable amount of instruction in other departments than the dissolving of wool. We tried some goods which were bought for all wool, and so warranted. It was astonishing how much material there was left after we had dissolved out all the wool, and it would not be surprising if, after all, some cotton had crept by mistake into these all-wool goods. At all events, it acted under the burning test exactly the same as cotton.

Now, in the washing of woolen fabrics, you can all apply the experiment without difficulty. I do not mean to insinuate that there is a single lady here present who does not know a great deal better than I do about flannels and blankets and their treatment. But there are sometimes agents and assistants in our houses whose natures are poorly understood.

I have before me the directions taken from a package of well-known and much-used soap powder: —

"To each pail of water add one tablespoonful. If the water is hard, increase the quantity. Clothes wash easier if soaked over night."

I dissolved a tablespoonful of this powder in half a pail of water and the specific gravity was five degrees Baumé. In other words, twice the minimum direction quantity of powder produces an alkaline solution which will dissolve wool in half an hour, and with the liberty given in the directions to increase the quantity, and the knowledge that a larger quantity will perform the required work in a shorter time, servants, and even housekeepers themselves, may, and often do subject their clothing to a dangerous test, which, in proportion to the violence of the process, washes away — dissolves out — the wool. Soap powders are of value, but there should go with their use a knowledge of their nature, — an appreciation of what may result from careless application of their properties.

The experiment has shown, to a certain extent, the points which the scourer of wool must care for, heat and strength of alkali. Greater heat and greater strength are the temptations. The efficacy of heat is so great that it may well be believed that as high a temperature will be maintained as is outside the limits of real danger to the fibre. It is also evident that, to a certain extent, or rather within certain limits, the greater the distance from the danger heat, the better the results, and a process which will scour wool at a lower temperature has its advantages, in the better condition of the scoured wool.

The usual temperature to-day is from 130 to 135 degrees F. Mr. Toppan's scour produces its results at 120 degrees at the outside. This fact, of itself, assures greater strength of fibre.

The time necessary for scouring wool is, as I have stated, not far from half an hour. I have seen it done quicker, but really good results require about this time. Mr. Toppan's process has somewhat the advantage in point of time.

The capacity of a scouring machine, which I saw at work some time ago, is about 900 lbs. of clean wool in a day of ten hours. It was at work on Cal. spring clip. A short time before my visit, the same machine had turned out, with the same number of attendants, 400 lbs. of the same wool in three and a half hours, or at the rate of 1,200 lbs. per day of ten hours. It is safe to say that the Toppan process can produce from one third to one half more wool in the same time, and from the same machine, than the old scour. I have seen a scour done in ten minutes actual time, but the machinery, running for the first time, so delayed the transfer of the stock from one vat to another, that the time of the whole scour was about equal to that of the process of to-day.

The scouring of wool is not an expensive process, so far as the chemicals used are concerned. The bill for labor is really of more consequence than that for the scour. I have had estimates from two or three different sources. From one mill I have an estimate that the cost of scouring is less than a quarter of a cent per pound; from another, and one of the best processes, the expense of scouring 2,000 lbs. of Texas wool is given as $2.79, or .135 cent, or a little more than an eighth. The expense of scouring 2,006 lbs. of the very same wool by the Toppan process was $5.07, or .2527 cent, almost exactly one quarter of a cent per pound.

Economy in the cost of the scouring liquor is not claimed by Mr. Toppan, but, on the other hand, an increase, at the outside, to twice the expense is conceded. But when it is known that the saving in oil will probably offset this loss, the disadvantage disappears. And then again, with the ability to produce in the same time, with the same plant, and the same force of workmen, twice or three times the amount of scoured wool, this disadvantage can hardly be urged.

With a material in use to the extent that wool is, a saving of any considerable amount of the material itself is an item not to be passed unconsidered.

It is a fact that wool scoured by Mr. Toppan's process yields a higher percentage of white scoured wool than do the scours of the day. Although the operation of wool scouring has been begun at Canton, it is to night too early to furnish comparative shrinkages from large quantities.

Shrinkage in wool is a variable quantity. It is different in different lots of the same wool, and indeed in different parts of the same fleece. In order to determine the comparative shrinkage from small lots, it would be necessary to take wool from the same lot and treat it by the old and the new process as nearly as possible under the same conditions. This result would be definitive.

The average shrinkage by the old process is, however, fixed from the results of many scours, and it is possible to state quite postively the shrinkage due to the scour.

When a sufficient number of scours have been made by the Toppan process, the average of these will be comparable with the figures now known with reference to the present systems. But if I cannot quote figures of my own, I have fortunately a series of experiments which are as reliable as anything can be expected to be under the circumstances.

Last year the *Manufacturers' Review and Industrial Record* of New York undertook a series of experiments which were conducted by their own men and, as they claim in their journal, for their own information only.

In order that an authoritative statement might be made to the trade, a series of tests and experiments was decided upon and Mr. W. B. Guild, the manager of their New England agency, was given entire charge of proceedings, with full authority to employ a dyer of his own selection to make any tests desired. The experiments were made for convenience at Canton and occupied several days. The utmost accuracy was maintained in the observations, and the weighing was done by Mr. Guild himself.

The results of these experiments I give in the words of the report as published in the *Record*: —

"The first test was taking $4\frac{3}{8}$ oz. of Texas fleece which was estimated to give a very heavy percentage of shrink. This was placed in the scour liquor at 120 deg. F. for five minutes, and then passed through an S liquor about one and a half to two minutes. There resulted from this $2\frac{11}{16}$ oz. of extremely clean, white, and handsome wool."

The loss in weight in the specimen, through shrinkage, was $38\frac{1}{2}$ per cent.

The other experiments are thus described, one of them being with a yellow buck fleece: —

"The yellow buck fleece was obtained for the purpose of getting the worst to scour that could be found. It was what is called a regular 'yellow bottom,' completely saturated with grease. The tags were very badly matted, and in order to get this fleece approximately clean and free from grease, with tags duly cleansed, etc., it required, by the old soda process, from twenty to thirty minutes, and even at that time the wool, though passably clean, was far from white or handsome. The average percentage of clean wool resulting from a number of trials by the soda process, made as fairly as possible, was $30\frac{1}{2}$ per cent clean wool.

"By the Toppan process, the same wool was scoured *perfectly clean*, at a temperature of about 123°, in time from two and a half to five minutes. This, when put through the S water (which worked as well, either warm or cold) for about two minutes, gave a result in clean wool of $39\frac{9}{16}$ per cent. These tests were made with especial care to get an average of the fleece for each style of scour, to give the soda scour 130° to 135° of heat, giving each about the same amount of liquor per pound of wool; and giving the Toppan process from 120° to 130° of heat, the average being 120°, which was found to give most satisfactory results. In every case, after the two and a half minute or five minute scour by the Toppan process. the yellow buck fleece came out far handsomer and cleaner than by the soda scour, even at thirty minutes. The yellow tinge was also bleached out, which was not the case when cleaned with soda."

The old scour yielded about 30 per cent clean wool. The Toppan yielded less than 40 per cent clean wool, an increase of not far from one third in quantit

hing
ent;
rink

$53\frac{2}{7}$
gave
per
over

also
tate-
how

nan-
nce

5m.	130°	Very clean and white.
2m.	135°	Extremely clean and white.
1½m.	123°	Handsomer than 20m. soda scour.
10m.	100°	Handsomer than 20m. soda scour.

YELLOW BUCK FLEECE.

Time.	Heat.	Result.
2½m.	135°	Very handsome.
5m.	130°	Very handsome.
4½m.	111°	Good.
15m.	100°	Handsome.

"The buck fleece, from its superior whiteness and in every way handsomer appearance, was in every case superior to the soda-scoured product, and in most cases so much so that it seemed incredible that it should have come from the same fleece."

While practice may or may not prove these percentages to be exact, it can be said that they were obtained by the most careful experiment, and to-day they represent our very best knowledge upon the subject. They point without doubt to a saving of some value in the weight of the scoured wool.

Wool product of the world in 1871 was....	2,000,000,000 lbs.
Australian product in 1883...............	400,000,000 lbs.
United States in 1885....................	100,000,000 lbs.
Imports into United States in 1885.........	100,000,000 lbs.

This will give some idea of the enormous amount of wool employed in our manufactures; and the process which can save to the consumer 10 per cent, or even 5 per cent, is of the highest value.

To show the power of Mr. Toppan's compound as a solvent, I have here one extreme example: At Hall's Mills, Hallville, Conn., some experimental scourings had been made with good result; more as a joke, perhaps, than in sober earnest, the superintendent said, "Well, I can give you something that you cannot scour," and he picked up a quantity of wool waste. This is torn from the wool in the different processes through which it goes, and is considered to be of absolutely no value. It is soaked with oil from the machines and the floor, and in practice is used as waste for wiping the machinery and is then burned. This was the material which was produced. I have some of it in this test tube, and I think that you can all see it or at least its color.

Mr. Toppan tried it by way of experiment, giving it a scour of three minutes' duration. The result I have here in this other test tube, and I think you can all see a difference. This cannot be cleansed by the old scour at all, yet it has a fairly long staple, and is an article of some commercial value. It is much better than shoddy for purposes for which shoddy is used, and is literally a production of something from nothing. As a test of the solvent power of the compound, it is striking in the extreme.

The opinion of an expert, with reference to comparative color and value, should not be passed over without comment, and the statement that the yellow tinge of the yellow buck fleece was removed, shows that the Toppan process is capable of better results in difficult cases than is the soda process.

And even further than this, the yellow tags have been scoured by Mr. Toppan, and put into condition to take light-colored dyes.

The white color of scoured wools is not permanent. When kept in stock, the scoured wool gradually assumes a yellow cast. The reason for this lies in the fact that in the scour, the animal oil is not all scoured out, and sufficient remains in the wool to come out after a time and show its color. It is a whitewashing, and, after a while, the natural color comes to the surface. The same is true of cotton. Cotton yellows, and there seems to be no way to prevent it, excepting at the expense of the fibre. Mr. Toppan's cottons, and his wools as well, retain their color. Specimens here have been scoured a sufficiently long time ago to prove this fact.

Wool scoured by this process is already mordanted for many colors. A mordant is a bond of union between material and the dye, and where there is dyeing of fabric or fibre, there is, I think, almost without exception, the preparatory process of mordanting. There are a dozen — possibly two dozen — shades which can now be dyed without mordant in some shape. In the case of wool, mordanting consists in boiling the wool for some hours in the mordant. It is pitched into vats, stirred, to secure an even distribution of the liquor throughout the mass, is forked out, and is then ready for the dyer.

This process, with the loss of time and with the injury to the wool that results from two handlings and a stirring, is completely eliminated in the Toppan wool. The compound is in itself a mordant for many colors commonly used, and enough of it remains in the fibre to prepare it for the dye. This is equally true of cotton, and, if you remember, at the other lecture, I had pieces of print which had been printed without mordant. The dyes take equally well on goods in the piece, without mordant. The saving in expense, by leaving out the mordant, is more than enough to pay for the scour.

The colors which need no mordant, when applied after Mr. Toppan's scour, comprise a very large variety of light shades, both in anilines and in wood colors.

Mr. Frank Sherry, who is here this evening, knows more about the dyeing of wool scoured by this process than any other man living, and has been experimenting for a year nearly, with these scoured wools. He can tell you all about it in the practical work, in the dye-room, and in the laboratory, and dyers can learn more from him, in this special feature, than from me.

I will simply give to you a few of the most salient points, and leave the technical parts, which would probably be of little interest to the major part of the audience, until I have finished, when Mr. Sherry will be pleased to answer any questions you may see fit to ask of him.

After mordanting the wool, it is put into the dye-vats, and remains in the hot dye for some hours. Throughout this time the wool is constantly stirred or poled, in order that the dye may take evenly. This poling is an injury to the wool.

The absorptive quality of the compound causes the dye to take more quickly, and it is evenly distributed. Mr. Sherry says: —

"The dyes take quicker, more evenly, with less poling, and probably with less dye. And further than that, the Toppan wool, being at least two shades whiter than any other scour, the color produced is proportionately brighter. The color is also permanent."

There are here wools done by Mr. Sherry, for Mr. Guild. They have been lying for nine months exposed to the light of two windows; one east and the other south, and within a couple of feet of the latter. There are some of the colors which are considered as rather hard to hold, yet a close examination fails to show any variation in shade. Here is yarn which was dyed in 1876 and has held its color.

There is another value to goods which are already mordanted, and that is with reference to household or home dyes. These dyes are very good under many circumstances, but they must be so put up as to be worked by the inexpert. They lie, therefore, under the disadvantage of not being mordanted, as a rule. The application of a mordant involves another process, and although in some instances the mordants are also given, yet this is usually not the case. The successful working of these colors without a mordant precludes the use of many beautiful shades, and they are as a rule quiet in tone. With goods which are already mordanted, the value of household dyes is largely increased. I have samples of wools dyed in these dyes, and to them I invite your special attention.

Wool scoured by Mr. Toppan's process has been woven a number of times in different mills in this country at dates as far back as 1878. And by the way, it is interesting to examine specimens which have been made this seven years. At these different times, there has been made a sufficient quantity of cloth to give substantial basis to statements which establish, without question, the value of the process, and which are of themselves of sufficient importance to work a change in the method of scouring. In the first place, less oil is necessary in spinning. From a third to a half is saved; not a matter of great economy to be sure, but small as it is, it has been estimated that the saving in oil would just about balance the additional expense of the scour. In the second place, there is a material diminution in waste in carding. About one half of the card waste is saved, and the wool being cleaner, there is less gumming of the cards, and they need to be cleaned only about half as often. Third, the Toppan wool will spin finer than the same wool scoured in the ordinary way.

Mr. Spalding, superintendent of the Ray Mills at Franklin, informed me that he was able to spin from a run to a run and a half finer than with his own scour. A run with Mr. Spalding means some 1,600 yards more of yarn to a pound of wool. Finer thread, and more of it; in other words, a cheaper grade of wool when scoured by this process is available for the same purposes, exactly, as a finer grade scoured in the old way, — a saving of several cents per pound of wool. This is not the substitution of a poorer article for a good one, or, in other words, an adulteration, but it is an advance in methods of production, whereby really valuable qualities, now to some extent latent, are made to take their proper place in the manufacture.

The antiseptic quality of the compound in the case of wool, as well as with cotton, is a preventive of mildew.

The dirt which comes on the fleeces is, to a considerable extent, the excrement of the sheep themselves. This dirt often amounts to half the gross weight of the wool. This is not really dissolved by the compound, but is softened and held in suspension. In a very short time, if allowed to stand in quiet, the dirt is precipitated, and the precipitate is a fertilizer of high order. There is no doubt but that this alone, if collected, would pay the cost of scouring. As to the value of the fertilizer, I quote from the report of Mr. John L. Hayes, to the government, on Sheep Husbandry in the U. S., page 17: —

"As a fertilizer, the manure of sheep in its intrinsic quality, and its distribution and prompt utilization among the roots of grasses, is unequalled. This has been so long and so notably manifest, that the sobriquet of 'Golden Hoof' for the ovine animal has become proverbial. In England the sheep is the main dependence in the fertilization of the soil for the wheat crop. If the mutton returns barely suffice to pay for the field value of the turnip crop, the manure is deemed a liberal profit. Good farmers in this country understand the value of the sheep as a means of soil improvement."

The general advantages of Mr. Toppan's method of scouring wool are the following: saving of time in scouring; saving of strength of fibre through less heat; the wool is cleansed—it is made really white; the white is permanent; there is less loss of wool through shrinkage; the wool is mordanted for many colors, and the cost of mordant and time of operation are saved; the dyes seem to take more quickly and evenly; there is probably a considerable saving of dye; the colors are permanent; in spinning, less oil is needed; there is less waste in carding; there is less gumming up of cards; there is less waste in spinning; the wool will spin from one to one and a half runs finer.

In closing the lecture, and before proceeding to the practical work of scouring, I desire to call your attention to the fibres and fabrics which have been brought here for your examination. There are some of the results of the cotton bleach; there are some fibres, flax, and hemp; there are several different grades of wool in the grease, scoured by the Toppan method, and whenever it was possible to get the same thing precisely, scoured by other regular scourers for the trade; there are two large triple sets of wool and several smaller ones; the Guild samples; flannels, made by Damon, which he said were whiter than the usual ones were, after sulphuring; woolen cloths, woven in 1878; wool dyed by Barrett, and also with household dyes; and many other things.

Thanking you for your kind attention to the written portion of the lecture, I invite you for a while to the scouring-room and dyehouse which have been improvised here this evening.

THE CLIMATOLOGY OF THE UNITED STATES.

With especial reference to the difference existing between the climate of the Pacific slope and that of the country lying between the Rocky mountains and the Atlantic coast.[1]

[From a lecture delivered by FRANK R. KIMBALL in the rooms of the Essex Institute, January 18, 1886.]

THIS subject, owing to its comprehensiveness, can be treated only in a superficial way. The details and the differences existing between minor districts must be omitted. These of necessity would be included in a discourse devoted to the consideration of climate in regard to health, but in the present case we shall merely examine the chief characteristics from a meteorological point of view. The climate of a country has a greater influence upon the health and prosperity of the people than is generally realized. Man needs sunlight to maintain life, and air to breathe, food to eat and material for clothing. Next in importance to these fundamental necessities comes climate and this is an important element in the progress of mankind. None of the leading nations are situated in the torrid or frigid zones and no nation has advanced to high civilization without the concomitant advantages of a good climate and the foremost nations of to-day are those pos-

[1] In regard to the technical character of the following it should be stated that, in previous lectures on this subject, the speaker has omitted the elements of meteorology, considering at greater length kindred topics including a more detailed description of the Pacific coast climate; but, as questions which followed have shown a misunderstanding of important facts, it was thought best to devote a portion to these matters even though this should be done at the expense of a more popular treatment of the subject.

sessing the most favorable climatic conditions within the temperate zone. The greatest inventors, generals, statesmen and authors and the leaders of civilization are the product of the temperate zone.

The heat and the cold of the torrid and frigid zones enervate and stupefy men and retard development, so likewise, to a less extent, extreme variations of temperature in the temperate zone have an unfavorable influence. We appreciate the fact that the degrees of heat or cold and the dryness or dampness of the air affect invalids who are frequently sent to other localities, according to the nature of their trouble where these conditions are different; but it is also true that healthy persons are affected more or less by all weather changes. Many are affected by changes in temperature and others feel depressed during the passage of an area of low barometer though they may not be able to account for their feelings, therefore it becomes a matter of more or less interest and importance to know somewhat of other climates; and we find a great variety in different parts of the world. Some regions are very hot and others very cold; some have rain a large part of the year, in others it seldom rains; some are subject to great extremes of temperature while others have very little change throughout the year. In order to form an idea of the climate of any given place we must know a few of the laws governing weather changes, and then with the addition of whatever statistics we may have, a tolerably accurate knowledge of the climate can be obtained; but if we seek that knowledge blindly, by a few general reports, we are likely to be misled. It is frequently noticed that, in geographies, works of science and books of travel, the mean annual temperatures of places are given; such are worthless for our purpose. As an example we might take the mean annual temperatures of the two cities San Francisco and

Boston, these are very nearly alike and yet the climates of the two places are very dissimilar. In Boston, the thermometer in the heated spells of summer often marks one hundred degrees in the shade, while in the coldest winter weather the mercury often falls to zero and sometimes below, showing a variation during the year of over one hundred degrees; while in San Francisco, the variation from winter to summer is not much over forty degrees and the changes are much less abrupt. The same liability to error exists in judging of the rainfall, so we must know what figures we need and how to judge by the various statistics at our command. In order to explain the character of and the laws governing the various phases of the weather, I shall first describe our own climate and the operation of the United States Signal Service, and then the climate of the Pacific slope, supplementing the whole with a short consideration of the climatic changes which have been taking place throughout the world during the last few years.

Within the limits of the United States there exist three distinct meteorological regions. The first including that part of the country lying east of the Rocky mountains. This region has a precipitation of rain or snow at frequent intervals throughout the year; the greater part of the region has cold winters and hot summers; it is subject to variable winds at all seasons. The second region embraces the country lying between the Rocky mountains and the Pacific coast and north of New Mexico and Arizona. It has a wet and a dry season, the former occurring in the winter months; the precipitation is almost entirely in the form of rain, except in the mountains and is about one-half of that in the above-named region. The winters are mild and the summers cool on the coast and hot in the interior. The winds are variable in winter and westerly in summer, appearing then like trade winds and are so called. These characteristics are more marked between the Sierra Nevada range and the Pacific coast. The elevated plateau between the Rocky mountains and the Sierra Nevadas, partakes somewhat of the character of the regions on either side ; its rainfall is however less than either of these. The third region consists of New Mexico and Arizona ; this like the last has a semi-tropical climate with a wet and a dry season, but these are reversed ; the wet season occurring chiefly in July and August, the total rainfall, however, being very small. The winters are warm and dry and the summers hot except in the mountains.

Before proceeding to consider the Pacific climate we will note some of the chief features of our own variable climate. In the first place we shall notice that throughout the year, at intervals of every two or three days, especially in winter, we are visited by storms of large area occupying from twelve hours to two days in passing; these storms travel in about the same direction and act in about the same manner. A person who is an observer of nature and interested in the phenomena occurring about us from day to day, would naturally put the following questions? What causes these storms? Where are they developed? Where do they go? and what becomes of them? A few words and a few simple illustrations may make the subject plain in a general way.

It is often noticed on a summer day at the seashore, that the air will be quiet and warm, and in the afternoon the wind will start up from the eastward and refresh us with cool ocean breezes ; this is owing to the air over the land becoming heated and rising, causing a current of cool air to flow in from the ocean to take its place ; in this case we may have merely an afternoon breeze created which will go down with the sun. Again, we may take the case of a great level plain heated by a summer sun till the air at some point commences to rise; as it rises air will flow in from all sides and will follow the upward current already created; in ascending, it will assume a spiral motion. This may be illustrated by taking a basin of water and allowing the water to run out through a hole in the bottom; the water will not flow in radial lines towards the hole, but in a curved line. And, again, if a column of smoke above a hot bonfire is noticed, it will be observed generally to rise in a spiral form; thus in the above case in the open plain, the air will rise in the same manner and currents will flow in from all sides, causing slight breezes along the surface of the ground. It is often noticed, on windy days, when the streets or roads are dusty, that little whirls of dust arise and travel for some distance; the action here is similar, but these, instead of being caused in a calm by the sun's action, are caused by conflicting currents of air; these of course being originally caused by the heat of the sun.

Atmospheric disturbances, similar to the above cases, occurring when the air is dry, will continue only so long as the sun remains above the horizon to heat the surface of the earth and the air. After sunset these will cool and the air will have no tendency to rise, hence such disturbances cannot develop into storms; but where there is moisture in the air the case is different.

It is a well-known fact that when water evaporates, heat is absorbed; hence we say evaporation causes cold. When the molecules of water separate and assume the vaporous condition, they need energy and so absorb all the heat they can. When condensation takes place, the molecules come together again and assume the cold, sluggish condition of a liquid, hence they do not need the energy to keep them in activity and the heat is given off again.

This latent heat plays a most important part in the production of storms.

In the above cases we have assumed that the air was dry. We will now suppose it to contain moisture to a considerable amount. Where the layers of air next to the surface of the earth become heated, the air rises and in so doing it expands and cools. The moisture condenses and we have clouds formed; but in condensing heat is given out which prevents the air from cooling as much as it would otherwise, therefore it continues to rise till it reaches a high altitude and overflows, passing off from the central spiral of ascending air; greater quantities follow and an activity is started by the new supply of heat which maintains the action after the sun has ceased to exert a direct influence; thus we have the development of a typical storm which continues day and night. Now, if we cut through this storm and take a horizontal section or ground plan, we shall see that in the centre is a calm of ascending air; about this a rain area and beyond this an area of clouds and we shall see that the winds rush in towards this centre. Therefore, on the north side of the storm we shall notice northerly winds, on the east side, easterly winds and so on, the storm appearing like a great wheel, with the exception that the winds, instead of following radial lines to the centre, as the spokes of a wheel do, tend to reach that centre by a more or less curved line, this curve changing according to the distance of the centre. At great distances from the centre the winds are drawn towards it in nearly radial lines, while of course at the centre the motion is nearly circular. This motion of the winds towards the centre is always in the opposite direction from the hands of a watch (that is, from right to left) in the northern hemisphere and from left to right in the southern hemisphere. Such are ordinary storms in all parts of the world; they are called cyclones on account of their form, though many people improperly restrict the term cyclone to a tornado or a very severe cyclonic storm, whereas a cyclone may be of very slight energy and may only manifest itself to ordinary observers as a slight shower.

Having now noticed the formation of storms the next question would be, Where do they come from? In answering this question we may suppose two lines to be drawn, one just north of the United States running east and west, and another running south from the eastern point of the United States. From some point within these lines all our storms come; that is, all the storms in the north temperate regions travel in an easterly or northeasterly direction, therefore every storm which passes over New England comes from a westerly or southwesterly point. No storm ever comes from the northeast or east; the majority come from the region extending from the Gulf States to the northwest states. A few come from west of the Rocky mountains, but whether they come up the great Mississippi valley or across the centre of the country, or from the northwest, they almost always pass to the lake region and thence down the St. Lawrence valley. Besides these, there are what are known as the West India cyclones which come from a southwestern or sometimes nearly a southern point, following the coast to Cape Hatteras or Cape Cod and then passing off to the eastward over the gulf stream. These occur most frequently from August to December and are very apt to be severe. By bringing to mind the horizontal section of a cyclonic storm before described, it will be readily seen that as these storms approach New England and pass off to sea that the northern side is usually the only one felt, therefore as it passes away and the weather clears, the winds will back from northeast to north and northwest instead of passing around to the south, southwest and west, as in the case of a storm passing down the St. Lawrence valley to the north of us. The majority of storms after leaving our coast travel to the northeastward, across the Atlantic and pass north of England. When a storm first develops it is of small area; but as it progresses from day to day its diameter increases and in high latitudes it disappears from this very fact; for when the diameter of the centre becomes so great that the ascending air does not overflow, but cools and sinks back into the centre again, the storm dies out.

Tornadoes are very destructive storms of small area and tremendous energy which frequent the centre of the country, being most destructive in Kansas, Illinois, Missouri and neighboring states. The South Atlantic states have also been visited by very disastrous ones, especially in February, 1884, when a great many people were killed and wounded and thousands of dollars' worth of property destroyed within a few hours. Until within the last few years very little has been known about the nature of these storms or the laws governing them; and it is only within the last two years that the Signal Service has attempted to give any daily indications of their probable occurrence for different localities. Their sudden development, narrow paths and short courses, together with their destructive force, have prevented very accurate observations until lately. What appears to be a thunder storm rises in the west and in the midst a funnel-shaped cloud appears suspended above the earth, moving up and down and swaying from side to side. The clouds above appear in greatest commotion, while an indescribable roaring is heard in the air. The storm travels like others, generally in a northeasterly direction, sometimes veering toward the north at the rate of about thirty miles an hour. They are liable to occur at any time of the year, but are mostly confined to the summer months and are most frequent in June in the latter part of the afternoon.

The path of great destruction varies from 300 or 400 feet to a quarter of a mile in width, and the course of the tornado ranges from a few miles to 100 or 200 miles. When one occurs in the daytime it can be seen on the western plains a long distance away and its roar can be heard in time for the inhabitants in its path to escape. When it is seen approaching from the southwest a flight to the southeast will soon take one beyond the limits of its devastating path; but when one occurs at night the inhabitants either awake to find it already upon them or are often so terrified as to lose their self-possession and judgment, and thus lose the opportunity for escape to a place of comparative safety. For this reason, it is common to have "dug-outs" in the ground connecting with the cellar or close at hand, to which a family may quickly resort in case of danger. The Signal Service has enlisted the coöperation of town officers, postmasters and others in the regions liable to these visitations, and these parties act practically as voluntary assistants to the regular signal office observers in different parts of the country in collecting information and statistics in regard to every tornado visiting their locality.

After a tornado has occurred, the United States' observer at the nearest station will often make a series of personal observations, going over the course of the storm and taking the observations and accounts of eye-witnesses, and combining them with his own observations make out a report which is forwarded to Washington. In this way much valuable information is obtained and the Signal Service has been enabled to give within the last year or so indications of the probable occurrence of tornadoes in which the percentage of verification has been very large considering the great difficulty of the subject, and very likely in this short period many lives have been saved. Many people in the east consider that the large destruction of property in the west by tornadoes is partly due to the light construction of the wooden houses there; but it should be borne in mind that brick and stone buildings succumb to these blasts almost as quickly as those of wood.

When a tornado strikes a building it generally tears it in pieces, carrying the débris aloft within the funnel-shaped cloud and throwing it out from the top to either side as it advances, leaving the wreckage of a homestead scattered along in a northeasterly line for distances, varying from a few yards to one or two miles.

It sometimes, however, happens that a house will explode by the expansion of the air within, as the rarefied air of the funnel passes over it, and the four walls will be thrown out in as many directions. This may occur frequently without being observed, as the parts may be carried away by the in-blowing currents and thus all trace of this action may be obliterated. Tornadoes have been found to travel in connection with some cyclonic disturbance to the north and their courses are generally parallel with the course of the main storm, though generally from 200 to 500 or 600 miles away. The theory which is now generally accepted is, that when a body of cool air flows southward and meets a mass of warmer air, it sometimes flows over instead of under the warmer air and in seeking a condition of stable equilibrium the warm air forces an opening through the stratum of cool air above, an interchange of positions thus taking place. Taking account of the temperatures, amount of moisture in the air and barometric pressures at the time, the Signal Service has succeeded in sending out very correct indications in regard to the results likely to follow such given conditions; and during the last summer western farmers were enabled to go about their work without being needlessly alarmed at the sight of every ordinary thunder shower.

These storms within the past five or six years have been spreading over a greater area and becoming more severe. This is in part merely apparent from the spreading of the population over hitherto unpopulated districts and the greater number of reports received of these storms; but aside from this there seems to have been a greater display of this form of atmospheric disturbance than formerly. Besides cyclones and tornadoes, we have thunder showers and local showers which need no special explanation after what has already been said.

Having now noticed the principles of weather changes in our climate, we will devote a few moments to the consideration of the United States Signal Service and its work in collecting reports of the weather and deducing therefrom the bulletins and indications which are daily sent out to the principal cities of the country. When meteorologists and scientific men found that storms moved and acted in a somewhat orderly way and travelled in about the same direction, it became apparent to them that some plan might be adopted whereby vessels about to leave port might be appraised of the approach of severe storms, especially those from the West Indies, and, accordingly, a movement was set on foot with this object in view. On February 9, 1870, Congress passed a joint resolution authorizing the Secretary of War to put this scheme into operation and a weather bureau was established in the Signal Service to collect weather reports and issue warnings and probabilities of weather changes for the benefit of commerce and agriculture.

On November 4, 1870, the first weather bulletin was issued. On that day twenty-four stations sent simultaneous reports to the office in Washington and the bulletins were prepared and sent to more than twenty cities. There are now nearly five hundred stations scattered over the country from the Atlantic to the Pacific, and from the Great Lakes to the Gulf of Mexico. These are classed as those of the first order, second order, cotton region, mountain, river and seacoast stations. The main office at Washington keeps a continuous record by means of self-registering instruments. Stations of the second order like Boston and other principal points take six observations and send three telegraphic reports to Washington daily and one monthly by mail. Other stations take five observations and send three reports daily; still others take only one observation daily. The river stations report the height of the water at various points on the great rivers as indicated on a gauge which is placed on the bank and extends from the extreme low water line to the danger line; thus, the central office is kept informed of the condition of the great rivers and their tributaries, and is able to give notice of any probable rise or of any approaching flood in the river valleys, and river commerce is quite dependent on these reports. The cotton region stations, numbering between 100 and 200, take one observation, daily at five P. M. The seacoast stations take various observations, including the character of the waves, or the approach of swells which indicate the presence of a storm at sea and are often forerunners of cyclones coming up the coast. These stations also work in connection with the life-saving stations and are connected by a coast telegraph line and with the central office.

Storm signals were first displayed on October 24, 1871, a red flag with a square black centre by day, and a red lantern by night is called the cautionary signal and denotes that a storm of considerable energy is approaching and that the wind will probably blow at the rate of twenty-five miles or more per hour. In this connection it should be noted that when the wind blows twenty-five miles per hour in Boston it may blow forty miles per hour off Cape Cod; therefore when a person in the city considers the warning not justified he should remember that it is displayed for the benefit of mariners, owing to the large number of vessels trading between ports scattered over an immense coast line extending from the provinces to the Gulf of Mexico. The display of signals at various points on that line is a matter of interest to a great many people having the care of a large amount of property, and when a very severe cyclone is coming up the coast the signal officer in a port like Boston, for example, not only displays the signal when he receives orders to that effect from Washington, but sends the police boat about the harbor to notify officers of vessels about to leave port of the character of the approaching storm. When the wind is expected to blow very strongly from the west or northwest the cautionary off-shore signal is displayed. This consists of a white flag with a black centre above the red flag already mentioned by day and a white light above the red light by night. The white flag alone indicates a cold wave. Of the display of these signals it may be said that about ninety per cent have been justified. When the wind does not attain a velocity of twenty-five miles per hour within the district the display of the signal is considered unjustified, yet the wind may attain nearly that velocity and so we may consider a larger proportion correct in a general way. The inland weather signals consist of three white flags, one with a red ball, one with a red crescent, and one with a red star denoting respectively higher temperature, lower temperature, and stationary temperature, and three white flags, one with a blue ball, one with a blue crescent, and one with a blue star denoting general rain or snow, clear or fair weather, and local rain or snow. These are not displayed by the government but are recommended for use, and responsible parties willing to display them regularly will be furnished with daily telegraphic reports from the signal office for that purpose.

In the preparation of the daily weather bulletins a number of charts must first be made out and when it is considered that several hundred stations send in their reports it is not surprising that a large force is necessarily employed at the main office. Seven graphic charts in all are prepared showing the barometric pressures, the temperature, direction and velocity of the wind, moisture in the air, etc., at the various stations throughout the country. These charts then pass into other hands and the bulletin giving a synopsis of the weather throughout the country is prepared and the indications are made out and telegraphed to all the principal cities in the United States. The per cent of verifications of these indications has averaged a little higher than that of the storm signals. In addition to these telegrams there are the Farmer's Bulletins which are printed and sent to the smaller places by rail. In this work some forty railroad companies assist in distributing two-thousand or more bulletins daily; these are posted in conspicuous places by station agents, postmasters, etc.

In 1873 General Myers, chief signal officer, attended the Meteorological Congress at Vienna, a gathering composed of the officers of the various national weather bureaus of Europe, and representatives of scientific organizations. On this occasion he submitted a plan for united work, whereby a simultaneous record of meteorological conditions in different parts of the world might be obtained from time to time or at regular intervals. The idea was favorably received and at the present time meteorologists are gaining considerable knowledge on the subject from the bulletins of the International Weather Bureau.

Before leaving the subject of forecasting weather changes, I will say a few words in regard to those who are known as weather prophets, men like Mr. Vennor and Mr. Wiggin who have enjoyed quite a notoriety at times. These men were not in the habit, as some have intimated, of sending out predictions, based upon nothing but the caprice of their own imaginations simply to attract public attention. On the contrary, they each had systems more or less worthy of scientific investigation and they themselves believed in their systems and at the same time endeavored to gain a reputation for accuracy in foretelling meteorological events. The late Mr. Henry G. Vennor, of Montreal, was a gentleman of learning, a Fellow of the Geographical Society, a naturalist and an author, having completed a record of meteorological observations extending over a period of many years. He found what appeared to be a series of recurring weather changes; that is, a period in which the weather would repeat itself, or go through the same changes as occurred in a former period: cold winters, hot summers, wet and dry seasons, etc., occurring in a certain order, through a certain number of years; these changes then being repeated throughout the next period of years, and so on. Mr. Vennor, however, did not disdain to seek aid for his predictions from other sources; and his knowledge in the field of natural history was of great advantage in enabling him to judge of the character of coming seasons from the migrations and appearance of birds, and the actions of animals and insects. He published a monthly bulletin and an almanac; these contained a great deal of matter more or less interesting and instructive in regard to the weather, agriculture, etc.

Mr. Wiggin, who has been connected with the finance department of the Canadian Government at Ottawa, is an astronomer, and though not devoting so much time to meteorological work as did Mr. Vennor; yet he has made a number of predictions, some of his earlier ones proving correct and creating for him quite a notoriety. His predictions, however, are based not on the recurrence of weather changes, but upon the influence exerted upon the earth with its elastic envelope of atmosphere by the superior planets and other heavenly bodies. Without doubt there is much in such a system and although we might not be able to rely upon it entirely, yet not only the sun and moon, but the other heavenly bodies, exert an influence to a greater or less extent upon us, or the earth and air. The chief difficulty with which we should meet would be the reduction of these general facts to any practical system. In order to use them, we should know how much influence is exerted under certain conditions, and how that influence would manifest itself. In making predictions, weather prophets, on whatever system they work, refer to conditions which have not at the time begun to manifest themselves; whereas the Signal Service, as a general rule, draws indications of the increase and progress of conditions already developed.

Having now considered the principal features of our eastern climate, and the operation of the Signal Service, we will cross to the Pacific and note some of the peculiarities of that climate. After crossing the Rocky Mountains we find ourselves in what is called the great enclosed American basin, a plateau of 4000 to 5000 feet elevation, extending westward to the Sierra Nevada range. This region is mountainous, dry and barren in general, with a few productive spots like the great Salt Lake Valley, which lies in the eastern part at an elevation of about 4000 feet above sea level. This valley is about the only locality here, capable of supporting at present any large population. Passing on to the west, we cross the great Alkali Desert; a region producing very little in the way of vegetation but sage brush. The rainfall in this section of the country is very light, ranging from eighteen inches at Ogden to four inches at Humboldt per annum, as compared with an annual precipitation in Boston of forty-eight inches; and as more water is lost here by evaporation than is furnished by the rainfall, the lakes, including Great Salt Lake, are gradually diminishing in size. The winters here are cool and the summers quite warm, but the extremes are not so great as in much of the country east of the Rocky Mountains, nor are the changes in temperature as great or as sudden. This condition appears to be the result of the relative position of the plateau with regard to the Rocky Mountains and the Pacific Ocean. We should expect to find it somewhat cooler than the lowlands of the great Mississippi Valley, but we also find that it is less subject to the violent fluctuations of temperature which we experience when warm areas of barometric depression are rapidly followed by cold waves from the west or northwest. The majority of these cold waves sweep down into the United States in a southeasterly and easterly direction from the northwest states and the region to the north, along the eastern slopes of the Rocky Mountains which here trend in a southeasterly direction. The region to the west of these mountains is subject to more or less change, but in a less degree; and again, the character of atmospheric changes, advancing from the west, would be influenced by the proximity of the Pacific Ocean which is milder than the Atlantic in the same latitudes, a matter which will be considered later. Having reached the Sierra Nevada range, we find the western slopes very much more abrupt than those of the Rocky Mountains, and we descend very rapidly into the valleys of California. We are now in a region which possesses well marked climatic peculiarities.

The state of California is about eight hundred miles long and two hundred miles wide, with a coast line of a little over one thousand miles. Its surface is cut up by mountain ranges running parallel with the coast, and dividing the state into numerous long narrow valleys.

The prominent features of the climate are, first, a wet and a dry season; the former occurring in the winter months, while from May to October rainfalls are rare, and a shower in June, July or August, is of very unusual occurrence. Secondly, a small rainfall, the amount of precipitation in the rainy season being no greater than that of the corresponding period in New England. Thirdly, mild winters, snow being a rarity except in the mountains, and the climate in the southern part of the state being of a semi-tropical character.

The first question which would naturally arise would be in regard to the cause of the dry season. A person in the east is very apt to consider that the same causes tend to produce precipitation either in the form of rain or snow in all seasons, and when one finds a region where the rain ceases in the spring and does not begin again until fall, curiosity is aroused as to the peculiar conditions which cause a cessation of rainfall during a part of the year. In considering this question, several important facts must be borne in mind. In the first place, there is a tendency for weather changes to move in an easterly direction; and, secondly, the western sides of the continents are milder than are the eastern sides in the same latitudes. This may be partly due to the influence of warm oceanic currents coming from southern latitudes, flowing in a northeasterly and easterly course and striking the western coasts with a temperature above that of the surrounding water.

The mild climate of the British Isles is attributed to the influence of the gulf stream. There may be other causes, but these currents certainly have a considerable share in producing the effects which we notice. The gulf stream flows northeasterly at some distance from our coast, while a cold current from the Arctic regions passes southward between the coast and the gulf stream, consequently much of the influence of this latter stream is here counteracted. In the Pacific, a great ocean current exists similar to the gulf stream; it is called the Kurosiwo or Japan current, and flows from the coast of Japan in a northeasterly course towards the Aleutian Islands and Alaska, a small part passing into Behrings Sea and the balance sweeping down the Pacific coast of the United States. Owing to its great size, it preserves a very even temperature throughout its long course, both in winter and summer, and consequently has a marked influence upon the climate, not only of Alaska but of British Columbia and the regions to the south, giving these places very mild winters. Sitka, in the southern part of Alaska, corresponds in latitude to the northern part of Labrador, and yet its winter climate is not much colder than that of New York.

