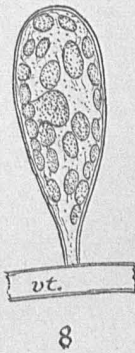
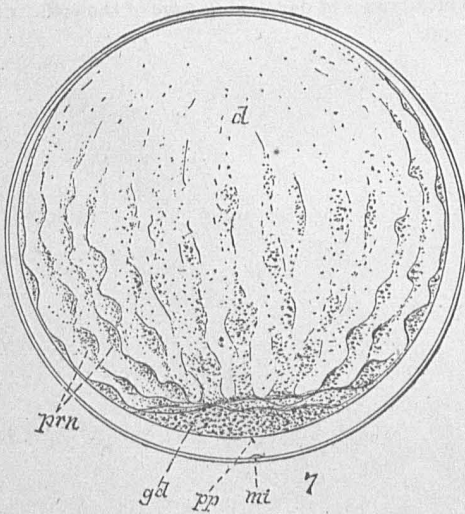
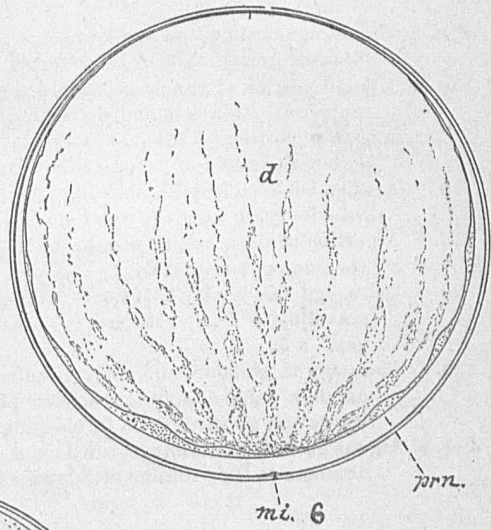
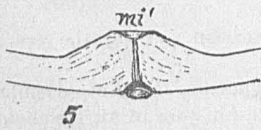
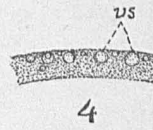
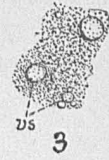
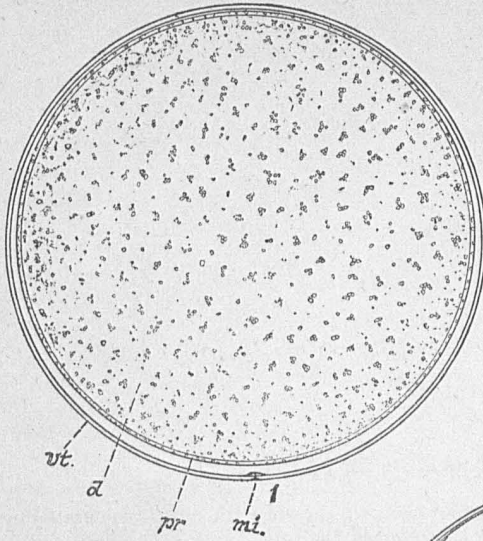


