large specimens a dark blue color on the outside, and a purplish pink color on the interior. The nuclei and the cell walls are brought out clearly. I did not have good success with the methyl colors, as they were easily dissolved out by the alcohol.

If specimens have not taken sufficient color, or if the alcohol has removed too much of the color, sections can be stained upon the slide, after they are cut. Any stain can be used, but none that I tried differentiated the parts sufficiently. Fuchsin will give enough color in a few seconds. The sections must stand in hæmatoxylin from two to ten minutes, and in alum cochineal from ten to twenty minutes. If it is intended to stain upon the slide, an alum fixative will be found better than collodion.

I heated the slides in the gas flame to melt the paraffine, and poured on turpentine to wash it out. The specimens were then mounted in balsam dissolved in chloroform. Air bubbles that appear when sections are first mounted, will disappear after the slides stand a few hours. If the razor or knife used for cutting is very sharp, small specimens may be cut 1-2500, or even 1-5000 of an inch in thickness. But larger specimens cannot be cut more than 1-600 to 1-1500 of an inch thick without crowding the tissues together, and giving them the appearance of being shrunken.—A. J. McCLATCHIE, *Lincoln, Neb.*

ZOOLOGY.

The Ontogeny of Limulus.—The following is preliminary to a more detailed account, with ample illustrations, which will be published soon. The work was done in the Marine Biological Laboratory at Woods Holl, Mass., during the summers of 1889 and 1890. In my views of the earlier stages, as seen from the surface, I fail to corroborate Osborn's account[1] in many particulars. The eggs were artificially fertilized, and were carried through until hatching.

(1) The segmentation nucleus is subcentral, and is surrounded by a thin pellicle of protoplasm. It undergoes several divisions before any signs of segmentation are visible from the surface. The products of this division migrate more rapidly toward that pole of the egg where the germ is subsequently to appear than to any other portion of the surface. Forty hours after impregnation the egg itself begins to segment, and this segmentation has in its general appearance a meroblastic character,

[1] Johns Hopkins University Circular, No. 43, 1885.

recalling to a slight degree Metschnikoff's,[2] Pl. XIV., Fig. 5. The result of this yolk segmentation is to divide the egg into a number of yolk cells, in the center of each of which there is a nucleus with its thin layer of protoplasm.

(2) The result of migration of the products of egg and nuclear segmentation is the formation of a blastoderm at first on one side of the egg, the cells of which are smaller and less charged with yolk than those of the rest of the ovum. At this time surface views show no traces of regularity. At one pole are numbers of poorly-defined small cells, while at the other the cells are greatly larger and fewer in number. The blastoderm thus formed produces a lighter spot on one side of the egg, which strikingly resembles the primitive cumulus of the Arachnids. With the formation of this blastoderm the secretion of the blastodermhaut (amnion of Packard, deutovum of my former paper[3]) begins.

(3) In from eight to eleven days after impregnation (the period varies in eggs of the same lot) a small circular pit appears in the center of the primitive cumulus. This I regard as the blastopore. This soon becomes triangular and then elongates, while on the next day a second cloud appears behind the first, but connected with it. At first the second cloud is smaller, but it rapidly attainse quality with the primitive cumulus, and soon surpasses it. During this process the outlines become indistinct, more so than in Balfour's[4] Pl. XIX., Fig. 1, which in other respects, except in length, agrees well. During this process the blastopore increases in length backwards, in the shape of a shallow groove (primitive groove), the enlarged anterior end of which continues to mark the original site of the first appearance of the structure. This primitive groove runs back into the posterior cloud and fades out behind. A second lighter area has now become prominent along the margins of the blastopore and its posterior continuation, produced by the proliferation, as shown by sections, of mesodermal cells from the margins. These wander in between the rest of the blastoderm (ectoderm) and the yolk (entoderm) cells which occupy the interior. Gastrulation produces no entoderm.

(4) In fifteen days this primitive groove has become less distinct, through the flattening of its walls; while the germinal area, now outlined by the limits of the extension of the mesoderm, has become divided by the appearance of a transverse groove into cephalic and post-

[2] Zeitschr. f. wiss. Zool., XXI, 1871.

[3] *Quarterly Jour. Micros. Sci.*, XXV., 1885.

[4] *Q. J. M. S.*, XX., 1880.

oral plates, the anterior being smaller and more sharply limited than the other. In twelve hours more a second groove appears behind the first, cutting off a narrow ridge, the first post-oral somite. At this stage the embryo is readily comparable with Metschnikoff's Pl. XVII, Fig. 3, except in the following particulars: The two ends of the embryo are more nearly equal, the single somite developed is much shorter, and the median groove is fainter and extends into both cephalic and caudal plates. Successive somites are added by budding from the caudal plate until the number six is reached. The embryo now closely resembles Balfour's Pl. XIX, Figs. 3*a* and 3*b*, except that it covers far less of the surface of the egg, the first somite is separate from the cephalic plate, the primitive groove extends across the somites, its anterior end terminating at the mouth, while posteriorly it runs into the caudal plate: the caudal plate is much smaller than in Balfour's figure.

(5) Just after six somites are formed, paired thickenings, the rudiments of legs, arise near the outer margins of each. Then six pairs arise simultaneously. I have seen no traces of Osborn's semicircular groove.