The average temperature of this current, as it reaches San Francisco, is about fifty-five degrees, and as it tempers the cold of winter it also mitigates the heat of summer; but here another feature of this climate, the trade wind as it is called, presents itself. This is in reality a continual indraught of air from the ocean during the summer season, caused by the rising of the air in the great interior valleys to the eastward, which are very dry and hot at this season of the year. We may include in the list of localities contributing to this, the regions even to the east of the Sierra Nevada range, for it seems quite probable that the great enclosed basin before referred to may constitute quite an important factor in the case. It is true that in a large part of it the heat is not excessive, but the aggregate of thermal energy throughout such a large area would amount to considerable, and in the southern part the heat is quite sufficient.

The most favorable conditions, however, for producing this summer wind are to be found in the great valleys of the Sacramento and the San Joaquin; these two in reality forming one continuous valley, running north and south between the Sierra Nevada and the coast ranges. The temperature is very high here in summer and the coast mountains are comparatively low and a number of openings in the range admit a flow of air at a low level from the sea to the valley.

The principal opening through which this wind reaches the valley is that through which the Sacramento flows, on its way to the Bay of San Francisco; hence this bay and the adjacent localities are subject to much stronger summer winds than other parts of the coast north or south. Now, as we have seen, the temperature of the sea along the coast is quite low, and the winds passing over it are cool and do not absorb much moisture; and when they strike the land which at this latitude is quite warm, whatever moisture they may contain is absorbed rather than condensed; consequently rain is impossible as long as these conditions continue.

When, however, the interior regions cool in the fall, there is no longer a continued demand for this cool ocean breeze, and winds, more or less variable, take its place.

Rain occurs and the climate assumes characteristics more or less like our own, with the exception of the cold, as the Japan current still exercises its influence on the temperature, causing, as above stated, mild winters. Such is a brief explanation of the causes operating to produce the dry season in California. The dry summers and the mild winters are the distinguishing features of this climate; but, in addition, the claim is reasonably made that no other region of equal area offers such a variety of climates as the State of California. This might seem somewhat contradictory, especially when applied to the summer season, but even then a great change in temperature may be found by travelling from the coast inland or from the valleys up into the mountain ranges. It may be argued that various climates in one sense may be found in New England in summer, by travelling from the coast inland or among the White or the Green mountains. It is true that in New England as elsewhere, it is likely to be cooler near the seashore than inland, but aside from this the two regions are quite dissimilar. In New England, on the coast, it is at times as warm or nearly so, as in the interior, and places in the interior are at times as cold as those on the coast, while the moisture in the air causes mugginess in warm weather and chilliness in cold weather; hence all localities here partake more or less of the same characteristics. In California, though there may be slight changes, the permanent climatic features of different localities are more marked: for example, in San Francisco, although it has a somewhat disagreeable climate, we may expect about the same weather from day to day throughout the summer season; while if we pass a few miles to the south into the Santa Clara valley, we may, likewise, expect about the same weather from day to day, but it will be unlike that of San Francisco, and although we may find disagreeable features in both, we may be very sure that they will not exchange places.

We should hardly expect to find in Santa Clara the fogs and the strong cold winds of San Francisco, while at the same time San Francisco was basking in the hot, clear air of Santa Clara. I have spoken of the dry air, especially in the interior, but we find along the coast a fog bank which encroaches on the land at night and retreats in the daytime; this is particularly noticeable at San Francisco. In the morning it extends some miles inland, the distance varying with the character of the country, the mountains offering a barrier to its progress. During the forenoon the land radiates sufficient heat to dissipate it and the rest of the day is bright. The fog bank, however, is likely to remain over the sea, appearing like a huge cloud rolling in towards the shore but not reaching it till sunset, when it spreads inland and a clear evening is uncommon. As we pass along the coast, away from San Francisco, the winds and the fogs become less noticeable, while if we go back into the Sacramento or San Joaquin valley we get beyond the reach of the fog, but we also lose the benefit of the cool breezes; consequently, the pleasantest climate is found nearer the coast, but at some distance from San Francisco.

The coast range sends out numerous spurs which form a broken line of hills or low mountains along the shore in many cases rising quite abruptly from the sea. Among these are many little valleys which are quite sheltered from the fogs and winds and yet are comparatively cool. Here we find small fruit ranches nestled at the foot of the hills or climbing the sides which are in some cases so steep as to necessitate terraces, and here and there are mineral springs and pleasure resorts on a small scale for summer and winter. The position of these mountain ranges running north and south in connection with the steady westerly wind produces (as has been stated) a great variety of temperatures. In San Francisco the thermometer registered 80° not more than five or six times in the summer and the average would be about 75°. When the interior valleys become a little cooler the trade wind becomes weaker and the weather warmer. On this account July and August are the coolest months and June and September are generally a few degrees warmer.

What are called dog days in the east are scarcely known on the Pacific Coast. When we reach Sacramento we experience a summer heat of 90° and as we go north or south towards the heads of the two great valleys we get beyond even the slight influence of the trade wind which Sacramento feels, and the temperature rises to 100° and over, and occasionally the mercury registers 110° in the shade; but, owing to the dryness of the air, a temperature of 100° is no more trying than one of 85° in New York, and this region has the advantage of cool nights; though the people of Sacramento have a mid-day heat of 90° they find blankets necessary at night.

The winters here are colder than on the coast but the rainfall is less, averaging about nineteen inches only; these valleys sometimes have nearly two hundred and fifty clear days in the year without fog or clouds. The rainfall increases from the southern part of the state towards the north. It is greatest near the coast, and is generally more on the western sides of the mountains than on the eastern; the amount is however quite variable from year to year. It averages in San Francisco twenty-three and one-half inches, at Santa Barbara fifteen inches, at Los Angeles twelve inches, at San Diego ten inches, and at Colton nine inches per year. The Los Angeles region like Nevada and Arizona is subject to occasional cloud bursts when the water comes down in a deluge carrying everything before it. These generally occur in the mountain canyons and small valleys and have not been known near the large towns, though the railroads and towns suffer from the rapidly rising streams at such times. Sand storms also occur here as they do in the San Joaquin valley. To the east of southern California lies the Arizona meteorological region in which the small rainfall occurs in summer; this season is excessively hot except in the mountains. The mercury in a few places sometimes reaching 120° in the shade, and the hot days are followed by hot nights; the southern part, however, has a fine winter climate the mountain districts being cold. The mean July temperature of Yuma, which is in the lowlands, is one hundred and four degrees and the rainfall at this place is only four inches. Between this region and southern California lies a desert which is influenced by the dry winters of the former and the dry summers of the latter. A year or more has often passed without rain, but an occasional cloud burst supplies the country with an unwelcome amount in a few minutes; coming in this way little good is done, and no vegetation is produced here. As I have stated Nevada and Utah differ somewhat from California in climate, so also Colorado and the western parts of Texas partake somewhat of the climate of the Arizona region, but the classification of the three principal regions of the United States already made is sufficient in a general way.

It remains to be stated that the above characteristics and statistics refer to the weather in its normal condition, but a change has been taking place throughout the world during the last five or six years, which the majority of meteorologists have as a general rule refrained from considering with the exception of some of the phenomena resulting therefrom. We may consider that somewhere about the years 1880, 1881 or 1882, we entered a cycle of astronomical disturbance, and this fact has manifested itself in the unusual terrestrial and atmospheric phenomena which we have witnessed in this period. The climatic changes occurring in various localities have been noticed and commented upon, but no general explanation has been given by the leading meteorologists to whom people look for information in such matters. Local changes have been attributed to local causes, and peculiar phenomena like the "Yellow Day" have been explained to the satisfaction of many, but not in a way to comply with the conditions in the case. The "Yellow Day" occurred in New England in September, 1881. I was at Marblehead Neck at the time and had a fair opportunity of observing the phenomenon. When I awoke on that morning I discovered the harbor and the surrounding landscape bathed in a most peculiar yellow light. This continued throughout the day. The grass appeared blue and all colored objects had a strange appearance and the atmosphere was very still and oppressive. People were at first unable to give any explanation or form a theory in regard to it. Men who went to their business in Boston returned with accounts of the peculiar aspect of the city where gas was used in many places throughout the day. The papers gave descriptions of it, but no adequate explanation. The superstitious believed the end of the world was near at hand, and the members of one religious sect prepared to ascend, and waited patiently all day. More practical people, particularly those who had been in tropical regions, expected that an earthquake or a hurricane would follow, but nothing of the kind took place; and when the sun had set, the strange light lingered but a little while and the moon and sky then appeared as clear as usual.

A theory was then evolved and adopted to explain this appearance. It was to the effect that owing to the extensive forest fires then raging to the north of New England, a great quantity of smoke had drifted to the south and east over the country, thus producing the yellow light; and in support of this theory it was stated that many persons noticed an odor of smoke and that in New Hampshire it was particularly strong. As no better explanation was offered it was accepted generally. Nevertheless, it would not satisfactorily stand a test.

The ordinary ruddy glow of sunset is simply caused by the way in which the rays of light penetrate the atmosphere which is apt to contain considerable moisture; but when we have to deal with a phenomenon like the Aurora Borealis (or northern lights) we find we have a more complicated subject to analyze. We can scarcely say that the light is caused by the presence of gross foreign matter in the air, unless we class magnetism and electricity as such. This light at times appears in the form of a few streamers or an arch of white light. At other times it will rise to the zenith and even stretch over towards the south. Occasionally, it spreads over a large part of the distance between the east and the west, and at times it assumes a reddish hue, and the flickering and darting motions of the streamers or rays are very common. It has been noticed that a brilliant display of this kind often accompanies or follows a sun storm, that is, a disturbance in the envelope of the sun, such as may be witnessed in the development and expansion of a so-called sun spot. A change of weather or of temperature is also looked for, after a display of northern lights. This subject is little understood, yet we can but feel that a bond of sympathy exists throughout the solar system and that oftentimes unexplained phenomena are but the manifestations of reactions between the members of that system. Now to revert to the subject under discussion; it appears to me quite necessary to attribute the cause of the "Yellow Day" to something higher than smoke in the air, and I will mention a few facts which seem to make the smoke theory untenable.

In the first place, it is granted that in the neighborhood of an extensive fire the sky assumes a murky hue from the smoke; but there have been many forest fires of great magnitude in the regions to the northeast, north, northwest and west of New England without being followed by any such conditions as were present on the "Yellow Day." It is claimed that the wind was not in the proper direction on these occasions, but that on the "Yellow Day" it was.

Now let me say that though there may possibly have been a little smoke in the air in northern New Hampshire and Vermont, yet the yellow light of that day appeared over other parts of New England nearly simultaneously. If smoke had been the cause, we should have had a gradual thickening of the sky, as the smoke advanced from one district to another southward and it would have passed away in the same gradual way. Such was not the case; it appeared in a short space of time and disappeared with the sun. Furthermore, if the wind had been violent enough to have brought such an immense volume of smoke down over New England and carried it away so suddenly, then that wind, even if at a high altitude, must have caused some motion in the air next to the earth. But the air was calm on that day, and, again, if such an amount of smoke had been carried along over so large a territory in so short a time, it would have presented more the appearance of masses of clouds driven before a strong wind, whereas there was very little appearance of that kind.

The yellow light seemed to be equally diffused over the heavens and at rest, though there occurred now and then whitish spots or what appeared to be breaks or openings in the yellow expanse, but no definite outlines were visible and the difference in the tints was so slight as to amount to no more than the variations in the sunset glow or the breaks in the white expanse of the northern lights.

A number of persons claimed to have noticed the odor of smoke in the air, but I think they may have remembered such a fact after being informed of the smoke theory, and one might quite readily imagine smoke in the air when it was so close and oppressive as on that day. In the northern part of New England I doubt not, there may have been more or less smoke in the air, not only on that day but for some time, not, however, in sufficient quantities to cause such a sudden and extensive combination of atmospheric conditions. Such facts we may consider as negative proofs. Let us now see if there are any cases in which such appearances occur without the presence of smoke. We have only to seek such information from a sea captain or some one who has been in tropical regions, and we shall find that a calm, sultry air and a brassy appearance of the heavens often occur before elemental disturbances of great violence, and even here in New England we have occasionally noticed such appearances before the breaking of a heavy thunder shower; and when we find that in some regions a calm, sultry air with a yellow light in the heavens continues for some time without the presence of smoke and is generally followed by atmospheric disturbances, we are led to believe that such conditions are produced by the same agencies, and that as these are variable, it is possible for the above appearances to exist under certain circumstances without the attendant disturbances.

Another fact in connection with the "Yellow Day" is that the same yellow light was observed within a day or two after, in Virginia and then in Iowa. In the latter state the light had a flashing appearance like the northern lights in activity. It certainly seems quite unreasonable to suppose that smoke came down to New England, then passed to Virginia and then over to Iowa. The only satisfactory way to account for it is, as above stated, on the supposition that it was caused not by the mere interference of gross matter held in suspension in the air, but by the same forces and conditions which are concerned in the production of many other singular terrestrial and aërial phenomena, and which may have much to do with the aurora borealis and the red afterglows at sunset which have attracted so much attention within the last two or three years. These brilliant results began in the fall of 1883, appearing in India in September, and being very marked in October, November and December, not only in Asia, but in Europe and America. The display began when the ordinary ruddy glow of sunset had faded; then a deep red light illumined the western sky, extending at times even to the zenith. A writer, describing the appearance in New England, says: "The display was almost startling and there was something almost bewilderingly grand in the evidences of the red glow. It was at almost six o'clock that the most peculiar phase of the phenomenon was witnessed, when in the starlit sky the peculiar ruddy glow came and went. The coldly brilliant stars seemed blue and green by contrast with red and their brilliancy was fantastically magnified." Astronomers and meteorologists here and abroad advanced different theories and each seemed plausible. Prof. Piazzi

Smyth, Astronomer Royal for Scotland, maintained that there must have been an excessive amount of vapor in the higher atmosphere caused by unusual meteorological conditions. The "New York Herald" also strongly supported this theory, while other leading astronomers claimed that the cause was to be found in the volcanic dust thrown up by the great eruption in the Island of Java. This theory has perhaps been more generally received than any other. Mr. Norman Lockyer, Professor Ball of Dublin and Mr. Raynard being among its supporters. Professor Loomis was not inclined to endorse either of these theories. It has also been claimed by several scientists of high standing, that the earth passed into a stream of meteoric dust about the time of the beginning of these displays, and others have sought the cause in the attenuated matter of a comet's tail in the atmosphere. The theory of volcanic dust from Java has, however, as above stated, been the one most universally accepted, and yet that seems scarcely adequate to explain the matter fully, for the eruption took place August 27, and three days later these afterglows were seen in Brazil, over nine thousand miles from the disturbance, and if the wind had borne the dust thither it must have travelled at a great speed ; and, furthermore, it must have travelled rapidly in various directions to have produced such results in Asia, Europe and North America as well, and there have been reports of such appearances before the earthquake. And, again, if the upper atmosphere had become so permeated with foreign matter, it seems very strange that the effects should not have been noticed every day. As it was, several days often passed without the display, followed by one or a number of successive brilliant afterglows, which at times assumed the motions of the northern lights, streamers of red darting upwards, and then retreating in a manner different from the ordinary changes of sunset hues, and scarcely to be accounted for on the mere supposition of light passing through a veil of suspended volcanic dust.

On the whole it appears quite as reasonable to suppose that the cause which produced the great earthquake of Java also produced atmospheric phenomena at the same time, and it does not particularly affect the case whether, as is generally supposed, the causes of earthquakes exist within the earth or whether, as is not improbable, outside influences are largely concerned in their production, or both. In referring to the matters above my object has been to show that unusual phenomena have occurred within the period before mentioned, and numerous other cases might also be cited; one or two of the principal ones I will hastily consider in order to make the case more distinct. The eruption of Krakatoa in Java in the summer of 1883 was the most powerful convulsion on record. Other great catastrophes have occurred within the last century or so, such as the great Lisbon earthquake of 1755; the Java earthquake of 1815, and that which devastated the western coast of South America in 1868; but the one we are considering destroyed more human beings and its disastrous action continued for a longer time—one-hundred thousand persons were killed. A range of mountains disappeared beneath the sea and the topography of the whole country and the neighboring regions was changed, so that mariners knew not where they were; waves rolled where dry land had formerly been, and land appeared where vessels had sailed, while the sea for a long time after was covered for miles upon miles with a layer of pumice stone and ashes. To this may be added the earthquake of England, which though slight in comparison with the above, was an unusually severe one for the country in which it occurred. The disastrous floods and tornadoes in the United States within the last five years have been unparalleled in the history of the country, and the frequency of severe storms all over the world has been very unusual. In January, 1884, a paper was read before the Academy of Sciences at Paris, giving a review of the year 1883. The following lines are taken from a synopsis of this paper.

"At the last January session of the Paris Academy of Sciences, M. Foye gave a rather startling summary of recent physical commotions both on the earth and on the sun. Among the numerous exceptional phenomena noted for some time such as the frightful volcanic explosion of Krakatoa, the immense sea waves and air waves which swept round the globe, and the strange celestial lights and colorations, he mentioned that the month of January in Europe resembled in temperature the month of April, while systematic observations disclose singular variations in sun-spot frequency and no less singular behavior of the magnetic needle. During the present summer in the southern hemisphere extraordinary heat has been recorded, the thermometer at Buenos Ayres rising in the shade to 101° and in Queensland to 106°. In consonance with the disturbed state of the earth, M. Wolf of Zurich reports two pronounced sun spot maxima in April and October last, and only four days in 1883 in which the sun was not spotted. Though these maxima were not so high as that of April, 1882, and there are now indications that the sun's activity is decreasing, physicists will not be slow to connect the terrestrial disturbances with the solar storms. The French scientist may now add to his list of strange phenomena the late unparalleled Ohio floods, the extraordinary southern tornadoes of recent date, with the reported death roll of several hundred persons and the phenomenally early and extensive efflux of Arctic ice upon the Atlantic." The above extract points quite plainly to the fact already mentioned, that is, the relation existing between the members of the solar system. If a sympathy exist between the sun and the earth, it must also exist between the sun and the other planets, and if changes in the sun affect these it is not unreasonable to suppose that they in turn may exert some influence upon the sun, and if they ever do, we should expect the effects increased when the superior planets occupy such positions with regard to one another as they have within the last five years. Now after these superficial observations, I will refer to my former statement that the characteristic climates of the different sections in the United States which I have described, have not within the last few years been in their normal condition. As an example the dry season in California has been growing shorter, the rains have continued later into the spring, and commenced earlier in the fall, and light showers have occurred in June and last summer a light one occurred the first of July, and in some localities in the state thunder and lightning accompanied it, a remarkable event for that region. A Spaniard who had resided in Monterey most of his life stated that he had never seen lightning until two years ago. The Californians boast of their freedom from thunder showers; light ones occur though very rarely but the state is subject to eight or ten earthquake shocks a year. These, however, are generally light, and in the majority of cases are scarcely noticeable, and the residents prefer them to thunder showers. In support of this preference they bring up the undeniable fact that in twenty years only forty deaths from earthquakes have occurred in the state, and these mostly by the falling of old adobe houses, while in the rest of the United States subject to thunder showers the deaths by lightning amount to nearly one hundred and fifty a year, and if the deaths by tornadoes be added, the total would be from 250 to 300 a year and sometimes more. Of course there always exists in California the liability of a severe earthquake, but though showers have taken place there lately, they are not likely to develop into any such severe and frequent electrical storms as are experienced elsewhere. Changes in our own climate are also quite plain: for several years our proverbial April weather has been a stranger. We have not had mild days with typical April showers and bright blue skies alternating in rapid succession, as formerly, but instead, we have had cold rainy Aprils more like November, with a few instances of unseasonable heat; and again, our winter season formerly preserved its characteristics in a regular and orderly manner. The snow came and the cold came and remained in quite an even way. We were accustomed to have sleighing through a large part of the winter, and we expected a short thaw of two or three days in the early part of January known as the January thaw, but of late years we have had very little continuous sleighing here, some years having very little snow and at other times having the larger part of it in one or two heavy storms. Our thaws have occurred every few days, nearly every snowstorm being followed within a day or two by one; cold waves and warm spells alternating in rapid succession. The present season has possessed more or less the true winter features, but we have had an alternation of many very severe storms, very cold waves, and warm spells. On the whole, the winter has been a cold one with considerable of the old time regularity in its snow falls, but nearly as changeable as others of late. This changeable and uncertain weather of the last few years has caused an unusual amount of sickness everywhere. The influences bringing about these changes have also manifested themselves in other ways.

The most important agents of climatic change within the control of man are the forests. These have an important bearing on the climate of a place and their wholesale destruction is apt to create an unfavorable change. This is confined chiefly to the temperature and the prevalence of droughts and floods. In the case of the latter in a deforested region, the effect, so far as the destruction of the forest is concerned, is not produced by an extra amount of precipitation but by the water reaching the streams more rapidly; and it often happens that barren regions suffer most from floods, other things being equal. It should be noted, however, that many of the unusual floods of late years have been caused by very heavy rainfalls on account of the abnormal conditions which we have been considering, but the results have been more marked in scantily wooded regions than they would have been had the hills been covered with a heavy growth of timber. It has been quite strongly maintained by some authorities that forests do not actually cause more rain; but if they do not in a direct way, they do indirectly, and numerous examples are afforded us for observation while the evil effects of forest destruction are too common. Whole districts which once were rich and productive have become dry and barren, their streams have dwindled to mere brooks, except after heavy rains, when they rise rapidly and sometimes overflow and the soil is gradually washing away from the hills. The effect in temperature varies somewhat with the surrounding conditions. The clearing of forest lands in Germany had the effect of raising the temperature. In England the same result followed, but in Iceland the temperature has been lowered. It may be said, however, as a rule that a forest equalizes the annual temperature as well as the distribution of the rainfall.

About ten years ago I wrote an article, calling attention to the importance of united work for the preservation of our already rapidly decreasing forests; and localities, which I then had in mind, have since been denuded of their timber, and the changes, above mentioned, to a certain extent, have been the result. The destruction of forests could not cause all the varied and unusual meteorological phenomena which we have been considering, yet a corresponding influence is contributed to exaggerate all abnormal weather changes. The "arbor days," instituted of late in a number of our states, are the result of excellent ideas, and if they are generally observed will be of great benefit in creating an interest in the subject.

I think many would find a source of recreation in the subject if their interest were once aroused. It is not only important from a climatic and sanitary point of view, but it is a very instructive and interesting study in other ways; and the organization of local societies, composed of both sexes, devoted to the study of forestry in all its branches, including botany, with the intention of making practical use of the knowledge thus gained by means of united work, would eventually bear as much fruit as many of the other societies organized for various purposes in our different cities and towns. But the subject of forestry is too vast to be considered at any length within the limits of the present discourse, and as I have been expected to confine myself to meteorology I have not digressed from that subject, and I will close with the hope that the questions which I have endeavored to explain have been made clear.

BULLETIN

OF THE

ESSEX INSTITUTE.

VOL. 18. SALEM: APR., MAY, JUNE, 1886. NOS. 4–5–6.

ANNUAL MEETING, MONDAY, MAY 17, 1886.

HELD this evening at 7.30 o'clock. The PRESIDENT in the chair. Records of preceding meeting read and approved.

The annual reports of the Secretary, Treasurer, Librarian and Auditor, were read and accepted.

The committee on nominations reported the following list of officers proposed for election. A ballot was taken and the ticket as reported was elected.

PRESIDENT:

HENRY WHEATLAND.

VICE-PRESIDENTS:

ABNER C. GOODELL, JR. DANIEL B. HAGAR.
FREDERICK W. PUTNAM. ROBERT S. RANTOUL.

SECRETARY:
GEORGE M. WHIPPLE.

TREASURER:
GEORGE D. PHIPPEN.

AUDITOR:
RICHARD C. MANNING.

LIBRARIAN:
WILLIAM P. UPHAM.

CURATORS:

History—HENRY F. WATERS.
Manuscripts—WILLIAM P. UPHAM.
Archæology—FREDERICK W. PUTNAM.
Numismatics—MATTHEW A. STICKNEY.
Geology—BENJAMIN F. MCDANIEL.
Botany—GEORGE D. PHIPPEN.
Zoölogy—EDWARD S. MORSE.
Horticulture—
Music—JOSHUA PHIPPEN, JR.
Painting & Sculpture—T. F. HUNT.
Technology—EDWIN C. BOLLES.

COMMITTEES:

Finance:

The PRESIDENT, *Chairman ex off.*

The TREASURER, *ex off.*

GEO. R. EMMERTON. DAVID PINGREE.
HENRY W. PEABODY. WILLIAM MACK.

Library:

E. B. WILLSON. HENRY F. KING. B. F. MCDANIEL.
WILLIAM D. NORTHEND. THEODORE M. OSBORNE.
The LIBRARIAN, *ex off.*

Publication:

EDWARD S. ATWOOD. JAMES A. EMMERTON. EDWIN C. BOLLES.
J. S. KINGSLEY. HENRY M. BROOKS. T. F. HUNT.

Lecture:

ROBERT S. RANTOUL. FREDERICK W. PUTNAM. A. L. GOODRICH.
FIELDER ISRAEL. WM. NEILSON.

Field Meeting:

The SECRETARY, *Chairman ex off.*

GEORGE A. PERKINS, Salem.
GEORGE COGSWELL, Bradford.
FRANCIS H. APPLETON, Peabody.
NATHANIEL A. HORTON, Salem.
GEO. A. BATES, Salem.
CLARENCE E. MURPHY, Salem.
FRANK R. KIMBALL, Salem.
EBEN N. WALTON, Salem.
WINFIELD S. NEVINS, Salem.
JOHN H. SEARS, Salem.

Mr. HAGAR, from the Board of Directors, presented and read the following report which, he said, had the cordial endorsement of the Directors.

"The sub-committee of the Directors of the Essex Institute appointed at a meeting holden April 16, 1886, would respectfully submit the following report.

The Salem Athenæum, the owners of Plummer Hall, on the 25th of May, 1885, gave the Essex Institute the two years' notice of the termination of the present contract between the two societies. The accommodation of the present Plummer Hall building being insufficient to meet the requirements of both societies, the Athenæum needing the whole of the second story for the proper arrangement of its library and reading-rooms, it was thought advisable to secure accommodations for the Institute library elsewhere.

The finance committee of the Institute was therefore authorized to negotiate for the purchase of the Daland estate, which purchase was duly effected and the proper deeds passed. In devising plans for the utilization of the purchase, it was deemed a fitting opportunity to attempt to obtain a public library for our city. A joint committee on the part of the Athenæum and the Institute was appointed to prepare a plan looking to the union of the libraries of these societies, the coöperation of other library organizations, and the city government. The plan proposed by such committee, not meeting with the unanimous approval of the proprietors of the Athenæum, and it being deemed unadvisable without such approval to carry the plan into effect, the committee was discharged from consideration of the subject.

It now devolves upon your committee to propose a plan looking to the establishing of the Essex Institute in its own building, which should be at once prepared for its accommodation, and in general terms, to say, that the Daland estate can be so prepared at moderate expense; plans have been drawn showing the proposed alterations and an estimate of the cost has been made. The plan proposes on the first floor, a large room 49 × 19 feet for meetings and social gatherings, an office or reception room, a room for the publications of the society, an historical room, a fire-proof room for manuscripts and valuable documents, toilet room, etc.

On the second floor, a commodious, convenient and well-lighted double room for a general reading room, which is to be stocked with the current reviews, periodicals, magazines, newspapers and books of reference. A room for the Story Library, separate rooms for special libraries with tables and conveniences for readers and for consultation, and a fire-proof room for the collection of war relics; on the third floor, special library rooms, and shelving for books and printed matter which may be useful for reference, but would not be of such general interest as the libraries located in the second story. Attic and basement for duplicates and general storage purposes. Certain slight alterations are to be made in the house, besides building a new stairway, and the rendering fire-proof of certain rooms in the brick addition. The library and reading room should be neatly furnished, and so arranged as to be made attractive for members and others visiting them and the advantages to be gained by joining the society be such that an increased membership may be looked for.

It is estimated that the sum of fifteen thousand dollars will more than cover all the expense to be incurred, besides providing a sum sufficient to pay the running expenses for the next three years, and increasing the library by the purchase of new books, works of reference and works relating to history, science and art, and furnishing the reading rooms with a selection of the best reviews, magazines, weekly and daily papers, English and American, for the use of members.

The active coöperation of every member and friend of the Institute is needed at this time. In the building we have secured, or in fire-proof additions that in the future may be erected on land in the rear, might be gathered and preserved the records and relics of the old families, the histories of cities and towns; in fact all that pertains to the old life and the new of the county; with a rallying centre so stable there would be a constant influx of books, manuscripts, works of art, etc., a collection which, with that already formed, would be of great value and interest to the whole community. The occupation of the new building will, undoubtedly, mark an important epoch in the history of the Society, and the necessary arrangements should be liberally provided for, with a careful and judicious consideration of the results in view.

Your committee would therefore recommend that the directors present this plan to the members at the annual meeting, at which time, a committee be appointed for the purpose of raising the money needed, and of carrying the plan into successful operation.

H. WHEATLAND,
Chairman.

Mr. HAGAR, in presenting the report, said that it was time that the Institute occupied its own building and this opportunity should not be allowed to pass unimproved. He hoped that the members of the Society would see that the plan was vigorously carried forward. Messrs. E. B. WILLSON, E. C. BOLLES, W. P. UPHAM, T. F. HUNT and F. W. PUTNAM spoke strongly in favor of the report, the general opinion being expressed that the recommendations contained in said report should be adopted.

Mr. F. W. PUTNAM, after stating that he was in full sympathy with the movement and should do all in his power to see it carried out, offered the following preamble and note.

Whereas in the alterations and improvements in the estate lately purchased by the Essex Institute contemplated by the report of the Directors just accepted, and in the carrying out of the plans therein outlined, the work of this Society can be carried on to better advantage and its plans of usefulness extended

Voted, That the Directors of the Society are hereby fully authorized to make all necessary arrangements to carry into effect the plans proposed, and are hereby given full power to appoint committees outside of their own number for the purpose of raising funds or for any other special purpose connected with the project, which they shall deem expedient. This vote was unanimously passed.

Mr. Upham, in speaking favorably of the proposed plan, said that he had hoped that the Institute might find it expedient to open a part of its library, free to the public, and open the way for an Essex Institute Free Library which he sincerely hoped might come at no distant day, but possibly it was not the time for it now.

The meeting was strongly in favor of the plans proposed in the report of the Directors and of the vote offered by Mr. Putnam.

The plans of the proposed alterations in the Daland estate were shown, also an estimate of the probable expenditures.

THE RETROSPECT OF THE YEAR

compiled from the several reports read at the meeting, and the remarks of several members in relation thereto, presents the work of the Institute in its various departments since the last annual meeting.

Members. Changes occur in the list of our associates, by the addition of new names and the withdrawal of some by resignation, removal from the county or vicinity, or by death. We have received information of the death of the following members.

Solomon Varney, one of the oldest retired tanners and curriers of Salem, died May 24, 1885; a son of Solomon and Esther (Buxton) Varney, born in Salem, 20 Nov., 1814. In early life a tanner and currier, afterward for a time associated in the Boston Leather firm of Varney, Haskell & Co.; an active member of the Universalist society and highly esteemed. Elected to membership, Nov. 4, 1872.

Martha Goodhue Wheatland died at Salem, June 6, 1885; daughter of Benjamin and Mary Eddy (Bemis) Wheatland, born at Newmarket, N. H., March 12, 1828; removed to Salem in 1846. Elected to membership, Aug. 18, 1865.

Samuel Appleton Safford died at Fortress Monroe, Va., June 14, 1885; son of Samuel and Joanna (Appleton) Safford, born in Boston Jan. 1, 1813. Resided in Salem; for many years a member of the firm of E. Dodge & Co., flour merchants; was for several years commander of the Salem Light Infantry, a popular and much esteemed officer. After his removal from Salem he was a clerk in one of the departments in Washington, D. C. An original member.

Luke Brooks died in Salem, June 23, 1885; son of Timothy and Abigail (Mason) Brooks, born in Salem, Aug. 9, 1797; went to Eastport, April 1819; returned in April 1832 and engaged in the lumber business with his brother Samuel. In 1843 went into the Eastern commission business in Boston, continuing his residence in Salem. Elected to membership, Feb. 1, 1854.

Samuel Pickman Walcott died at his residence on Lafayette Street, in South Salem, June 25, 1885; son of Samuel Baker and Martha (Pickman) Walcott, born in Hopkinton, Mass., Feb. 11, 1834. Elected to membership, May 9, 1866.

John Francis Tuckerman died suddenly of heart disease in Salem, on Saturday, June 27, 1885; son of Gustavus and Jane (Francis) Tuckerman, born in Boston, June 13, 1817; graduated Harvard Coll., 1837, and from the Medical School, 1841. In early life a surgeon in the U. S. Navy, afterwards in mercantile pursuits, and has been a resident of Salem for more than a generation. He possessed great musical taste and culture, and has been distinguished as a composer as well as a practical vocalist and an accomplished musician. Admitted to membership, July 6, 1864.

Charles M. Richardson died in Salem, July 2, 1885. He was son of Charles and Sarah (Mansfield) Richardson, born in Salem, 17 Jan., 1807; a pupil in the famous Master Archer's School. On the 11th of July, 1822, he entered the hardware store of William Dean, corner of Essex street and Derby square. In that locality his business was continued until his death, being interested in the successive firms, Wm. Dean & Co., Adams & Richardson, Richardson & Waters. He has held offices in the state legislature, the city government, and in various institutions, religious, charitable, etc. Elected to membership, April 6, 1853.

Augustus Timothy Brooks, a well-known and highly esteemed citizen, died on Tuesday evening, July 28, 1885. He was a son of Thomas and Mary (Richardson) Brooks;

born in Salem, Oct. 9, 1814; a member of the first class in the Salem English High School; left May 24, 1828, and entered the store of a relative, the late Isaac P. Foster. In a few years he established himself in the grocery and ship chandlery business on Derby street, gradually merging the latter into an extensive flour and grain, and coal business, remaining for half a century in the same neighborhood. He served in the common council several years and was one of the most prominent and active members of the Tabernacle Church and Sunday School. He was elected to membership, March 8, 1854.

James Silver Williams, one of our younger class of shipmasters, died at Salem, Aug. 1, 1885, after a brief illness. He was son of Charles F. and Sophia (Silver) Williams and was born at Salem, Oct. 1, 1843; after graduating from the High School, he went to sea and soon rose to the command of vessels in the Zanzibar and East African trade, owned by the late Capt. Bertram; during the late civil war, he entered the U. S. Navy as acting volunteer ensign; afterward agent for Capt. Bertram in the East; was several years U. S. consul at Aden, Arabia, whence he returned only a few months since. Admitted to membership, May 12, 1875.

Henry Kemble Oliver, originally Thomas Henry Oliver, died at his residence in Salem, on Wednesday, Aug. 12, 1885. He was son of Rev. Daniel and Elizabeth (Kemble) Oliver; was born at North Beverly, Nov. 24, 1800. He was fitted for college at the Boston Latin School and Phillips Academy; entered Harvard in 1814, remained there two years and then removed to Dartmouth college, entering the junior class in 1816, graduated 1818. He entered upon teaching in June, 1819, at the Salem Latin

School; on the establishment of the High School in 1827, he was appointed to the mastership and remained there three years. He then erected a building on Federal street, Salem, for an academy of which he was the instructor, until 1844, first for boys, afterwards for girls, when he was appointed by Gov. Briggs, Adjutant General of the state. In 1848, appointed agent of the Atlantic Mills, he removed to Lawrence where he continued twelve years, serving the city in various ways, especially on the school committee and as its mayor; in 1860 elected state treasurer; and then he returned to Salem. The constitutional term having expired, by invitation of Gov. Bullock, he visited the manufacturing districts, respecting the employment of children. In 1869, he was appointed by Gov. Claflin, chief of the Bureau of Labor and Statistics; he held this office four years. In the year 1876, a member of the Board of Judges at the Centennial Exhibition, Philadelphia; Mayor of Salem, 1877–8–9–80, retiring in 1881 from public life. He was many years a member of the examining committee of Harvard College and in 1846, secretary of Board of Visitors at U. S. Mil. Acad., West Point; lectured frequently on literary and educational subjects; composer of music, etc. Admitted to membership, July 6, 1864.

George Johnson Breed died at the Homœopathic Hospital, Boston, Aug. 12, 1885; son of Capt. Holten J. and Nancy (Symonds) Breed; born in Salem, January 7, 1827. In the decease of Mr. Breed, Salem loses one of its most accomplished musicians. That he was extremely modest and unambitious and hence unknown to many does not impair the statement that we have seldom had among us a more thorough pianist, a more brilliant performer, a better teacher; yet his peculiar temperament led him to withdraw from society and exert his talents for the benefit of a few only. He was an excellent gentleman and had many warm friends and admirers. Admitted to membership, April 14, 1873.

Albert Gallatin Browne, a well-known citizen of Salem, died on Friday, Oct. 9, 1885, after a long illness. He was a son of James and Lydia (Vincent) Browne and was born in Salem, Dec. 8, 1805. In early life a cordage manufacturer, afterwards an agent of the Boston Hemp Co. In 1852 a member of the Executive Council. During the civil war, he held a government agency in the south, having the custody of the southern cotton. In late years he had retired from business. He was one of the early abolitionists and a friend of Garrison, Whittier and Sumner. Admitted to membership, Jan. 21, 1867.

Joseph Chisholm died on Saturday, Oct. 10, 1885. He was a son of William and Martha (Vincent) Chisholm, and was born in Salem, July 20, 1806. The father was a Scotchman of the ancient clan of Frazer, and the mother was a granddaughter of an Italian from Tuscany; a ropemaker by occupation, and was the clerk of the Naumkeag Fire Club from its organization, August, 1832. He was a person of extensive reading, and interested in the literary and religious institutions of the city. Admitted to membership, Nov. 10, 1852.

Charles T. Jenkins, a well-known citizen of Salem, died very suddenly of heart disease on Wednesday, Nov. 18, 1885, at the age of sixty-two. He was born in New York, June 18, 1827, and was the son of James and Susanna (Jordan) Jenkins. He came to Salem from California about fifteen years since and married a daughter of the late Nathaniel Weston; a man of wealth, a director of the Naumkeag Street Railway Co., and a member of the Masonic Fraternity. Admitted to membership, Aug. 17, 1874.

David W. Bowdoin died at his home in Washington, D. C., on Tuesday, Dec. 1, 1885, at the age of sixty-nine years. The body was brought to Salem and buried in Harmony Grove cemetery, on the Thursday following. He was born in Braintree, Mass., came to Salem in early life and was a well-known photographer. About 1873 he removed to Kentucky, a few years after settled in Washington, D. C., following the occupation he pursued in Salem. He married Florence E., daughter of the late Gilbert Tapley of Danvers, who survives. Admitted to membership, Sept. 8, 1858.

Thorpe Fisher died in Salem, Dec. 9, 1885. He was the son of Moses and Louisa (Thorpe) Fisher, and was born at Francestown, N. H., April 24, 1804. He came to Salem in early life and was engaged in several occupations. In his declining years he was interested in the cultivation of his garden, contributing to the exhibitions of the Institute many specimens of choice fruits and flowers. An original member.

Rev. Sumner Ellis, D.D., died in Chicago, Ill., Jan. 26, 1886. He was born in North Orange, Franklin County, Mass., May 17, 1828. He was installed pastor of the Universalist society, Salem, Feb. 1, 1854, and closed a successful ministry, Sept. 1, 1858. The society flourished by his earnest labors. Admitted to membership, Jan. 8, 1858.

William Sluman Messervy, ex-mayor of Salem, died on Friday, Feb. 19, 1886, after a long and painful illness. He was a son of Capt. William Messervy, an old-time shipmaster in the East India and other trades. His maternal grandfather, Capt. William Sluman, for whom he was named, commanded a private-armed vessel in the Revolutionary war, and lost his life in the service. He was born in Salem, Aug. 26, 1812; after leaving school he went to Boston and served as clerk and book-keeper in several extensive establishments. In 1834 went to St. Louis, and found employment; in 1839 he engaged in the over-land trade to Mexico and went to Santa Fé. He spent seven years in Chihuahua and six in Santa Fé. Upon the organization of the territory of New Mexico he was elected delegate to Congress, and was at one time Secretary; during the absence of the Governor he became acting Governor. In 1854 he returned to Salem and in 1856–7 was the Mayor. After his return from Mexico he was engaged in attending to his own business affairs and as a director in one or more insurance offices and other corporations. He took an active interest in several of the literary and scientific institutions. Admitted to membership, Sept. 1, 1852.