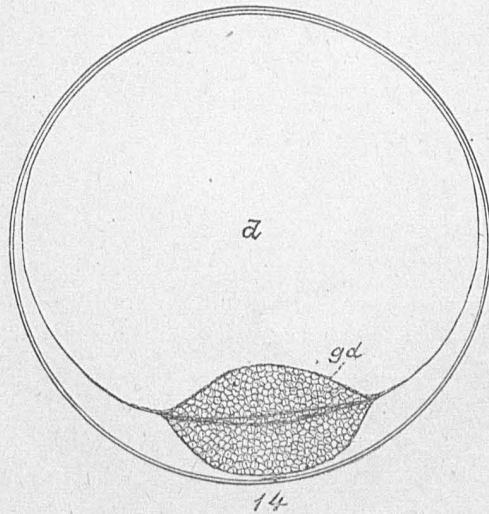
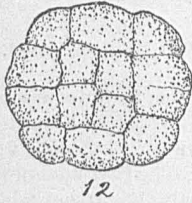
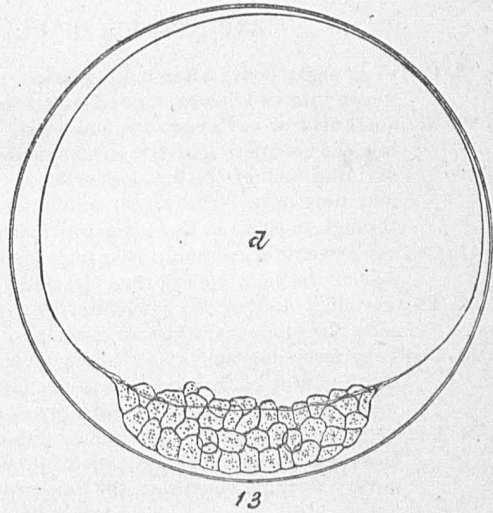
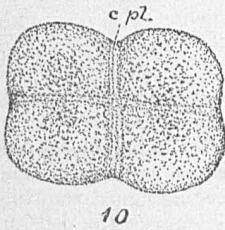
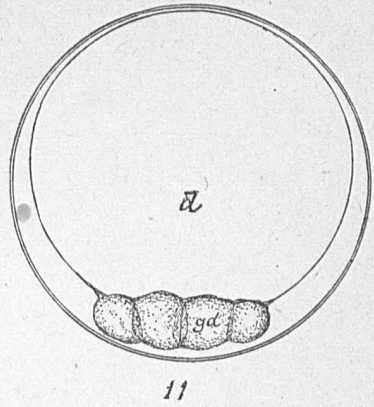
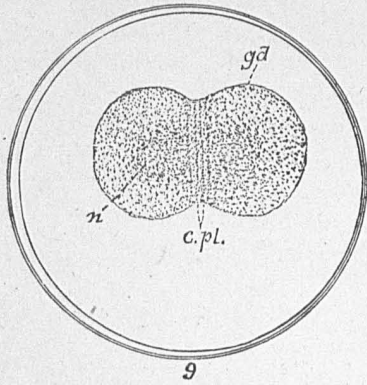
EXPLANATION OF PLATE I.

- FIG. 1. Unimpregnated mature egg of the cod, showing the outer vesiculated protoplasmic germinal layer *pr*, covering the yolk. $\times 55$.
- FIG. 2. A small portion of the protoplasmic germinal layer, more magnified, showing numerous minute included vesicles. $\times 225$.
- FIG. 3. A similar portion of the protoplasmic layer of an impregnated egg. The vesicles have united or become confluent, larger, and less numerous. $\times 225$.
- FIG. 4. A stage between 2 and 3, showing the protoplasmic layer in section, with the vesicles lying next the outer surface. $\times 225$.
- FIG. 5. A portion of the vitelline membrane in optic section, showing the structure of the micropyle. $\times 1200$.
- FIG. 6. Cod's egg one and a half hours after impregnation, the protoplasmic layer traveling in beaded streams towards the lower pole in an amoeboid manner. $\times 55$.
- FIG. 7. Cod's egg three hours and forty minutes after impregnation, with the germinal disk defined, and the beaded protoplasmic processes extending outwards and upwards from it, clasping the yolk. $\times 55$.
- FIG. 8. Algal growth, containing brown chlorophyll bodies, found attached in great numbers to the vitelline membranes of developing eggs of the cod. $\times 500$.



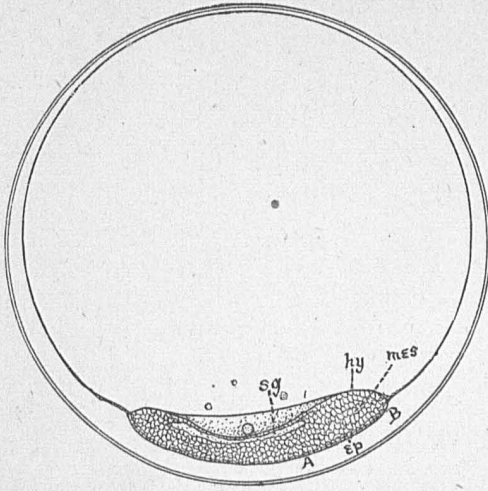
EXPLANATION OF PLATE II.