(6) Almost simultaneously with the outgrowth of the legs, paired thickenings for the nervous system appear. There are a pair of these in each somite of the body, while three pairs appear in the cephalic plate. A few days later a series of six pairs of segmentally arranged sensory thickenings arise outside of the legs, and extend in a line from the cephalic lobes backwards, as briefly described by Patten.[5] These have different fates. The first pair gives rise to the median ocelli of the adult; the second to a peculiar sense organ as yet undescribed, occurring on the thin skin just in front of the first pair of appendages; the third soon disappeares; the fourth forms the "dorsal organ" of Watase, which persists longer than the third; the fifth gives rise to the paired compound eyes; while the sixth is evanescent. At first these are all similar and are plainly sensory. These organs are connected with each other and with the brain by a longitudinal nerve, which takes an undulating course between the organs and the bases of the legs.

(7) There is a precocious separation of ectoderm and entoderm (yolk cells) during the formation of the blastoderm. Blastopore and primitive groove produce no invagination of entoderm cells. The entoderm retains its primitive character as a solid mass of large yolk cells until after the caudal spine appears. The yolk cells are not true

[5] *Jour. Morphology*, III.

vitellophags. They metabolize the yolk which is contained in each, but the cells themselves are directly converted into the lining epithelium of the mid gut. By this process a lumen is formed, first at the anterior end. The stomodeal-mesenteric wall is first to break through ; the opening into the proctodeum appears much later. The proctodeum is very short, not extending far from the anus.

(8) In embryos at the time of hatching the sternal artery has arrived at the condition found in the adult scorpion. It consists of a tube lying on the upper surface of each half of the œsophageal nerve ring. Not until much later than my studies have gone does it attain the investing character of the adult.

(9) Packard's "brick-red gland" is of mesodermal origin. It contains in its interior the cavity of the fifth post-oral somite. Its inner end is terminated by a thin layer of flattened epithelium. It soon becomes folded on itself, and the region of the bend grows rapidly forward. The outer limb of the fold becomes in turn folded at four points, and these new bends grow out in each body segment, giving rise to the lobes characteristic of the organ in the adult. With the folding numerous fusions of the walls occur, followed by perforations, giving rise to the peculiar anastomosing structure of the adult organ.

These points, so briefly summarized, go far, I think, toward the support of that view which would recognize a close relationship between Arachnids and Limulus, while at the same time they serve to remove the Merostomata more widely from the Crustacea.—J. S. KINGSLEY, *July 17, 1890.*

A Review of Some of the North American Ground Squirrels of the Genus Tamais.—By J. A. Allen.—Bull. Am. Mus. Nat. Hist., Vol. III.—This paper is a revision of the "*Tamais asiaticus*" group of a former monograph of the genus Tamias, made necessary by the accumulation of a variety and quantity of new material during the last five years. It is a valuable contribution to mammalian literature.

The material in hand seems to require the provisional recognition of not less than twenty-four forms, of which thirteen are here for the first time described. These twenty-four forms fall into several more or less well-marked groups, as follows:

1. The *hindsii* group, consisting of (1) *T. hindsii*, (2) *T. townsendii*, (3) *T. macrorhabdotis*, (4) *T. senex*, (5) *T. quadrimaculatus*, (6) *T. merriamii*.

2. The *dorsalis* group, consisting of (1) *T. dorsalis*, (2) *T. obscurus*.

3. The *umbrinus* group, consisting of (1) *T. umbrinus*, (2) *T. cimereicollis*, (3) *T. bulleri*.

4. The *quadrivittatus* group, consisting of (1) *quadrivittatus*, (2) *T. luteiventris*, (3) *T. affinis*, (4) *T. neglectus*, (5) *T. borealis*, (6) possibly also *T. gracilis*.

5. The *minimus* group, consisting of (1) *T. minimus*, (2) *T. consobrinus*, (3) *T. pictus*.

6. The *frater* group, consisting of (1) *T. frater*, (2) *T. amœnus*.

T. speciosus is a rather isolated species, more closely resembling *T. frater* than any other form. *T. asiaticus* has no close affiliation with any of the American forms.

A table of measurements, a "key" giving the salient features of the various forms of Tamias, and a diagram indicating the status, relationships, and lines of probable intergradation, accompany the paper, and make it a complete exposition of the group considered up to date.

PHYSIOLOGY.

Functions of Central Nervous System of Invertebrates.—Steiner[1] endeavors to determine experimentally what ought to be regarded as the the brain of those invertebrates that possess a supra-œsophageal ganglion, œsophageal commissure, and ventral ganglia. He regards the brain as characterized by the presence of the general motor centre in connection with at least one of the nerves of the special senses. In the crustaceans (Astacus, Carcinus, and Maja) removal of one-half of the supra-œsophageal ganglion, or cutting of the œsophageal commissure, caused circular movements toward the uninjured side. This indicates the presence of the general motor centre in the ganglion, and since it also gives origin to the nerves of the higher senses, the author regards it as the brain of the crustaceans. Experiments on insects (Blatta, Blaps, Carabus, Geotrupes, Musca, Vespa, Pieris, Papilio), and on myriapods (Julus), gave similar results. In molluscs (Pterotrachea, Pleurobrachea, Aplysia) destruction of even the whole of the supra-œsophageal ganglion did not affect the movements, but the latter ceased as soon as the pedal ganglion was destroyed. In Octopus, after destruction of the dorsal ganglion, the movements took place normally, but only after stimulation, never spontaneously. This ganglion hence appears to perform the part of a cerebrum instead of a whole brain. Among annelids (Ophelia, Eunice, Diopatra, Nephthys) cutting the œsophageal commissure caused disturbance of movement.

[1] Sitzber d. königl. Preuss. Akad. d. Wissensch. zu Berlin, 1890, II., p. 39. Cf. *Centralb. f. Physiologie*, Bd. IV., p. 180, 1890.