Charles Roundy, the oldest of our old-time ship masters died at his residence, Salem, on Friday, Feb. 26, 1886. He was the son of Capt. Nehemiah and Rebecca (Boynton) Roundy, born in Beverly, Oct. 15, 1794. About 1804 the family removed to Salem. In 1809 he entered upon a seafaring life in the ship Augustus and continued in the merchant service always in the employ of Capt. Joseph Peabody one of Salem's most enterprising and distinguished merchants, until he left the sea in 1835. During the period of the war with England which interrupted the commerce of the country, he enlisted in the Navy and served in the Frigate President, Commodore Rodgers and the Frigate Guerriere, Commodore Decatur, from which he was discharged in March, 1813. Upon leaving the sea, Capt. Roundy was interested as a merchant in many foreign voyages and other enterprises. Admitted to membership, June 9, 1864.

Abraham J. Stanley, a well-known musician, died in Salem, on Sunday, March 21, 1886. He was a son of Abraham and Thankful (Fish) Stanley and was born in Salem, Aug. 2, 1826. He had been connected with the Salem Brass Band for upwards of twenty-five or thirty years; a clarionet player; also a member of Gilmore's Band. Admitted to membership, July 14, 1864.

Jeremiah S. Perkins, long favorably known as superintendent of burials in Salem, died on Friday, March 12, 1886. He was the son of Aaron and Sarah (Staniford) Perkins, and was born in Ipswich, April 13, 1797. At the age of sixteen he came to Salem, and learned the tailors' trade and subsequently established himself in business, Mr. Samuel Chamberlain being his partner for five years; later he was associated with his brother Daniel, and afterwards took his son Jeremiah into partnership. In 1847 he was appointed superintendent of burials and continued in this office until his resignation in 1885. He was Captain of the Salem Mechanic Light Infantry from 1828 to 1834. Admitted to membership, July 6, 1864.

Francis Willoughby Pickman died at his residence in St. John, N. B., on the evening of March 21, 1886. He was the son of Benjamin and Anstiss (Derby) Pickman and was born in Salem, May 13, 1804. He generally resided in the Province of New Brunswick, occasionally in his native city. Admitted to membership, May 12, 1858

John James Babson, a prominent citizen of Gloucester, died on Tuesday, April 13, 1886. Born in Gloucester, June 15, 1809. He occupied many positions of trust. For many years cashier of the Gloucester Bank and for more than forty years a member of the school committee, being chairman for twenty-five years. Bank commissioner of Massachusetts in 1864 and 5, and member of both houses of the State Legislature. The historian of Gloucester and a trustee of the Sawyer Public Library; a member of Mass. Hist. Society and of the N. E. Hist. Gen. Society, and was in all an active worker. An original member.

Aaron Perkins died in Salem, on Wednesday, April 14, 1886. He was the son of Aaron and Sarah (Staniford) Perkins, and was born in Ipswich, June 16, 1799, and came to Salem when a youth. He learned the trade of a sailmaker, and afterwards by himself, and subsequently with William B. Brown, carried on an extensive clothing and furnishing business on Derby street. For many years, he was an active participant in the public affairs of his day, a director and afterwards President of the Mercantile National Bank. He was a member of both boards of the City Government and a Representative of the Massachusetts Legislature in 1846 and 1847, and an officer of various charitable and other institutions. Admitted to membership, April 16, 1866.

MEETINGS. Regular meetings were held on the first and third Monday evenings of each month. The following communications and lectures may be specified.

From *Edward S. Morse*, a familiar talk on "The Study of Natural History.

Chase Palmer, a lecture on "Combustion."

William D. Northend, on "The Bar and the Legal Proceedings in Essex County."[1]

---

[1] See Hist. Coll., E. I, XXII, 161.

Frank R. Kimball, on the "Climatology of the United States."[2]

Frank Hamilton Cushing, a familiar talk on "Zuñi Folk-lore, or Myths and Stories of the Zuñis."

B. F. McDaniel, a lecture, "The First Steps in Geology."

Edwin C. Bolles, on the "Microscope and its Application."

John Ritchie, of Boston, a lecture with experiments and illustrations, on "The New Process of Wool-scouring lately invented by Charles Toppan."[3]

F. W. Putnam, on "Some Problems in American Archæology and their partial solution."

E. S. Morse, a paper on "Ancient and Modern Methods of Arrow Release."[4]

J. S. Kingsley, a familiar talk on "The Modern Methods of the Study of Natural History."

Howard Ayers, of Ann Arbor, Mich., on "The Carapax and Sternum of Decapod Crustacea."[5]

Stephen P. Hathaway, jr., of Marblehead, "The Second Congregational Church in Marblehead."[6]

George A. Perkins, "The Family of John Perkins of Ipswich, part II."[7]

James A. Emmerton, "Salem Baptisms."[8]

John H. Gould, of Topsfield, "Topsfield in the Revolution."[9]

FIELD MEETINGS. These have been held during the season, as follows: *First*, on Thursday, July 9, 1885, at Nantasket Beach in Boston Harbor. At 2.30 o'clock the afternoon session was held in the large parlors of "Hotel Nantasket." The President in his opening remarks alluded briefly to several meetings that had been held on the sea-

---

[2] See Bulletin of E. I., XVIII, 15. [3] See Bulletin, XVIII, 1. [4] See Bulletin XVII, 145. [5] See Bulletin XVII, 49. [6] See Hist. Coll., XXII, 81. [7] See Hist. Coll., XXII, 103. [8] See Hist. Coll., XXII, 177. [7] See Hist. Coll., XXII, 297.

coast, in years past, especially to that on Salem Neck, June 22, 1880, to commemorate the two hundred and fiftieth anniversary of the landing of Winthrop in 1630. He also spoke of the previous arrivals at Salem: Conant in 1626, Endicott in 1628 and Higginson in 1629 and read extracts from the diary of Higginson under dates of June 26 and June 29, 1629, giving a very pleasing and flattering description of the harbor of Salem, its shores and its islands.

Mr. Henry Fitz Waters was introduced, and gave a very interesting account of his recent genealogical researches in London. He commenced by presenting his method of work, the difficulty experienced by those not possessed of special privileges in gaining access to the records, and alluded to some of the famous places where he sought for information. He spoke of himself as a gleaner gathering everything within his reach of value to America and especially to New England. Short descriptions were given of the Somerset House, where are kept the wills for a period of five hundred years, and of the British Museum with its vast fund of historical information, especially the valuable and interesting manuscripts, including the Maverick manuscripts and an old map of New England made in 1634 or 1635. Mr. Waters acknowledged the help he had received from antiquarian friends, and especially from James Russell Lowell, the U. S. Minister to England. He concluded by reading some extracts from curious old wills.

Prof. E. S. Morse said that, owing to the great heat, he was unable to take his anticipated stroll on the beach to collect specimens upon which to base his remarks; in lieu thereof he gave a short but very interesting description of the process of photo-engraving, showing several specimens of the work, and plaster casts, in illustration.

Second, at Salisbury Point, on Thursday, July 23, 1885. The party went by steam cars to Newburyport, and by horse-cars to the place of meeting. At Deer Island, Hon. Richard S. Spofford invited the party to alight and to accept his hospitality. His fine residence and extensive grounds were thrown open and an hour was most pleasantly passed. Again taking the cars, the party visited a curious formation of stones supposed by the residents in the vicinity to be of Indian build. These flat stones are placed in a circle, somewhat in the manner in which wells are built, the diameter of the circle about six or seven feet; shovels and hoes were put in use and more or less of the earth was removed from the inside, but nothing indicating that it was built or even used by the Indians was discovered. Mr. F. W. Putnam, who was of the party, expressed the opinion that the stones were placed by the white men at an early period, but for what purpose he could not say. Thence the party proceeded to River-side Hall where the afternoon session was held at 2.30 o'clock. The meeting was called to order by the President, who introduced *Rev. Anson Titus* of Amesbury, who made a short address of welcome. *Mr. Joseph Merrill* of Amesbury read an interesting account of "Golgotha" the oldest burying-ground in Salisbury; *Mr. Alfred Osgood* of Newburyport gave a humorous paper on the "Green-head Fly *Tabanus lineola*." *Mr. F. W. Putnam* of the Peabody Museum of American Archæology and Ethnology at Cambridge, spoke for an hour or more on the general subject of archæology and described several small collections of Indian implements which had been brought to the meeting for identification; all of these articles, arrowheads, gouges, sinkers, etc., were found in Amesbury or Salisbury. The speaker said that all these specimens belonging to individuals should be brought together and a good local collection commenced, and such a collection should be confined to articles found in the immediate vicinity. He said that some of the specimens before him were remarkably fine and well worthy of very careful preservation. During his remarks he explained the methods of manufacture and the uses of the various implements exhibited.

Rev. B. F. McDaniel of Salem, being called upon, said "It seems fitting before we part that we give some expression to the feelings and thoughts that have been uppermost in our hearts and minds to-day. As we left our homes to assemble at this place, the tolling bells struck sadly on our ears, and we knew that the great soldier of the Union, whose patience, courage, and genius saved the Union to us in the time of its great need, had passed into the larger and higher life. Our hearts have been with him in his months of suffering, and now, as the inevitable end has come, we begin to realize what a loss has befallen our country. With the things we have seen and heard to-day to be added to our stores of mental riches, are mingled his image and deeds. I do not offer these remarks as a formal resolution, but as a simple expression in my own words of what is in all our minds and hearts."

Mr. Putnam answered several questions regarding the stone-work near the Chain Bridge. The Secretary offered a vote of thanks for the courtesies and favors extended to the members of the Institute and their friends during this pleasant visit to Salisbury Point, and the meeting then adjourned.

Third, Wednesday, Aug. 12, 1885, at Marblehead Neck. The afternoon session was held in the Hall of the Marblehead Neck Association at 2.30 o'clock. The President called the meeting to order and introduced *Mr. Julius A. Palmer* of Boston who spoke of mushrooms and toadstools as food for man. The speaker said that without a pretence to a scientific knowledge of the subject he had devoted much time during the past ten years to the examination of these vegetables as articles of food. We neglect things of the greatest delicacy in ignoring mushrooms. Toadstools and mushrooms are, to a certain extent, synonymous terms, but the latter is in particular applied to the species (*Agaricus campestris*) most commonly cultivated and eaten. The little heads we get in cans and glass jars from France are of this species and are raised in the catacombs of Paris. Mr. Palmer spoke of many species not now in use, which are exceedingly palatable, and of some poisonous ones. He tested all species, the qualities of which are not already known, by first eating a bit; then, if not unpleasant, larger portions. Heroic tests are made only by the ignorant and foolhardy. The speaker answered several inquiries and related some anecdotes in relation to the subject. *Dr. J. S. Kingsley* was the next speaker and he gave an interesting account of the snails of our coast. He spoke chiefly of the true "periwinkle," an introduced mollusk, which has spread along our coast during the past twenty years so that it has become our most common species. This is edible, and in flavor is equal to the clam, and by many persons is preferred to that bivalve. *Mr. J. J. H. Gregory* of Marblehead followed, speaking of the rocks, particularly the porphyry and the uses made of the ledges of that rock on the Neck. *Mr. J. H. Sears* gave an account of the flora of the "Neck" and referred to many interesting plants. *Mr. John Robinson* made a few remarks on the mushrooms suggested by Mr. Palmer's statements, and offered a vote of thanks to the Marblehead Neck Association for the use of the Hall and to all others who had extended courtesies on this occasion.

Library.—The additions to the Library for the year (May, 1885 to May, 1886) have been as follows:

By Donation.

Folios	33
Quartos	92
Octavos	500
Duodecimos	250
Sixteenmos	90
Twenty-fourmos	33
Total of bound volumes	998
Pamphlets and serials	5,513
Total of donations	6,511

By Exchange.

Folios	7
Quartos	23
Octavos	163
Duodecimos	20
Sixteenmos	13
Twenty-fourmos	2
Total of bound volumes	228
Pamphlets and serials	2,833
Total of exchanges	3,061

By Purchase.

Quartos	28
Octavos	50
Duodecimos	37
Sixteenmos	12
Twenty-fourmos	5
Total of bound volumes	132
Pamphlets and serials	58
Total of purchases	190
Total of donations	6,511
Total of exchanges	3,061
Total of purchases	190
Total of additions	9,762

Of the total number of pamphlets and serials, 2,301 were pamphlets and 6,103 serials.

The above figures do not include the number of volumes contained in the library of the late Augustus Story, which was received in October last, from the estate of Miss E. A. Story; it comprised upwards of 1,000 volumes and will be enumerated in the next annual report.

The donations to the Library for the year have been received from one hundred and forty-eight individuals and seventy-four societies and governmental departments. The exchanges from seven individuals and from one hundred and sixty-seven societies and incorporate institutions of which ninety-six are foreign; also from editors and publishers.

The annual examination of the Library has been made; of the sixteen volumes missing last year, twelve have been returned; nine others are now missing from their places.

Donations or exchanges have been received from the following:—

	Vols.	Pam.
Adelaide, So. Australia, Royal Society,		1
Allen, J. A., Cambridge,		1
Almy, James F.,	1	14
Alnwick, Eng., Berwickshire Naturalists' Club,		1
American Association for the Advancement of Science, Newspapers,	2	
American Ornithologists' Union,		4
Ames, George L.,		2
Amherst College, Amherst,		104
Amiens, Société Linnéenne du Nord de la France,		16
Amsterdam, Société Royale de Zoologie Natura Artis Magistra,		1
Anagnos, M., So. Boston,		1
Andover, Phillips Academy,		1
Andover, Theological Seminary,		1
Andrews, William P.,		45
Appleton, William S., Boston,		1
Archæological Institute of America,		1
Augsburg, Naturhistorischer Verein,		1
Baltimore, Maryland Historical Society,	1	3
Baltimore, Md., Johns Hopkins University,		21
Baltimore, Md., Peabody Institute,		1
Bancroft, C. F. P., Andover,		1
Barstow, Morey Hale, New York, N. Y.,		1

Bartholomew, George W., Jr., Austin, Tex., . . .	1	
Batavia, K. Natuurkundige Vereeniging in Nederlandsch Indie, ...	2	1
Bayley, Miss E. S., Boston, ...		1
Beauchamp, Rev. W. M., Baldwinsville, N. Y., ...		2
Bergen, Norway, Bergen Museum, ...	1	
Berkeley, Cal., University of California, ...		27
Berlin, Gesellschaft Naturforschende Freunde, . . .		1
Berlin, Verein zur Beförderung des Gartenbaues, . .		52
Bern, Naturforschende Gesellschaft, ...		2
Blair, H. W., Washington, D. C., ...	4	
Blanchard, Miss Sarah B., ...	1	13
Bodge, Rev. George M., E. Boston, ...		1
Bolles, Rev. E. C., D.D., ...	1	108
Bologna, R. Accademia delle Scienze, ...		1
Bonn, Naturhistorischer Verein, ...	1	3
Bordeaux, Société Linnéenne, ...	2	
Boston, American Academy of Arts and Sciences, . .	1	4
Boston, Appalachian Mountain Club, ...		3
Boston Board of Health, ...		14
Boston, Bostonian Society, ...		2
Boston, City of, ...	7	
Boston City Hospital, ...	1	
Boston, Massachusetts Historical Society, ...	9	514
Boston, Massachusetts Horticultural Society, . . .		3
Boston, Massachusetts Medical Society, ...		1
Boston, Massachusetts State Board of Health, . . .	1	
Boston, National Association of Wool Manufacturers, .		3
Boston, New England Historic Genealogical Society, .	1	10
Boston Public Library, ...		4
Boston Society of Natural History, ...		7
Boston, State Library of Massachusetts, ...		1
Bradlee, Rev. C. D., Boston, ...		1
Bradley, C. B., Berkeley, Cal., ...		1
Bradley. C. S., Providence, R. I., ...		1
Breed, Estate of the late George J., ...	12	
Bremen, Naturwissenschaftlicher Verein, ...		2
Bristol, Eng., Naturalists' Society, ...		2
Brooklyn Library, Brooklyn, N. Y., ...		3
Brooklyn, N. Y., Long Island Historical Society, . .		3
Brooks, Henry M., ...	37	5
Brooks, Luke, ...	55	409
Brookville, Ind., Society of Natural History, . . .		1
Brown, Henry A., ...	5	126

Brunn, Naturforschender Verein, ...		3
Brunswick, Me., Bowdoin College, ...		1
Bruxelles, Académie Royal des Sciences, des Lettres et des Beaux Arts de Belgique, ...	6	
Bruxelles, Société Belge de Microscopie, ...	2	9
Bruxelles, Société Entomologique de Belgique, ...	2	
Bruxelles, Société Royale Malacologique, ...	3	23
Buenos Aires, Sociedad Cientifica Argentina, . . .		9
Buffalo, N. Y., Historical Society, ...		1
Buffalo, N. Y., Society of Natural Science, . . .		1
Buffalo, N. Y., Young Men's Association, . . .		1
Burgess, George L., Portland, Me., ...		1
Burley, Charles, Exeter, N. H., ...		1
Burns, Charles, ...		2
Caen, Académie Nationale des Sciences, Arts et Belles Lettres, ...	2	
Calcutta, Geological Survey of India, ...		11
Cambridge, Harvard University, ...	1	2
Cambridge, Museum of Comparative Zoölogy, . . .		6
Cannon, H. W., Washington, D. C., ...	1	
Carpenter, Rev. C. C., Andover, ...	2	2
Case, Andrew, ...		10
Chadwick, James R., Boston, ...		5
Chamberlain, James, ...	7	89
Champaign, Ill., State Laboratory of Natural History, .		1
Chapman, Miss M. R., Beverly, ...	1	29
Charleston, S. C., Elliott Society of Science and Art, .		3
Cherbourg, Société Nationale des Sciences Naturelles, .	1	1
Chicago, Ill., Historical Society, ...		4
Chicago, Ill., Public Library, ...		1
Christiania, Commission Géodésique de la Norvege, . .		2
Christiania, Videnskabs Selskabet, ...	1	
Cincinnati, O., Board of Education, ...	1	
Cincinnati, O., Public Library, ...	2	
Cincinnati, O., Society of Natural History, . . .		4
Clarke, George K., Boston, ...	1	
Cleveland, O., Western Reserve Historical Society, . .		6
Cole, Mrs. N. D., ... Newspapers,		75
Conant, W. P., ... Newspapers,		
Concord, New Hampshire Historical Society, . . .	1	
Cook, James P., ...	1	
Copenhague, Société Botanique, ...		3
Crocker, Uriel H., Boston, ...	1	
Crowell, Rev. E. P., Amherst, ... Circulars,		

Curwen, James B., ...	12	34
Cutter, A. E., Charlestown, ...		1
Danzig, Naturforschende Gesellschaft, ...		1
Darmstadt, Verein für Erdkunde, ...	1	
Des Moines, Ia., Academy of Science, ...		1
Dodge, James H., Boston, ...	1	
Dow, Herbert B., Andover, N. H., ...		1
Dresden, Naturwissenschaftliche Gesellschaft "Isis," .		2
Dresden, Verein für Erdkunde, ...		1
Dublin, Royal Irish Academy, ...		8
Dublin, Royal Society, ...		5
Dunlap, Lauren, Huron, D. T., ...		9
Edes, H. H., Charlestown, ...		1
Ellery, Harrison, Boston, ... Circular,		
Emden, Naturforschende Gesellschaft, ...		1
Erfurt, Akademie Gemeinnütziger Verein, . . .		1
Erlangen, Physikalisch-Medicinische Gesellschaft, . .		1
Essex Agricultural Society, ...		1
Exeter, N. H., Phillips Academy, ...		1
Falmouth, Eng., Royal Cornwall Polytechnic Society, .	1	
Florence, Italy, R. Biblioteca Nazionale Centrale, . .		8
Florence, Italy, R. Istituto di Studi Superiori, . .	2	1
Fogg, Miss Ellen M., ...	3	7
Forbes, R. B., Boston, ...	1	1
Forbes, S. A., Champaign, Ill., ...		1
Foster, Joseph, Philadelphia, Pa., ...		1
Frankfurt, A. M., Senckenbergische Naturforschende Gesellschaft, ...	2	
Freiburg, Naturforschende Gesellschaft, ...		1
French, A. D. Weld, Boston, ...	1	
Genève, L'Institut National Genèvois, ...	1	
Genève, Société de Physique et d'Histoire Naturelle, .		1
Glasgow, Natural History Society, ...		10
Gloucester, Evangelical Congregational Church, . .	1	
Göttingen, K. Gesellschaft der Wissenchaften, . . .	2	
Goodell, Mrs. A. C., jr., ... Newspapers,		16
Gould, John H., Topsfield, ...		2
Grant, Frederick, ...	1	
Granville, O., Dennison University, ...		1
Green, Samuel A., Boston, ...	63	629
Güstrow, Verein der Freunde der Naturgeschichte, . .	1	
Hale, Rev. E. E., Roxbury, ...		29
Halifax, N. S., Institute of Natural Science, . . .		1
Hamilton, Morris R., Trenton, N. J., ...	2	

Hamilton, R. I., Narragansett Historical Publishing Co.,			3
Hannover Naturhistorische Gesellschaft, ...			1
Harden, William, Savannah, Ga., ...			1
Harlem, Société Hollandaise des Sciences, . . .			6
Hartford, Conn., Trinity College, ...			2
Hill, B. D., ...	Newspapers,		1
Hill, H. A., Boston, ...		8	
Hingham, Town of, ...		1	
Hixson, William D., Maysville, Ky., ...			2
Hobart Town, Government of Tasmania, . . .			1
Hobart Town, Royal Society of Tasmania, . . .			2
Holmes, John C., Detroit, Mich., . . .	Circular,		
Horsford, E. N., Cambridge, ...			5
Hosmer, Rev. George H., ...		55	121
Hunt, T. F., ...		48	189
Iowa City, Ia., Historical Society, ...			6
Israel, Rev. F., ...	Newspapers,	2	47
Kimball, Mrs. E. D., ...			1
Kimball, James P., Washington, D. C., ...		15	1
Kimball, William T., Lawrence, ...		1	
King, H. F., ...			1
Kinsman, Mrs. N., ...		85	2
Kjöbenhavn, K. D. Videnskabernes Selskab, . . .			4
Kjöbenhavn, Société R. des Antiquaires du Nord, . .			4
Königsberg, Physikalisch-Oekonomische Gesellschaft, .			2
Langworthy, Rev. I. P., Boston, ...			1
Lansing, Mich., State Agricultural College, ...		1	10
Lansing, Mich., State Board of Agriculture, . . .		2	
Lansing, Mich., State Library, ...		29	3
Lausanne, Société Vaudoise, ...			1
Lawrence, Public Library, ...			1
Lee, F. H., ...		2	398
Leeds, Josiah W., Philadelphia, Pa., ...			1
Leeds, Eng., Philosophical and Literary Society, . .			1
Le Mans, Société d' Agriculture, Sciences et Arts de la Sarthe, ...			2
Liège, Société Royale des Sciences, ...		2	
Lincoln, Neb., State Historical Society, ...		1	
Liverpool, Eng., Literary and Philosophical Society, .		1	
London, Eng., Conchological Society, ...			4
London, Eng., Royal Society, ...			11
Lovett, Thomas D., Cincinnati, O., ...		1	
Lowell, Old Residents' Historical Association, . . .			1
Lund, Université Royale, ...		6	4

Luxembourg, Société Botanique,		1
Lyon, Académie des Sciences, Belles-Lettres et Arts,	3	1
Madison, Wis., State Historical Society,	1	2
Madrid, Observatorio,	10	
Madrid, Sociedad Española de Historia Natural,		2
Manchester, Rev. L. C., Lowell,		1
Manchester, Eng., Literary and Philosophical Society,	1	2
Mannheim, Verein für Naturkunde,		1
Manning, Robert,		718
Manson, A. S., Boston,		1
Marietta College, Marietta, O.,	1	1
Marshall, John W., Rockport,		1
Massachusetts, Commonwealth of,	4	1
Mayberry, S. P., Cape Elizabeth, Me., . Newspapers,		
McClurg, A. C., & Co., Chicago, Ill.,	1	
McDaniel, Rev. B. F.,	3	182
McLoud, Mrs. Anson, Newburyport, . Newspapers,		
Meek, H. M.,	2	
Merrill, William, jr., West Newbury,		23
Mexico, Museo Nacional,		2
Middlebury, Vt., Historical Society,		1
Milwaukee, Wis., Public Museum,		1
Minneapolis, Minn., Academy of Natural Sciences,		4
Mitchell, Donald G., New Haven, Conn.,	1	
Montreal, Canada, Natural History Society,		5
Montreal, Canada, Société Historique,		1
Morse, E. S.,	1	29
München, K. B. Akademie der Wissenschaften,	1	13
Münster, Westfälische Verein für Wissenschaft u. Kunst,		1
Nashville, Tennessee Historical Society,		1
Nashville, Tenn., State Board of Health,	1	
Nevins, W. S., . Newspapers,		10
Newark, New Jersey Historical Society,	1	1
Newark, N. J., Library Association,		1
New Bedford, Public Library,		1
New Haven, Conn., Academy of Arts and Sciences,		1
New Haven, Conn., Yale College,	1	4
Newport, R. I., Natural History Society,		3
New York, N. Y., Academy of Sciences,	1	9
New York, N. Y., American Geographical Society,		2
New York, N. Y., Chamber of Commerce,	1	
New York, N. Y., Genealogical, Biographical Society,		4
New York, N. Y., Historical Society,	2	

New York, N. Y., Huguenot Society of America, . .		1
New York, N. Y., Maimonides Library, ...		1
New York, N. Y., Mercantile Library Association, . .		3
New York, N. Y., Microscopical Society, ...		7
New York, N. Y., Union Defence Committee, . . .	1	
Nichols, Andrew, jr., Danvers, ...		6
Nichols, John H., So. Wilton, Conn., ...	12	3
Nolcini, C. A., ...		2
Northampton, Smith College, ...		1
Northend, William D., ...	3	77
Norwegian North Atlantic Expedition, ...		3
Nourse, Miss Dorcas C., ... Newspapers,		1
Nourse, Henry S., Lancaster, ...	2	50
Oliver, Henry K., ...	5	17
Oliver, H. K., Boston, ...		1
Osnabrück, Naturwissenschaftlicher Verein, . . .	1	
Ottawa, Canada, Geological and Natural History Survey,	2	
Ottawa, Canada, L'Institut Canadien-Français, . .		6
Ottawa, Canada, Royal Society, ...	1	
Packard, A. S., Providence, R. I., ...		1
Palfray, Charles W., ... Newspapers,		399
Paris, Société d'Acclimatation, ...		15
Paris, Société d'Anthropologie, ...		5
Paris, Société des Etudes Historiques, ...	1	
Peabody, George L., ...	79	61
Peabody Institute, Peabody, ...		3
Peaslee, John B., Cincinnati, O., ...		2
Peet, Rev. S. D., Clinton, Wis., ...		6
Peirce, Henry B., Boston, ...	6	1
Perkins, A. T., Boston, ...		1
Philadelphia, Pa., Academy of Natural Sciences, . .		2
Philadelphia, Pa., American Philosophical Society, . .	1	3
Philadelphia, Pa., Historical Society, ...		6
Philadelphia, Pa., Indian Rights Association, . . .		1
Philadelphia, Pa., Library Company, ...		2
Philadelphia, Pa., Numismatic and Antiquarian Society, .		1
Philadelphia, Pa., Zoölogical Society, ...		1
Pickering, Miss Mary O., ...	22	
Pillsbury, Parker, Concord, N. H., ...		2
Plumer, Miss Mary N., ... Newspapers,		3
Pool, Wellington, Wenham, ...		2
Porter, Rev. Aaron, ...		1
Providence, Rhode Island Historical Society, . . .	20	10

Providence, R. I., New England Meteorological Society,		2
Providence, R. I., Public Library, ...		1
Putnam, F. W., Cambridge, ...	1	12
Putnam, H. W., ...	57	1
Rantoul, Robert S., ...	9	3
Regensburg, K. B. Botanische Gesellschaft, . . .	1	
Regensburg, Naturwissenschaftlicher Verein, . . .		1
Rice, Rev. C. B., Danvers Centre, ...		1
Richardson, Estate of the late Miss Eunice P., . . .	135	218
Riga, Naturforschender Verein, ...		1
Roberts, Miss M. L., ...		4
Robinson, John, ...	3	237
Russell, Mrs. Thomas B., ...		4
Safford, J. H., ... Newspapers,		
Salem, Peabody Academy of Science, ...	1	1
Salisbury, Edward E., New Haven, Conn., . . .	1	
Sampson, Murdock & Co., Boston, ...	1	
San Francisco, California Academy of Science, . .		1
San Francisco, Cal., Mercantile Library Association, .		1
Savannah, Georgia Historical Society, ...		1
Sedalia, Mo., Natural History Society, ...		1
Sewall, J. B., Braintree, ...		1
S'Gravenhage, Nederlandsche Entomologische Vereeniging, ...		4
Shanghai, China Branch of the Royal Asiatic Society, .	1	4
Sibley, Estate of the late John L., ...	3	
Smith, Miss Alice B., Hickman, Ky., . . Newspapers,		
Smith, George Plumer, Philadelphia, Pa., ...	1	
Smith, Miss Louise, Hickman, Ky., . . Newspapers,		
Snively, Rev. W. A., Brooklyn, N. Y., ...	1	
So. Boston, Massachusetts School for the Feeble-Minded,		1
Spinney, W. F., ...	1	12
Springfield, Illinois Department of Agriculture, . .		11
Stettin, Entomologischer Verein, ...	1	
St. Gallen, St. Gallische Naturwissenschaftlicher Verein,	2	
St. John, New Brunswick Natural History Society, . .		1
St. Louis, Mo., Public School Library, ...		1
Stockholm, K. S. Vetenskaps Akademien, . . .	6	10
Stockholm, Société Entomologique, ...		2
Stone, Benjamin W., ...	3	1
Stone, Eben F., Washington, D. C., ...		127
Stone, Robert, ... Newspapers,		
St. Pétersbourg, Académie Impériale des Sciences, . .		3

St. Pétersbourg, Comité Geologique, ...		1
St. Pétersbourg Société Entomologique, ...	1	
Sutton, Estate of the late William, ...	34	
Sydney, Royal Society of New South Wales, . . .	1	
Taunton, Old Colony Historical Society, ...		2
Taunton, Public Library, ...		1
Taunton, Eng., Somersetshire Archæological and Natural History Society, ...	1	
Thacher, Peter, Boston, ...		1
Thompson, Waldo, Swampscott, ...	1	
Throndhjem, K. N. Videnskabernes Selskab, . . .	1	
Tierney, P. F., ...	2	
Topeka, Kan., Academy of Science, ...		1
Topeka, Kan., Historical Society, . . Newspapers,		
Topeka, Kan., Natural History Department of Washburn College, ...		2
Topeka, Kan., Washburn College Laboratory, . . .		2
Toronto, Can., Canadian Institute, ...		2
Trenton, N. J., Natural History Society, ...		1
Tyler, Mrs. J. H., Winchester, ...		1
Unknown, ...	54	171
Upham, Rev. James, D.D., Chelsea, ...	1	
Upham, W. P., ...	1	
Upsal, Societas Scientiarum, ...		1
U. S. Bureau of Education, ...	1	5
U. S. Bureau of Ethnology, ...	1	
U. S. Chief of Engineers, ...	5	
U. S. Chief Signal Officer, ...	2	2
U. S. Civil Service Commission, ...		1
U. S. Coast and Geodetic Survey, ...	1	
U. S. Department of Agriculture, ...		3
U. S. Department of the Interior, ...	115	2
U. S. Department of State, ...	5	15
U. S. Fish Commission, ...	3	
U. S. Geological Survey, ...	6	17
U. S. Life Saving Service, ...	1	
U. S. National Museum, ...		42
U. S. Naval Observatory, ...	1	
U. S. Patent Office, ...	4	53
U. S. War Department, ...	6	
Verity, Mrs. J. S., Washington, D. C., ...	1	
Vilas, William F., Washington, D. C., ...	1	
Wagner, E. C., Philadelphia, Pa., ...		1

Ward, Rev. Joseph, Yankton, D. T., ...	1	
Waring, George E., jr., Providence, R. I., ...		1
Washington, D. C., Anthropological Society, . . .	1	
Washington, D. C., Legacion Mexicana, ...		1
Washington, D. C., Smithsonian Institution, . . .	6	
Waters, H. F., ...	1	
Waters, J. Linton, ...	9	39
Waterville, Me., Colby University, ...		1
Watson, Miss C. A., ...		61
Watson, S. M., Portland, Me., ...		5
Wheildon, William W., Concord, ...		1
Whelpley, A. W., Cincinnati, O., ...	10	
Whipple, George M., ...		11
Whitcher, Mary, Shaker Village, N. H., ...		12
Whitney, Mrs. H. M., Lawrence, . . Newspapers,		
Wicksteed, Rev. John, Ottawa, Can., ...		1
Wien, K. K. Naturhistorische Museum, ...		1
Wien, K. K. Zoologisch-Botanische Gesellschaft, . .	1	2
Wiesbaden, Verein für Naturkunde, ...		1
Wilkes-Barré, Pa., Wyoming Historical and Geological Society, ...	22	1
Willson, Rev. E. B., ...		12
Wilmington, Delaware Historical Society, . . .		1
Winnipeg, Can., Manitoba Historical and Scientific Society, ...		4
Winsor, Justin, Cambridge, ...		36
Winthrop, Robert C., Boston, ...	1	1
Winthrop, Robert C., jr., Boston, ...		2
Wisconsin, National Home for Disabled Soldiers, . .		1
Woburn Board of Trade, ...	1	
Woodbury, Charles Levi, Boston, ...	1	
Worcester, American Antiquarian Society, Newspapers,	1	3
Worcester, Society of Antiquity, ...	1	1
Würzburg, Physikalisch-Medicinische Gesellschaft, .	1	
Zurich, Naturforschende Gesellschaft, ...		14

The following have been received from editors or publishers:—

American Journal of Science.
Cape Ann Bulletin.
Chicago Journal of Commerce.
Danvers Mirror.
Fireside Favorite.
Gardener's Monthly and Horticulturist.
Groton Landmark.
Ipswich Chronicle.
Lawrence American.
Le Naturaliste Canadien.
Lynn Bee.
Manifesto, The.
Marblehead Messenger.

Musical Herald.
Musical Record.
Nation, The.
Naturalists' Leisure Hour and Monthly Bulletin.
Nature.
Our Dumb Animals.
Peabody Press.
Quaritch's Catalogue.
Sailor's Magazine and Seamen's Friend.
Salem Evening News.
Salem Evening Telegram.
Salem Gazette.
Salem Observer.
Salem Register.
Traveler's Record.
Turner's Public Spirit.
Voice, The.
Wade's Fibre and Fabric.
Zoologischer Anzeiger.

FINANCIAL.—The Treasurer's Report of the receipts and expenditures of the past year:

RECEIPTS.

Income of *General Account.*

Assessments of members,	$811 00	
Publications,	671 33	
Excursions, Use of Hall, etc.,	370 64	
Dividends N. Webster Bank,	17 50	
Return Tax,	4 34	
Portion of bills, Salem Athenæum,	178 62	
		2,053 43
Income, Historical fund,	12 00	
" Nat. History fund,	36 00	
" Davis fund and past income,	489 87	
" Ditmore fund,	140 00	
" Manuscript fund,	28 04	
" Ladies' Fair fund,	60 00	
" Derby fund,	18 00	
" Howes fund,	1,477 79	
" Story fund,	591 50	
" Peele fund,	101 00	
		2,954 20
Sale of securities to pay for		
Daland estate, $11,000 bonds =	12,742 00	
Salem Five Cents Saving Bank check,	1,000 00	
Salem Savings Bank check,	258 00	
		14,000 00
		$19,007 63

EXPENDITURES.

Balance last year, overdrawn		$117 52
Paid on *General Account.*		
Salaries,	1,920 00	
Publications,	937 43	
Fuel and Gas,	197 00	
Books, binding, printing and stationery,	639 30	
Repairs, expressage, postage and incidentals,	150 30	
Premium fire insurance,	61 25	
Salem Athenæum, as per agreement,	300 00	
Salem Athenæum, services of Librarian, etc.,	79 12	4,284 40
Paid Ditmore annuity,		110 00
Story annuity (ceased)		83 00
"Manuscript" account funded,		28 04
"Derby" account funded,		18 00
Paid for the Daland House, from the W. B. Howes fund,		14,000 00
Paid expenses thereon, insurance, coal and repairs,		254 34
		18,895 30
Balance on hand,		112 33
		$19,007 63
Amount of invested funds including real estate,		$48,896 63

EXCURSION TO NIAGARA AND TRENTON FALLS.—A party, consisting of members and friends of the Essex Institute, left Salem on Wednesday, June 10, 1885, by the Hoosac Tunnel route and the West Shore Line for Niagara Falls and spent two days in the examination of the principal points of interest in that locality. Thence went to Trenton and found a welcome retreat for Sunday's rest in Moore's Hotel, a quiet, good, old-fashioned English inn.

A large garden fronts the hotel and the most delightful of forests lies back of it, bordering the gorge for several miles; paths traverse it in various directions, affording frequent glimpses of the stream and the falls. What a haunt for the botanist with its many attractive plants, and how fascinating to the geologist with the high, rocky walls, the leaves of the strata superimposed on each other as evenly as those of a book and crowded with fossils! Rev. B. F. McDaniel was of the party and pointed out the principal geological features and explained the fossil contents of the stràta. Some good specimens were found.

Rev. William Silsbee, a native of Salem and a graduate of Harvard in the class of 1832, who has been for many years the revered and beloved pastor of one of the churches, extended a cordial welcome. He has a charming home; and the exterior of the fine stone building, that holds the Free Public Library, which he has gathered as one of the ripened sheaves of his work, was duly noticed.

The day following, the party proceeded to North Adams, and soon after arrival a large proportion of the tourists took carriages to Williamstown, only a few miles distant, the seat of Williams College, a most beautiful village, without fences on the street (hardly one in sight) ample lawns of the richest and closest verdure, overarching trees and wealth of shrubbery, a fine and striking illustration of the influence of the village improvement societies that have been organized in many of the rural villages of the New England states. The next day, Tuesday, left North Adams in the morning and arrived at Salem the same afternoon.

In this short week, many new pictures have been hung in Memory's halls and through them will echo the sweet music of Trenton and the mighty tones of Niagara.

The Rose Show, on Thursday, June 25, 1885, was well attended, and there was a fine collection. Among the contributors were Hon. J. B. F. Osgood, Mrs. Benj. Creamer, Miss E. Ropes, Mr. Charles Bowker, Mr. John H. Punchard, Miss Carrie Read, Mrs. C. H. Miller, E.

Putnam, Miss Lottie Chase, Mrs. John West, Jesse B. Edwards, George D. Phippen, Mrs. S. J. Peck, R. B. Gifford, jr., S. P. Fowler, George Russell, H. W. Putnam, Wm. J. Foster, Mrs. N. B. Mansfield, W. S. Ward, Frederick Lamson.

Mr. John Robinson exhibited some curious Japanese and Siberian roses which were very pretty. There were also some handsome begonias, poppies and other flowers.

The committee on awards reported as follows: honorable mention, for best four blooms of roses, to Mrs. S. J. Peck; second best four to J. B. F. Osgood; best single bloom, to J. B. F. Osgood; second best single bloom, to Mrs. N. B. Mansfield; best twelve blooms, to J. B. F. Osgood; second best, to the same. Tea roses, best four blooms, to W. S. Ward; second, to F. Lamson.

Museum.—The specimens of natural history, including archæology, which have been given during the year, are on deposit with the Trustees of the Peabody Academy of Science, in accordance with previous arrangements. Those of an historical character, or that possess an artistic interest, have been arranged in the rooms.

The following may be specified as contributors: T. F. Hunt, Geo. L. Peabody, Ezra Brown, Israel R. Phelps, Mrs. Anna J. Haskell of Roxbury, Miss Ellen M. Fogg, Wm. McGrane, Mrs. Geo. F. Choate, John P. Peabody, Thos. D. Lovett, Cincinnati, O., J. Linton Waters, John Robinson, Peabody Academy of Science, Jos. S. Carels, Nashville, Tenn., estate of Miss E. P. Richardson, Mrs. Wm. Sutton, B. D. Hill, J. W. Dunphy, Boston, Capt. Henry F. King, John H. Nichols, So. Wilton, Conn., Mrs. Morrill Ricker, J. W. Moulton, Wm. D. Northend, Mrs. Edmund Upton, Miss Mary R. Kimball, S. B. Buttrick, Samuel A. Green, Boston, Mrs. Jas. Kimball, R. S.