- FIG. 9.** Cod's egg eight hours after impregnation, the germinal disk undergoing division into two halves, viewed from below; oblique illumination. $\times 30$.
- FIG. 10.** Germinal disk of cod's egg nine and a half hours after impregnation, showing the completion of the second cleavage through its longest diameter dividing each of the first two cells of the preceding figure, resulting in four new ones. The nuclei and granular contents of the cells shine through in this and the foregoing figure. Oblique illumination. $\times 30$.
- FIG. 11.** Cod's egg twenty-three hours after impregnation; the disk is shown at lower side of the yolk, viewed from the side. $\times 30$.
- FIG. 12.** The germinal disk of the preceding, viewed from below, showing fourteen cells, the products of further cleavages. $\times 30$.
- FIG. 13.** Cod's egg forty-five and a half hours after impregnation, in optic section, showing still further progress in the cleavage of the disk, as a result of which about three superimposed layers of cells have been formed. $\times 50$.
- FIG. 14.** Cod's egg four days after impregnation, showing a still further advance in cleavage, through which a multicellular disk (morula) has arisen, which is very strongly convex on the inner side towards the yolk. $\times 50$.

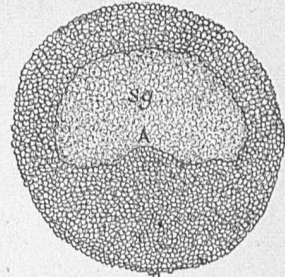


EXPLANATION OF PLATE III.

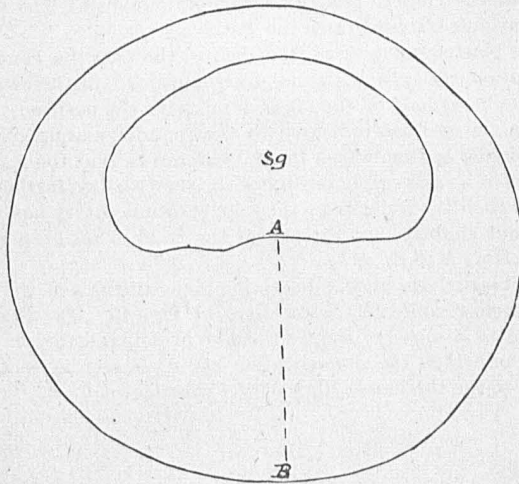
- FIG. 15.** Cod's egg seven days after impregnation, with the concave blastoderm fully formed, and viewed from the side in optic section, and beginning to spread laterally over the yolk; a segmentation cavity *sg* has been developed, and the epiblast and hypoblast may be plainly distinguished in the right-hand portion extending from A to B, the extremities of the axis of the embryo lying in the embryonic disk. The floor of the segmentation cavity is drawn too distinctly. $\times 50$.
- FIG. 16.** The same blastoderm viewed from below, showing the contour of the segmentation cavity *sg*, with the embryonic disk lying below it, and embracing the lower half of the blastoderm, with the position of the head end of the embryo fish indicated by the rounded margin of a cellular area just below A, from which its axis extends to B at the margin. $\times 50$.
- FIG. 17.** Blastoderm of a cod's egg in outline of the seventh day, further advanced and larger than the foregoing; the segmentation cavity has altered its contour but slightly, but the axis of the embryo has been somewhat elongated from A to B. $\times 55$.
- FIG. 18.** The same blastoderm viewed in section along the axis of the embryo, showing greater concavity below than in Fig. 15. The thickened portion from A to B clearly displays the two principal embryonic layers, to the right of which the segmentation cavity is seen in section, extending down to the thickened rim *r* of the blastoderm. $\times 55$.



