come back to them again thinking they could get back to the streams to spawn where they spent their childhood days, but the leaps are too much for them. There never were any salmon caught in the Genesee before last year. I have fished the river for fifty years. I do not know whether they were California or Kennebec salmon; I did not see them. The fishermen think we do not want them caught, and have kept shy of me. I have spent some days on the river since to let them know that we did want them caught in the spring of the year, and to let me know if they catch any more.

NOTES ON THE DEVELOPMENT, SPINNING HABITS, AND STRUCTURE OF THE FOUR-SPINED STICKLEBACK, APELTES QUADRACUS.

BY JOHN A. RYDER.

Nests and ova of this species were recently brought to me for investigation by Mr. W. P. Seal, who obtained them in the ditches along the Delaware, below Philadelphia. More recently (April 27), the same gentleman had the kindness to bring me a pair of adults about to spawn, the male very industriously completing the nest under my observation in an aquarium extemporized for the purpose.

The early stages of development I did not witness, as the first lot of eggs had the blastoderm already formed, and inclosing the vitellus, and those laid by the pair in confinement were unluckily not impregnated. The egg-membrane is a true zona radiata, being perforated by numerous pore canals, and is covered by an adhesive material, which agglutinates the eggs together into a mass to the number of 15 to 20, the number laid at one time. The ova sink to the bottom, and must be taken charge of by the male, as the female after having ridden herself of them takes no farther interest in their welfare. They measure one-twelfth of an inch in diameter, and are of an amber color. I was not able to discover a micropyle, but believe that one exists, nevertheless; at one pole of the egg a large number of button-shaped appendages are attached to the surface of the egg-membrane by means of pedicels, and it is in the midst of these that the micropyle is found in the European species, *Gasterosteus leiurus*, according to Ransom.

Not having witnessed the early stages of development, I will only describe the structure of the ovum. There is no germinal disk developed when the egg first leaves the ovary, and the germinal layer is uniformly distributed as a thin uniform granular envelope, inclosing the clearer vitelline protoplasm, which itself incloses a number of very refringent oil spheres of very variable size. Later, it appears that a germinal disk is developed without the influence of impregnation.

The formation of the segmentation cavity I have not witnessed, but I have a belief that it is present, inasmuch as there is a space developed on either side of the embryo and in front of the head, which answers to it. It is, however, greatly obscured afterwards, if not obliterated at a comparatively early period, by the remarkable way in which the blood vascular system of the embryo is formed.

On the fourth or fifth day after impregnation, the primary divisions of the brain are marked off, one of the most striking characters being the extraordinary dimensions of the cerebral vesicles, the walls of the brain cavity being thinner proportionately than I have ever found them in other forms. The optic cups also differ in their structure from those found in other fishes, in that there is a great space between the floor of the cup and the lens, the origin of which from an induplication of the epiblast may be very readily traced. Immediately behind the auditory vesicles, and shortly after their invagination, the rudiments of the breast fins appear as a pair of longitudinal folds. These therefore originate closer to the branchial arches than those of any other species studied by me. As they often are found to originate on either side of the embryo above the posterior end of the yelk-sack, and near a vertical from the point where the vent appears. This latter is their mode of development in the cases of the young of the moon-fish (*Parephippus*) and the Spanish mackerel (*Cybium maculatum*). In the stickleback, however, there is an extraordinary acceleration in the development of the breast fin, so much so that by the time the young fish leaves the egg, the breast fins are as greatly developed as in a mackerel four days old. The pigmentation of the young stickleback is also accomplished at a very early period, so rapidly, indeed, that it soon becomes impossible to see the viscera through the mantle of pigment cells. There is another complication which needs mentioning here, and that is the fact that a second kind of brown pigment cell, much larger than the black ones appears on the skin before the young slips out of the egg. These brown cells blotch the embryo on the sides and back somewhat symmetrically, and foreshadow the style of pigmentation of the adult.