Rantoul, Miss Sarah B. Blanchard, Dr. Charles Haddock, Beverly, Charles Pulsifer, Mrs. H. R. Cooke, New York.

The Secretary, in his report, says: "The most important society event of the year is the acquisition by purchase, of the estate adjoining Plummer Hall, known as the Daland estate. The report of the sub-committee, endorsed by the directors, will be read later, giving particulars of the purchase and information concerning the needs of the Institute in order that the new building may be fitted for occupancy. This report should receive the cordial support of every member of the society. Its recommendations, if carried out, will vastly strengthen the Institute and increase its usefulness; not only this, but members will personally find in the new building many advantages, privileges and comforts not possible in the years past."

The Secretary closes his report in the following words: "The society remembers with gratitude its members and many friends who have so cordially and so continuously supported it, and without whose aid it could not have lived; from its small beginnings in 1848 to the present time, its growth has been slow perhaps, but sure; and soon in a comfortable home of its own it hopes to show the valuable accumulation of books, pamphlets and historical articles, the work of years, properly arranged and in condition for use."

Dermatochelys Coriacea, Trunk Back or Leathery Turtle.

BY J. H. SEARS.

The preparation of the present paper was suggested by the capture, August 25, 1885, within the limits of Essex County, of a fine specimen of the leathery or trunk turtle which is now preserved in the collection of the Peabody Academy of Science.

This reptile is classed in the order Testudinata, section Sphargididea, genus Dermatochelys. There are two species : *D. coriacea*, inhabiting the tropical Atlantic and adjacent waters, and *D. schlegeli*, the tropical Pacific and Indian oceans. This classification is taken from Mr. Samuel Garman's Reptiles and Batrachians of North America, published in the Bulletin of the Essex Institute, Vol. XVI, 1884.

As early as 1554, this reptile was described by Rondeletus under the name of *Testudo coriacea mercurii.* In 1766, Linnæus figured and gave some account of this species in his Natural System, which he named *Testudo coriacea.* Blainville, in the Bulletin Société Philomatique in 1816, named the species *Dermatochelys coriacea*, as the name denotes, *Derma*, skin, *chelys*, turtle. To separate the species which have no shell from the Testudo or tortoises, Merrem, in his Amphibia, published in 1820, gave to this genus of sea turtles the name of *Sphargis* and applied the specific name *mercurilis* to the species under consideration. In 1829, Gravenhorst, in Okin Isis, gives a description of one of these reptiles to which he gave the name *Testudo tuberculata.* Wagler, in his system

Amphibia, 1830, called the species *Dermatochelys porcata.* In 1831, Gray in his synopsis of the animal kingdom classed this reptile as *Chelonium* (*Sphargis*) *coriacea*, and later, in the same year in his Cataphracta, he gives it the name of *Sphargis coriacea.* In 1836, Lesueur, in Cuvier's Animal Distribution, gives the name *Dermatochelys atlantica.* From this date until 1871 nearly all that has been recorded concerning this reptile has been under the name of *Sphargis coriacea.* In 1871, Dr. Albert Günther in the Zoölogical Record, Vol. VIII, mentions an example of Dermatochelys having the extreme dimensions of nine feet. This specimen was taken on the coast of New South Wales.

This reptile is recorded as having been taken on the coasts of France, England, Scotland, China, Japan, Africa and America, but its occurrence has been so rare that no accurate accounts of it have yet been published. According to Count Lacepède, a French naturalist, it was this species of turtle with which the Greeks were best acquainted, and he supposed it to have been particularly used in the formation of the ancient harp or lyre which was originally constructed by attaching strings or wires to the carapace of one of these marine reptiles. Rondeletus mentions that the ancients procured the turtle from Arcadia which is situated on the sandy shores of the Gulf of Arcadia, where these turtles lay their eggs, but Cuvier and other modern writers discredit this statement, as it is said that the turtle used was procured from the groves or woods of Arcadia, also that the back of this turtle with its seven sharp ridges was likened to a harp with the strings attached which gave it the name of Luth. It is said that the flesh is coarse and offensive, but that the Carthusian monks will eat no other turtle. In the Encyclopedia Brittanica I find the following account of a leathery or trunk turtle: "In the month of August, 1729, three leagues from Nantes near the mouth of the Loire one of these marine reptiles was taken which measured seven feet and is said to have uttered a scream so loud as to have been heard a mile." Dr. D. Humphreys Storer, in his Report upon the Reptiles of Massachusetts, says, "The naturalist may judge of the great rarity of this species from the following observations by Dumeril and Bibron in their Erpetologie générale ou Histoire complete des Reptiles. This species is very rare. It inhabits the Mediterranean and the Atlantic ocean. Rondeletus mentions a *Sphargis luth* five cubits long which was taken at Frontignon. Amoreux describes another which was taken in the harbor of Cette, and Borlais gives a figure of a *Sphargis luth* that was taken in 1756 upon the coast of Cornwall, England."

In the Reptiles of Bermuda, by Samuel Garman, Bulletin No. 25, U. S. National Museum, I find the following notice in regard to the ovulation of Sphargis. The items are copied from the Morning Journal of April 30, 1846, by Gosse, in the Naturalist's Sojourn in Jamaica, 1859, p. 350, and bears the marks of its origin in evidence of desire to make the most of it, yet as Mr. Gosse remarks, it has sufficient appearance of accuracy to warrant preservation. The locality of the occurrence is Negril Bay at the west end of Jamaica. "The anxiety of the fishermen in this little village was aroused on the thirtieth of last month by the track of a huge sea monster called a trunk turtle which came on the sea beach for the purpose of laying her eggs; a search was made when a hole was discovered about four feet deep and as wide as the mouth of a half barrel, whence five or six dozen white eggs were taken; the eggs were of different sizes, the largest being the size of a duck's egg. On the morning of the tenth of this month at half-past five o'clock she was discovered by Mr. Crow on the beach near the spot where she first came up; he gave the alarm when all the neighbors assembled and got her turned on her back. It took twelve men to haul her 200 yards. I went and measured her and found the dimensions as follows: from head to tail 6 feet 6 inches, from the outer part of her fore fin to the tip of the other 9 feet 2 inches, around her neck 3 feet 3 inches, widest part of fore fin 18 inches, the hind fins 2 feet 4 inches. Her back is formed like the round top of a trunk with small white bumps in straight lines resembling the nails on a trunk; her color is variegated like the rainbow. There is no shell on her back but a thick skin like pump leather. The date would place the laying time in the latter part of March instead of as early claimed by the fishermen and turtlers, December, January and February, for this genus. Sphargis is the most rare and least known of the sea turtles."

Dr. D. Humphreys Storer in his report of the Reptiles of Massachusetts, published in 1839, has the following: "*Sphargis coriacea.* The first one taken on the coast of the United States was found on the surface of the water in Massachusetts Bay in 1824 and brought to Boston where it was purchased by Mr. Greenwood of the New England Museum of its captors for two hundred dollars." In the summer of 1852 or 1853 one was washed on the shore at Nahant, and one was captured on the coast of Maine in July, 1866, from which specimen Prof. E. S. Morse made a sketch. The one now in the cabinet of the Boston Society of Natural History was taken at Annisquam in 1880. Mr. Winchester Smith of Salem in September, 1882, bought one of these turtles from some fishermen in Gloucester; it was caught some distance from that port and was purchased of Smith and Parker of Salem in 1884, by the Peabody Academy of Science. Another one was taken in Portland harbor July 22, 1885, and on the twenty-fifth of August, 1885, Mr. Parsons of Rockport caught a fine specimen of the leathery or trunk-back turtle alive. This turtle was found entangled and completely wound up in a mackerel net which was set in the cove between the Salt Rocks and Milk Island opposite Long Beach, Rockport. It was towed to shore on Long Beach, where it required the efforts of eight men to load it on a wagon; it was carried to Pigeon Cove from which place Mr. Parsons sent a telegram to the Peabody Academy of Science announcing that he had a new species of turtle. On going to Pigeon Cove the next morning, I found he had caught a superb specimen of the leathery or trunk-back turtle. This specimen measured 7 feet, 3 inches from his nose to the end of his tail, 5 feet across the back in the widest part; his anterior flippers or arms were 3 feet long and 16 inches across in the widest part; the posterior flippers were 22 inches long and 20 inches wide. The skin on his back and upper portions of the body was a peculiar greenish brown color not unlike dried fucus. The sides and upper parts were a creamy white blotched with a bluish black. The motions of this turtle were remarkably quick for so large a creature when out of its natural element; it moved around the room in which it was confined, upsetting barrels, tables and the stove as easily and as quickly as a Texas wild steer would have done, causing a general commotion. In its struggles while being secured (which was accomplished by lashing the anterior flippers together on the under side) it uttered a sound of great volume, an indescribable kind of noise such as is heard sometimes at a menagerie. Its eyelids open vertically or in the opposite direction to that of other turtles. Unlike other turtles, this species cannot turn their head sidewise or move it up or down, so that we were perfectly safe from his vicious snaps while securing his flippers.

This turtle lived two and one-half days in captivity, and on the twenty-eighth of August was purchased by the Peabody Academy of Science. Before his preparation for the Museum I made a partial examination of his internal structure. Each lobe of the brain measured eleven and one-half inches in longitudinal circumference and nine and three-quarters inches transversely; the whole brain weighed seventeen ounces. From its close convolutions and weight I considered that it would be a high order of development. This is unlike other species of turtles, as they are all described as having a small brain and of a lower order of development. The base of the tongue, roof of the mouth and the whole inside of the digestive canal was lined with a series of long, sharp, pointed spines. In the mouth, throat and œsophagus they were of a hard, horny substance throughout. In the stomach cavity these spines were one-third of an inch in diameter and two and one-half inches long, of a cartilaginous nature with hard, sharp points, all of which pointed downwards. The entire digestive canal with its lining of spines has been preserved for future study. The widest part was eight inches across and four feet six inches long. Before this canal was cut open it was quite rigid, being completely filled with these spines which would seem to prevent anything of a large size from being swallowed, and as the turtles have no teeth they are obliged to swallow their food whole or in such parts as they can bite off with their beak-like jaws. To whatever use in the digestive economy these spines are adapted I shall not attempt to consider, but they led Mr. Garman to remark that it was an excellent provision for rapid digestion. In Dr. Storer's Report of the Reptiles of Massachusetts, published in 1839, I find the following in regard to these spines: "Upon the middle and posterior portions of the roof of the mouth are strong spinous processes and a portion of the œsophagus is in the cabinet of the Boston Society of Natural History; it is completely armed with long, firm and very sharp spines." In the digestive canal I found quite a number of Amphipod crustaceans of the genus Hyperia, identified by Doctor Faxon of the Museum of Comparative Zoölogy. The species is unknown. These little crustaceans are often found attached to the under side of the larger jelly fishes and it is possible that the jelly fish forms a portion of the food of this reptile, though in the stomach there were found some pieces of what appeared to be loligo partially digested. In Wood's Natural History I find the following: "The Leather turtle feeds upon fish, crustacea, mollusks, radiates and other animals." In the smaller intestines there was found a kind of whitish mucus and curiously enough a piece of bark about two inches in diameter. The gall-bladder was quite large, holding I should think about a quart of very dark green matter. The lungs were over two feet in diameter, transversely, and eighteen inches in length; they were traversed by air tubes a quarter of an inch in diameter. The heart was about the size of an ox and not unlike it in general shape. Just inside the skin was a lining of a cartilaginous substance from one-half to one inch thick on the sides and back; when this was cut into, a clear, yellow oil would run out, but upon coming into the air would soon congeal to a granular mass resembling cosmaline. The skin on the under side was about a quarter of an inch thick resembling coarse sole leather. The turtle proved to be a male and weighed 750 pounds. When found in the net there was a large specimen of the pilot fish under his flipper which I procured from Mr. Parsons, and it is now in the collection of the Peabody Academy of Science. As this specimen of the Dermatochelys is the third one taken on the coast of Essex County, it may be recorded as one of the Testudinata of this county. This is in accordance with the recorded list of birds, fishes, etc., in the county collection, as many species of birds that are recorded as county specimens are only occasional visitors, or rest here during their migrations to the north in the breeding season.

I append a list of the Testudinata of Essex County, as represented in the cabinet of the Museum of the Peabody Academy of Science, as follows :

TESTUDINATA OF ESSEX COUNTY.

Sphargididæ.

Dermatochelys coriacea *Blainville.*
Trunk Back or Leathery Turtle.

Chelydroidæ.

Chelydra serpentina *Schweigg.*
Snapping Turtle.

Cinosternoidæ.

Aromochelys odorata *Gray.*
Stink-pot or Musk Turtle.

Emydoidæ.

Chrysemys picta *Gray.* Painted Turtle.
Cistudo carinata *Flem.* Box Turtle.
Nanemys guttata *Ag.* Spotted Turtle.
Emys melagris *Brongn.* Blanding's Tortoise.
Glyptemys insculpta *Ag.* Wood Tortoise.

List of native and introduced plants observed in flower in the vicinity of Salem, during the spring of 1886, on or before May 1.

BY J. H. SEARS.

Symplocarpus fœtidus, *Salisb.* Skunk Cabbage.
Draba verna, *Linn.* Whitlow Grass.
Anemone hepatica, *Linn.* Liver Leaf.
Erythronium Americanum, *Smith.* Dog's-tooth Violet.
Oakesia sessilifolia, *Watson.* Bellwort.
Trillium erectum, *Linn* Purple Trillium.
Nepeta Glechoma, *Linn.* Ground Ivy.
Taraxacum Dens-leonis, *Desf.* Dandelion.
Antennaria plantaginifolia, *Hook.* Everlasting.
Tussilago Farfara, *Linn.* Coltsfoot.
Houstonia cærulea, *Linn.* Bluets.
Aralia trifolia, *Gray.* Dwarf-Ginseng.
Chrysosplenium Americanum, *Schwein.* Golden Saxifrage.
Saxifraga Virginiensis, *Michx.* Early Saxifrage.
Ribes hirtellum, *Michx.* Gooseberry.
Potentilla Canadensis, *Linn.* Common Cinquefoil.
Fragaria vesca, *Linn.* Strawberry.
Cerastium arvense, *Linn.* Field Chickweed.
Stellaria media, *Smith.* Common Chickweed.
Viola sagittata, *Ait.* Arrow-leaved Violet.
Viola pubescens, *Ait.* Yellow Violet.
Capsella Bursa-pastoris, *Moench.* Shepherd's Purse.
Sanguinaria Canadensis, *Linn.* Blood-root.
Aquilegia Canadensis, *Linn.* Columbine.
Caltha palustris, *Linn.* Marsh Marigold.
Thalictrum Anemonoides, *Michx.* Rue Anemone.
Anemone nemorosa, *Linn.* Wind-flower.
Medicago lupulina. Black Medick.
Thalictrum dioicum, *Linn.* Early Meadow Rue.
Ranunculus abortivus, *Linn.* Small-flowered Crowfoot.
Callitriche verna, *Linn.* Water Starwort.
Viola lanceolata, *Linn.* Lance-leaved Violet.
Viola blanda, *Willd.* Sweet White Violet.
Actea spicata, var. rubra, *Michx.* Red Baneberry.
Senecio vulgaris, *Linn.* Common Groundsel.

Introduced Garden Plants.

Pachysandra procumbens, *Michx.* Pachysandra.
Trillium sessile. Dark-flowering Trillium.
Trillium grandiflorum, *Salisb.* Large White Trillium.
Trillium erythrocarpum, *Michx.* Painted Trillium.
Ranunculus ficaria, *Linn.* Pilewort.
Narcissus jonquilla. Jonquil.
Narcissus pseudo-Narcissus. Daffodil.
Galanthus nivalis. Snowdrop.
Crocus vernus. Spring Crocus.
Tulipa suaveolens. Sweet Tulip.
Tulipa Gesneriana. Common Tulip.
Scilla verna. Squill.
Hyacinthus orientalis. Hyacinth.
Muscaria Botryoides, *Mill.* Grape Hyacinth.
Vinca minor. Common Periwinkle.
Uvularia grandiflora, *Smith.* Large-flowered Bellwort.
Tiarella cordifolia, *Linn.* False Mitre-wort.
Claytonia Virginica, *Linn.* Spring Beauty.
Viola Tricola, *Linn.* Heart's-ease.
Viola odorata, *Linn.* Sweet Violet.
Primula sinensis. Chinese Primrose.
Primula officinalis. English Cowslip.
Primula grandiflora. True Primrose.
Dodecatheon Meadia. Dodecatheon.
Buxus sempervirens. Box.
Lamium amplexicaule. Dead Nettle.
Phlox subulata. Ground or Moss Pink.
Mertensia Virginica. Lung Wort.
Fritillaria melargris. Guinea Hen Flower.
Iberis sempervirens. Evergreen Candytuft.
Iberis montana. Common Candytuft.
Phlox setacea. Neuroloma.
Phlox nivalis. White Neuroloma.
Corydalis nobelis. Large-flowered Corydalis.
Tulipa sylvestris. Scotch Tulip.
Saxifraga crassifolia. Thick-leaved Saxifrage.
Dicentra spectabilis. Bleeding Heart.
Helleborus nigra, *Linn.* Black Hellebore.
Trollius laxus, *Salisb.* American Globeflower.
Adonis vernalis, Spring Adonis.
Anemone Hortensis, Star Anemone.
Uvularia perfoliata, *Linn.* Perfoliate Bellwort.
Polygonatum giganteum, *Dietrich.* Great Solomon's Seal.

Fritilaria Imperialis. Crown Imperial.
Lunaria bienis. Honesty.
Lamium album, *Linn.* White Dead Nettle.
Lamium maculatum, *Linn.* Spotted-leaved Dead Nettle.
Corydalis aurea. Golden Corydalis.
Dicentra eximia. Dutchman's Breeches.
Eranthis hiemalis. Winter Aconite.
Alyssum Saxtile. Rock Alyssum.
Epimedium alpinum. Barren Wort.
Epimedium macranthum. Large-flowered Barren Wort.

NATIVE GRASSES, SEDGES, ETC.

Poa annua, *Linn.* Low Spear Grass.
Carex præcox, *Jacq.* European Sedge.
Carex vulgaris, *Fries.* Sedge.
Carex Pennsylvanica, *Linn.* Wood Sedge.
Luzula campestris, D C. Wood Rush.
Equisetum arvense, *Linn.* Common Horsetail.

NATIVE TREES AND SHRUBS.

Acer dasycarpum, *Ehrhart.* White or Silver Maple.
Acer rubrum, *Linn.* Red or Swamp Maple.
Acer saccharinum, *Wang.* Sugar or Rock Maple.
Acer platanoides, *Linn.* Norway Maple.
Salix discolor, *Muhl.* Glaucous-leaved Willow.
Salix humilis, *Marshall.* Prairie Willow.
Salix cordata, *Muhl.* Heart-leaved Willow.
Salix petiolaris, *Smith.* Petioled Willow.
Salix viminalis, *Linn.* Basket Willow.
Salix livida, *Wahl.* var. occidentalis. Livid Willow.
Salix alba, *Linn.* White Willow.
Ulmus Americana, *Linn.* White Elm.
Ulmus campestris, *Linn.* English Elm.
Alnus incana, *Willd.* Hoary Alder.
Alnus serrulata, *Ait.* Smooth Alder.
Populus tremuloides, *Michx.* American Aspen.
Populus grandidentata, *Michx.* Large-toothed Aspen.
Populus balsamifera, *Linn.* var. candicans. Balm of Gilead.
Populus alba, *Linn.* White Poplar.
Corylus Americana, *Walt.* Wild Hazel-nut.
Corylus rostrata, *Ait.* Beaked Hazel-nut.
Ostrya Virginica, *Willd.* Hop Hornbeam.
Carpinus Americana, *Michx.* American Hornbeam.
Taxus baccata, *Linn.* American Yew.

Juniperus Virginiana, *Linn.* Red Cedar.
Juniperus communis, *Linn.* Juniper.
Lindera Benzoin, *Meisner.* Spice Bush.
Cassandra calyculata. Leather-leaf.
Epigea repens, *Linn.* Trailing Arbutus.
Vaccinium Pennsylvanicum, *Lam.* Dwarf Blueberry.
Amelanchier Canadensis, *Torr.* Shad Bush.
Comptonia asplenifolia, *Ait.* Sweet Fern.
Myrica Gale, *Linn.* Sweet Gale.
Betula lutea, *Michx.* Yellow Birch.
Betula alba, L., var. populifolia, *Spach.* American White Birch.
Fraxinus Americana, *Linn.* White Ash.
Fraxinus sambucifolia, *Lam.* Black Ash.
Ribes aureum, *Pursh.* Missouri Currant.
Ribes rubrum, *Linn.* Red Currant.
Prunus Cerasus. Cherry.
Prunus Persica. Peach.
Amygdalus nana. Flowering Almond.
Zanthorhiza apiifolia, *L'Her.* Shrub Yellow-root.
Pyrus communis. Pear.
Forsythia viridessima. Forsythia.
Forsythia suspensa. Slender Forsythia.
Forsythia Fortunii. Forsythia.
Salix caprea. European Willow.
Salix kilmarnock. Kilmarnock Willow.
Dirca palustris, *Linn.* Leather-wood.
Magnolia conspicua. Yulan of the Chinees.
Spiræa prunifolia. Bridal Wreath.
Larix Europea, *Linn.* European Larch.
Prunus domestica. Garden Plum.
Daphne Cneorum. Garden Daphne.
Magnolia soulangeana. Hybrid Magnolia.
Negundo aceroides, *Maench.* Box-leaved Elder.
Shepherdia argentea, *Nutt.* Buffalo-berry.
Pyrus malus, *Linn.* Apple Tree.

BULLETIN

OF THE

ESSEX INSTITUTE.

Vol. 18. Salem: July, Aug., Sept., 1886. Nos. 7-8-9.

THE DEVELOPMENT OF CRANGON VULGARIS.

SECOND PAPER.[1]

(With Plates I and II.)

BY J. S. KINGSLEY, Sc. D.

The observations here recorded were made at Salem, Mass., during the summers of 1885 and 1886. I have here to return my thanks to Dr. Henry Wheatland, Mr. George D. Phippen and the Naumkeag Street Railway for many facilities afforded me. The literature of crustacean embryology has become so enormous that any résumé of the work of previous writers, even on the limited group of decapods, is next to impossible. I have, however, endeavored to give proper credit in the text for all work done by other embryologists, while appended is a bibliography of the papers quoted. Full titles are given of only those papers which are not mentioned in Faxon's valuable bibliography (**'82**).

[1] The first paper of the series is upon the development of the compound eye and appears in the first number of Whitman's "Journal of Morphology."

Several authors have investigated the development of Crangon, and an enumeration of their names may not be out of place here in order that the present paper may have an historical completeness.

Rathke ('36 and '37) was the first to study the development of the species,[2] but his account to-day possesses but little more than historic interest, though he describes the changes which occur within the egg. He compares it with Palæmon and Astacus, but failed to see the gastrula which is such a conspicuous feature in the latter genus, according to the accounts of all observers. Captain Du Cane describes and figures ('39, pl. vii, figs. 7 and 8) the newly hatched Crangon, while R. Q. Couch ('44) describes the same species as it escapes from the egg. Neither of these two papers has any present value. L. Agassiz makes a curious statement regarding this and some other genera. He says ('52) that Cuma is a larval form, the so-called different species being the young of Palæmon, Crangon and Hippolyte. This he claims to have proved beyond a doubt because he has raised them from the egg. A little later, C. Spence Bate showed that the Cumacea were adult, whereupon Agassiz reiterates ('56) his statement. Claus ('61) describes and figures a larva from Heligoland which he regards as the young of the present species. It is farther along in its development than any of the stages included in the present article. E. Van Beneden ('70, p. 142, pl. x, fig. 20) has some remarks upon the segmentation of the egg in this species which are quoted and criticised on a subsequent page of the present article. Smith ('73, p. 529) merely mentions

---

[2] Rathke calls his form *Crangon maculosus*, but it is clearly but a color-variation of the widely distributed *Crangon vulgaris*.

the date at which the young appears in Vineyard Sound. Spence Bate ('76) states that in Crangon and several other genera of shrimps, "he has demonstrated that the three pairs of mobile appendages in the cirripedal or *Nauplius* form of larva homologize with the eyes and two pairs of antennæ, and not with the antennæ and mandibles, as stated by Fritz Müller, Anton Dohrn, and others." It is unnecessary to go into any detailed demonstration to show that nothing of the sort really occurs. Kingsley ('86 and '86a) gives a brief account of the development of the compound eye in this genus.

METHODS.

I was not very successful in keeping my shrimps in confinement, owing, doubtless, to insufficient means of renewing the water. On this account I was obliged to depend for my material on fresh specimens caught almost daily, and to rely upon chance for the successive stages. Many attempts were made to obtain the parents before oviposition and to have them lay in confinement, but without success. I made some observations upon the ovarian egg, but they are not complete enough for publication.

For surface views I studied the fresh egg, and in the earlier stages I found it extremely useful to allow weak alcohol to run under the cover glass while the eggs were on the stage of the microscope. In this way parts before invisible are rendered distinct, and, at a certain stage of the process, the embryonic portions, when viewed by reflected light, are white upon a dark ground afforded by the yolk; by transmitted light, brown upon a translucent surface. This effect soon vanished, and all portions, when thoroughly impregnated with the alcohol, appeared alike. Stained specimens, viewed as opaque objects, were also of great value as may be seen from the plates.

Attempts to render the whole egg transparent and to mount it in balsam were not very successful.

For hardening, Perenyi's fluid, followed by successive strengths of alcohol in the usual manner, was found to be the best. For staining, Grenacher's alum-carmine gave the best results. Kleinenberg's hæmatoxylon and Grenacher's borax-carmine were also used with success. It was found impossible to remove the egg membranes, but the reagents mentioned penetrated fairly well. Except in studying the eye after the deposition of pigment had begun, the embryos were stained entire. The eggs were embedded in paraffin by means of chloroform; the sections were cut by the Thoma microtome and fastened to the slide with Schällibaum's collodion clove-oil mixture. I do not find it necessary, in using this, to heat the slide until the clove oil has evaporated, but merely enough to melt the paraffin and allow the sections to drop into the sticky film. The paraffin was then dissolved in turpentine and balsam and cover glass applied. The sections never became loosened. The processes involved in studying the eye are given elsewhere and need not be repeated here.

The small size of the eggs rendered it difficult to employ the ordinary method of orientation and so the following process was devised: The eggs (from thirty to fifty at a time) were placed in melted paraffin in a flat watch-crystal, and allowed to cool. Then, on looking *through the glass* with a hand-lens the exact position of each egg could be readily ascertained, and those suitable for sectioning could be cut out with a knife and mounted on the plug of the microtome in any desired position.

The drawings illustrating this paper were all made with the Oberhauser camera; in some the outlines being drawn by it and the details then filled in freehand, while in others every nucleus was placed in the drawing with that instrument.

THE EGG.

The eggs are laid at Salem from the middle of June until the latter part of July. The method in which they are attached to the pleopoda calls for no special remark. They are placed in a single row in long, apparently structureless tubes which may frequently be untangled and straightened out, when they present a moniliform appearance. The eggs themselves vary slightly in size; some are nearly spherical but the majority are ovoidal and have a major axis of .024 and a minor one of .018 inch. As I have not been fortunate enough to see the oviposition, I cannot say whether, at the time of laying, the nucleus (apparently) disappears. In the earliest stage I have seen (Fig. 1), it was present, and the egg presented but slight difference from the later ovarian egg. The egg is enveloped in a very thin structureless envelope, inside of which I have found no traces of an inner or vitelline membrane, nor is there any space between the shell and the yolk. The protoplasm occupies a central position; it is not regular in outline, but gives off pseudopodal prolongations which ramify and pass between the yolk spherules in all directions. Whether these anastomose in their finer filaments or not, I am unable to say. I have not seen any such unions in the larger branches. The protoplasm is granular, the granules apparently taking a deeper stain than the rest, though this appearance may be due to a different refractive index. The nucleus is large and vacuolated, and in its interior is a well developed chromatin reticulum which traverses it in all directions, the fibres uniting on the wall of the nucleus in a thickened layer. Whether this reticulum is formed from one or from several filaments, my lenses and preparations do not allow me to determine. I have seen no trace of any connection between the nuclear reticulum and the protoplasm of the egg. The yolk is granular, the yolk globules ranging considerably in size. The color of the fresh egg is a dirty-white.

SEGMENTATION.

The first and second segmentations of the egg take place before the so-called segmentation planes appear, and they are so similar in character that they may be described together. With the first segmentation the protoplasm begins to leave its central position and seek the surface of the egg; before the second division is completed it has reached the surface, leaving the yolk in the centre. In the process of cell division I have never seen any traces of karyokinesis; the division seems to be direct, and affects first the nucleus and next the protoplasm. Fig. 2 represents a section taken through the egg at the second segmentation, the plane passing through each of the resulting nuclei and the as yet unsevered protoplasm connecting the two potential cells. It exactly parallels, except in being nearer the surface, the phenomena of the first segmentation. The two nuclei have taken their places near the extremities of the elongate protoplasmic mass and each is vacuolated and provided with a chromatin reticulum. The protoplasm at either end shows the radial ramifying condition characteristic of the same material in the unsegmented ovum; but between the two nuclei extends a smooth cord, in the interior of which the granules present the appearance of longitudinal striæ. There is, besides, in this region an appearance as if the connecting band were double. As will be seen at either end, the protoplasm has reached the surface of the egg and surface views show that it there extends itself in the same stellate manner as was seen in the unsegmented ovum. The character of the protoplasm and the yolk need but a word. The vacuoles in the former I attribute to the action of the reagents. In the latter the yolk globules have become largely confluent and have lost the spherical shapes which are seen in the fresh egg. The round marks are oil globules. The whole yolk stains faintly but I have not thought it necessary to represent it.

After the second protoplasmic segmentation is effected, the first segmentation furrows appear, the one following close upon the other. The first to appear corresponds in its direction to the first nuclear division, the second is at right angles to it. Though well marked when viewed from the surface, these furrows are in reality shallow grooves which affect but the superficial layers of the deutoplasm and which never have the depth of those occurring in many if not in most decapods (*e. g.*, Palæmon, Astacus, Eupagurus, Homarus, Cancer, etc.). In sections they show but as superficial constrictions; the mass of yolk never segments. That this is not the result of the hardening reagent (Perenyi's fluid) is shown by the fact that yolk segments do not appear in eggs hardened with alcohol alone. Still it does not follow that the segmented egg with unsegmented yolk is a syncitium. The nuclei and the surrounding protoplasm are completely separated and these are the essential portions of the cells; the yolk is secondary and adventitious and is to be regarded as occupying an extracellular position not only in Crangon but in many other cases, Balfour's remarks ('80, p. 98) to the contrary notwithstanding.

The general features of a decapod segmentation have been detailed so often (Haeckel, '75; Ishikawa, '85, Mayer, '77; Faxon '79; etc.) that it is not necessary here to follow it throughout in Crangon, which presents no marked differences from other genera except in the direction already indicated. Figs. 3 and 4 are respectively surface and sectional views of a stage with about sixteen nuclei, and are introduced for the purpose of showing the external appearance and some of the points of internal structure. As will be seen from fig. 4, most of the protoplasm has reached the surface of the egg but there still remains some near the centre of the yolk. Whether this is the same as the protoplasm described by several authors (Reichenbach in Astacus, Ludwig in Spiders, '76) I cannot say; but I am certain not only that it is derived from the first segmentation nucleus, but also that it plays a part in the formation of the blastoderm. As this retardation of a portion of the cells in their journey to the surface seems to explain several points in the early stages of the arthropods, a moment may be given to it. While the cells which have reached the surface and which have thus formed a blastoderm are undergoing division, this central protoplasm also divides and gives rise to several cells which migrate, though much more slowly to the surface. In fig. 6 this migration is clearly shown, and it is to be noted that the cells are all proceeding in the same direction, apparently toward one side of the egg. This is shown in several of my sections, and not one indicates that these belated cells migrate to several portions of the surface.

This migration of the belated cells toward one point, together with a more rapid division of those in the same region which earlier reached the surface, results in the formation of the not very clearly delimited germinal area. Fig. 5 represents a section through the area shortly before the formation of the gastrula. In other parts of the egg, the nuclei are placed near the surface as at *b*, each surrounded with a scanty amount of protoplasm; but in the germinal area, the protoplasm is far more abundant and forms a layer of considerable thickness (*ga*). In sections this has the appearance of a syncitium, as I am unable to discover any cell boundaries. In surface views, it is true, the cells here, as earlier, seem clearly marked off from each other; but as the figure shows, these lines of demarcation are but superficial and do not descend to any depth. This obliteration of cell walls here may be due to the action of Perenyi's fluid and I regret that this idea did not occur to me at the proper time to test it, so I cannot positively state that this region is really a syncitium. In the figure is represented, at *c'*, one of the belated cells which has not yet joined its fellows; the complete series of sections of the egg show that it was the only one which remained behind. In surface views it is not easy to assign limits to the germinal area as it shades off insensibly into the surrounding undifferentiated blastoderm and is merely a portion of the surface where the protoplasm is more abundant and the nuclei more numerous than in other parts. In its general appearance it does not differ much at this stage from fig. 8, except that the blastopore shown in that figure is, of course, absent.

The variations in the character of the segmentation and the method of forming the gastrula and the germinal layers are so closely connected that a discussion of the segmentation of Crangon, as compared with that of other arthropods, is deferred until the end of the next section of the present paper; but here it is necessary to mention a conflict between my results and those of another observer.

Edouard van Beneden ['70, p. 142] says:— "Chez les Crangons, il se produit un fractionnement total du vitellus, comme chez les *Gammarus locusta*, et les cellules du blastoderme résultant de ce que dans chacun des segments, il s'opère en séparation compléte entre les éléments protoplasmiques et les éléments nutritives du vitellus." Though not referred to in the text, his figure 20 on plate X was apparently introduced to illustrate this point. It, however, does not do so, for it does not represent the central portion of the egg as divided, but can readily be interpreted to agree with the opinion here maintained. Van Beneden cut no sections, but depended on surface views for his results. Here I believe is the cause of our difference, for I can hardly regard it as the result of our having studied different species, since *Crangon vulgaris* is by far the most abundant Crangonid on the shores of Europe. In surface views the furrows of all crustacean segmentation seem deeper than they actually are and this I am confident led him into error. I may remark in passing that, to my mind, Van Beneden's statement (*l. c.*) that *Gammarus locusta* has a total, while a congeneric form has a partial, segmentation needs confirmation, as the point cannot be settled by surface observation. The illustrations given by Van Beneden of the segmented egg of *Gammarus locusta* certainly do not prove his point.

As to the presence or absence of karyokinesis in the segmentation and cell division of Crangon, my observations are not conclusive. I have not had the lenses necessary for a careful study of the subject, but even in the large nuclei of the earlier stages of segmentation as well as later in the large, rapidly-dividing, endodermal nuclei, I have not seen anything which I could interpret as relating in any way to karyokinesis, although the nuclear reticulum was clearly visible under my highest objective (Hartnack, viii). Under the circumstances, I am inclined to believe that the cell division is direct. Mayer in Eupagurus ('77) does not state whether a spindle metamorphosis of the nuclei occurred, but like myself he saw elongate nuclei and two nuclei in a cell. In fact, I do not recall a single statement of karyokinesis being witnessed in decapod segmentation, excepting in Astacus (Reichenbach, '86) ; though it occurs in other Crustacean groups (*e. g.*, Cladocera, Copepoda, Grobben, '79 and '81). On account of the large size of the nuclei in the eggs of Cancer and Crangon they form especially favorable objects for studies in this direction.

THE GASTRULA AND GERM LAYERS.

Owing to the difficulties of following the changes of the cells in the living egg, I have been unable to follow out the phases of gastrulation as clearly as I could wish ; but still my permanent preparations and my sections give a fair idea of the steps. Three of these are shown in figs. 7, 8, and 9. Of these the earlier is 8, which represents the invagination as already begun and is taken from an alum-carmine specimen, mounted entire. It shows the germinal area fading out on all sides into the general blastoderm while near the posterior margin of the area the blastopore is seen, the endodermal cells having already sunk beneath the surrounding surface. I am unable to say whether earlier these endoderm cells could have been recognized among the others of the germinal area ; but I feel confident that there is no specialization of the mesodermal cells before the formation of the gastrula such as is described by Grobben ('79) in Moina and ('81') Cetochilus. Neither was there the shallow pit seen by Ishikawa in Atyephyra ('85, pp. 411–412) which is subsequently divided into two.

In the cells which surround the margin of the blastopore (fig. 8), the nuclei are mostly placed in the distal ends of the elongate cells, while in fig. 7, which represents a slightly later surface view, this feature of the circum-blastoporal cells is still further emphasized, the inner ends of the cells seeming to run down into the closing blastopore. What interpretation is to be placed on this I do not know.

The more prominent of the internal features of the gastrulation may be seen in fig. 9, which represents an oblique section through a stage intermediate between those shown in surface views. The endoderm cells (*h*) are being forced almost vertically into the yolk, though with an inclination towards the anterior end of the egg. The nuclei are placed at the deeper ends of the cells, the protoplasm of which stretches upwards to the blastopore. In the upper ends of these endoderm cells the boundaries between the cells can be seen with some distinctness as is shown in the figure, but deeper they entirely disappear. This invaginated endoderm is a solid mass and contains no lumen, or archenteron, and the blastopore itself is but a depression in the general surface of the egg. The subsequent fate of these cells will be traced later; but here we may say that they soon separate from the parent layer and sink into the yolk where they divide into two groups, a few going to the region where the stomadæum is subsequently to form, while the greater portion do not move far from the point of their differentiation and later unite with their fellows and with the proctodæum. These cells here, as in other species, form the mesenteron, the cavity of which exists, until after hatching, only in a potential condition, being filled completely with the deutoplasm. Through all of the larval stages these endodermal cells can be readily recognized by their larger size and by the fact that their nuclei stain less deeply than those of mesodermal or ectodermal origin.

Fig. 9 also shows some features in the origin of the third germinal layer, the mesoderm. On either side of the endodermal invagination may be seen some cells with large nuclei and amœboid outlines, which are plainly budding from the cells at the mouth of the blastopore and sinking into the yolk. Owing to the great difficulties encountered in orienting the eggs at this early stage, I cannot say that

I have fully satisfied myself as to the limits of the origin of the mesoderm. It certainly arises from both sides and from the anterior margin of the blastopore; whether it also has its origin from the posterior margin or not, I cannot positively say, though I am inclined to think that it does not. It certainly does not form there as abundantly as it does in front. Later, the mesoderm may be recognized by the fusiform cells with small nuclei crowded between the ectodermal structures and the yolk. It acquires its greatest development at first in the abdomen but appears only as a thin sheet in the cephalothoracic region until the embryo is nearly ready to hatch. I have at no time seen anything looking like 'mesenchyme' nor have I seen anything that could be interpreted as a budding of mesoderm cells from either ectoderm or endoderm. Neither do I see anyway, looking at Crangon alone, of deciding from which of the other germinal layers the mesoderm arises. It seems to come from the junction of the two.

Before the next stage becomes outlined the blastopore becomes completely closed. As a considerable time elapses between this closure and the formation of the stomodeal and proctodeal invagination it is a matter of considerable difficulty to say exactly what are the relations of the blastopore to either mouth or anus. As no appendages are as yet developed, there are no landmarks by which the position of the blastopore can be recognized in surface views and all that there is to guide one is the general outline of the rapidly changing germinal area. From this it would appear as if the anus arose either within or a very little in front of the position formerly occupied by the mouth of the gastrula; and I am inclined to the former view, since there is in the meantime a very rapid division and hence considerable extension of the circumblastoporal cells.

The relations of the mesoderm to the proctodæum would also seem confirmative of this view, for, as will appear later, most of it remains in the region where the anus is formed. The mouth appears to arise some distance in advance of the blastoporal region.

While the phenomena of gastrulation are well developed in most of the Crustacea, in the Hexapods and Acerata (Arachnids *plus* Limulus, Kingsley '85), they are so obscured as to have caused no little trouble for students. It seems to me that the facts detailed above for Crangon throw some light upon the other members of the group and show that the peculiar manner of origin of endoderm in the old group of 'Tracheates' is to be reconciled with the gastræa theory.

The great majority of the arthropods have a segmentation which is usually characterized as superficial (Haeckel, '75), or centrolecithal (Balfour, '80), both terms indicating that the segmentation is confined to the surface of the egg, while the centre is occupied by yolk which may, but which usually does not, segment. The term endolecithal, introduced by Claus, is synonymous with the earlier one of Balfour. Bruce ('86) is, as far as I am aware, the only one who has questioned this centrolecithal or superficial terminology. He says that the process in Thyridopteryx "can hardly be called a centrolecithal segmentation."