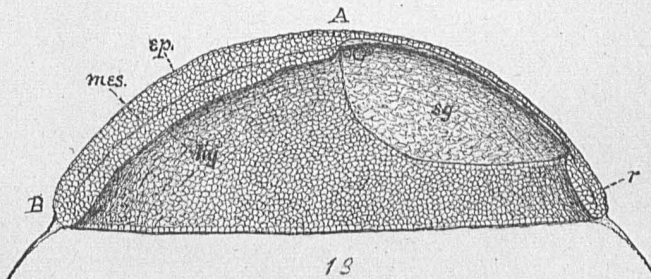
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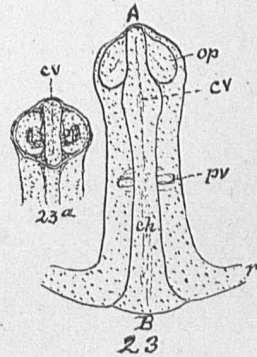
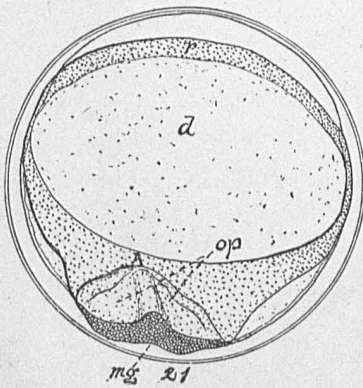
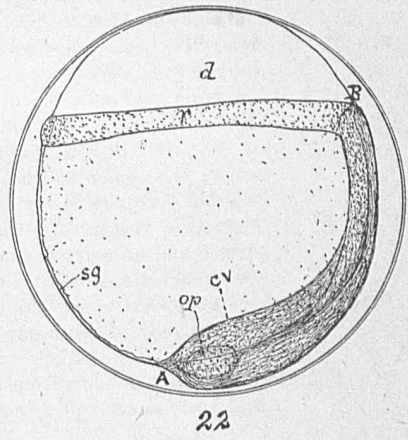
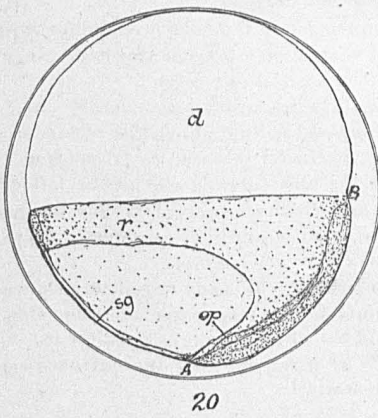
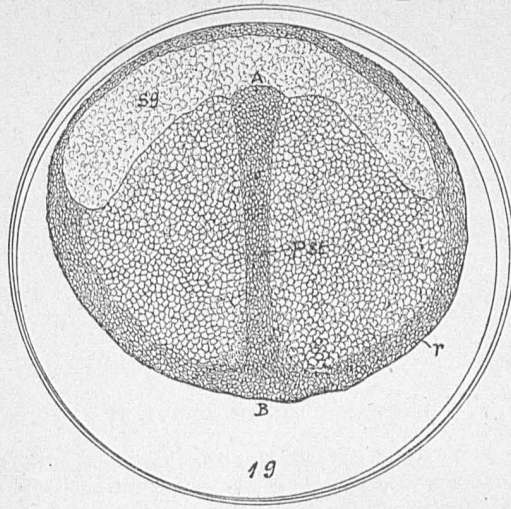
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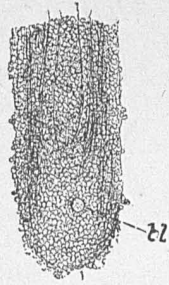
EXPLANATION OF PLATE IV.

- FIG. 19. *Cod's* egg on the eighth day, showing the appearance of the neural or medullary plate *p. st*, the contour of the segmentation cavity *sg*, and the blastodermic rim *r* continuous with the embryo, viewed from below. x 57.
- FIG. 20. *Cod's* egg on the ninth day after impregnation, showing the embryo from the side, the head being already defined as a well-marked thickening to the right of *A*, with indications of the optic vesicles. x 30.
- FIG. 21. Embryo of the same age, viewed obliquely, with the head directed forwards; the cerebral structures forming, with indications of the beginnings of the optic vesicles at the sides of the head at *op*. x 30.
- FIG. 22. Embryo ten days old; the blastoderm has grown very considerably, and all of the yolk which now remains exposed is that above the blastodermic rim *r*; the lumen of the segmentation cavity is seen to extend from the head at *A* to the lower edge of the blastodermic rim at the left side. The optic vesicles are defined, and the first cerebral vesicle has been formed and become very much flattened laterally or compressed, so that its "keel" dips down into the yolk very considerably.
- FIG. 23. Embryo somewhat older than the preceding (the body only being shown); the first pair of muscular segments *pv* have appeared on either side of the neural or medullary canal and the chorda dorsalis *oh* below it.
- FIG. 23 a. The head of the same from directly in front, showing the flattened cerebral vesicles and optic vesicles in section.