The heart appears about the fourth day as a heap of mesoblast cells just below and behind the head, and is at first a simple spherical sinus. It does not begin to contract vigorously until the seventh day, when its pulsations are nearly if not quite 100 per minute. Its venous end rapidly elongates until it extends fully the diameter of the body beyond the right side of the embryo, a large pericardial space being developed below the head at this point for its lodgment, which space dips down deep into the amber-colored vitellus. It keeps contracting from this time onwards, but there are as yet no blood corpuscles. A large space now appears on the right side of the embryo and underneath the latter. This we may consider a venous sinus or channel of indefinite outline. The floor of this space is, as far as I have been able to convince myself, formed of the hypoblast from which knobbed cells project upwards, which appear to be budding off portions of themselves which will become blood corpuscles. Now follow amœboid contractions of the yelk by means of which it appears that this sinus is pushed out more to the right and subdivided into minor channels, the corpuscular contents of which flow towards the heart, pouring their contents into its venous end. At first it can scarcely be said that there is a circulation; the corpuscles appear and the pulsation or pumping action of the heart causes an oscillation or swaying back and forth of these corpuscles. As soon as the aortic channel underneath the chorda dorsalis is broken through the blood commences to pour through the sinus from the tail end headwards, as the cycle is now complete. The cardinal vein is formed about the same time. From it the feeders of the sinus, now the vitelline vessels, are soon developed and they now spread out over the yelk as narrow channels, becoming more and more numerous. They at first spread out over the aboral pole of the yelk, and a great common venous channel begins on the left side of the embryo and goes round to the right side over the yelk like a girdle, to feed the heart. Into this equatorial vascular girdle the blood pours from the hemi-meridional, aboral channels. This asymmetrical or right-hand side channel is gradually pushed forward until it encircles the head below and in front of the point where the mouth will appear. The yelk is now becoming less in bulk, and finally the vessels arrange themselves so that the main venous channel lies in the middle line, while the feeders which get their supply from under the body of the embryo trend outwards and somewhat backwards, but as they turn to traverse the lower face of the yelk they one and all trend forward to converge and join the great venous channel.

The above arrangement may be described as a diffuse omphalomeseraic system, and differs from that of *Zoarces* described by Rathke, in being asymmetrical, and from that of the pike as described by Truman, in the disposition of the vessels, their more meridional course, and in their being fed from the under side of the body in a diffuse manner. It differs widely from that of birds and reptiles and sharks in there not being any differentiation of venous and arterial trunks over the blastoderm. Also from the system described by Vogt in *Coregonus palæa*, in that the latter is comparatively rudimentary, while as compared with the cod, smelt, moon-fish, and Spanish mackerel, there is the broadest and most fundamental difference of all, in that in every one of the latter there is nothing whatever which can be considered as representing an omphalomeseraic or vitelline system of vessels.

Gensch* has lately studied the development of the blood in *Zoarces* and *Esox* by means of sections, and has reached the conclusion that the blood corpuscles in these forms are developed by budding off from the hypoblast as it has appeared to me in the case of the stickleback. This announcement at first appeared almost incredible to the writer, but upon investigating the form above described it appeared perfectly reasonable, but it must be borne in mind that there are no less than four or five dis-

*Die Blutbildung auf dem Dottersack bei Knochenfischen. Arch. für Mik. Anat., xix, pp. 144–136.

tinct hypotheses as to the origin of the blood in embryos, besides this one, so that the matter cannot be considered as settled. In all cases where there was no vitelline circulation I have not been able to arrive at a satisfactory conclusion in regard to the manner in which the matter in the yelk-sack was absorbed; whether by transudation, amœboid migration, or gemmation, and it therefore still remains an unsettled problem. It will not, it appears to me, satisfy the facts in the case, that because the blood originates by *gemmation from* the hypoblast in those cases where there is a vitelline circulation, it should so originate where such a circulation is absent. The corpuscles of the stickleback are at first irregular and amœboid in outline, and do not acquire their oval shape for some time, or till about the tenth or twelfth day, when the young fish is ready to leave the egg, which is strong evidence in confirmation of Gensch's view as to the manner of origin of the blood of types with a vitelline or omphalomeseraic circulation. In other forms it has always appeared to me that there was strong ground for believing that the blood had its origin, in part at least, in the lacunæ which make their appearance in the mesoblast of the body late in embryonic life.

The heart retains its horizontal position in the stickleback for a longer time than in any other form which I have studied, and is an instance of what Professor Cope would call retardation in the development of a part; indeed, the comparative histories of the several species investigated by the writer afford most beautiful illustrations of both principles enunciated by the learned biologist just referred to, namely, *acceleration and retardation* of development, both synchronous and heterochronous. This long retention of an embryonic character is, however, to be considered as caused to some extent by the development of an omphalomeseraic system, and as in some degree dependent upon the correlative interdependence of parts serving a common purpose.

Kupffer's vesicle was found to be present, and at one time I believed that it became the allantoid vesicle, but owing to the opacity of the eggs I failed to trace it satisfactorily to myself. The allantoid, however, occupies the usual position, and is large and inclosed by a proper cellular wall. The course of the intestine when the embryo is nearly ready to hatch is marked by a greenish color. The blood very soon becomes reddish in color before the fish leaves the egg, a character which it has in common with no other form studied by me, except perhaps the sculpin. In all other cases investigated by me, the blood is developed after the embryos leave the egg. There is also a well-developed system of vascular loops existing in the natatory folds along the back and belly before the fish is ready to leave the egg, while the branchial vessels, arches, and opercula are already in an advanced condition at this period, all of which are accelerated conditions of development as compared with other forms.