These terms (centrolecithal, endolecithal, superficial segmentation) seem unfortunate, for while there is a considerable similarity in the mode of segmentation of most arthropod eggs, in the earlier stages the yolk does not occupy a central position, nor is the segmentation superficial. As I have shown above, the egg nucleus, and presumably the segmentation nucleus, occupies, at first, at least in the egg of Crangon, a central position ; while, gathered around it is the protoplasm of the egg, the whole being enveloped with the deutoplasm, a condition just the reverse of that implied by the terms endolecithal or centrolecithal. The first segmentation is confined to this central protoplasm, and it is not until the second segmentation is nearly completed (*vide* fig. 2) that any of the protoplasm reaches the surface; and for a long time afterward that which remains behind continues to undergo cell-division as well as that which has earlier reached the surface and has there begun to form the blastoderm. Hence at first, the segmentation is clearly not superficial.

The same state of affairs is recognizable throughout the whole of the series of so-called centrolecithal eggs, as can readily be seen by an examination of the results of all who have studied arthropodan segmentation by means of sections. It is even to be recognized in the results of many of the earlier workers. It is not necessary to give an exhaustive résumé of the work of previous students but a few may be instanced in support of this position.

In the Crustacea but few have carefully studied the phenomena of segmentation, and in some instances (Moina, Cetochilus, Lucifer) they throw but little light upon the present point. Haeckel's observations on the segmentation of Peneus ('75) seem at first sight to conflict with this view, for he represents the egg at the end of the second segmentation as divided into four segmentation spheres, in each of which is a nucleus, while the spheres are united at their inner surfaces in an undivided mass of yolk. The later stages present the same appearance. When we consider that Haeckel depended entirely on optical sections, an explanation readily suggests itself. He does not give the first segmentation, and if we regard his nuclei as really nuclei enveloped with protoplasm like those of Crangon, which are migrating toward the surface, the correspondence between the two is at once evident.

That we are justified in making these assumptions is shown by several things. First, Haeckel naturally took the bodies inside the lobes of the egg for nuclei alone, as at that time the structure of the cells was less understood than at present, and from what was known of other eggs, that seemed the only way to regard them. A comparison of Haeckel's figures with those of other students of Decapod segmentation shows that this explanation accords well with what is known of other forms. Thus Mayer ('77) describes, in the segmenting egg of Eupagurus, nuclei surrounded with a layer of protoplasm extending out, amœboid fashion, with the surrounding yolk. These must be regarded here, as in Crangon, as true cells, and their origin from the original nucleus and protoplasm must have been by segmentation in the centre of the egg. As in Crangon, they migrate to the surface and form a blastoderm enveloping an unsegmented mass of yolk. Faxon ('79), though he cut no sections, clearly shows that in Palæmonetes the same is the case. His figures 1 and 2 represent the nucleus surrounded in the same way with its protoplasm. Ishikawa ('85) apparently obtains the same result in Atyephyra, judging from his plates. .His figures 35 and 36 are especially interesting in this connection, for they appear to substantiate the view here maintained, and when taken in connection with figures 38 and 39 clearly show that there is a migration of cells to the surface.

The extremely scanty observations on the segmentation of Limulus by Osborn ('85), and by Brooks and Bruce ('85) do not allow us to arrive at any very definite conclusions as to the character of the division, but the fact that, according to the last-mentioned authors, at the close of segmentation the entire yolk "consists of a uniform mass of large spherical yolk cells, each with its nucleus," would seem to indicate that here the segmentation is not "superficial;" while on the other hand, there is nothing in either account that would indicate any migration toward the surface like that in Crangon. The origin of the nuclei of the "yolk cells" was not traced.

In the spiders, according to both Ludwig ('76) and Locy ('86), the process of segmentation is readily brought into accord with that in Crangon. According to the latter author, the segmentation nucleus, surrounded with a mass of protoplasm which sends off processes among the yolk granules, occupies a position in the centre of the egg; while the outside of the egg is covered with a thin layer of non-nucleated protoplasm, the blastema, the existence of which was denied by Ludwig. At the first segmentation, this nucleus divides into two and with it the protoplasm also divides, while traces of a similar segmentation can be seen in the deutoplasm. These nuclei now occupy a subcentral position in the egg. At the eight-cell stage, the nuclei are still nearer the centre than to the surface; and even when the egg has at least thirty cells, none have emerged at the surface. Later, they do appear and then the contiguous protoplasm of the blastema unites with that surrounding the nucleus, derived from that originally in the centre of the egg, and in this way the blastoderm is formed. It is to be noticed that the emergence of the internal cells takes place first at that portion of the egg known as the animal pole, and only later do they appear on the other portions. The bearings of this will appear a little farther on.

In the case of the Hexapods the great bulk of the evidence is certainly in favor of the view of segmentation which I have thus shown to be the case in spiders and decapods. Without attempting an exhaustive review, we may summarize our knowledge as follows: Although many writers (*e. g.*, Korotneff, '85, p. 571) confess their inability to connect the nuclei of segmentation with the

"Keimbläschen," there can be no doubt, in view of what is known of the eggs of other animals, that they are derived from it. This egg-nucleus has at first a central position, and hence in its segmentation we have a parallel to that already pointed out in spiders and decapods. Several writers (Brandt, '69; Bobretzky, '78) have failed to recognize or have denied the presence of a blastema[1] first pointed out by Weismann ('63) in the eggs of Chironomus and Musca; but this seems a point of minor morphological importance, and its existence is readily to be explained in those forms where it occurs on the ground of a precocious accumulation of protoplasm on the surface of the egg where it is soon to be utilized in the formation of a blastoderm. The amount of protoplasm thus early segregated probably differs with the species.

In some eggs the nuclei resulting from the earlier segmentations are certainly surrounded with protoplasm, thus presenting a close similarity with the egg of Crangon; and these migrate to the surface to form the blastoderm in almost exactly the same manner as in that form or as in Agelena as described by Locy and the older authors. Thus Bobretzky ('78), in the lepidopterous genus Porthesia, speaks of these nuclei and the surrounding protoplasm as true cells. Graber ('78) describes in several

---

[1] The view of a blastema here adopted is that of Weismann ('63, p. 111): "eine dünn Schicht einer vollkommen homogen, stark lichtbrechenden, bläulichen Masse,"—and differs considerably from that of Patten ('84, p. 563). The blastema is composed of protoplasm and contains no nuclei; when the latter enter it, it is converted into a blastoderm, no matter whether the cell walls are developed or whether the layer has a syncytial nature. Patten says, "it is not impossible or even improbable that a 'blastema' may occur in some instances without nuclei, although at present this has not been observed to occur." Weismann in both Chironomus ('63, pl. vii, fig. 1) and Musca (pl. x, fig. 52, 52a) clearly shows that in these forms it does occur. Metschnikoff also shows it in Cæcidomyia ('66, pl. xxiv, fig. 8), Aphis (pl. xxviii, figs. 3, 4, 5) and Aspidotus (pl. xxxii, fig. 2). Witlaczil ('84, p. 567, pl. xxviii, figs. 3-7) confirms the observation on Aphis, while Locy ('86, pp. 67-70) clearly shows its nature in the spiders.

genera (Lina, Pyrrhocoris, etc.) a number of amœboid cells in the centre of the yolk which appear to be in the process of division and to be connected together by a protoplasmic network. Ayers ('84), studying Œcanthus, finds in the yolk both amœboid nuclei and amœboid cells, some of which migrate to the surface, and the cells, joining each other by a fusion of the protoplasmic filaments, form the blastoderm. Patten ('84) could not see the nuclei arise into the blastema in the living egg of Phryganids. In his earliest stages, the blastema, though not divided into distinct cells, was nucleated, while below this were numerous amœboid cells, distributed through the yolk and connected by protoplasmic filaments. In later stages these cells have almost entirely disappeared, while the blastoderm has become much thicker and the nuclei more numerous; from which the conclusion is obvious that the nuclei formerly seen in the yolk have migrated to the surface. Korotneff ('84) does not recognize a blastema in Gryllotalpa. He has the blastoderm arise by a migration of amœboid cells to the surface.

In other eggs (*e. g.*, Aphis, Metschnikoff, Witlaczil) it has not been shown that the nuclei, before leaving the centre of the egg, have each their own proper protoplasmic envelope; but in these cases there can not be the slightest doubt that the segmentation proper takes place, at first, not on the surface, but in the centre of the egg. According to Witlaczil ('84), the nuclei in Aphis do not reach the surface until sixteen of them are formed. These observations, as well as those quoted before, show that the view of Robin ('62) that the nuclei of the blastoderm arise by budding is as little justified by facts as that of Weismann ('63) that they arise spontaneously. They do, however, conclusively show that we do not have here a "superficial" segmentation, but instead one which is readily reduced to the normal alecithal type. The protoplasm segments, the yolk in most hexapods and some crustacea, does not, but this yolk in either group is to be regarded as superficial rather than central, and the term ectolecithal, though not necessary, is far preferable to endo- or centrolecithal. The view I take of this segmentation is essentially the same as that of Bobretzky ('78) and I fail to see the force of the objections raised to it by Balfour ('80, p. 98). The nuclei, and the surrounding protoplasm, are clearly to be regarded as cells, and that they do move about with comparative freedom in the yolk is shown in almost every hexapod and many crustacean eggs. The segmentation of the yolk, like the yolk itself, is a secondary feature; and the fact that it truly segments in Astacus, Homarus and Eupagurus while in Crangon and Peneus it does not, shows the slight importance of this point. In Eupagurus several divisions of the nuclei and the surrounding protoplasm take place before the appearance of the segmentation planes which are to divide the yolk. A still further postponement of their appearance would give us the condition occurring in Crangon or in the Hexapods. Balfour quotes his observations on the eggs of spiders in support of his position, but Locy's observations on still earlier stages of the same genus (Agelena) are readily made to support the view here adopted. The segmented hexapod egg is not a syncytium; the cells are completely divided or nearly so and the intercellular spaces are occupied by the yolk which is here certainly to be regarded as a secondary element in the egg.

Having thus described the phenomena of segmentation in the more common type of arthropod egg we may proceed to the discussion of the gastrula, leaving until later the meroblastic and holoblastic segmentation occurring in some forms.

In Crangon, so far as I have been able to see, all the amœboid cells reach the surface and take part in the formation of the blastoderm before the process of gastrulation begins. In that form no yolk pyramids occur. In Astacus, Lereboullet ('62), Bobretzky ('73) and Reichenbach ('77 and '86) have shown that they do occur, and Reichenbach shows that they terminate in a central mass the nature of which is doubtful. In Atyephyra (Ishikawa, '85) the yolk pyramids are less evident, but in Palæmon (Bobretzky '73) they are almost as plain as in Astacus, although here the central mass is absent. In both Palæmon and Astacus, as well as in Eupagurus, all of the protoplasm (certainly the nuclei) is used in forming the blastoderm, unless the central mass have a nuclear or a protoplasmic nature. In Atyephyra, on the other hand, Ishikawa figures numerous amœboid cells remaining behind in the yolk after the blastoderm is formed and when the process of gastrulation has begun.

The process of gastrulation in the decapods is so evident that there is no difficulty in connection with it. The invaginated entoderm may either contain a lumen (archenteron) as in Astacus, or it may be solid as in Palæmon, Atyephyra, Crangon, and Eupagurus. In the former case the deutoplasm is between the entoderm and the mesoderm and ectoderm; in the latter the entoderm cells form a more or less complete wall around the yolk, so that this substance comes to occupy the potential archenteric cavity. There is but little to be said on these points beyond what has been already said by other writers and hence no further discussion is to be given here. Among the other arthropods however there are some points concerning which there is a difference in interpretation and hence these may receive some light from the conditions occurring in Crangon and its allies. The confusion which has existed is my only excuse for the following excursus.

Regarding the entoderm in the hexapods and its relation to the gastrula, various views have been held. The older authors did not trouble themselves much concerning this question, but usually regarded the germinal area as several cells in depth. Kowalevski (**'71**) was the first to cut sections of the hexapod embryo and to introduce the germ layer theory into the group of arthropods. In Hydrophilus, Apis, Phryganids and other forms, Kowalevski noticed the groove on the ventral surface of the embryo, and in sections saw arising from the edges of this groove another layer which in Hydrophilus (*l. c.* pl. IX, fig. 23) contained a distinct lumen. This was very naturally interpreted as an invagination for the production of the entoderm; but he also discovered that the mesodermal tissues also arose from the same layer, which led him to regard this band of tissue as different from the entoderm (Darmdrüsenblatt) of vertebrates (p. 58). A little later, Haeckel in his papers on the "Gastræa Theorie" (**'75**) adopted Kowalevski's view, considered this a true gastrulation, and regarded the portion thus invaginated as a true entoderm. Hatschek, studying Bombyx (**'77**), did not pay much attention to this layer, but (p. 117) describes it as small in amount and limited to the most anterior part of the primitive streak, in front of the segmenting embryo. Graber (**'78**) also regards the process described by Kowalevski in Hydrophilus as a true gastrulation and says that in Musca it is so well developed "dass man wirklich, wie bei einer typischen Gastrula, von einer Doppelphase reden kann." In Pyrrhocoris and Lina the process is different, for besides the cells arising from the primitive groove, the inner embryonal cells, which have marked amœboid characters and which are the 'Wanderzellen' of the older authors, enter into the formation of the mesenteron, which thus has a double origin.

Bobretzky (**'78**) thinks that, in the Lepidoptera, while some of the cells migrate to the surface to form the blastoderm, some remain behind in the yolk to form the centre of the yolk spheres; and though he has not carefully traced the history of these he believes they form the entoderm. The views of Tichomiroff ['79], though differing much from those of Bobretzky, are still capable of being reconciled with them in their broader features.

Balfour, usually so prolific in explanations, does not appear to have expressed any very definite reasons for his ideas of the morphology of gastrulation in the higher arthropods. In his studies on spiders ['80a] he does not consider the segmentation, but regards the yolk spheres (each of which is nucleated) which fill the egg after the formation of the blastoderm as constituting the entoderm. In his Comparative Embryology ('80, pp. 336, 378; '81, p. 278) he extends the same view to the hexapods; claims that the primitive groove is not a gastrula; regards the yolk cells as endoderm, and while stating that the mode of formation of the endoderm in the 'tracheates' reminds one of delamination, "there are strong grounds for thinking that the tracheate type of formation of the epiblast and hypoblast is a secondary modification of an invaginate type", and further, that the primitive groove may be a modified blastopore.

The Brothers Hertwig ['81], recognizing the difficulties which surrounded the interpretation of the gastrulation in the hexapods, studied the early development of Noctua, and for the first time gave a clear interpretation of the phenomena in accordance with the gastrula theory. According to them, the primitive groove is an actual blastopore, and it must be considered that both the nucleated yolk and the mesoderm are potentially invaginated; but that the abundance of yolk has prevented the entoderm (yolk) cells from reaching the surface and taking part in the formation of the blastoderm, and also that the same substance has prevented any saccular invagination and the formation of an actual archenteron. This view is good as far as it goes; but, as will readily be seen, it leaves some points unexplained.

Tichomiroff's final paper on the development of the silkworm ('82) is unfortunately buried in the Russian language, and all ordinary students must depend upon abstracts for their knowledge of its contents, together with an inspection of the cuts in the text and the figures on the plates; there being, fortunately, no distinctively Russian method of drawing. The blastoderm is formed by a migration of cells to one pole and the neighboring sides of the egg (*vide* fig. 11, p. 28). Not all the cells thus come to the surface but some remain behind in the yolk. These are distinctively amœboid in shape and form, the "primitive entoderm." With regard to the "secondary entoderm" he agrees with Bobretzky. After the formation of the amnion and serosa and their union over the germinal area, the primitive groove appears, deeper and more symmetrical in front than behind (*vide* figs. 14 and 15, p. 33). It later closes, but not completely behind; but before its closure the mesoderm appears from both ectoderm and entoderm, and not only from the region beneath the primitive groove, but from all parts of the ectoderm. There is nothing in the sections figured to warrant the statement that the mesoderm has such a wide origin; the arguments for it in the text remain sealed.

Weismann ('82) describes the early stages in several species (Rhodites, Biorhiza, Chironomus, Gryllotalpa). The account, so far as statements of facts go, is most detailed with Rhodites. Here we have to do with two elements: the ordinary cells, all of which migrate to the surface to form the blastoderm; and the two "polkern," one of which is placed at either pole of the egg. From the anterior of these "polkern" arise the inner "keimzellen." Besides this, a gastrulation is described which is peculiar in being at right angles to the longer axis of the egg and to the normal primitive streak. Its history is not traced, but one can hardly resist the impression that this structure has nothing to do with gastrulation, but is merely a folding of the ventral surface of the egg. Certainly the figures will support such a conclusion.

Dr. Ayers ('84) describes the early history of Œcanthus and differs from all other authors as to his interpretation of the primitive layers. According to him the blastoderm is to be regarded as largely entodermic, the ectoderm at first forming but "a small area on the dorsal side in the region of the gastrula mouth," which gradually "encloses the yolk and endoderm by a genuine epibole." As I understand his description, he regards the germinal area and the amnion as the ectoderm, while the serosa is entoderm, the yolk being "an inert mass of food substance between the particles of which numerous *indifferent cells* are found." Hence the line between the amnion and serosa is to be regarded as the boundary between ecto- and entoderm. These membranes now fuse so as to form the well-known double envelope about the germinal area and then the second fusion takes place followed by the rupture in the place of fusion, and eversion of the embryo. The serosa now contracts and pulls the amnion from the dorsal surface, while its cells gather together and form a yolk sac which at last comes to lie within the body, being last seen at the back of the head. The amnion is distinctly stated to form the dorsal wall of the insect, while "the serosa functions as a yolk sac" and the "so-called dorsal organ is but the remnant of the yolk sac" (p. 261). In various places the serosa is spoken of as an "endodermic sac," while, in figures 36 and 37 on p. 260, the serosa is labelled "*en*" (endoderm), and the dorsal organ "*gast. mo.*" (gastrula mouth). It would seem as if the only interpretation to be placed on these facts is that the serosa is regarded as the endoderm and the dorsal organ as the gastrula mouth. In a note on p. 261, Dr. Ayers modifies some of these statements in the light of Balfour's researches on the embryology of Peripatus. He now regards the primitive groove as produced by an elongation of the blastopore and says that in some insects this groove, with the mesoderm arising from it, is to be regarded as the only indication of the previous existence of a gastrula mouth. This of course modifies many of the other conclusions summarized above, but to what extent does not readily appear from the text.

Patten says ('84) that in the Phryganids all the nuclei of segmentation migrate to the surface and take part in the formation of the blastoderm, leaving the yolk entirely free. Then (p. 573) "the endoderm arises from any point in the blastoderm by delamination, and the process may continue even after the blastoderm has been converted into the ventral plate." In support of this view he figures (pl. XXXVI B, fig. 5) a section of an egg with the ventral plate well-differentiated, in which cells which he regards as yolk cells or endoderm, are budding from the dorsal portion of the blastoderm (serosa). In another place (p. 572) he says that the cells arising from the primitive groove ("gastrula") are to be regarded as both mesoderm and endoderm, and farther on he describes and figures amœboid cells, like those mentioned above, budding from the mesoderm and extending into the yolk. What the fate of these latter is he is not prepared to say, but he is not ready to affirm that the result of this is to increase the number of yolk cells. We may note in passing, that Doctor Patten mentions the fact that no karyokinetic figures were visible in the young stages, even where cell division was actively going on.

Witlaczil, in his masterly paper on the development of the Aphides ('84), agrees with the others that the nucleated yolk spheres represent the endoderm and that they later give rise to the "Wanderzellen," of whose wandering, however, he has doubts. These yolk spheres he regards as products of segmentation, but he makes no comments upon their relations to the blastopore or to any invagination.

Korotneff ('85), studying Gryllotalpa, arrives at conclusions much like those of Patten. The yolk cells all migrate to the surface and there take part in the formation of the smooth blastoderm. Here some of the blastodermic cells (usually in the neighborhood of the scarcely apparent primitive streak) become larger than their fellows and send protoplasmic prolongations down into the yolk, and then sink themselves into that substance. This takes place by scattered cells here and there and forms what this author terms "diffuse gastrulation." He makes no mention of mesodermal cells sinking into the yolk, but derives his entoderm solely from these amœboid cells arising from the blastoderm. This constitutes one of the differences between him and Patten; another consists in the fact that Patten has the yolk cells budded from those of the blastoderm, while Korotneff has the blastodermic cells themselves sink into the yolk.

Bruce has a different view. In Thyridopteryx ('85) the germinal area becomes two cells deep, apparently by a delamination which takes place beneath and at the sides of the primitive groove. The inner layer then separates from the other and, splitting into two bands, grows laterally and dorsally, and portions of it then extend around and enclose the yolk. These are said to "form the epithelium of the mid-gut and consequently are to be regarded as endoderm cells." The large yolk cells are not regarded as taking any part in the formation of the endoderm, but nothing is said of their fate. Apparently (if we may judge from the two figures given) the process in Thyridopteryx is much like that in Noctua, as described by the Hertwigs, and the layer which Bruce describes as endoderm is regarded as mesoderm by them. In Bruce's fig. 2, this layer bends around almost exactly as it does in Noctua to form the splanchnopleure. Bruce's "clear migratory cells" are not represented in Noctua. Bruce says nothing of their fate nor does he indicate how the mesoderm arises. While he quotes Balfour, Kowalevsky, Tichomiroff and Dohrn, he fails to refer to the Hertwigs in connection with the origin of the endoderm.

In the bee, according to Grassi ('85) the blastoderm is formed by a migration of the amœboid cells to the surface where, at one end of the egg, they at first form a layer of cells which gradually increases until the whole is covered, just as was described by Kowalevsky. Numerous nuclei are left in the yolk. In the median ventral line the formation of the mesoderm takes place, a broad plate of the blastoderm sinking and being overgrown by the remainder of the blastoderm. At first this mesoderm is a single cell in thickness, but it soon becomes two or more cells deep. This closing in takes place first in the anterior third of the embryo and is concluded at the posterior end of the germ. After this mesodermic plate is formed and enclosed by the ectoderm it grows forwards and backwards beyond the limits of its origin, curving at either end to surround the yolk. It is these terminations that Grassi regards as forming the endoderm. In other words he derives the endoderm from the anterior and posterior ends of the mesodermal plate. He refers to numerous sections figured to support this view but they are to me far from conclusive. Indeed they do not in the least appear to support him; but on the other hand seem to be in full accord with the explanation advocated below. In a second portion of his paper (Ital. edit., pp. 191–194; French edit., 267–268) he says that this mode of origin is in full accord with the theory of the gastrula, that the line of invagination is to be regarded as an elongate blastopore, the invaginated tissue is to be regarded as a meso-entodermal layer and that gastrulation is here rudimentary rather than falsified, the nutrition rendering a perfect gastrula unnecessary. Concerning the yolk cells, which are clearly like those of other arthropods, our author says that he has never seen them take any part in the formation of the endoderm. The lack of method in the arrangement of his figures renders it a difficult task to follow the sequence of his sections; but a study of figs. 3, 13, 14, 29 on pl. VII, figs. 6, 7 on pl. VIII, as well as many others, would seem to show beyond a doubt that the endoderm in the bee was formed by a migration of the amœboid yolk cells to the surface of the yolk and their arrangement there into an epithelial layer inside the mesoderm and resting directly upon the yolk. The appeal to figures like pl. VII, fig. 4, to prove that the yolk cells take no part in the formation of the endoderm is far from conclusive. Further studies on the development of the bee will be necessary before this question can be regarded as settled. Grassi thinks that the results of the Hertwigs and Tichomiroff ('82) can be explained to agree with his views, but this does not readily appear.

From this review (which is not exhaustive) we see that there have been almost as many theories as writers concerning the origin of the endoderm in the hexapods and its relation to the gastrula. It has not been our purpose to trace their results beyond the point of the recognition of the three layers and hence we have omitted those portions which treat of the modification of the primitive endoderm into the epithelium of the mesenteron. Since Haeckel, most authors have realized that the primitive groove is in some way connected with gastrulation and many are of the idea that the yolk cells and the "Wanderzellen" have a part to play in the formation of the endoderm. Not so Dohrn. He says ('76) that they have no connection with the primitive groove though they may come to lie beneath it. The "Wanderzellen" occur in the adult as well as in the embryo. They form the fat bodies and the blood and they pass out through the dorsal organ into the space between the embryonic envelopes. He also mentions that the neurilemma is derived from similar appearing cells. It is highly probable that Dohrn has taken similar appearance for actual identity and has confused amœboid mesoderm cells with similar cells derived from yolk cells which are really endodermal.

Of the early stages of the myriapods we know comparatively little. Stecker ('77) describes a regular gastrulation in four genera of Diplopods (Iulus, Craspedosoma, Polydesmus and Strongylosoma) but a glance at his plates convinces one that his statements deserve the criticism to which Balfour subjects them. More recently, Heathcote has investigated the development of Iulus and his account, ('86) while confirming that of Metschnikoff, adds other details. The nuclei of segmentation, each surrounded with protoplasm, migrate to the surface to form the blastoderm, the later nuclei uniting with others derived from the blastoderm to form a keel like that described by Balfour in Agelena. This keel furnishes the mesoderm, and Heathcote regards it as homologous with the primitive streak of other arthropods. Other nuclei remain in the yolk and these eventually become partly mesodermal and partly endodermal. Metschnikoff's slight account of the early stages of Geophilus would indicate that the Chilopods are much like the Diplopods. Sograf ('83) has a Russian paper on Geophilus from which it would appear that there is a similar migration of some cells to form the blastoderm while others remain behind in the yolk.[1] The mesoderm arises in much the same way, but some of the later sections would tend to show that not all the nuclei remaining behind in the yolk were utilized in forming the endodermic epithelium but that they were utilized as food like the yolk. One figure would seem to indicate that the endoderm may bud off cells to take a place among the mesoderm.

This confusion regarding the origin of the endoderm in the hexapods, arachnids and myriapods, and the belief that the facts shown by the decapods aid in an interpretation of the various phenomena are my excuse for thus taking up more space than, perhaps, the subject demands. The existence of a gastrula stage in all Metazoa, whether of the type of "archigastrula" or of some of the numerous modifications recognized by Haeckel, is admitted by all; but, so far as I am aware, no one has as yet brought the hexapods in full accordance with that theory. My present attempt may not be deemed more satisfactory than the twenty or more that have preceded it; it has, however, the merit of reconciling more facts than any other.

---

[1] In the abstract quoted from (see bibliography) it is stated that the eggs of myriapods are very peculiar in that they have the protoplasm at first at the centre, the cells migrating to the surface, and it is suggested that this probably distinguishes them from the Arthropoda "since in no other arthropodous form does the vitellus so constantly occupy a superficial position and so completely invest the first segmentation cells, which are then aggregated in a cluster at the centre of the egg"! It is one endeavor of the present paper to show that just this condition is characteristic of the Arthropoda as a whole; and (Tetranychus and the meroblastic forms excepted), so far as the writer is aware, there is not a single arthropod in which there is an abundance of food yolk but what has just this type of egg, here regarded as decidedly myriapodous.

From our historical review it will be seen that the great majority of the evidence is in favor of the following points:—(1) The segmentation begins at the centre of the egg. (2) The blastoderm is formed by the migration of the cells produced by segmentation to the surface. (3) The endoderm, in many types of hexapods is formed by cells which remain behind in the yolk. (The exceptions to this will be considered later.) To these a fourth is to be added, which is so generally recognized as to need but little argument:—The primitive groove of hexapods is the homologue of the blastopore. This is shown by its relations to the origin of the mesoderm and, later, of the nervous system, which are almost exactly like those of vertebrates,[1] where the same homology is recognized. Except in a few cases in the hexapods (Korotneff, Patten, Bruce, etc.), it is not claimed that the primitive groove is in any way connected with the actual production of the endoderm or that there is any passage of cells from the blastoderm to the interior of the egg. How then has this state of affairs arisen? and how is it to be explained?

In all these there is a migration to the surface closely like that of Crangon. Now, in this genus (and the same is apparently true of other forms, *e. g.*, Atyephyra) the majority of these migrating cells go to form the germinal area, more going to that region than to any other, and, as fig. 9 shows, the later migration is all toward that point. Here it is that the gastrula is formed, and as a necessary result some of these very cells are returned by that operation into the yolk from which they have just emerged. Should some of these migrant cells be still farther delayed, it is a plausible supposition that they might be-

[1] As will be shown later, the supra-œsophageal commissure, which completes the œsophageal ring and thus makes the invertebrate nervous system so different from that of the vertebrate, is developed after the rest of the system is outlined.

come entangled among the invaginating cells and thus be carried back into the yolk where they would form a part of the endoderm without ever having taken part in the formation of the blastoderm. Such an effect might result from an increase of deutoplasm in proportion to the protoplasm. Still further increase it and more cells would be delayed and finally enough would remain in the yolk to form the whole of the endoderm. Such a process is in perfect harmony with the theory of acceleration and retardation of Professors Cope and Hyatt; and it would be accompanied by a considerable saving of vital force to the egg.

The endoderm cells in eggs with a large yolk need to take a position in close connection with the deutoplasm, for from the moment of their formation they are actively engaged in assimilating it (*cf.* Reichenbach, '86, pp. 101–102, pl. VIII, fig. 67); hence any process which leaves them scattered through the yolk is an evident advantage to the embryo. The mesoderm, on the other hand, is first needed in the neighborhood of the developing appendages where muscles, etc., will be earliest required, and hence it is no economy to the individual to change the mode of its formation. From this reason, as well as from heredity, the egg would retain the appearance and go through the motions of gastrulation, even though it formed no endoderm by the operation, and the result would be such as has been described by the majority of observers.

The conflicting accounts of recent date are those of Bruce, Patten and Korotneff. In the case of Bruce ('85) I think a reconciliation is to be effected on the supposition that he has misinterpreted his observations. A comparison of his account with that of the Hertwigs seems conclusively to show that the yolk cells are to be regarded as endoderm, while his endoderm is clearly the splanchnopleure of the authors of the "Cœlomtheorie." The observations of Korotneff ('85) and Patten ('84) are less easily explained, for both state that cells arise from all parts of the blastoderm and pass into the yolk to form the endoderm, and that before this "diffuse gastrulation" more are left in the yolk. Were it not for this, the statements and figures of Patten (p. 572, pl. XXXVII B, fig. 12) that the primitive streak "gives rise to a part of the endoderm and all of the mesoderm," might be readily understood as the last stage in a process of gastrulation previous to the condition of affairs which we have supposed above. Korotneff's recognition of two mesodermal elements — myoblasts and mesenchyma—and his description of their mode and places of origin still further complicate the matter and make a reëxamination of his results desirable.

While upon this subject of arthropod segmentation and gastrulation it may be well to refer to another point which seems to have caused considerable trouble, and for which an explanation is apparently more easy than in the cases already discussed. In a few arthropods — Scorpio (Metschnikoff, '71), Nebalia (Metschnikoff, '68), Mysis (Van Beneden, '69[b]), Oniscus (Bobretzky, '74), and Cymothoa (Bullar, '78), the segmentation is of a meroblastic character, recalling quite strongly that of the meroblastic vertebrates or even of the teleosts. While we greatly need new observations upon these forms I think the facts in our possession fully warrant us in regarding them as not greatly different from the more normal types.

In all arthropod eggs there is a certain amount of polarity and in some it becomes quite marked, the cells appearing at one point more abundantly and earlier than at others. This was noticed by Locy in Agelena, but is more apparent in the cases of Aphis, Gryllotalpa, and, it would seem, in Neophalax.[1] In the mite, Tetranychus (Claparède, '68) the process has gone a step farther, for here the segmentation nucleus reaches the surface before it divides. In this case the segmentation is necessarily superficial, but it takes but a very short time to have the whole surface of the egg covered with nuclei, a process which is apparently completed before the appearance of anything like a germinal groove. In this connection, Claparède's pl. XL, figs. 1, 2 and 3, are instructive, for they clearly show us that a *superficial* segmentation in the Arthropoda is necessarily meroblastic, though here this condition lasts but a short time. A superficial segmentation demands that both nucleus and protoplasm be placed practically at the surface of the yolk; in other words, an egg which cannot be distinguished from one of the regular meroblastic type. When segmentation commences, it must necessarily begin at the pole occupied by the nucleus; and, for at least the first few divisions, proceed most rapidly in that region, the result being a meroblastic segmentation, which cannot be defined as distinct from that occurring in Cephalopods, Elasmobranchs, Sauropsida, etc. It is certainly superficial, but superficial exactly in the same way as in those forms mentioned which have never been classed in the category of "centrolecithal eggs."

From the condition which occurs in Tetranychus, it is but a step to that occurring in Oniscus, Scorpio, etc. In these the segmentation nucleus reaches the surface before or soon after segmentation begins, but the resulting blastoderm spreads more slowly over the yolk than in the mite just mentioned, differentiation of the germ layers taking place before the blastoderm covers half the yolk. Gradually, however, the blastoderm completely covers the yolk.

[1] "Ten or twelve hours after oviposition . . . a clear space makes its appearance at the surface of the egg and gradually increases until it has attained the breadth of the future blastoderm" — Patten ('84, p. 563).

Balfour apparently confounded this with an epibolic gastrulation, for (**'80**, p. 99) he seems to think that the closure of the blastoderm is synonymous with the closing of the blastopore, hence in these cases the blastopore would be situated on the dorsal and not on the ventral side of the ovum. Again (p. 378), he says "The growth of the blastoderm over the yolk in scorpions admits no doubt of being regarded as an epibolic gastrula. The blastopore would, however, be situated dorsally, a position it does not occupy in any gastrula type so far dealt with. This fact, coupled with the consideration that the partial segmentation of Scorpio can be derived without difficulty from the ordinary Arachnidan type, seems to show that there is no true epibolic invagination in the development of Scorpio." That he nevertheless adhered to the first of these rather conflicting ideas is seen from his statement a year later (**'81**, p. 282) that "the epibolic gastrula of the scorpion, of Isopods and of other Arthropods, seems also to be a derived gastrula." Ayers holds a similar view for he says (**'84**, p. 261) :—In Scorpio, Mysis and Oniscus, the blastopore is dorsal in position."

This view seems to me totally erroneous. If true, it introduces some wonderful differences into the arthropods and makes it impossible to trace close homologies between forms as closely related as Mysis and Peneus; for in the latter case the blastopore is certainly ventral in position, if we can trust Haeckel's figures. Unfortunately, we know almost nothing about the inner germ layers of Scorpio, but the little that Metschnikoff tells us (**'71**) is apparently in accord with Bobretzky's account of Oniscus (**'74**) and since the latter is much more fully described and moreover was studied by sections, it may be taken to represent these meroblastic crustacean ova.

When the blastoderm of Oniscus covers about a third of the egg, lower layer cells appear between it and the yolk and, rapidly increasing in numbers, split into two layers, thus becoming differentiated into meso- and endoderm. The cells of the latter layer sink into the yolk, "den ganzen Nahrungsdotter in sich einsaugen," and thus convert the interior of the egg into a mass of yolk spheres which Bobretzky says form the endoderm. In Scorpio, Metschnikoff's plates certainly leave much to be desired; but his figures 7 and 9 on plate XIV can be reconciled with the condition occurring in Oniscus, if we interpret the layer cells of fig. 7 and the "zweites Blatt" of fig. 9 as mesoderm. Haeckel's interpretation is apparently wrong. In Cymothoa the conditions are apparently the same as in Oniscus. Van Beneden tells us nothing of the formation of either mesoderm or endoderm in Mysis, but the subsequent development would indicate a similarity to Oniscus. The same remarks would apply to Nebalia.

In Oniscus, Bobretzky says there is no invagination, but he says that here the lower layer cells arise from the blastoderm. Delamination here is of a different nature from that in the Cœlenterates and is easily seen to be but a slight modification of gastrulation. This gastrulation takes place at or near the middle of the germinal area, and there is to be sought the blastopore. We know nothing about the presence or absence of a primitive groove in any of these forms. Such being the case, the gastrulation of these genera is of a very different character from that of the teleosts and some other vertebrates where the rim of the blastoderm is clearly the blastopore. In these arthropods there is merely an acceleration of development, whereby the gastrula is formed before the blastoderm has had time to spread over the very large yolk. The case offers a close parallel to that of the chick. The edge of the blastoderm has nothing to do with the formation of either mesoderm or endoderm, and, hence, except in its closing, it has nothing in common with a blastopore.

Nusbaum ('86) failed to see the first stages in Oniscus but that he takes essentially the same view of the blastopore as that here advocated is readily seen. "Au milieu du disque de segmentation (blastopore) formé par une seule couche de cellules, apparaît une accumulation des cellules (gastrulation), dont une partie, comme Bobretzki l'a bien remarqué s'enfonce dans le vitellus, pour l'absorber et pour former des cellules vitellines (Dotterzellen) une autre partie reste diffuse au dessous de l'ectoblaste et donne naissance, d'après l'auteur cité, aux éléments du mésoblaste ; selon mes recherches cette seconde partie donne non seulement le mésoblaste, mais encore l'entoblaste." Nusbaum does not regard the "Dotterzellen" as true endoderm but thinks that they play a part in the softening of the yolk. His endoderm is derived from two lateral masses at the anterior end of the meso-endodermal thickening and these give rise to the endoderm of the hepatic cœca which Bobretzky thought arose from the yolk cells. He refers to a recent Russian paper by Kowalevsky on the development of the scorpion as agreeing with his results. This I have not seen. Kowalevsky and Schulgin have a short paper on the embryology of this form ('86) which came to hand after the present paper was in the hands of the printer, and which doubtless contains the same facts as that referred to by Nusbaum. Their youngest eggs had the blastoderm complete and occupying one pole of the egg, while neither nuclei nor cells were to be seen in the yolk. The rudiments of the middle and inner germ layers first appeared as a thickening in the middle of the under surface of the blastoderm ; and "nicht selten kann man konstatieren, dass mehrere Zellen von den obern Schicht nach innen getreten sind," certainly indicating a solid invagination. The authors at first regard these invaginated cells as entoderm but later as ento-mesoderm. From the lower surface of this layer many cells bud off and sink into the yolk to form yolk cells, which, the authors say, play no part in the development of the tissues, but act as solvents of the yolk. Later, the true entoderm is formed by the separation of a layer of cells from the ento-mesodermal layer, which come to lie close upon the yolk. Nothing is said of the portion of the invaginated cells from which these entoderm cells arise. The mesoderm is later in becoming differentiated.

Nusbaum's observations as to the place of origin of the entoderm seem to afford a partial support to those of Grassi on the bee noted above; but without illustrations it is not easy to see how far this is really the case. Kowalevsky and Schulgin do not say whether the entoderm arises from the whole lower surface of the invaginated cells or from their anterior region. All three agree, however, in saying that the yolk cells play no part in the formation of the epithelium of the mesenteron. In this connection my own observations ('85) on the development of Limulus are of interest. Nothing is known of how the yolk cells arise in that form, my few observations only lending probability to the view that they are derivatives of the early segmentation which do not migrate to the surface. My sections, however, seem capable of but one interpretation—that the peripheral yolk cells eventually form the epithelial lining of the liver and the intestine and that they gradually devour those lying inside them, thus producing the lumen of this portion of the alimentary tract. To a certain extent these observations are reconcilable with those just noted; for, in Limulus, the yolk cells break up and digest the yolk, but some of them beside seem to be true entoderm for they form a true entodermal tissue.

A reconciliation of the differences will only be possible upon the publication of figures and a detailed account of the processes in Oniscus and Androctonus.

The observations on the relations of the mouth and anus to the blastopore in the Crustacea are extremely few. Reichenbach's account of Astacus ('86) is by far the most complete and conclusive, and there the anus is clearly in front of the position of the blastopore. Ishikawa ('85) has the same result in Atyephyra; and in Crangon, though not certain, I still think that the anus occupies a similar position with reference to the blastopore. In none of the Crustacea do we find that elongate blastopore (primitive groove) which is so characteristic of the tracheate arthropods and the fact that the blastopore entirely disappears before the appearance of either permanent opening of the digestive tract renders it rather difficult to trace their general relationships. Reichenbach's studies and his figures ('86, pls. II and III) seem to be conclusive upon the point that there is no proliferation which would extend the limits of the circumblastoporal cells as far forward as the point where the mouth is formed or even far enough to include the anus.

In Crangon I have been unable to recognize but one kind of mesoderm and that is not differentiated until gastrulation. It arises, as numerous sections show, from the edge of the blastopore and from nowhere else. Bobretzky recognized but one kind of mesoderm in Palæmon, but this arose from cells clearly endodermal. Reichenbach ('77 and '86) has a secondary mesoderm which is budded from the true endodermal cells after the process of gastrulation is completed. Ishikawa, in Atyephyra, also has two kinds of mesoderm, one arising from the edge of the blastopore; while the other arises from the endoderm, all of the endodermal cells elongating and budding off cells which go to make up the third germinal layer. The earlier of these mesodermal cells of endodermal originally closely resemble their fellows, but later they are much smaller and stain more deeply. These latter are regarded as comparable with the secondary mesoderm of Reichenbach. It does not appear that either of these two groups of mesoderm fall under the head of the mesenchyme of the Hertwigs.