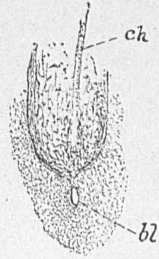


EXPLANATION OF PLATE V.

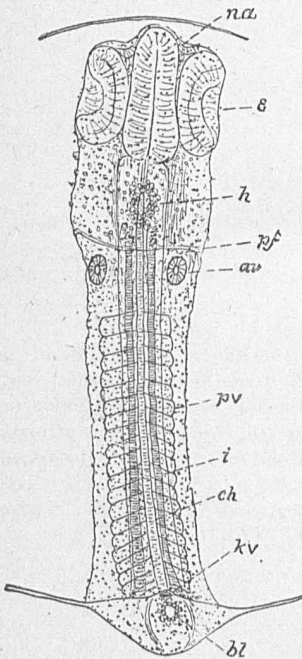
- FIG. 24.** Tail of embryo cod on the thirteenth day, viewed from below, showing the position of the yolk blastopore *bl*. x 55.
- FIG. 25.** The same seen somewhat obliquely from the side, with the chorda dorsalis shining through.
- FIG. 26.** Embryo cod fourteen days old, seen from below. x 55.
- FIG. 27.** Head of an embryo eleven days old, viewed from above, nearly as far advanced as Fig. 26, in optic section, showing the structure of the head. x 150.
- FIG. 28.** Head of embryo seventeen days old, from the side, showing the lumen of the heart *h*, the nasal and auditory vesicles, the vesicles of the primary divisions of the brain, lateral longitudinal fold *ff* of the right side, which develops into the pectoral or breast fin.
- FIG. 28 a.** Tail of an embryo cod, looking nearly at its end, showing the blastopore *bl* and the lumen of Kupffer's vesicle *kv*. x 55.