When the embryo leaves the egg there are already lateral sensory organs developed on the skin. If the young fish is allowed to assume its normal position in a cell, and the microscope is applied, looking down past the sides of the body from above, certain thickenings of the epiblast or skin layer will be noticed. These thickenings are surmounted by transparent cells which project freely for a little distance from the general level of the surface. The cells to the number of ten or twelve are somewhat separated from each other, and have blunt truncated tips which are not surmounted with sensory hairs or filaments. As compared with the similar structures in the young cod, which have sensory hairs surmounting them, they differ in having the peculiar, somewhat separated truncated transparent cells clothing their surface externally, while in the former nothing is seen from above but a smooth rounded elevation.

Spinning habits and structure of the male.—The male binds the nest together by means of a compound thread which he spins from a pore or pores behind the vent, while he uses his bobbin-shaped body to insinuate himself through the interstices through which he carries his thread with which he binds a few stalks of *Anacharis* or other water-weeds together, bringing in his mouth every now and then a contribution of some sort in the shape of a bit of a dead plant or other object, which he binds into the little cradle in which the young are to be hatched. The thread is spun fitfully, not continuously. He will go round and round the nest for perhaps a dozen times, when he will rest awhile and begin again, or turn suddenly round and force his snout into its top with a vigorous, plunging motion as if to get it into the proper shape. Its shape is somewhat conical before completion, an opening remaining at the top through which it is supposed he introduces the eggs. The thread is wound round and round the nest in a horizontal direction in the case we are describing, and if this thread is placed under the microscope when freshly spun, it is found to be composed of very thin transparent fibers to the number of six or eight; where they are broken off they have attenuated tapering ends as though the material of which they were made had been exhausted when the spinning ceased. Very soon after the thread is spun particles of dirt adhere to it and render it difficult to interpret its character. I have seen the thread being drawn out from the abdomen repeatedly, but not from the vent; it appeared to me more probable that it came from the openings of a special spinning gland. Its glass-like transparency shows that it is not made up of ingested food, the particles which would exhibit themselves were that the case. The nest measures half an inch in height and three-eighths in diameter.

Upon opening the male I find a large vesicle filled with a clear secretion which coagulates into threads upon contact with water. This vesicle appears to open directly in front of the vent, separately from the latter. It measures one-fifth inch in length and an eighth in diameter. As soon as it is ruptured it loses its transparency, and whatever secretion escapes becomes whitish after being in contact with water for a short time. This has the same tough, elastic qualities as when spun by the animal itself, and is also composed of numerous fibers, as when a portion is taken which has been recently spun upon the nest. The nature of the opening was not learned with precision as I possessed only a single specimen. The vesicle lies to the right side of the intestine, and there is very little doubt but that it opens in front of the anus. The testes are two ovoid glands, the ducts of which unite into a common canal, both glands and ducts being covered with black pigment cells; they measure something less than an eighth of an inch. As to the origin of the secretion I have no suggestion to make, but there are certain glandular structures lying close by, the significance of which I was at a loss to understand.

This spinning habit of *Apeltes* was first noticed by my friend Mr. Seal, who has watched the breeding and nursing habits of these interesting fishes very closely, and it is my hope that I may some time be able to deal more at length with this part of the subject with the help of his notes and beautiful sketches.

PHILADELPHIA, *April* 29, 1881.

A CALL FOR CARP FROM NEVADA.

BY I. D. PASCO.

This country is the most God-forsaken country in the world—a mining camp (silver), and the water small streams from the mountains. The nearest fish are in the Reese River, 30 miles distant. Reese River would not be called a creek in Pennsylvania; it would be a brook. When I tell you that last winter trout came from Truckee and Walker Rivers embalmed in snow and ice, and sold for 37½ cents per pound, you will see that we have reason to be anxious about the matter. The big thing is to get a good start (to get the fish), get them to breeding and we will supply and stock the country. I would give $5 for a pair that are big enough to spawn now. Our waters teem with insect life but not a fish, and I know that fish would live in them although our springs are all warm, and some boiling hot. The water in the streams from the mountain, consisting of snow water, sinks sooner or later. I have as a place to begin with a pond—an old channel of this stream (Meadow Creek) 16 feet wide, 40 rods long, and 2 feet deep, of pure water. I will give you a description of a place Mrs. Hathaway, a widow, owns: There are as many as twenty springs rising in a half circle and running a stream about 3 miles, a good step across the stream; there are fish that never get longer than 3 inches, too small for use. How they ever got there is unknown, for the water does not connect with any place. Here a 3-foot dam, 50 yards long, would cover 50 acres. Give us the fish, and we will build reservoirs to hold the snow water, and use for irrigation and fish ponds. The two will work well together. I cultivate the water cress for sale in Belmont; it does well, but the *algæ* (frog spittle) is a great bother in the cress beds. Here are two articles that the carp would eat; and I believe in the warm springs they would not in the winter be dormant in the mud, but grow all winter.