Reichenbach claims that in Astacus the mesoderm is differentiated before the actual gastrulation, and he figures mesodermal cells in advance of the blastopore. This reminds one of Grobben's studies on the Entomostraca. In Cetochilus at the thirty-two cell stage there are already differentiated one mesoderm and two endoderm cells, besides two more which are partly mesodermic and partly endodermic, but it is to be noticed that, according to Grobben's interpretations, the mesodermic cell is *behind* the endodermic ones. In Moina the same differentiation of mesoderm before invagination is noticed, and the mesoderm occupies the same position with relation to the endoderm. Here, however, the genital cells are differentiated from the other mesodermal ones before either are invaginated, exhibiting an instance of precocity only paralleled in some Hexapods (*vide* Witlaczil (**'84**, pp. 571 and 671–677).

Concerning Lucifer there is some question. According to Brooks (**'82**) the egg has a regular and total segmentation followed by a blastopore stage. At the close of segmentation one of the cells is differentiated from the rest by containing a large amount of food yolk. In invagination this cell becomes divided, and the two resulting cells do not take a part in forming the endoderm, but are pushed into the segmentation cavity. Brooks is uncertain whether the whole of the primitive yolk-bearing cell becomes thus pushed in or whether only its deeper end is segmented off and placed into the blastocœle. The further history of these cells was not traced. It would seem probable that they go to form the mesoderm, and, if so, they would afford another instance of early differentiation of that layer. Brooks, however, is inclined to the belief that they go to form a food-yolk like that of other decapods. His reasons, however, are far from apparent.

In the other groups of Crustacea the information as to the origin of the mesoderm is extremely scanty. In Oniscus (Bobretzky, '74), it would appear that both mesoderm and endoderm are formed at the same time and are differentiated by a delamination at a later date. Bullar's results in Cymothoa do not differ greatly from this. Nusbaum's account of the process in Oniscus is summarized above. New observations are, however, greatly needed, for these accounts lack greatly in desirable details, and it will possibly prove that the origin of the mesoderm in all these meroblastic types does not differ greatly from that of the more common uninvaginate forms.

EXTERNAL DEVELOPMENT.

From this point where the three germ layers are developed, it is necessary to follow out the different organs separately, since the whole cannot be described at once. In order to have a means of correlating the stages of growth of the different systems, I give first an outline of the external features up to the time of hatching, leaving the internal organs until a later time. I may say at the outset that I do not attempt to trace the various modifications of the appendages in detail, but merely to figure and describe the general external appearance, so that the reader may have landmarks to guide him in the discussion of the internal development.

Immediately after the gastrulation, the embryo begins to be outlined. As will be seen by fig. 8, the germinal area is mostly in front of the blastopore and is characterized by smaller and more closely placed cells. It is here that the most marked changes first take place. The next stage is represented in fig. 10; a larger and more detailed representation of this stage is shown in fig. 1 of my other paper ('87). At the posterior end of the egg is shown a broad, somewhat kidney-shaped disc, *ta*, the representative of the germinal area in fig. 8, and which, following Reichenbach, I call the thoracico-abdominal area. The blastopore closed in the median line of the posterior portion of this disc. From the two anterior angles of this disc, two cords of smaller cells extend outwards and forwards, each terminating in an oval disc or plate of still smaller cells (*ol*), the rudiments of the optic lobes for whose subsequent history the reader is referred to the paper just quoted. In the fresh egg treated with dilute alcohol, this somewhat U-shaped germ is brought into strong relief, while staining shows that it is differentiated from the rest of the blastoderm by the smaller size of the cells and the consequently closer position of the nuclei. The cells are smaller in the optic lobes and in the thoracico-abdominal area than in the cords connecting them. In section these cells are all more columnar than those of the undifferentiated blastoderm, which are very flat and much as in the earlier stages.

This stage of the egg, which I may call *A*, corresponds rather closely with Reichenbach's ('86) stages *A*—*D*, with the following exceptions: Most noticeable is the fact that I have not seen the optic lobes in Crangon before the closure of the blastopore, while Reichenbach (*l.c.*, pls. I and II) has them well differentiated in Astacus even before invagination begins. Again, Reichenbach has the nuclei of the optic lobes and the two halves of the thoracico-abdominal region exhibiting a marked concentric arrangement. This I have not seen in Crangon. Besides these points and the relatively greater distance in Crangon between the optic and thoracico-abdominal lobes, and the smaller number of cells (a necessity from the much smaller size of the egg) our results compare favorably.

Mayer, in his studies of Eupagurus (**'77**) did not go into such detail as Reichenbach, as he did not trace the cells in his earlier stages. His figures 14 and 15 compare well with that of Crangon now under discussion, except he does not figure the cords connecting the optic lobes (Kopfanlage) with the thoracico-abdominal area. In Crangon, these cords are fainter than the rest of the germ, and hence they may have existed in Eupagurus but have escaped observation. In other respects — the shape of the thoracico-abdominal region and the distance between this and the optic lobes — there is a close resemblance between these two forms.

Accepting the terminology which Ishikawa applies to his figures of the early embryos of Atyephyra (**'85**, pl. XXVI, figs. 55 to 59) it is not easy to reconcile his results with mine. It would seem, however, that his mandibles and abdomen are not in reality such but that together they form the thoracico-abdominal region. There is, however, not sufficient evidence to decide this point as the stages between these figures and his figure 60 are lacking. If this view be the true one (his mandibles being but the lateral expansions of the thoracico-abdominal region) his results will compare well with those of Reichenbach and Mayer as well as with my own and we shall be relieved of the difficulties surrounding the appearance of the mandibles before any other appendages are outlined. Connected with this area by a slender peduncle is a circular area interpreted as the "carapace." Unless this be what I have termed the dorsal organ which will be described later, I have seen nothing to compare with it in Crangon. The optic lobes in Atyephyra are at about the same distance from the thoracico-abdominal area as in Crangon, but Ishikawa does not represent the cords of small cells connecting them.

Between the stage just described and the next, which I designate as *B* (fig. 11) there occurs a gap in my material but the changes which have occurred in the interval can easily be understood. The embryonic area is now considerably *smaller* than before (a subject to be mentioned later), while its form has undergone considerable alteration. The optic lobes are now larger than before and more closely approximate, the broad area of undifferentiated blastoderm which formerly existed between them, (reaching back to the thoracico-abdominal area) having disappeared except for a V-shaped prolongation which extends between the optic lobes. These lobes are also much nearer the rest of the embryo ; and the thoracico-abdominal area shows the beginning of the differentiation which justifies the name applied to it. The cords of cells uniting the optic lobe with the rest cf the embryo in fig. 10 have now united in the median line to form part of the ventral surface of the shrimp. The optic lobes at this stage are elsewhere described, but the rest of the embryo needs further mention.

From the lateral cords a broad plate formed by their union has developed, with the mouth, a shallow pit (*mo*) near its anterior margin, while on either side is seen the first rudiment of an appendage (*I*) which the subsequent history shows to be the first antenna or antennula. It is to be noticed that this appendage at this time is distinctly postoral in its position. Behind this appendage this region becomes confluent with the undifferentiated portion of the thoracico-abdominal area. At the outer portion of this region the nuclei are more closely placed than in the centre, and sections show that in the former portions the cells are more columnar, while in the median line they are more nearly pavement like. The line of demarcation between the two kinds of cells is rather abrupt and indicates the division between the ectoderm of the median line and that which is to give rise to the ventral nervous cord. In the thoracico-abdominal area a differentiation is also taking place, as the abdomen is budding out. This is accomplished by an infolding near the anterior margin of the area (*af*) by which the abdomen is separated from the rest of the area, while the ectoderm, thus inpushed, forms the ventral surface of both thorax and abdomen. This inpushing does not at first take place clear across the thoracico-abdominal area, but begins near the median line and proceeds there more rapidly than at the sides, the result being to form a pouch projecting some little distance into the egg, the walls of which are formed by the ectoderm of the ventral surface. I think that Ishikawa has been misled by this development of the abdomen and has interpreted the pouch thus formed as the proctodæum. Certainly his "*pd*" in fig. 62 (**'85**, pl. XXVII) is not the hind gut, but is the beginning of the abdominal fold. In Crangon, as we shall see later, the proctodæum does not appear until some little time has elapsed. In this formation of the abdomen, Crangon agrees closely with Eupagurus. Mayer's fig. 28 (**'77**, pl. XIV) represents a condition which is frequently seen in cutting sections of the earlier stages of Crangon parallel with the general ventral surface, so far as the thorax and abdomen are concerned; the amœboid cells there figured I have not seen. The scattered mesoderm and endoderm cells have no such appearance in Crangon.

It is at this stage that I have first distinctly seen the first embryonic cuticle, though I have seen traces of it in the stage A. It is a delicate, cuticular pellicle, secreted by all the cells of the blastoderm and forms a second envelope inside the chorion. Its fate I have not traced. What these blastodermic cuticula mean from a phylogenetic standpoint I am not ready to say. They occur in various arthropods, having been described in many Crustacea and some Arachnids as well as in Limulus (Kingsley, '85). In Atax, Limulus and Apus they form a protective envelope for the embryo after the splitting of the chorion, and in such cases Claparède's term deutova may be applied to them. In other cases they seem to play no part in the subsequent history of the animal. They clearly have no connection with the protective envelopes (amnion and serosa) of hexapods, nor have they any connection with the dorsal organ (micropylar apparatus) of the Edriophthalma. Kennel ('84) sees in them a remnant of the trochosphere of the annelid ancestor of the arthropods, a view which seems to have but little to support it.

In stage *C* (figs. 12 and 13) the optic lobes are more elongate, the upper lip (*l*) has developed, covering the mouth, while a second pair of appendages (*II*), the antennæ, have been formed between the antennulæ and the thoracico-abdominal area. The antennulæ and the mouth begin to show a change in their relative positions, for while in the last figure the base of this appendage was distinctly postoral, it has now moved forward so that the mouth is opposite the middle of the base. The abdomen is also farther developed by the inpushing of the pouch already described, the extent of which is best shown by the side view, fig. 12, *af*.

Stage *D* (fig. 14) is characterized by the appearance of the mandibles (*III*), the increase in size of antennulæ and antennæ (*II*), the indications of the supracœsophageal and optic ganglia, the larger size of the abdomen and the appearance of the rudiments of the heart and dorsal vessel, *d*. There is no longer a large space between the labrum and the tip of the abdomen, and the latter exhibits traces of segmentation. Both pairs of antennæ are in front of the mouth.

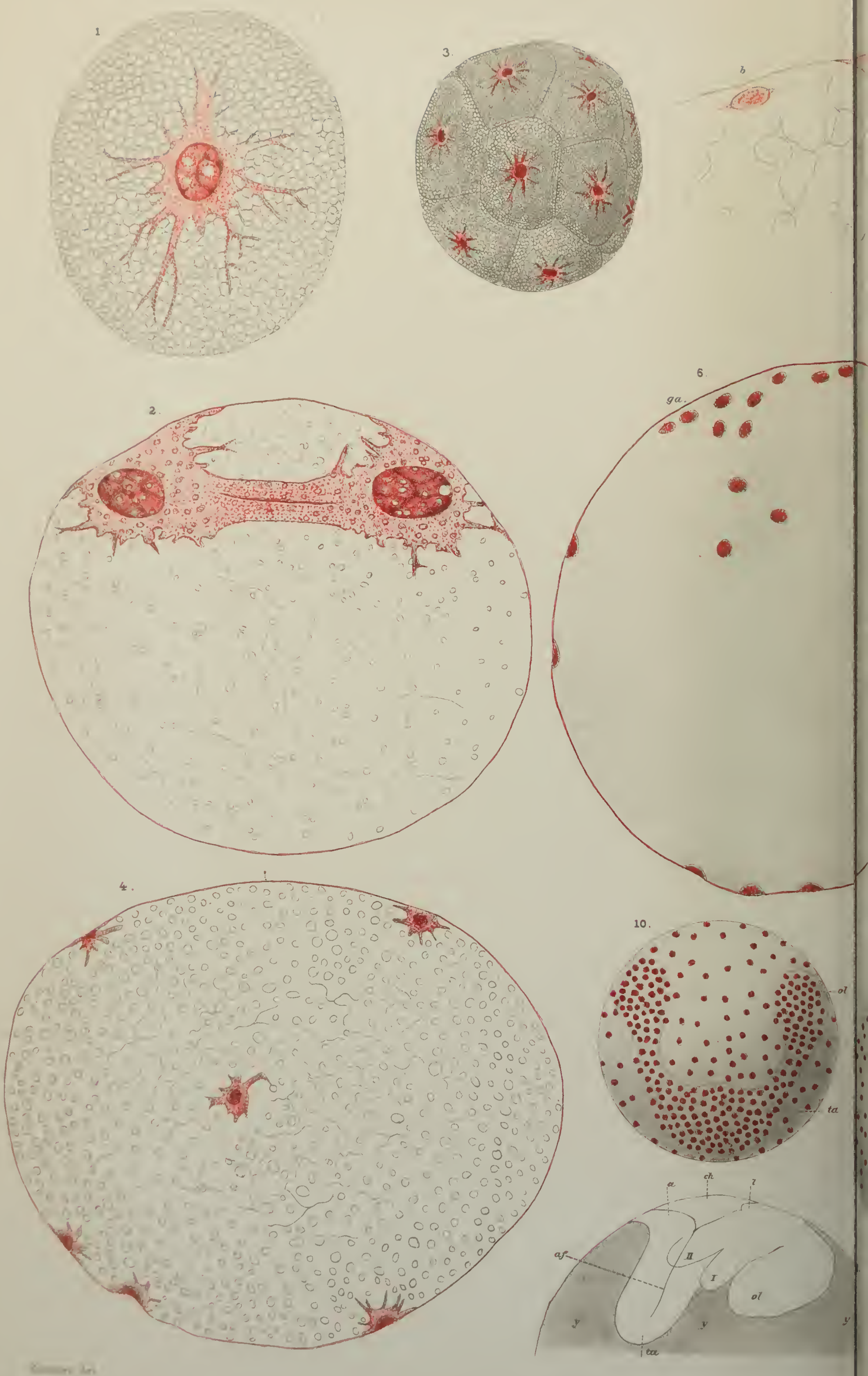
Stage *E* is another step in advance (figs. 15 and 16) in which the most marked features are the development of four pairs of appendages behind the mandibles, making seven in all (a number which persists for some time) and the biramose condition of the second antennæ (*II*). The proctodæum is also visible, although it was formed in the preceding stage.

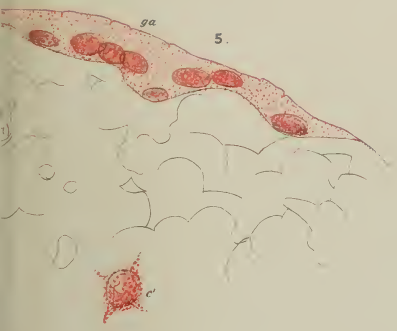
This account varies considerably from that of other observers on the early stages of decapods. For instance, Reichenbach ('86) describes the mandibles as the first appendages to appear and then the antennulæ and lastly the antennæ,[1] thus arriving at the so-called nauplius stage. Like myself (*cf*, '86, pl. 11*a*, fig. 7*a*, "*lb*" *et* "*EII*") he has all the appendages at first distinctly postoral, while he does not find that the mouth is distinctly behind the antennæ until a stage (his "*G*") comparable to my stage *E*. This primitively postoral position of all the crustacean appendages has now been too firmly settled to admit of dispute. Ishikawa has the mandibles appear first in Atyephyra, but this, as explained above is, I think, a mistake.

There is one feature in the history which has already been detailed to which attention should be called. A com-

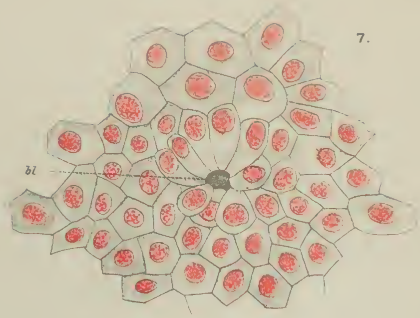
---

[1] Reichenbach regards the ophthalmic stalk as an appendage homonomous with the rest, hence there is a discrepancy of one in the nomenclature of our plates.

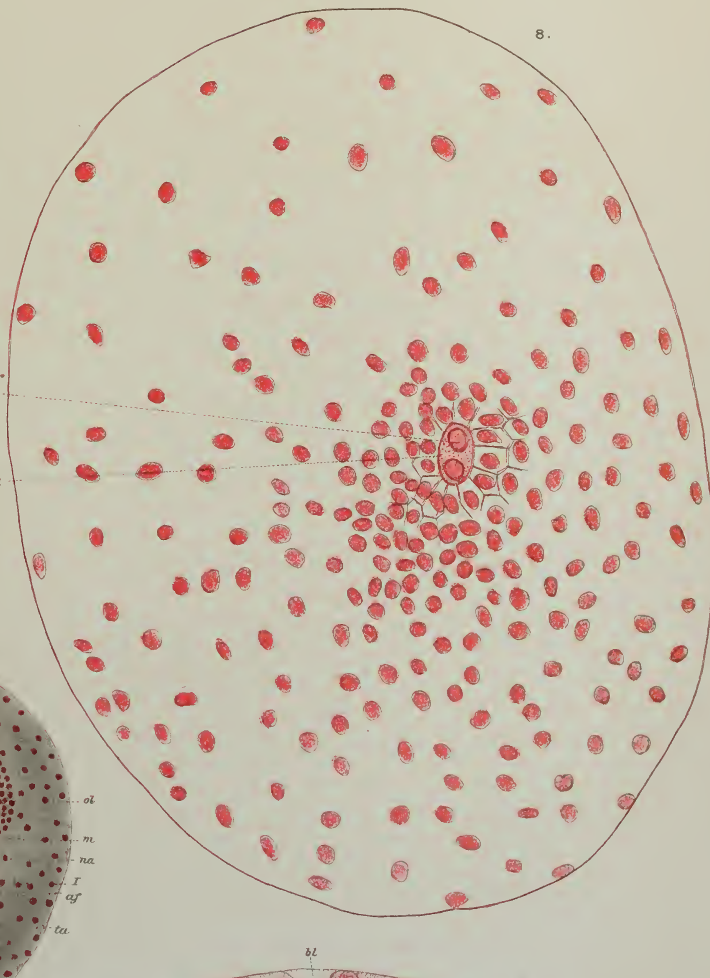

1
3.
b
6.
ga.
2.
4.
10.
ol
ta
a
ch
l
af
II
I
ol
y
y
y
ta



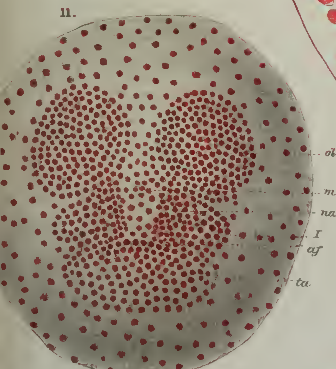
5.



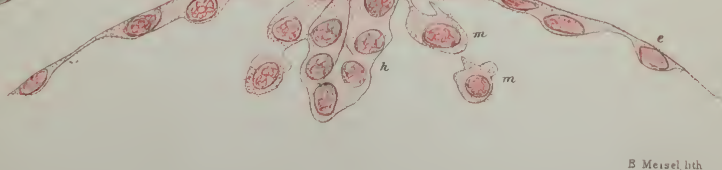
7.



8.



11.

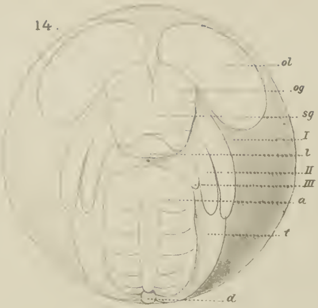


9.

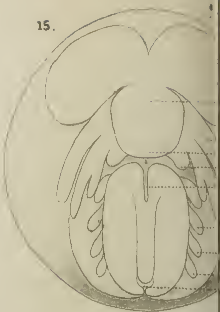
B. Meisel, lith.

13.

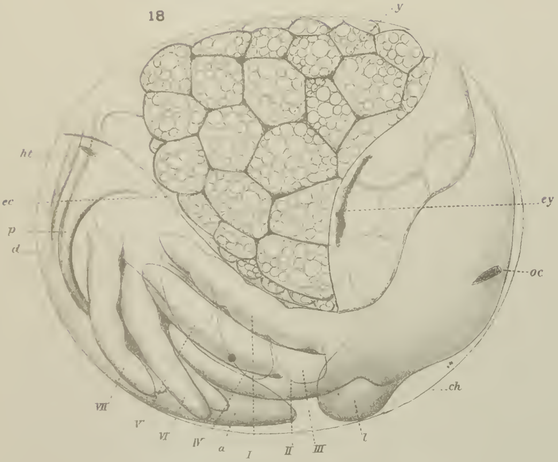
14.



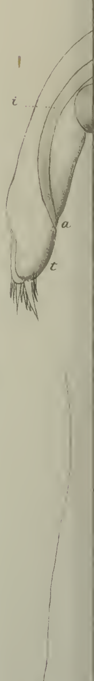
15.



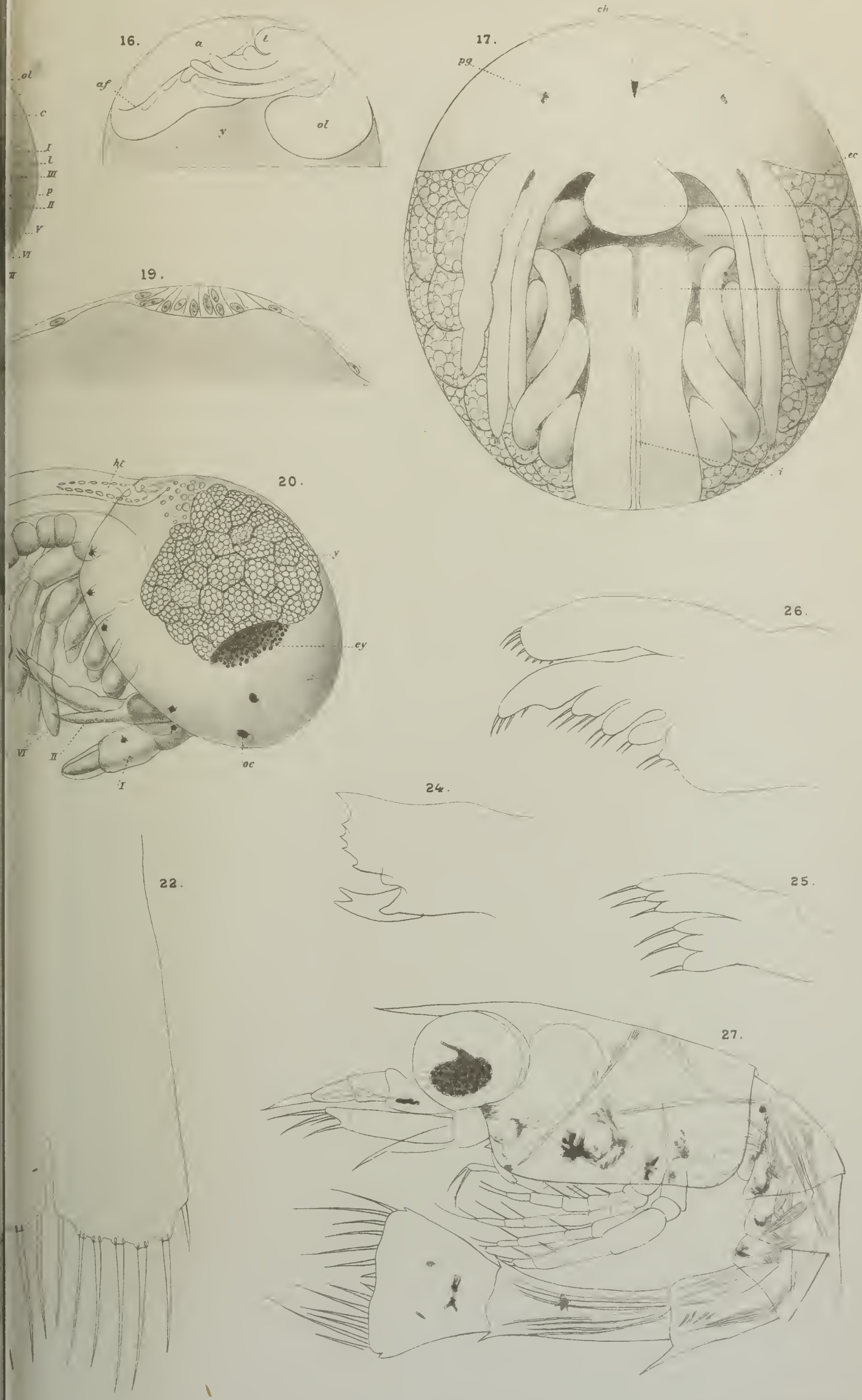
18



21.



23.



E. Meisel lith.

parison of figs. 10 and 11 shows, as was mentioned above, a considerable difference in the size of the embryo, the older being considerably the *smaller* of the two, the original dimensions not being regained until the stage just past. Mayer ('77), calls attention to a similar state of affairs in Eupagurus, while Ishikawa's figures show that the same occurs in Atyephyra. In Astacus, according to measurements of Reichenbach's plates, there is a similar contraction of the germinal area, though not to so great an extent as in the other forms mentioned. So far as I now recall, this circumstance is not readily paralleled in the animal kingdom, nor is it easy to explain. Indeed, I can think of but one interpretation to be placed upon it and that is not over satisfactory. It is as follows: almost all decapods now leave the egg and begin a free life in a comparatively advanced condition, but the evidence presented by Lucifer, Penæus, etc., shows that their ancestors began their free life when much more immature[1], or at least when in a condition far less like that of existing adults than is the newly hatched embryo of to-day. There is evidence that this early crustacean had an egg with comparatively little food yolk; indeed, this element seems to have been introduced at a comparatively recent date. For such an embryo it would be a great advantage to begin its free life with only those organs necessary to its existence and hence the more rapidly the whole egg was converted into the germ the better for the individual and hence for the race. The more direct the development within the

---

[1] As will appear in the sequel, I do not give the nauplius that extreme phylogenetic importance which many do. I regard it as an introduced, adaptive, larval condition which, of course, has become hereditary, and marks a connection between all Crustacea, but which must not be regarded as representing the adult condition of any ancestor. The arguments are too many against such a view. A full discussion of this and allied points is reserved for the concluding sections of my studies of Crangon.

egg the better, and hence any modification which would place each organ in its proper place at first, without the aid of later interstitial growth, would be a material gain. In this way the two extremities of the body would come to lie at the two poles[1] of the egg (compare fig. 10 or better, Mayer, ('77, pl. xiii, fig. 15), while the appendages would arise between.

An increase in the amount of food-yolk would result in an increase in the size of the egg, and, supposing the first formed rudiments to retain their relative positions, this would of course widely separate the organs first to appear. Now, we may imagine it would be an economy for the embryo, in its early stages, when the protoplasm was scanty in comparison with the food-yolk, to have its parts near together, and it may be that in this way this strange contraction of the germ has been introduced. In other words the widely-separated, optic lobes and thoracico-abdominal area of stage *A* are an inheritance from a small egged precocious ancestor, while the contraction seen in the later stages is a consequent of the increase in amount of food-yolk.

The manner in which this contraction is produced is almost equally obscure. I regret that I have made no accurate measurements on the living egg which might throw light upon it. For the present I accept the explanation of Mayer ('77, p. 232. "Offenbar kommt eine solche Näherung aller einzelnen Partien auf der Bauchseite des Embryo nur dadurch zu Stande, dass sich die zwischen ihnen liegenden Blastodermzellen contrahiren und sich hiermit zugleich in ein Cylinderepithel umwandeln." This of course involves a corresponding expansion of the blastoderm of the dorsal surface, and Mayer calls for the

---

[1] The term pole is used with a mathematical and not with a physiological significance.

testimony of his sections to support his view. He further thinks (p. 228) that the germinal area is formed by a similar contraction and consequent thickening of the cells, but I am confident that in Crangon the germinal area is due largely if not wholly to the mode of formation described above. Whether there be a contraction as well I cannot say.

At stage *C* there appears another structure, the meaning of which I do not understand. On the dorsal surface of the egg, about opposite the mouth in the median line, one sees a patch of about twenty or thirty cells much smaller than those of the surrounding blastoderm. This I have termed a "dorsal organ" for the reason that it agrees with all other structures known by the same name in being unintelligible. In sections (fig. 19) it is seen to be made up of columnar cells with elongate nuclei, the cells being arranged in a radial manner as though an invagination were taking place. The development, so far as my sections show, goes no farther and in the later stages the cells of this region are not distinguishable from those of the surrounding ectoderm. This structure, as shown in fig. 19, at once recalls the early stages of the dorsal organ as described by Bullar ('78) in Cymothoa. It bears less resemblance to the dorsal organs of other forms.

The next stage (*F*) is shown in figs. 17 and 18, which need no extended description. The most prominent features are the beginning of the deposition of pigment, the appearance of the edge of the carapax and the beating of the heart. The deposition of pigment brings plainly into view the compound eyes as well as the median ocellus (*oc*). There also appears in either half of the cephalic ganglion a double pigment spot (*pg*, fig. 17) which so simulates an ocellus that I have been unable to decide whether it were such or not. The pigment of the compound eye is first deposited in a linear patch (fig. 18, *ey*). In this stage the yolk is much less abundant than in the previous one.

The changes which occur between stages *F* and *G* (fig. 20) are chiefly those of degree. The yolk is less extensive, the edge of the carapax is free all around, the eye has more pigment and pigment spots are visible upon the sides and on the antennulæ. In the abdomen the ganglia are plainly visible (*na*) and the telson (*vide* fig. 22) is bifurcate and armed with the typical seven spines on either half. The anterior end of the intestine terminates in a wide open funnel which spreads to embrace the yolk and the whole tube keeps up a constant peristaltic motion which forces the yolk granules in the funnel-like extremity back and forth with an oscillating motion. The heart beats as rapidly and more vigorously than before. Its general appearance is shown drawn to a larger scale in fig. 21. A detailed description of it will be given later.

Stage *H* (fig. 23) is the young shrimp nearly ready to hatch. The abdomen has now become greatly longer and is wrapped around the body, its tip passing between the eyes to the front of the head. The yolk is greatly reduced, two large lobes of it remaining in an unbroken condition while another portion is being rapidly converted into yolk globules by the waves caused by the peristaltic action of the intestine. The heart is larger and more vigorous than before. It still possesses but two ostia (one on either side) but a new feature is seen in the appearance of bipolar nerve-cells in its walls. I have not been able to trace the origin of these cells. The gills are beginning to bud from the bases of the limbs as small lobes. The mouth-parts (figs. 24, 25, 26) are well shown in the drawings and call for but little comment. The mandible, however, has one feature which should be mentioned. In the adult Crangon the mandible is bent at right angles and terminates in a toothed occludent surface but is not provided with a palpus. In the embryo at stage *H*, the mandible has much the appearance of the adult (fig. 24) but it possesses, besides, a prolongation from the outer lower angle which I am inclined to regard as a mandibular palpus though in its bifid termination it is unlike any palpus with which I am acquainted. I was unable to ascertain whether it were freely movable upon the mandible or not.

The last figure upon the plate (fig. 27) represents the shrimp after escaping from the egg, a stage which may be designated by the letter *I*. With this the shrimp passes beyond the scope of my inquiries and the figure is introduced so as to connect my series with the later larva of Claus (**'61**). Claus represents a form which he believes to be the young of Crangon; but his figure depicts a more advanced stage than mine for it has an additional pair of thoracic appendages while the caudal fin is formed by the outgrowth of the pleopoda of the penultimate abdominal segment. There are also differences to be noted in the shape of telson and the relative lengths of its marginal spines, the size and development of the antennæ and antennulæ as well as in other points.

To be continued.[1]

---

[1] The bibliography will be given with a succeeding portion of the present article. The references to it in the text are given in full face type which indicate the date of each article.

EXPLANATION OF PLATES I AND II.

REFERENCE LETTERS.

a anus.
ab abdomen.
af abdominal folds.
b blastoderm cells.
bl blastopore.
c cerebrum.
ch chorion.
d dorsal vessel.
do dorsal organ.
e ectoderm.
ec edge of carapax.
ey compound eye.
ga germinal area.
h hypoblast or entoderm.
ht heart.
i intestine.
l labrum.
m mesoderm.
mo mouth.
mp mandibular palp.
na neural rudiments.
oc median ocellus.
og optic ganglion.
ol optic lobes.
os ostium of heart.
p proctodeum.
pg pigment.
sg supraœsophageal ganglion.
t thorax.
ta thoracico-abdominal area.
te telson.
y yolk.

The Roman numerals refer to the serial number of the appendages.

Fig. 1. Section of the unsegmented egg of Crangon showing the nucleus and protoplasm in a central position.

Fig. 2. Section of an egg during the second segmentation, passing through one of the dividing cells in which two nuclei are already present.

Fig. 3. Surface view of a stained egg with about sixteen segmentation spheres.

Fig. 4. Section of the egg shown in fig. 3.

Fig. 5. Section of an early stage of the germinal area.

Fig. 6. Section showing the migration of nuclei to one pole (*ga*) of the egg.

Figs. 7 and 8. Surface views of the egg and region of the blastopore. Of these, fig. 8 is the earlier; it was inadvertently turned around, the anterior end being placed towards the bottom of the plate.

Fig. 9. Section through the blastopore, showing the origin of mesoderm and endoderm. The section is obliquely transverse.

Fig. 10. Embryo after the closure of the blastopore and the formation of the optic lobes. Stage *A*. This should be compared with fig. 1, pl. II, of my paper on the development of the compound eye in Whitman's Journal of Morphology, Vol. I.

Fig. 11. Stage *B*. Characterized by the development of the mouth (*m*), antennulæ (*I*) and the abdominal fold (*af*).

Figs. 12 and 13. Side and ventral views of stage *C* in which the antennæ. (*II*) are outlined.

Fig. 14. Ventral view of stage *D*. The mandibles (*III*) are outlined.

Figs. 15 and 16. Ventral and lateral views of stage *E*, characterized by the existence of seven pairs of appendages.

Figs. 17 and 18. Ventral and lateral views of stage *F*.

Fig. 19. "Dorsal organ" of stage C in transverse section.

Fig. 20. Stage *G*, removed from the chorion.

Fig. 21. Surface view of the heart of stage *G* showing the ostium of one side.

Fig. 22. Telson of stage *G*.

Fig. 23. Stage *H*; the embryo is nearly ready to hatch; the gills are budding from the bases of the sixth and seventh pairs of appendages, and nerve cells have made their appearance in the walls of the heart.

Fig. 24. Mandible of stage *H*.

Fig. 25. First maxilla of stage *H*.

Fig. 26. Second maxilla of stage *H*.

Fig. 27. Young shrimp after hatching, taken with a surface net.

BULLETIN

OF THE

ESSEX INSTITUTE.

VOL. 18. SALEM: OCT., NOV., DEC., 1886. NOS. 10–11–12.

CONVENTIONALISM

IN ANCIENT AMERICAN ART.

BY F. W. PUTNAM.

THE study of the ceramic art of ancient America is productive of much that is of importance in showing the connections between the various peoples who have inhabited the country in past times, their points of contact, and the routes of their migrations. It also enables us to trace the development of that innate principle of the human mind which among all nations finds its varied expression in ornament and art. There is now sufficient evidence to show that the artistic powers of man, like the languages, were developed in distinct centres, from primitive forms of expression which, necessarily, had principles in common. This will, probably, account for the close resemblances which occur in the early expressions of art in different and widely separated centres, and the resultant cosmopolitan forms of various objects. Thus it is that we find in the lower stratum of human development many cooking vessels, water jars, dishes and other utensils made of clay, that are of the same form and style of ornamentation; but after the particular form of vessel desired was attained, and the early methods of ornament by finger marks, indentures, scratches, cross-lines, and the imprint of cord or fabric, had been carried to their full extent, we can easily understand that something higher would follow. This advanced step is represented in various ways by different prehistoric peoples, but it is when this step is taken that the imprint is given to the art of each.

Among other ways, this higher expression seems to be shown in the realistic representation of inanimate and animate objects, often of a mythological or historical character. In course of time, as art attained increased power of expression, it progressed beyond mere realism and led to the representation of an object by certain conventional characters, without that close adherence to nature which was at first necessary to a clear understanding of the idea intended to be conveyed. Thus conventionalism began. Side by side with this conventional representation of objects are found realistic forms,— conservatism, which is such a strong characteristic of primitive peoples, leading to both methods of expression at the same time.

As already stated, it is during this stage of the art of a people that a special imprint is given, and the line of development which follows is so marked that the particular art of one centre of development can be traced as it spreads and infringes upon another. While a comparison of these various forms of art expression may not necessarily prove the routes which different peoples have travelled in their migrations, it does indicate their points of contact, and to this extent it is so important to a proper understanding of their history that it cannot be neglected.

In the course of my studies in this direction, I was led, some years since, to investigate these realistic and conventional forms and I have called attention to some of the interesting features noticed in the pottery from the stone-graves of the Cumberland valley in Tennessee and from the burial mounds of Missouri and Arkansas.[1]

As a knowledge of this conventionalism is important to our studies I have traced it in the art of those American peoples among whom it has had an existence, although, it is proper to add, it was not developed among them all. With the ancient Mexicans, for instance, their higher ceramic art was more symbolical than conventional, using this latter term with the meaning here given to it. The ancient Peruvians, too, west of the region influenced by the Aymaras, or their predecessors in the vicinity of Lake Titicaca, seem to have been lacking in these methods of conventional representation, and their highest art may be called realism, to which is often added the expression of an action. In the region of Lake Titicaca another type of art expression exists, and while our collection from this region is still meagre there is enough to show a remarkable resemblance to those early old-world forms which culminated in the classical type of the Mediterranean peoples.

In the conventionalism represented on the Cumberland valley pottery, the head of a mammal is one of the most instructive studies. There are, however, other forms less marked, which indicate a contact with the Missouri and Arkansas potters, in whose art the fish, the frog, the owl, the human form and the squash, are the most prominent objects conventionalized. In Nicaragua, the principal forms conventionalized are the animal heads on the feet of tri-

---

[1] Communications on this subject were made to the Boston Society of Natural History in 1879; to the American Association for the Advancement of Science in 1879; to the American Academy of Arts and Sciences in 1882; and in lectures at the Peabody Museum and in other places, since 1878, but the details have not been published. I have, however, long had series arranged in the Peabody Museum at Cambridge to show the several groups of conventionalized forms.

pods, the human face, and the face combined with the serpent, moulded on the burial jars, although other forms are treated in an interesting manner.

THE ANIMAL HEAD ON POTTERY FROM TENNESSEE.

An illustration of conventionalism, as seen in the pottery from the stone-graves of Tennessee, is shown in the figures on Plate I.

Figures 1 and 2 are of a vessel, rudely realistic, representing the head of an animal. As vessels in every way similar to this are found among the Missouri pottery, it is probable that this form had a single origin. The treatment here given to this animal head has resulted in an unsymmetrical vessel of rude form, not at all pleasing to the eye. An attempt to correct this lack of symmetry is shown in figure 4, in which the ears have been pushed back and the eyes forward, while to offset the nose and mouth on the front, a knob, which we may call a tail, has been placed opposite; but still we cannot say that the effect is pleasing, for here we observe the absence of the natural relation of parts without compensation in other ways.

In the next vessel, figure 3, we see a higher expression, and realism has slightly given way to the desire for symmetry. Here we see the effort to make a symmetrical vessel and also to add two handles, while at the same time the character of the animal head is retained. The nose, eyes and ears are represented, on each side of the vessel, in a row from handle to handle.

In figures 5 and 6, the nose and mouth form the central object on one-half of the vessel, with an eye on each side. On the opposite half, the tail and an ear on each side are the balancing features, and a handle is placed in the centre between the eye and ear on each side.

With this arrangement of the parts, conventionalism has full play, and in figures 7 and 8 are seen two vessels on which the nose, eye, ear and tail are rudely represented in the same positions as in the preceding. Several other vessels are of the same character, but slightly modified in the more or less realistic representation of the several parts, until, finally, the climax of conventionalism in this direction is reached in the vessel shown in figure 9, where the nose, tail, eyes and ears are represented by six round knobs of equal size, holding the positions assigned to the several features in the preceding figures.

In this last specimen realistic work has entirely given way to symmetry, and a common cooking pot has become chaste in style as the result of a development of artistic feeling.

All the examples to which I have referred are from the stone-graves in the burial places of a people who must have lived in towns near together in the Cumberland valley. Unfortunately, we cannot ascertain how long it took for this development, but that these burial places contain the dead of many generations there is no doubt.[2]

OTHER FORMS CONVENTIONALIZED.

In the case of the fish, particularly in the pottery from the St. Francis valley in Arkansas, the realistic forms are of the same character as the mammal's head in the preceding figures 1 and 2, from Tennessee, and the line of conventionalism is carried out on similar principles; that is, the

---

[2]It is important to state that the study of the art of this ancient people is based upon a collection derived from over six thousand of the singular stone-graves in the Cumberland valley, which were opened by myself or by assistants working under my direction. I was in particular aided by the faithful labors of the late Mr. Edwin Curtis, of Nashville, who for several years acted as my principal assistant in the Cumberland valley and in Arkansas. It is also important to state that in all these graves there was not a single object found indicating contact with Europeans.

vessel, first in the form of a fish, gradually loses its piscine shape, and either the dorsal and anal fins alone are left to serve as handles, or the head and tail are reduced to simple knobs for that purpose.

In the case of the frog, also largely used in Missouri and Arkansas art, the realistic representations are common, but in the process of conventionalism the legs of the frog become ridges on the sides of the vessel and serve as handles. It is an interesting fact that there are vessels from Nicaragua which have the same conventional ornaments on their sides ; but as I have not seen any intermediate forms between them and the realistic frog, which also occurs in Nicaraguan work, I cannot assert positively that this conventionalized form is here actually derived from the frog, although it seems probable.

In the bird, human and squash forms, particularly prominent in the jars from the Missouri burial mounds, the modifications are principally at the top of the vessel, and all three forms are conventionalized to a simple type, having the appearance of an intermediate form. From a casual examination of the series of Missouri pottery in the Museum, having these forms, it would be easy to conclude that the jars in the shape of women were a development from those of the squash form, were it not that the realistic work in every case preceded the conventional.

THE HUMAN FACE ON POTTERY FROM NICARAGUA.

The many ways of treating the human face as an ornament on ancient pottery from Nicaragua is an interesting study, and its combination with the serpent is a remarkable feature in this old art to which I shall refer on another occasion. For the present only one of the methods is considered, and this is selected on account of its close resemblance to the treatment of the animal head on the jars from Tennessee. In fact the underlying principle in both is the same.

Plate II contains figures of the human face as seen on seven small vessels from ancient burial places near together in Nicaragua.

In figure 1, we have a well carved human face. In this effort the potter evidently did his best to make a symmetrical head and the only lack is in the eyes, one of which is apparently represented as closed and the other half closed, or with the upper lid drawn down. The realism is further shown by the stud-like ornaments in the enlarged ear-lobes.

Figure 2 is still realistic in the portions represented, but the mouth is absent, and the nose and eyes are the prominent features, while the ears are rudely done.

In figure 3 the several features are distinctly presented and each one is characteristically represented.

In figure 4 the same method of showing the parts of the face is followed, but from the eyes extend lines representing the eyebrows. This is probably the beginning of the combination of the serpent with the face as shown in another series.

Figure 5 shows all the features, but each is reduced to its characteristic parts.

In figure 6 the eyes and ears are nearly the same as in the preceding, but the nose has become simply a round knob. The mouth has now disappeared in this series of conventionalized forms, and, finally, in figure 7, the nose, eyes and ears are all reduced to simple knobs formed of pinches of clay added to the surface of the jar, thus representing the several features of the face in the same manner as in the jar from Tennessee. Although the arrangement of the parts in the ultimate forms of the two groups is different, the realistic beginnings of the two series are similar, and the method of conventionalization is the same in principle.

THE FISH ON THE FEET OF TRIPODS FROM CHIRIQUI.

The recent acquisition by the Peabody Museum of a large collection of pottery from the ancient graves in Chiriqui, Panama, has drawn my attention again to the conventional representation of the fish upon the feet of the tripods, where the whole purpose to be served seems to be simply and purely ornamental. This is the more probable from the fact that other animals, and even the human form, are represented on other tripods from the same graves. I have selected the fish for illustration, as the series belonging to this group is larger and more perfect than the others.

In the two figures represented on Plate III, the shape of these tripods is shown. In one, the legs are plain, in the other, they are ornamented in such a manner as to give several of the special features of a fish. On each of the feet, in the latter, we see the projecting and wide mouth, the eyes, the pectoral fins, and a forked tail. The space where the dorsal fins naturally would be placed was cut away before the vessel was baked, and through this slit can be seen the movable ball of clay with which these hollow legs are generally provided.

In not a single instance is there an attempt to represent the anal fin, which would have its natural position on the opposite, or inner side of the foot of the vessel. Its absence can be taken as another evidence that this treatment is purely for ornament, and it probably owed its origin to the fact that the potter, realizing the adaptability of the fish to his purposes, gave way to his fancy and added to his art that of the sculptor.

On Plates IV-VII, are shown this series of feet from tripods, illustrating the different ways in which this primitive conception became conventionalized by the prehistoric people of Chiriqui, who carved in stone as well as in clay, and who were also remarkable for their work in copper and gold, in which materials their realistic and conventional art followed a course similar to that shown in their pottery.

Plate IV. Figure 1 is a plain foot of a tripod and shows the adaptability of this form to the essential external characters of a fish.

Figure 2 is a rudely realistic representation of a fish, with mouth, eyes, two dorsal fins, and the pectoral and ventral fins on the sides. All are in approximately natural positions, while the caudal fin is represented as an horizontal instead of a vertical termination of the body. The manner in which the several features are here shown must be kept in mind as we follow out the series, particularly the central indentures in the small oval pieces of clay representing the eyes, and the incised lines running from the body on the bits of clay which indicate the dorsal and paired fins, although these details are sometimes omitted.

In figure 3 the ventral fins are not represented, while the pectoral, dorsal, and caudal fins are shown nearly as in figure 2, except that the pectorals are placed close to the mouth. In the raised bands representing the upper jaw, the outline of the mouth is retained as in figure 2; but here artistic license comes into play, and the lower jaw is brought up to a level with the upper, and as the whole space allowed for representing the head is thus disposed of, the eyes are placed forward of the mouth, at a point where this foot joins the body of the vessel.

The Chevron Ornament. Plate V. Figures 1, 2 and 3, are from one tripod, and this is the only instance in the series where the three feet of a vessel are not essentially the same, and even here there is a general similarity though the details vary. It will be noticed that in all three, the caudal fin is represented in its natural, or vertical position, the rays being indicated by the notches cut across the edge of the compressed terminal portion of the foot which is turned forward.

In figure 1 the head of the fish is triangular, and terminates in a truncated nose, on each side of which is the mouth, shown by incised lines. The eyes are two small round bits of clay without the usual line cut across them. Just back of these is the dorsal fin, and on each side of the long central opening of the foot are the pectoral fins, below which the artist has cut two rows of chevron-like lines, which, possibly, may have been suggested by bands of color upon the sides of many tropical fishes.

In figure 2 there is a slight change from figure 1 in the shape of the head, but the eyes and dorsal fin are in nearly the same relative positions, although varying in their details. The pectoral fins are absent, but the ventrals are represented although not directly opposite each other, and the bands of chevron-like lines are placed between these fins and the eyes.

In figure 3 there is a marked difference in the manner of representing the mouth. Curved lines are cut in a broad band of clay. Back of these is an enlarged dorsal, on each side of which are the pectoral fins, the eyes being omitted. Below, the ventral fins are introduced, and between them and the pectoral fins are the chevron bands nearly the same as in figure 2.

The foot from another tripod, given as figure 4, exhibits a result of this chevron ornament. In this all parts of the fish are omitted except the pectoral and ventral fins which are placed on each side of the long opening in the foot, and the dorsal fin which is placed over it. Pendent from the knob representing the dorsal fin are the two chevron bands. In this conventionalized form a simplicity in ornament has been reached which is far more pleasing to the eye than are the crude and crowded expressions in the preceding figures.

As the two tripods with this chevron ornament are from graves near together, they may represent the successive efforts of the potter struggling to give expression to artistic feelings.

The Pectoral and Ventral Fins. Plate V. Figure 5 is another instance where an addition has been made to the characters of the fish. In this case the head is expressed by the nose and eyes which are carved in relief upon a triangular piece of clay added to the upper part of the foot. On each side of this piece of clay are the pectoral fins, while the ventral fins are united by a band of clay crossing the opening in the foot. On this band are several slight v-shaped indentures. As in the last figure and in the following, there is no attempt to represent the caudal fin.

A resultant form from the last is shown in figure 6. In this the general curved outline of the head, or mouth, of the fish is retained as the upper border of the foot, while the pectoral and ventral fins are expressed by rather large pieces of clay with deep notches.

Two more lines are to be traced in this conventionalism of the fish. In one the mouth is the essential feature and in the other the dorsal fin. They both start from a realistic form like fig. 2, Pl. IV, but they soon diverge and the results are decidedly different.

The Mouth. Plate VI. In figure 1, as will be seen, the mouth, with its pointed jaws, is the essential feature. The pectoral fins are at the angles of the mouth. The eyes are in their normal position. The dorsal and ventral fins are absent. The caudal is represented as in fig. 2, Pl. IV.

In figure 2 the pointed nose and mouth are prominent features. The pectoral and caudal fins are not striated. The eyes are similar to those in figure 1.

In figure 3 the deep lines cut in the bands of clay forming the jaws, and others between them representing the teeth, are evidence that the thoughts of the artist were concentrated upon representing the mouth of a fish. The pointed nose in the previous figure here gives way to the forced expression of a mouth, and is placed on the under jaw, with a license similar to that used in representing the eyes in fig. 3, Pl. IV. The pectoral fins are in the same position as in the two preceding figures, while the ventral fins are copied from the realistic form. The caudal fin has entirely given way to a rounded knob.

In figure 4 there is a raised pointed portion over the opening in the foot. On this part a deep line is cut corresponding to the line which gives emphasis to the jaw in the preceding figure. The striated patch of clay on each side below the angle of the mouth represents the pectoral fins. All other parts of the fish are wanting.

In figure 5 the pointed jaw alone is preserved in the mass of clay placed above the opening in the foot; and, finally, in figure 6, the climax in this line of conventionalism is reached by cutting two sets of oblique lines on the surface of the foot itself.

The Dorsal Fin. Plate VII. In the final series, the prominence which the dorsal fin is to have is exemplified by figure 1. In this, the mouth, eyes and pectoral fins

PLATE I.

Fig. 1.

Fig. 2.

Fig. 5.

Fig. 7.

Fig. 9.

Fig. 3.

Fig. 4.

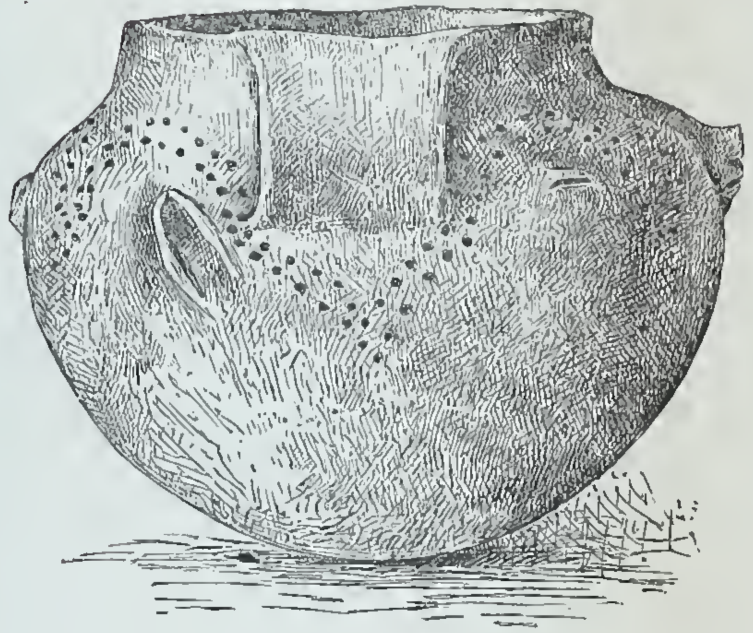


Fig. 6.

Fig. 8.

THE ANIMAL HEAD ON ANCIENT POTTERY FROM STONE-GRAVES IN TENNESSEE.

PLATE II.

Fig. 1.

Fig. 2.

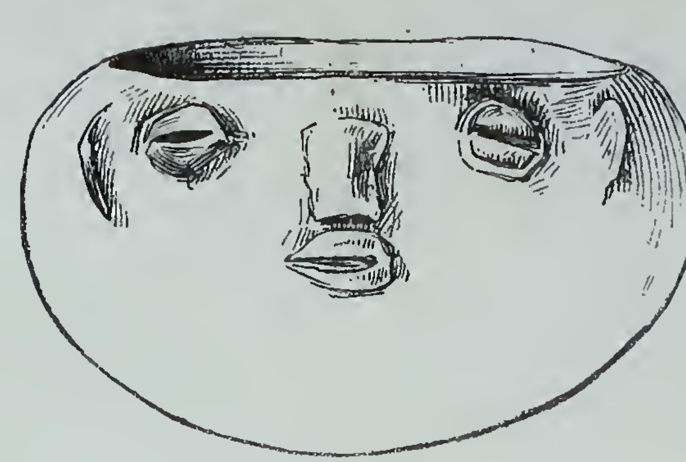


Fig. 3.

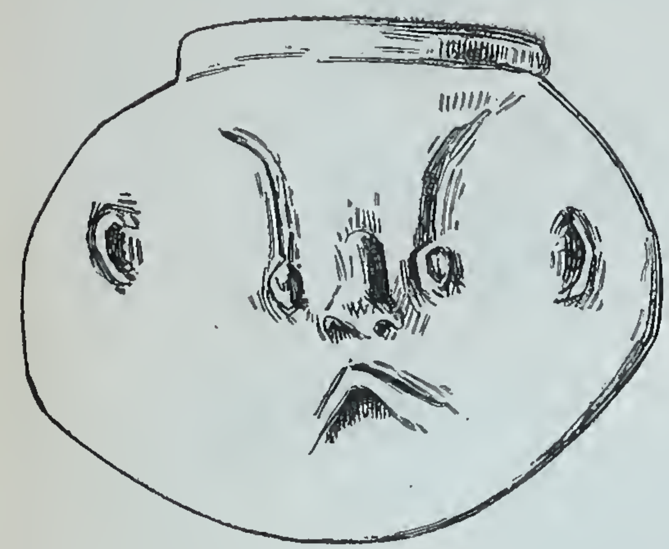


Fig. 4.

Fig. 5.

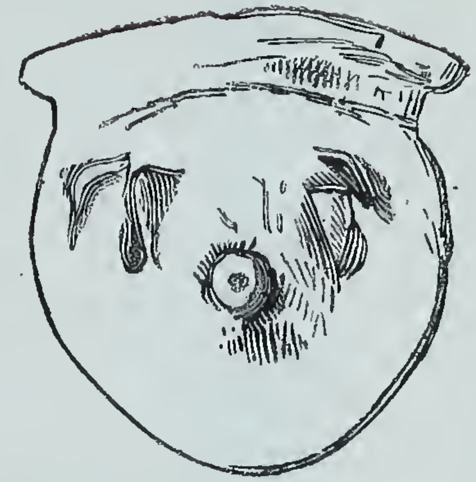
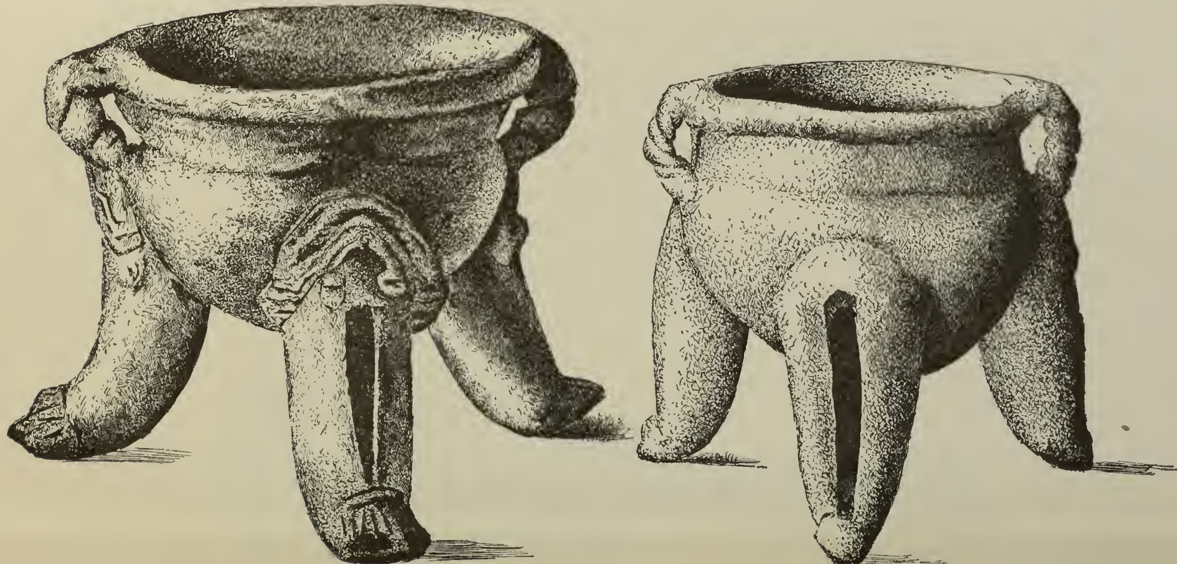


Fig. 6.

Fig. 7.

THE HUMAN FACE ON POTTERY FROM NICARAGUA.

PLATE III.



TRIPODS FROM CHIRIQUI.

PLATE IV.

Fig. 1.

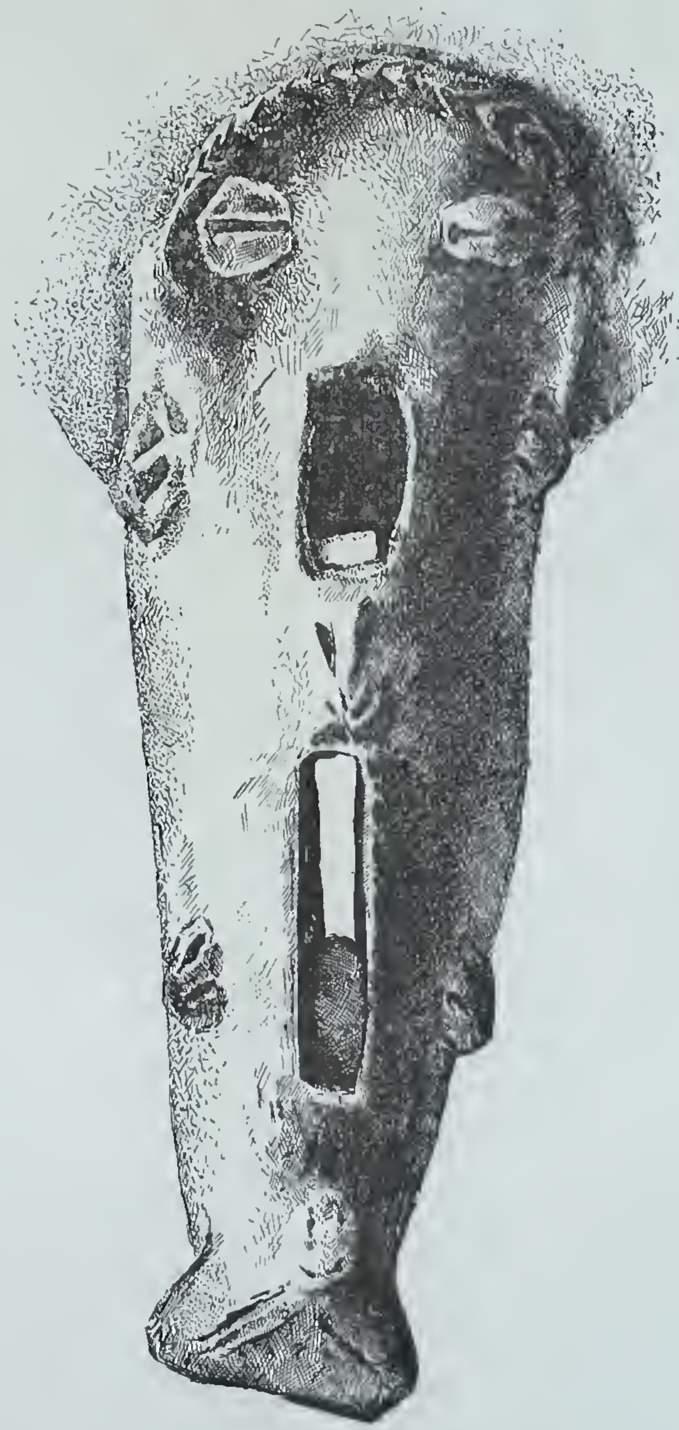


Fig. 2.

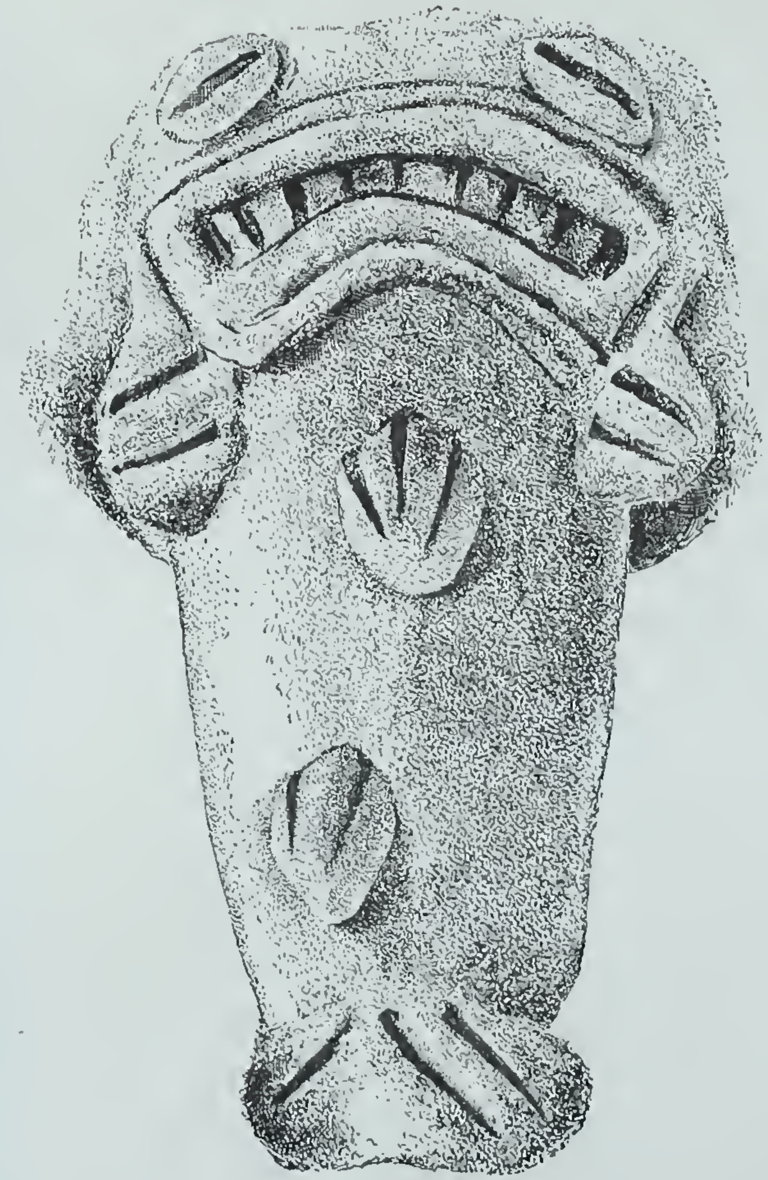


Fig. 3.

THE FISH ON THE FEET OF TRIPODS FROM CHIRIQUI.

PLATE V.

Fig. 1.

Fig. 2.

Fig. 3.

Fig 4.

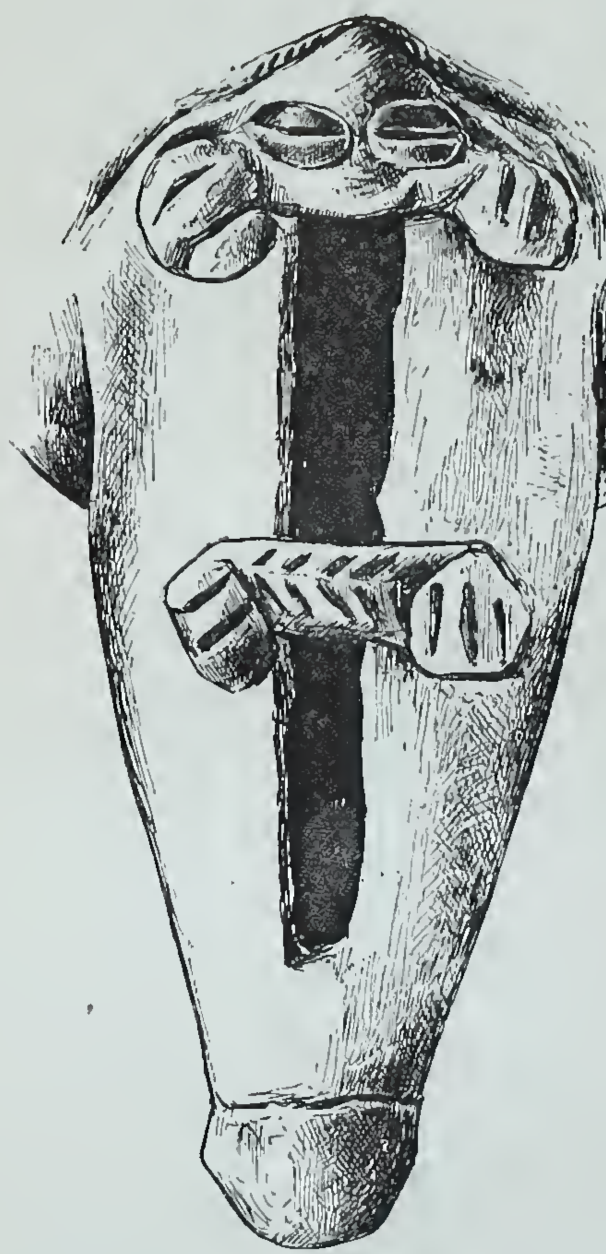


Fig. 5.

Fig. 6.

—Figs. 1-4. The Chevron Ornament.—

—Figs. 5-6. The Pectoral and Ventral Fins.—

THE FISH ON THE FEET OF TRIPODS FROM CHIRIQUI.

PLATE VI.

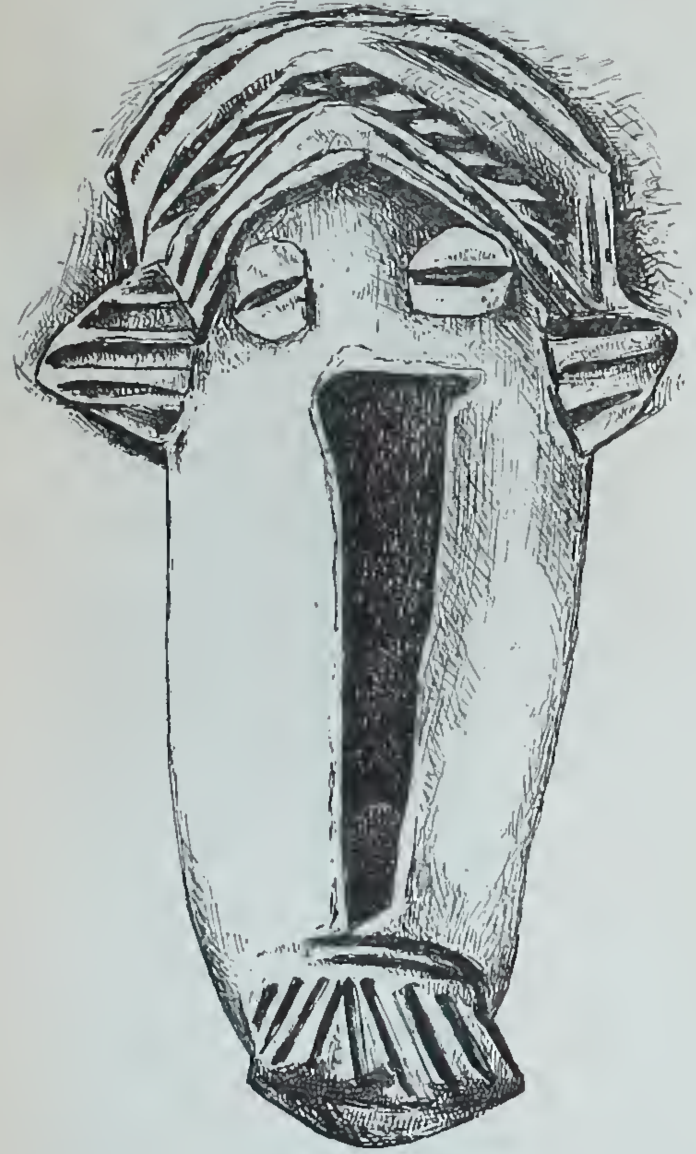


FIG. 1.

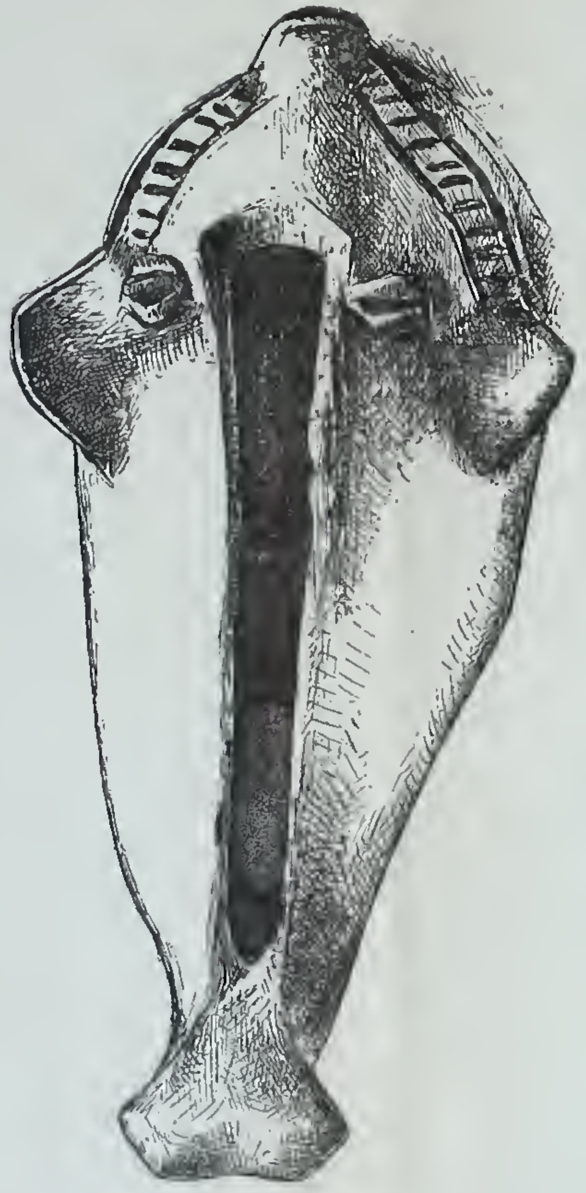


FIG. 2.

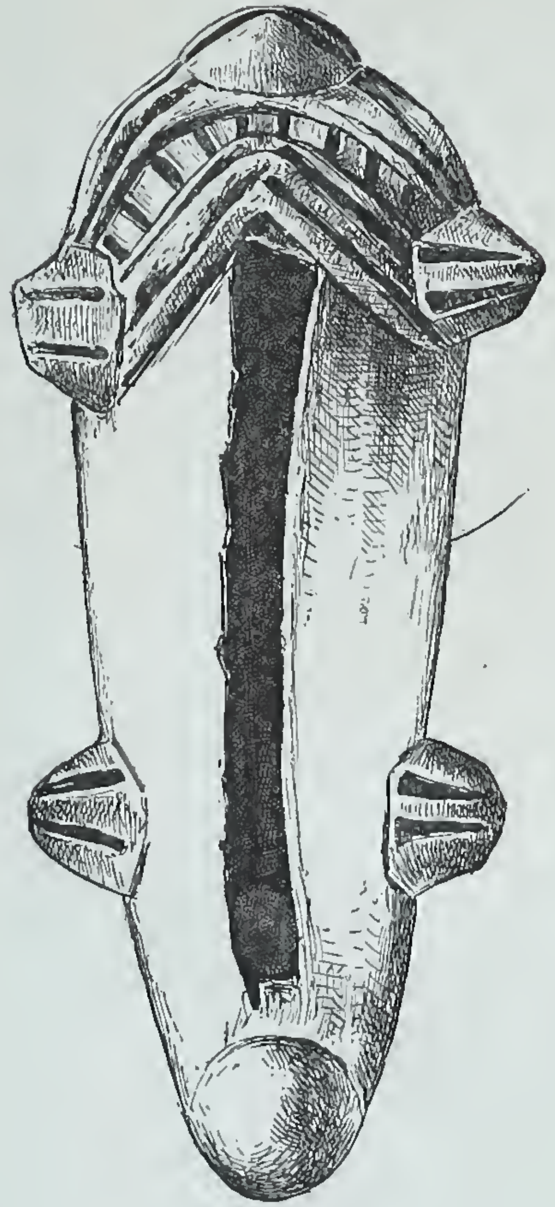


FIG. 3.

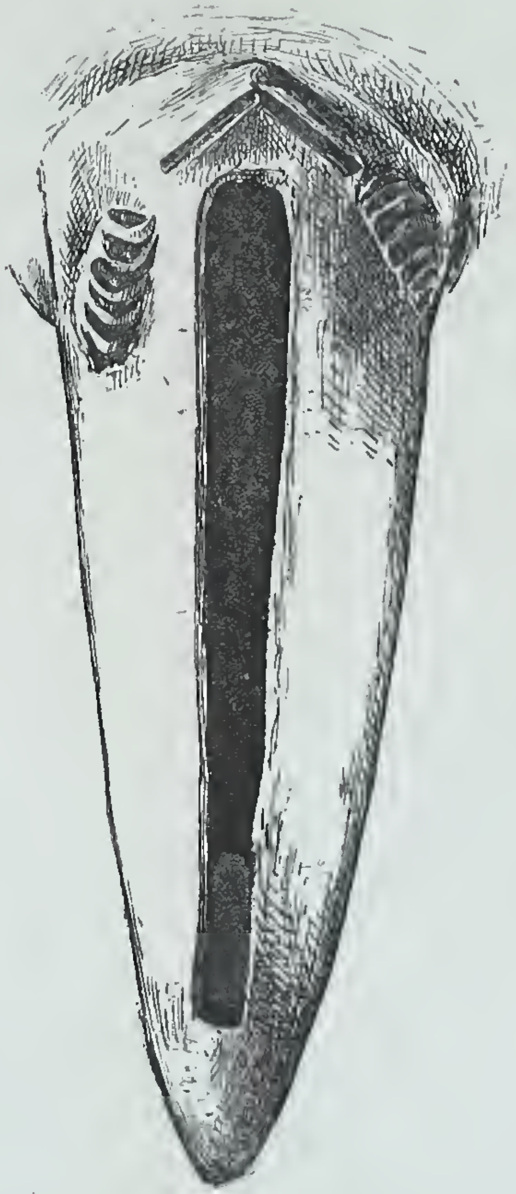


FIG. 4.

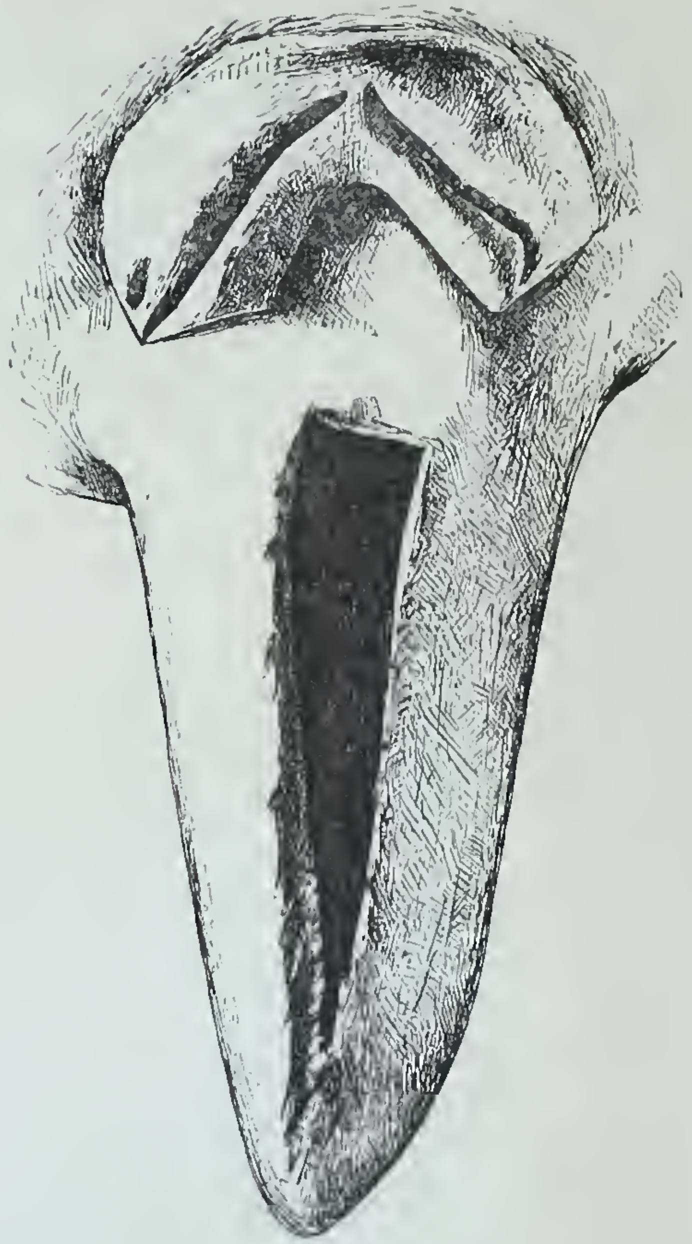


FIG. 5.


FIG. 6.

THE FISH ON THE FEET OF TRIPODS FROM CHIRIQUI.

—The Mouth.—

PLATE VII.

Fig. 1.

Fig. 2.

Fig. 3.

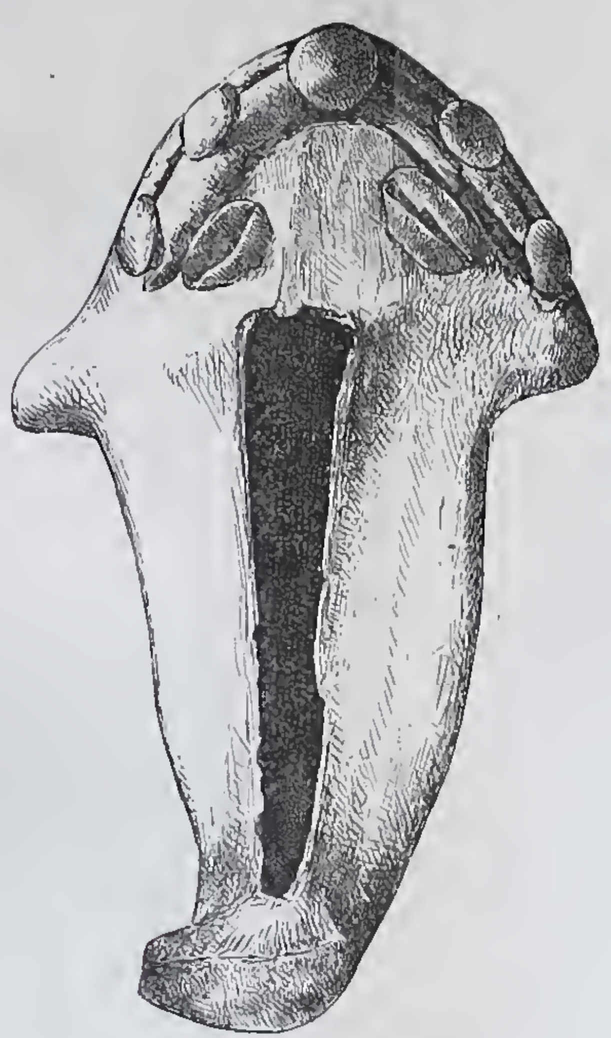


Fig. 4.

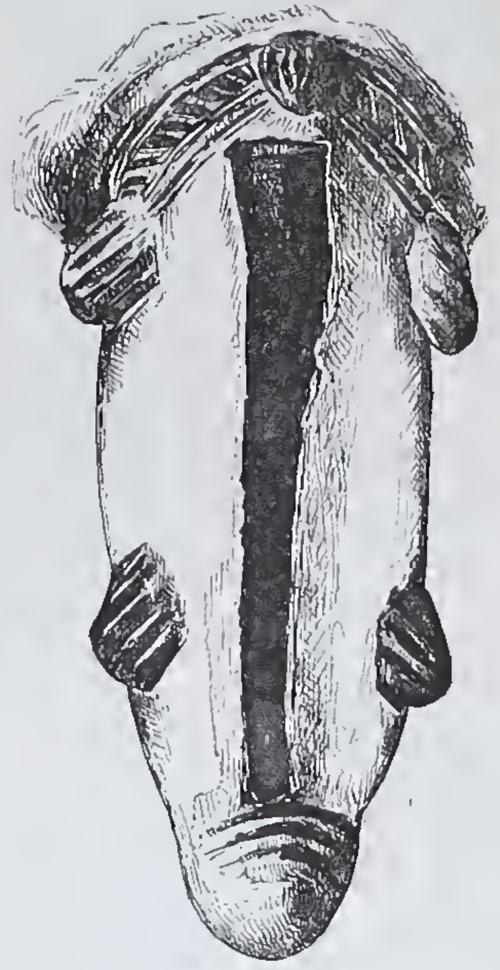


Fig. 5.

Fig. 6.

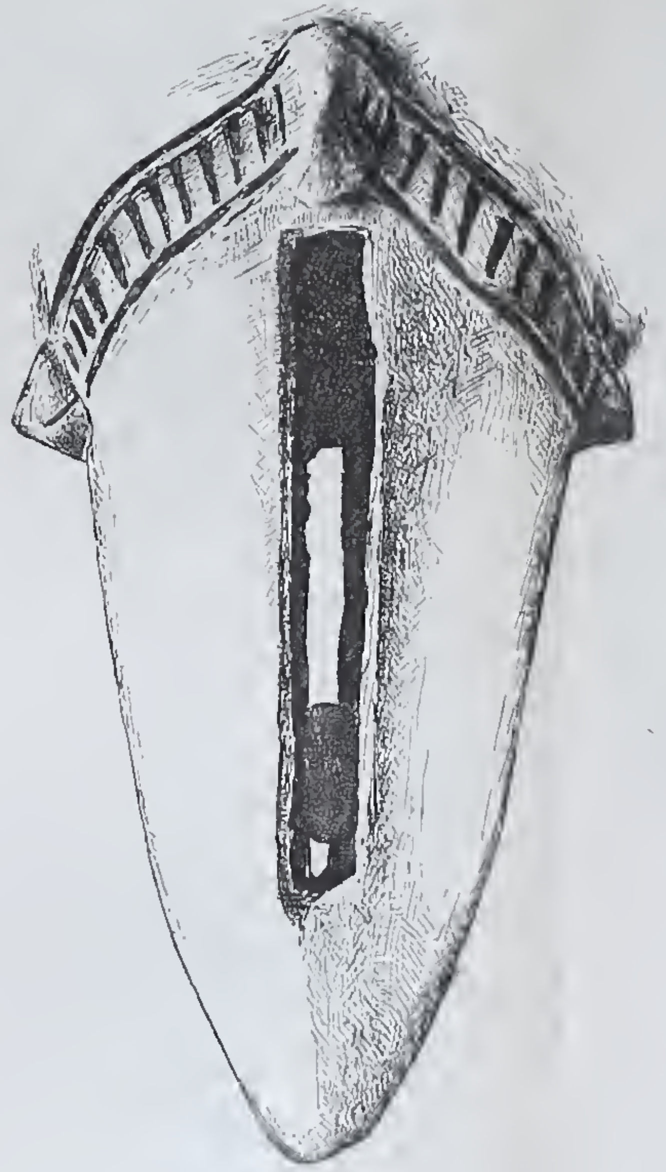


Fig. 7.

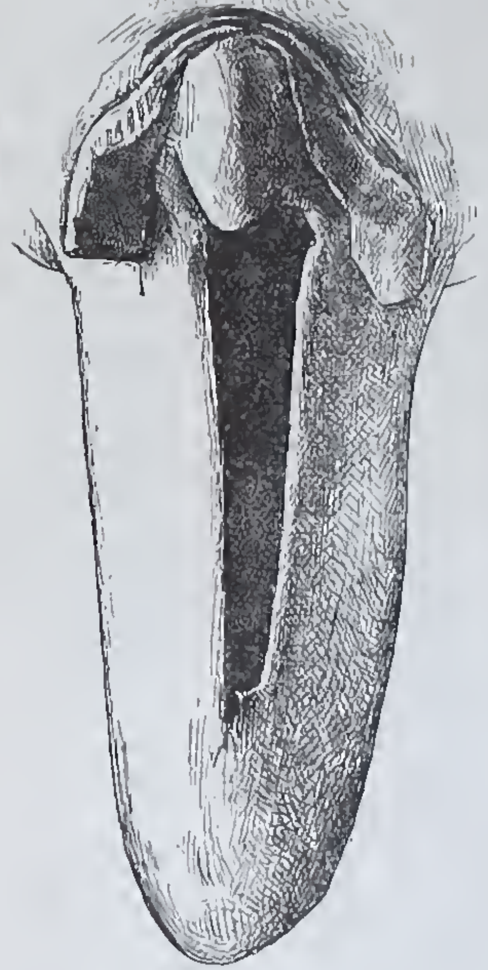


Fig. 8.

Fig. 9.

THE FISH ON THE FEET OF TRIPODS FROM CHIRIQUI.

—The Dorsal Fin.—

are all prominent, realistic features, and the dorsal fin is conspicuous by its size and position forward of the eyes.

In figures 2 and 3, the several parts of the head, while rudely done, are expressive, and the dorsal fin placed between the eyes in both is a prominent feature. In figure 3, the teeth are represented by bands passing from jaw to jaw.

In figure 4 these bands become small rounded masses, while a larger one in the centre represents the dorsal fin, as it holds the same position as a striated knob in the following figure.

In figure 5 the mouth and teeth are represented by cut lines, and the ventral, as well as the pectoral fins, are shown somewhat as in fig. 3 of the preceding plate.

In figure 6 the pectoral fins are more closely united to the mouth than in the last, and the dorsal fin is a small striated cone in the centre of the raised lines forming the mouth.

The next step is shown in figure 7, where the pectoral and dorsal fins are represented by three small cones, between which are incised lines for the mouth and teeth.

In figure 8 a deep notch is cut on the upper part of the foot, defining the mouth of the fish under the raised knob representing the dorsal fin, on each side of which are two slight knobs for pectoral fins.

In figure 9 all the parts have been eliminated except the dorsal fin, or the round striated knob above the opening in the foot. On one of the feet of the same tripod the incised lines on the knob are omitted, and in this we find the conventionalized fish reduced to its simplest form,—which may be represented by my period.

A FEW ADDITIONAL NOTES CONCERNING INDIAN GAMES.

BY ANDREW McFARLAND DAVIS.

In the seventeenth volume of the Bulletin of the Essex Institute, beginning page 89, I furnished a communication concerning the character and distribution of the games indulged in by the Indians of North America during historic times. In that communication I cited authorities which covered, in geographical extent, the entire territory of the United States. These citations were, however, fuller and more exhaustive in some localities than in others. It will increase the bibliographical value of the research if I add to what has already been published a few references which cover the ground more completely. It will be observed that some of these contain new facts, but even where this is not the case, the citations will not be without value. In presenting these references, I shall follow the same general classification of games as before.

LACROSSE.

My former paper was separately printed and a few copies were distributed among persons who were presumed to be interested in the subject. Mr. F. P. Deering, of San Francisco, in his acknowledgment of the receipt of a copy which I sent him, communicated the following interesting information :—

"I have delayed acknowledging your kindness in sending a copy [of Indian Games] to me, to get some facts about the Oregon game of Koho played by the Indians of that section. Mr. Simpson, a friend of mine,—a lawyer here,—passed much of his youth on an Indian reservation in Oregon, of which his father was the head. He tells me that the favorite game with the various tribes stationed there, was one which was played sometimes by members of the same tribe, and at others by different tribes, and called as if spelled k-o-h-o. A wooden ball whittled out of the knot of some tree, maple I think, was placed in the ground midway between the goals which were usually three-quarters of a mile apart. A hole about as large as a man's hat was dug in the earth and lightly filled with dust and leaves. In this the ball was placed. The chiefs, each with one koho stick, about as long as a walking-cane, widened to two or three inches perhaps, at the end, and bent upward, stood on either side of the hole; and, at a given signal, struggled to get possession of the ball with their sticks. The men on either side were at liberty to take what stations they pleased anywhere in the field. The goals were not like those in lacrosse, but were arbitrary lines, the length of the whole end of the field, and across one of these lines the ball had to be driven. The game, as it was described to me, was extremely rough; tripping, pushing and catching men by the legs with the koho stick being permitted. Striking one another with the stick was even resorted to, although the last was supposed to be forbidden. The players were often severely hurt, but my informant knew of no case where any one was killed, or where bones were broken. He tells me of different instances where the heat of the game led to fights among individual players and says that on one occasion when the game was between different tribes, and the losing party began to attack the winners with their kohoes,[1] the spectators, sympathizing with the winners, fired rifles at the losers.

Gambling was one of the features of the contest, just as with the games you describe, and the participants and lookers-on often wagered every stitch of clothing they had on. So far as costume for the game is concerned, I could not learn that any special preparation was made."

In the description of lacrosse as played on the Pacific coast, which was quoted in the former article, the bat was described as "constructed of a long, slender stick, bent double and bound together, leaving a circular hoop at the extremity, across which is woven a coarse meshwork of strings." In the game of koho, it will be noticed that this form of bat is changed, and the consequent modifications of the game, from inability to strike sharply with the cross, do not appear. We have a game which closely approximates lacrosse as described in early times in the east. The koho stick resembles the "curved wooden head" of which Morgan gives an account, but which, so far as my observations go, is mentioned by no other writer. The method of opening the game seems to be

---

[1] The mention of this word in the English plural naturally brings to mind the fact that the town of Cohoes in New York bears an Indian name, apparently pronounced like the name given the bats in the Oregon game. Morgan, in his "League of the Iroquois," p. 474, gives the Mohawk name for Cohoes as Ga-ha-oose, and defines its meaning to be "shipwrecked canoe." In "A General History of Connecticut," etc., by a gentleman of the province, London, 1781, reprinted with supplement, New Haven, 1829, the author (said to be Rev. Samuel Peters) says, p. 110, "In the Connecticut river there are three great bendings, called Cohosses, about 100 miles asunder." This is evidently the same word applied through its descriptive force, to places dangerous for navigation on each of the rivers. A coincidence of the use of the same word in dialects used by tribes so widely separated as those living in the valleys of the Mohawk and Connecticut, and those living in the valley of the Columbia, is not impossible but is not probable.

In a dictionary of the Niskwalli, by George Gibbs, Contributions to North American Ethnology, Vol. I, p. 292, "ka-hōs, ka-ho-sin, a club," is given. Dr. Trumbull, whom I consulted, called my attention to the word "ko-ko, to knock," given in Gibbs' dictionary of Chinook Jargon. See Dr. Shea's Library of American Linguistics, No. XII.

entirely original. It had this advantage over the ordinary plan of starting through the agency of an umpire or some disinterested party, that no favors could be shown. By means of this description—if doubts existed before—we are enabled to identify, beyond cavil, the game of lacrosse as one of the amusements indulged in by our Pacific coast Indians.

William Strachey[2] contributes an interesting account of games in Virginia in the beginning of the seventeenth century. He refers to ball playing as follows: "A kynd of exercise they have amongst them much like that which boyes call bandy[3] in English, and maye be an auncient game, as it seemeth in Virgill; for when Æneas came into Italy at his marriage with Lavinia, King Latinus' daughter, yt is said that the Troyans taught the Latins scipping and frisking at the ball."

The comparison, by Strachey, of the ball game played by the Virginian Indians to bandy, favors the inference that the game was rather hockey than lacrosse. Capt. James Smith describes such a game among the Wyandots. "They commonly struck the ball with a crooked stick," is his language.[4] It is nevertheless quite probable that Strachey's ball game was lacrosse. Our previous examination of French authors has shown that they almost invariably compare lacrosse with tennis. If the game which Strachey saw was lacrosse, his comparison to bandy

---

[2] The First Booke of the Historie of Travaile into Virginia Britannia, etc., by William Strachey. Edited by R. H. Major, London, for the Hakluyt Society, 1849, p. 77.

[3] Bandy ball is described by Strutt. In the Chatto & Windus Edition, London, 1876, this description appears, p. 170. Accompanying it is an illustration representing "*Bandy-Ball, XIV Century*." In the scene portrayed by the artist, two players are seen with hockey sticks in their hands. One is about to strike the ball which lies upon the ground at his feet.

[4] An Account of the Remarkable Occurrences in the Life and Travels of Col. James Smith, during his Captivity with the Indians in the years 1755-1759. Cincinnati, 1870, p. 77.

would have been much more justifiable than the comparison to tennis by the French writers.

Ball play seems to be associated with the legends of the Indians. Elias Johnson,[5] himself an Indian, tells about a tradition of a little old man who frequently presented himself among the ball players. His presence in no way affected the game, but he was afflicted with innumerable ailings and to a kindly woman who received him in her hut, he successively disclosed the treatment which would cure each of his complaints, until he reached consumption, which he pronounced incurable. Whether the use of the game by the medicine men, as a cure-all, is based on the tradition, or the tradition on the use, does not appear, but the connection is evident.

In 1768, J. Long[6] arrived at Montreal. He spent many years among the Indians of Canada and the northwest. Part of the time he was engaged in mercantile pursuits, and during a portion of the Revolutionary War he coöperated with the Indians engaged on the English side. He describes lacrosse. It is not clear among what tribes he means that he saw the game played, but I infer that it was among the Chippewas. The ball was of stuffed deer-skin. The rackets were about two feet long and were laced at the end. The ball was to be struck "into a goal, at the distance of about four hundred yards, at the extremity of which are placed two high poles, about the width of a wicket from each other; the victory consists in driving the ball between the poles." He also records the good humor which prevailed during the games, even in case of serious hurt.

---

[5] Legends, Traditions and Laws of the Iroquois, etc., by Elias Johnson, a native Tuscarora chief. Lockport, 1881, p. 58.

[6] Voyages and Travels of an Indian Interpreter, etc., by J. Long. London, 1791.

Although Long mentions but one goal, it is evidentth a he is describing the ordinary game. His account covers merely the action of one side and omits all mention of opposition, except that the play of the parties was said to be to intercept each other. Apparently both sides were intent upon driving the ball into the same goal; but the confusion of the account is removed if we interpret it as an attempt to describe the game as ordinarily played, making allowances for the inexact way in which a man whose life has been mainly spent in the woods, would naturally express himself when committing his thoughts to paper.[7]

PLATTER OR DICE.

The quaint descriptions of dice, foot-ball, etc., quoted from the pages of Ogilby,[8] in the former article were taken by the compiler from Wood's "New England's Prospect."[9] Governor Hutchinson[10] availed himself of the same work in describing games among the Massachusetts Indians. Roger Williams in his "Key into the Language, etc.,"[11] furnishes another account of these games, somewhat similar in its curious style of language and containing an interest-

---

[7] Major Z. M. Pike in "An Account of Expedition to the Sources of the Mississippi," Philadelphia, 1810, describes a game of cross between the Sioux, and the Puants and Reynards, Vol. I, p. 100.

[8] America, being an Accurate Description of the New World, etc. Collected and translated by John Ogilby, London, 1670.

[9] William Wood's New England's Prospect. London, 1634. Reprinted by the Prince Society, Boston, 1865. See p. 96.

[10] The History of the Colony of Massachusetts Bay, etc., by Mr. Hutchinson, Lieutenant-Governor, etc. The Second Edition, London, 1765, p. 470.

[11] A Key into the Language of America, etc., together with brief Observations of the Customes, Manners, etc., by Roger Williams of Providence in New England. London, 1643. Reprinted in the collections of the Massachusetts Historical Society for the year 1794. Vol. III, p. 234. In this reprint the Key is somewhat abridged. Reprinted in full in the Collections of the Rhode Island Historical Society, Vol. I, Providence, 1827. Reprinted also in full by the Narragansett Club, in Vol. I of their publications, Providence, 1866. This edition was published under the supervision of Dr. J. Hammond Trumbull, who carefully eliminated the errors of the other reprints and added greatly to the value of the work by copious annotat ions.

ing description of the assembling of the Indians in their play houses. He divides the games into two sorts, private and public. "Their publique games," he says, "are solemnized with the meeting of hundreds, sometimes thousands, and consist of many varieties, none of which I durst ever be present at that I might not countenance and partake of their folly after I once saw the evill of them." Under the name, "Puttuckquapuonck, a playing arbour," he describes their play house as follows: "This Arbour or Play house is made of long poles set in the earth, four square, sixteen or twentie feet high, on which they hang great store of their stringed money, have great stakings, towne against towne, and two chosen out of the rest by course to play the Game at this kind of Dice, in the midst of all their abettors, with great shouting and solemnity." "This kind of dice," he had already described as "plumb-stones painted, which they cast in a tray with a mighty noise and sweating."

In a note to the edition of the "Key" published by the Narragansett Club, Dr. Trumbull, the editor, says: "The Abnakis (Râle, s. v. *Jouer*) played this game with eight such dice or counters. When the black and white turned up 4 and 4, or 5 and 3, the player made no count; for 6 and 2, he counted four, for 7 and 1, ten, and when all eight were of one color, twenty."

Major Stephen H. Long translates the Omaha word for dice, as Dorsey does "Plum-shooting," and adds that the game was played with sticks as counters.[11a]

Long,[12] the Indian interpreter, describes a form of dice, under the name *Athtergain*, which was played with black

---

[11a] Account of an Expedition from Pittsburgh to the Rocky Mountains, etc. Vol. I, p. 215. For this reference and for other suggestions, I am indebted to the kindness of Mr. Lucien Carr, Assistant Curator Peabody Museum. The paper of Dorsey is referred to in Note 65, former paper.

[12] Voyages and Travels of an Indian Interpreter, etc. London, 1791, p. 52.

and white beans, one of which had small spots and was called the king. The beans, he says, "are put into a shallow, wooden bowl, and shaken alternately by each party, who sit on the ground opposite to one another; whoever is dexterous enough to make the spotted bean jump out of the bowl, receives of the adverse party as many beans as there are spots. The beans do not count for any thing."

J. G. Kohl[13] describes a form of platter or dice, which he encountered in his travels about Lake Superior, in which figures resembling chess-men were used. These were carved neatly out of bone, wood or plum-stones, and represented different objects, such as a fish, a hand, a door, a man, a canoe, a half-moon, etc. The figured pieces could stand upright. Associated with them were the ordinary plum-stones, plain one side and red the other. The figures and plum-stones were placed in a bowl which was then twirled, the bowl itself having first been placed in a hole in the ground prepared for the purpose. The position of the figures and the sides exposed by the dice after the twirl determined the count.

Among the Sioux the game of dice was made use of to effect a distribution of the property of deceased Indians. Some person was selected to represent the ghost, and the games were conducted in the lodge of the deceased. The stakes apparently were only put up by the ghost. The players participated in the game with the ghost, one at a time. If they won, they took their winnings. If they lost, they went away. This curious custom is fully described in a paper on the Mortuary Customs of the North American Indians by H. C. Yarrow.[14] The author treats of games as "an adjunct part of funeral rites, which con-

---

[13] Kitchi-Gami, Wanderings Round Lake Superior, by J. G. Kohl. London, 1860, p. 82.

[14] First Annual Report of the Bureau of Ethnology, Smithsonian, 1881, p. 195.

sist in gambling for the possession of the property of the defunct." This paper is illustrated with a picture of the game of plum-stones. Illustrations, showing the marks on the plum-stones and the winning throws, are also given.

STRAW OR INDIAN CARDS.

The first game described by Roger Williams in his Chapter on Gaming[15] is "A Game like unto the English Cards, yet, instead of Cards, they play with strong Rushes." In his vocabulary he gives "Akésuog: they are at cards, or telling of Rushes; Pissinnéganash: their playing Rushes; Ntakèsemin: I am a telling, or counting; for their play is a kind of Arithmatick." Dr. Trumbull calls attention in a note, in his edition, to the fact that Rasle gives as a meaning for the word which in his vocabulary corresponds to Pissinnéganash, "*les pailles avec quoi on joue.*"

Strachey[16] found this game among the Indians in Virginia. He describes it as follows: "Dice play, or cardes, or lotts, they know not, how be it they use a game upon rushes much like primero,[17] wherein they card and discard and lay a stake or two, and so win and loose. They will play at this for their bowes and arrowes, their copper beads, hatchets, and their leather coats."

Robert Beverley,[18] a native of Virginia, published anonymously, in 1705, a History of Virginia, which was trans-

---

[15] Chapter XXVIII, of the Key to the Language of America.

[16] Strachey's Book of Travaile, p. 65.

[17] *Primero* is described in Strutt, p. 433, as "among the most ancient games of cards known to have been played in England." It is useless to attempt to derive any information as to the game "upon russhes" from Strutt's rules for *Primero.* The "card and discard" upon which Strachey perhaps predicated the similarity of the games, evidently referred to the system of counting followed in the game of "straws," in which the players told off the straws in bundles of ten.

[18] The edition which I have consulted was a French translation: Histoire de la Virginie, etc., par D. S. Natif et Habitant du Pays. Traduit de l'Anglois et enrichie de figures. Amsterdam, 1712. See p. 302.

lated into French and afterwards published at Amsterdam and at Orleans. He says the natives engaged in "certain violent plays, which they enjoy much and in which they run and leap upon each other."

"There is one in particular, which pleases them much, and in which they take handfuls of sticks, or pieces of stiff straw, which they count as quickly as the eye can move, with marvellous dexterity." Beverley seems to have comprehended the fact that the separation of the straws into piles was connected with the process of counting, but he has not ventured to describe the details of the game.[19]

It is easy to recognize in these various descriptions, the game which the French writers invariably call "*Pailles*", and it is curious to note that the features of the game which evidently made the most vivid impression upon these authors were described in substantially the same language by other writers, in separate localities and at different periods of time. We have a new authority for the statement that the game is a "kind of Arithmatick", a fresh comparison with cards,[20] and additional testimony to the marvellous rapidity with which the players counted.

CHUNKEE OR HOOP AND POLE.

Laudonnière,[21] describes a curious alley near an Indian village which was found by a French expedition, in the middle of the sixteenth century. He says: "There is at the coming forth of the village a great alley about three

---

[19]I am indebted to Dr. Trumbull for information that a MS. Illinois Dictionary (probably compiled by Gravier, about 1700) gives many of the terms used in the games of straws and dice.

In his edition of Roger Williams' Key he has pointed out that the literal meaning of the Massachusetts and Narragansett word "akésuog" for playing "at cards or telling of rushes" is "they are counting."

[20]In the Illustrated Catalogue of the Smithsonian Collection from the Pueblos, No. 69, 340, is given to—— "Wooden cards for betting game."

[21]Hakluyt's Collection of Early Voyages, Vol. III, p. 415.

or four hundred paces long, which is covered on both sides with great trees." Is it not probable that this refers to a plot of ground prepared for the game of chunkee? In the previous paper I have quoted a number of descriptions of chunkee grounds which resemble this. In these descriptions the grounds were spoken of as, "a fine level square;" "a square piece ground well cleaned and fine sand is strewed over it;" "an alley of about two hundred feet in length," etc. No chunkee ground is described as being four hundred paces in length, but distances are not, as a rule, accurately stated by early writers. It seems to me probable therefore that Laudonnière's "great alley" was the village chunkee ground.

Major Stephen H. Long[22] describes dice, and hoop and stick among the Omahas, in the account which he published of his expedition to the Rocky Mountains. He says hoop and pole was played among the Pawnees on a smooth beaten path. The pole had a crook at the end and the aim of the player was to slide the pole after the hoop so that when it fell the hoop should be caught by the hook.

Major Pike,[23] in 1810, published an account of his expedition to New Mexico and of his exploration of the sources of the Mississippi. He mentions two forms of hoop and pole among the Pawnees which differ from any that have been described. In the first a small leather ring was held by thongs within a larger circle, the outer being four feet in diameter. The attempt was made to check the hoop while it was in motion and pierce the central ring with a

---

[22]Account of an Expedition from Pittsburgh to the Rocky Mountains, etc., under command of Stephen H. Long. Philadelphia, 1823. Vol. I, p. 444.

[23]Pike's New Mexico, etc., was published in 1810. It was translated into French and published at Paris in 1812, under title Voyage au Nouveau-Mexique, etc., par le Major Z. M. Pike.—See Vol. II, p. 278 of translation, where the game of "Plate, of which many travellers have written" is also mentioned. In the original, see part II, pp. 15 and 16. The third game is here called "La Platte."

pole which was six feet in length. In the second form the ring was four inches in diameter. The pole was a small stick with hooks on it. The ring was to be picked up with the stick, and the points now depended on the position of the hook in which the ring stopped.

H. M. Brackenridge[24] describes hoop and pole as played at the Arikara village on "a level piece of ground appropriated for the purpose and beaten by frequent use." He also mentions the second form of the game which Pike described. "Instead of poles they have short pieces of wood, with barbs at one end and a cross piece at the other, held in the middle with one hand; but instead of the hoop before mentioned, they throw a small ring, and endeavor to put the point of the barb through it."[25]

The seventh volume of the Report upon United States Geographical Surveys contains a paper on perforated stones, by Mr. F. W. Putnam, Curator of the Peabody Museum. A great many stones of this kind have been found in southern California, on the mainland and islands. Mr. Putnam shows that similar stones have been used elsewhere as hammer-stones, weights for digging-sticks, club-heads, net-sinkers and as spindle-whorls, and he infers the probable use in that region, of the better class of these perforated stones, as club-heads. Since the publication of that paper he has secured and now has, at the Peabody Museum, specimens of such club heads mounted on wooden handles, which came from a cave in southern California.

---

[24]Journal of a Voyage up the river Missouri, etc., by H. M. Brackenridge, Baltimore, 1816, pp. 158, 159.

[25]John T. Irving describes the principal game of the Pawnees as one in which a barbed javelin was hurled at a ring four inches in diameter, while the ring was in rapid motion along the surface of the ground. "The javelin is filled with barbs nearly the whole length, so that when it has once passed partly through the ring it cannot slip back. This is done to ascertain how far it went before it struck the edges of the ring, and the farther the cast the more it counts in favor of the one who hurled it." Indian Sketches, Philadelphia, 1835, Vol. II, p. 142, note.

On the other hand, Mr. H. W. Henshaw of the Bureau of Ethnology, Smithsonian Institution, writes me that in 1884 he obtained from the Santa Barbara Indians some interesting points concerning perforated stones from California. He is now preparing a paper on the subject which will be published at an early day. In this paper will be embodied in substance the statement that he "obtained evidence directly from Indians, showing that formerly these perforated stones were largely used in two ways: first, as weights and digging-sticks; second, in playing a game which answers in all essentials to the game of 'chungke.'" This game was described in the former paper in widely separated localities and in various forms. It is not strange, therefore, that evidence has been discovered that it was played by the Indians of southern California.

In the History of Georgia, Charles C. Jones, jr.,[25a] describes the old chunkee grounds of that region, and the chunkee stones. He says, "No longer is this famous game played within the limits of Florida of the olden time."

OTHER ATHLETIC GAMES.

Le Moyne,[26] an artist who accompanied Laudonnière in his expedition to Florida in 1564, describes a game similar to one which was quoted in the former paper from Lafitau. He says:—"They also play a game of ball as

---

25a The History of Georgia, by Charles C. Jones, jr., LL.D., Boston, 1883, p. 27. The description of chunkee stones, etc., from Jones, and the description of a ball-game played with "curiously carved spoons" which was alluded to in Note 12 of the former paper, are quoted in a work called Se-quo-yah, by George S. Foster, Philadelphia, 1885.

A description of chunkee, as played by the Mandans in the winter time, is given under the name of "billiards" by Henry A. Boller in his Among the Indians, p. 196.

26 Narrative of Le Moyne, an artist who accompanied the French Expedition to Florida, under Laudonnière, 1564, Translated [by Frederic B. Perkins] from the Latin of De Bry, Boston, 1875. Description of Illustrations, p. 13; the narrative is also given in Hakluyt's Collection of Early Voyages, a third edition with additions. London, 1810, Vol. III, p. 370.

follows: in the middle of an open space is set up a tree some eight or nine fathoms high, with a square frame woven of twigs at the top; this is to be hit with the ball, and he who strikes it first gets a prize." The cage in this game was fixed, and in the illustration given by De Bry, it is evident that the cage could not easily be turned. In this respect this description differs from that given by Lafitau.

Strachey informs us that foot-ball was found in the South. He bears testimony to the honorable spirit in which the game was conducted: "Likewise they have the exercise of foot-ball, in which they only forceably encounter with the foot to carry the ball the one from the other, and spurned yt to the goale with a kind of dexterity and swift-footmanship, which is the honour of yt; but they never strike up one another's heels, as we doe, not accompting that praiseworthie to purchase a goal by such an advantage."

Roger Williams describes this game as it was played among the Narragansetts. His account is relieved from the absurdities which occur in the description given by Wood in "New England's Prospect." "Besides, they have great meetings of foot-ball playing, onely in Summer, towne against towne upon some broad, sandy shoare, free from stones or upon some soft, heathie plot, because of their naked feet, at which they have great stakings, but seldom quarrell."

Colonel Dodge in "Our Wild Indians"[27] records the fact that among the Nez Percés and other western tribes the women are extremely fond of a game of ball similar to our "shinny" or "hockey," and Boller in "Eight Years in the

---

[27] Our Wild Indians, by Colonel Richard Irving Dodge. Hartford, 1882, p. 344.

Far West,"[28] tells us that he found the young squaws (Minnetarees) "playing a game of ball, resembling shinny or foot-ball, inasmuch as the curved sticks and feet are called into service." A game of ball, similar to the one described by Catlin among the Sioux women, was played by the women whom Kohl met.[29] Two leathern bags stuffed with sand and connected by a thong were substituted for balls.

OTHER GAMES OF CHANCE.

Several different forms of the guessing game as played by the Indians of the northwest coast are described in the former paper. The descriptions referred to in notes on that paper and there credited to "The Northwest Coast," by James G. Swan, will be found in substantially the same form in the "Smithsonian Contributions to Knowledge."[30] The same author has also contributed a description of a game played among the Haidahs[31] which closely resembles the game described by Poole in his "Queen Charlotte Islands" to which reference was made in the former paper. In that description the guess was whether the number of sticks in the hand selected was odd or even. In the game described by Swan, forty or fifty sticks were used, each having some designating mark. One stick was entirely colored and one was entirely plain. The guessing was devoted to picking out the hand in which the plain or the colored sticks were held. The sticks were beautifully

---

[28] Among the Indians. Eight Years in the Far West, by Henry A. Boller. Philadelphia, 1868, p. 67.

[29] Kitchi-Gami, Wanderings Round Lake Superior, by J. G. Kohl, London, 1860, p. 90.

[30] The Indians of Cape Flattery, by James G. Swan, Smithsonian Contributions to Knowledge, Vol. XVI, No. 220, p. 44.

[31] The Haidah Indians of Queen Charlotte's Islands, British Columbia, etc., by James G. Swan. Smithsonian Contributions to Knowledge, Vol. XXI, No. 2(7, p. 8.

rounded and polished. They were put under a heap of bark-fibre, were separated into two piles, wrapped in bark and shifted from hand to hand while still beneath the pile of bark-fibre. They were then exposed in their bark wrappings for the guesser to make his choice.

According to Swan's observations, the Indians north of Vancouver's Island use this style of sticks for gambling. On the other hand, George Gibbs,[32] speaking of the Indians of western Washington and northwestern Oregon, says: "farther down the coast ten highly polished sticks are used instead of disks."

Dr. J. Hammond Trumbull kindly pointed out to me that information concerning Indian games could be obtained from Indian Dictionaries and Vocabularies. In the Abnakis Dictionary of Father Rasles[33] a game is mentioned, which is described as played upon *des espèce de lozanges entrelassées*, by which is meant, I presume, interlaced lozenges. The statement that the *grains* bet upon the game were placed upon the interlaced lozenges would seem to show that the game was played upon a prepared surface with a pattern of this description upon it. As there is no further account of the game, no conclusion can be drawn as to how it was played. Rasles calls another game "chariot" and says the one who makes chariot does not take the *grains*. The only description given of this game, *traîne qui roule* — is too brief to suggest any idea of the method of the play.

In some of the Western dialects, Dr. Trumbull finds mention of "a game of wheels or roulette," and he has furnished me some references taken from the Kalispel (Flat-

---

[32] U. S. G. & G. Survey. Contributions to North American Ethnology, Vol. I, p. 206.

[33] The dictionary of Rasles, Rasle, Râle or Ralle—for the name is spelt in each of these ways by different authors — was printed in Vol. I, N. S. Memoirs of the American Academy of Arts and Sciences. Cambridge, 1833. The original MS. is in the Harvard College Library.

head Indian) dictionary, 1879. Names are then given for "playing at wheels," "playing at wheels or circles, *joues à la roulette*," and "the play wheels, *la roulette*."

CONTESTS OF SKILL.

Kohl [34] found among the Lake Superior Indians a contest which consisted in shooting "slipping sticks" along the ice. This is evidently Morgan's "snow snakes" and La Potherie's "*fuseaux.*"

Long [35] says that the "Cahnuaga" (Caughnawaga) boys were expert in trundling hoop, and that some of them drove hoops while others with bows and arrows shot at the hoops while they were in motion. He states that they would "stop the progress of the hoop when going with great velocity, by driving the pointed arrow into its edge."

OTHER AMUSEMENTS OF WOMEN AND CHILDREN.

Strachey,[36] whose pen has furnished a graphic account of ball playing and of straw elsewhere in the same volume, draws a picture of the light-hearted but immodest amusements of the Indian girls, as shown in the conduct of "Pocahontas, a well-featured but wanton yong girle, Powhattan's daughter," who when about eleven or twelve years old would come to the fort and "get the boyes forth with her into the markett place, and make them wheele, falling on their hands, turning up their heeles upwards, whome she would followe, and wheele so herself, naked as she was, all the fort over."

---

[34] Kitchi-Gami, p. 90. Rasles describes a similar play among children. "They slide a flat piece of wood along the frozen snow."

Schoolcraft gives representations of these Snow Snakes in plate 78, Vol. II, Indian Tribes. I am indebted to Mr. Albert S. Gatschet of Washington, for information concerning a game played among the Wintún Indians, called Ka-rá which is played by throwing up two disks of wood connected by a string about three inches long. These are to be caught when they come down. Mr. Gatschet refers to Mr. Jeremiah Curtin, Bureau of Ethnology, for his authority.

[35] Voyages and Travels of an Indian Interpreter, p. 53.

[36] History of Travaile into Virginia.

H. M. Brackenridge[37] found a game among the women at the Arikara village, which resembled jack-stones. "Five pebbles are tossed up in [from] a small basket with which they endeavor to catch them again as they fall."

Rasles, under the heading *Joüets des Enfans* gives, in addition to the form of "snow snake" already alluded to, a game the phrases used in which he interprets as follows: *toupie sur la glace*, etc.; *sur la terre; je la fouette*. This description applies to the spinning of something like a top. Blind-man's-buff is also described—"My eyes are blindfolded and I hunt for some one."

In Shea's "Library of American Linguistics", No. X, is a republication of the radical words of the Mohawk Language, etc., by Rev. James Bruyas. "Atnenha," *Noyau* (the stone of a fruit) is given, and to a compound of the word this definition is added: "to play with fruit-stones as women do, throwing them with the hands." Another compound is defined: "to play at platter."

GAMBLING IN GENERAL.

In the former paper I quoted numerous extracts from authors to show the propensity of the natives for immoderate gambling. The writers who have furnished material for this second paper bear similar testimony. Roger Williams says that in their games they would sometimes stake their money, clothes, house, corn, and themselves, if single persons. He adds that they then became weary of their lives and ready to make way with themselves. The scene which he describes in the play-arbour, the fierce frenzy of the gambling spirit, and the solemn shouting of the lookers-on and players, bring before us much the same scene as that described by Father Lalemant in 1639. Winslow, in his

[37]Journal of a Voyage up the river Missouri, p. 149.

" Good Newes from England,"[38] says "they use gaming as much as anywhere and will play away all, even their skin from their backs, yea their wives' skin also, though it may be they are many miles distant from them, as I myself have seen."

Wood in his "New England's Prospect,"[39] besides furnishing the curious descriptions of games which were used by Ogilby, also dwells in another place, upon the propensity of the natives with whom he came in contact, for gaming. "They are so bewitched," he says, "with these two games, that they will lose sometimes all they have, beaver, moose-skins, kettles, wampompeage, mowhackies, hatchets, knives, all is confiscate by these two games."

Daniel Gookin,[40] writing at a later period, adds his testimony as to gambling among the New England Indians in the following words: " They are addicted to gaming; and will, in that vein, play away all they have."

METHODS OF COUNT.

The examination of Indian vocabularies has disclosed several new points concerning the methods of counting the several games.

According to Rasles, the count was sometimes kept by thrusting sticks in the ground. In case of loss, the sticks were removed. This is shown by Indian words used in the games which Rasles interprets respectively: "I thrust

---

[38]Good Newes from New England; or a true Relation of things very remarkable at the Plantation of Plimouth in New England, London, 1624—reprinted in Chronicles of the Pilgrim Fathers of the Colony of Plymouth, etc., by Alexander Young, second edition, Boston, 1844, p. 307. Purchas gives an abbreviation of Good Newes, etc., in his Pilgrimes, Vol. IV, Lib. X, Chap. 5. The quotation will be found p. 1859. See also on this point, Morton's New English Canaan, published at Amsterdam, 1637, and reprinted by the Prince Society, Charles Francis Adams, jr., Editor, Boston, 1883, p. 138.

[39]New England's Prospect, Part II, Ch. 14.

[40] Historical Collections of the Indians in New England, etc., by Daniel Gookin. Collections of the Massachusetts Historical Society for the year 1792, Vol. I, p. 153.

a stick in the ground to mark the games;" "I win a game from him, I place a stick," etc.; "He takes the mark for a game away from me, he removes a stick, etc;" "He takes away all my marks, he removes them all, etc."

Rasles speaks of the *ronds* and the *grains* used in the game. The former were evidently the dice,[41] of which descriptions have been given in so many forms in the former paper. Concerning the latter, Rasles in one place gives the same word for them in connection with the game of platter as he gives for the *ronds*, but elsewhere speaks of them as if they were wagered on the game. Referring to the definition of *porcelaine* in Rasles, Dr. Trumbull points out that the *grains* were the beads of wampum. The value at which "Wampampeag" should pass current as money was, at one time, fixed by law in the colony of Massachusetts Bay.[42] It is, therefore, evident that when Rasles represents the *grains* as placed upon interlaced lozenges (*lozanges entrelassées*), he is describing a form of betting where what was practically money was directly put up on the game.[43]

---

[41] Defined, according to Dr. Trumbull in the Illinois MS. Dictionary, as follows: "*Fêves pour jouer, comme des dez, noyaux des prunes, corne de cerfs, osselets a jouer.*"

[42] The General Laws and Liberties of the Massachusetts Colony, Cambridge, 1672, p. 154. See also, Code of Laws, Colonial Records of Connecticut, Vol. I, p. 546.

In Perrot's description of Straw, the *grains* spoken of were described as seeds of trees much like apricots. Of these, he says, they took a certain amount representing a gun, a cover, etc. If he had used *grains* in the sense of wampum, there would have been no necessity to describe the stakes as having a representative value. Wampum itself had a distinct value as a circulating medium among many of the tribes. Rasles gives the measure of the different varieties in beaver.

[43] In what I have said concerning the information to be derived from Indian dictionaries, I have tried to make clear the fact that I was indebted to the generous help of Dr. J. Hammond Trumbull. Many of the citations were inaccessible to me and of those which were at my command, no such comprehensive analysis would have been possible without his aid. The development of this part of the subject would have additional value for the reader if I could have copied what he said; but as it was in the form of letters, and not intended for publication, this was impossible.

CONCLUSION.

The foregoing references and quotations are mainly cumulative. They show that the early English explorers and settlers found in New England and Virginia the same games which the French found in Canada, with the addition of foot-ball, of which I have not seen any mention made by the French writers. As this game required for its play a smooth surface, it is not likely that it was played to any extent, except where the flat sandy beaches furnished a ground fitted by nature for the purpose. The game of koho carries lacrosse unmistakably across the continent, although like most of our information concerning Pacific coast games, that which we have concerning this game is too recent to have especial value or significance. The game of chunkee, of which Mr. Henshaw has found evidence that it was formerly played among the Santa Barbara Indians, had already been traced in substantial form west of the Rocky Mountains. From the facts collated in this paper no new inferences can be drawn. Their tendency is merely to corroborate whatever conclusions may be drawn from the former paper.

BULLETIN

OF THE

ESSEX INSTITUTE,

VOLUME XVIII.

1886.

SALEM, MASS.
PRINTED AT THE SALEM PRESS,
1887.

CONTENTS.