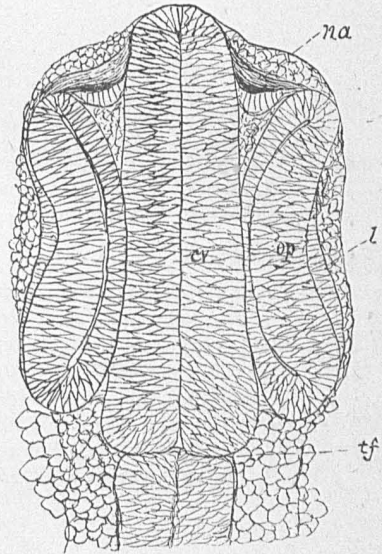
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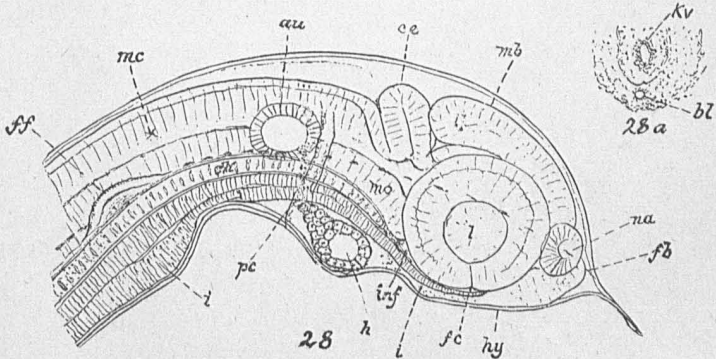
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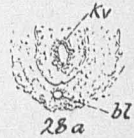
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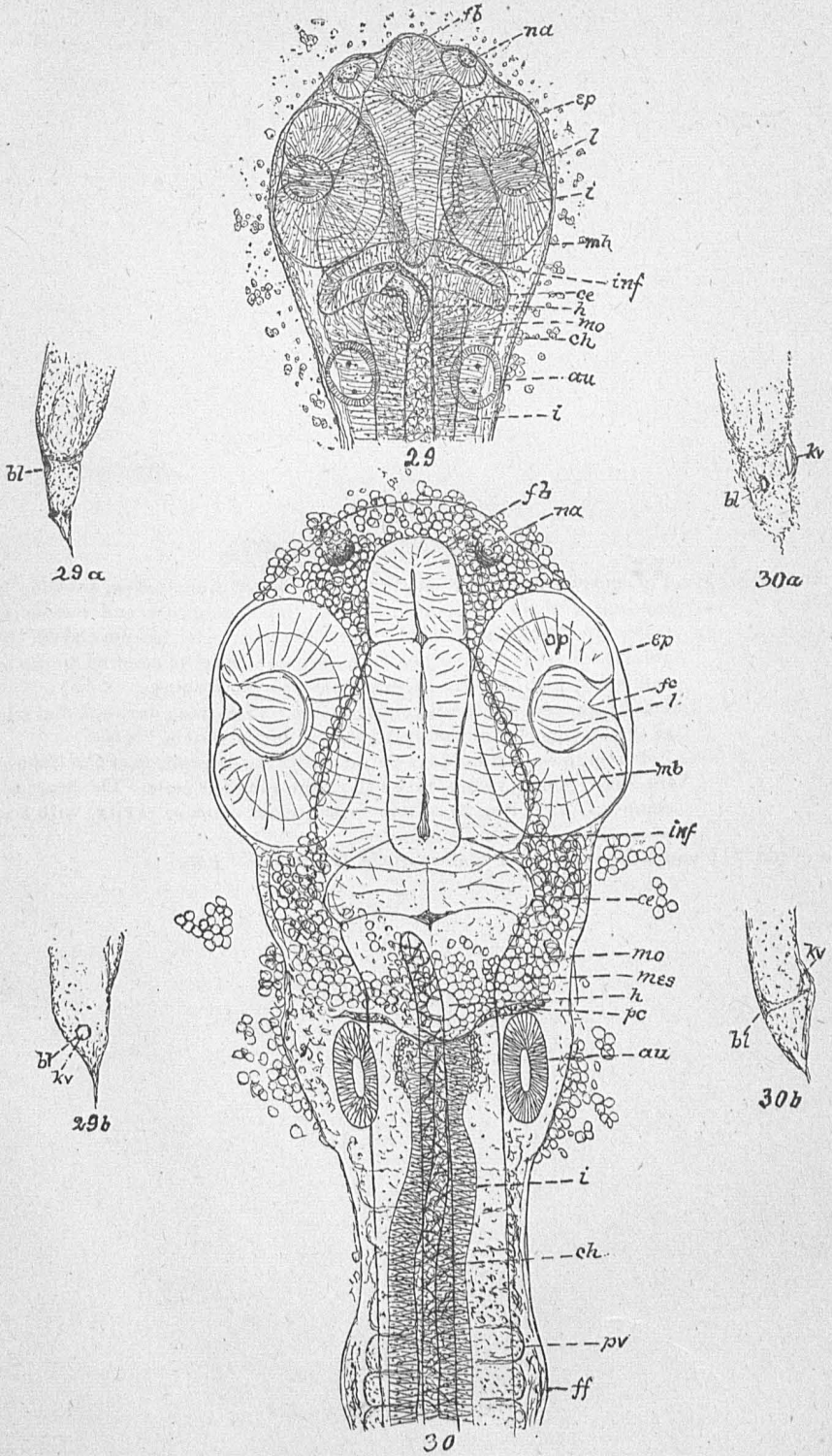
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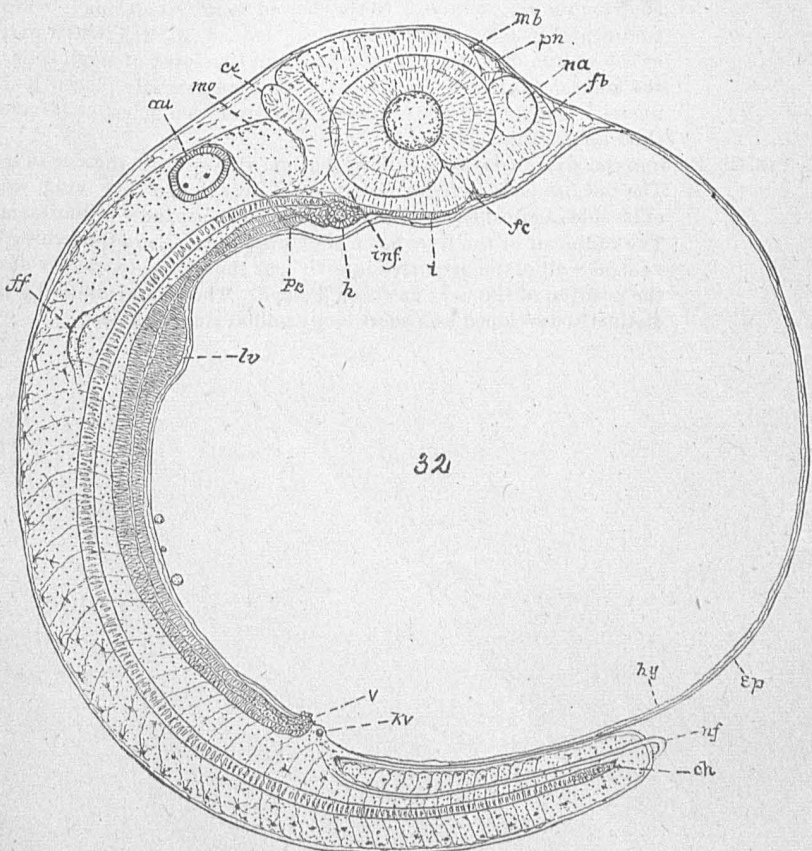
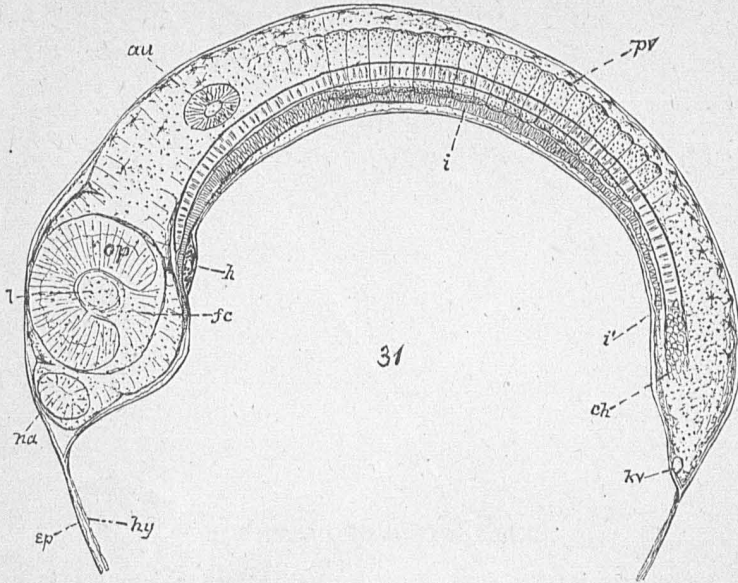
EXPLANATION OF PLATE VI.

- FIG. 29. Head of embryo cod seventeen days old, viewed from below, showing the cerebral vesicles differentiated, and the hypoblastic and mesodermal tracts of cells *t*, from which the trabeculæ cranii, etc., are developed. The anterior dilated extremity of the embryonic heart is bending to the left, and is destined to become the auricle and venous sinus. x 55.
- FIGS. 29 *a* and 29 *b* represent the caudal ends of embryos thirteen days old, and relate to the history of the blastopore and Kupffer's vesicle. x 55.
- FIG. 30. Head of embryo cod fifteen days old, showing the disposition of the tissues in the head region, indicated by the large rounded cells. The heart *h*, as compared with Fig. 29, is a mere spherical sinus or cavity, with a wall of mesodermal cells. x 65.
- FIGS. 30 *a* and 30 *b* relate to the history of the blastopore. x 55.



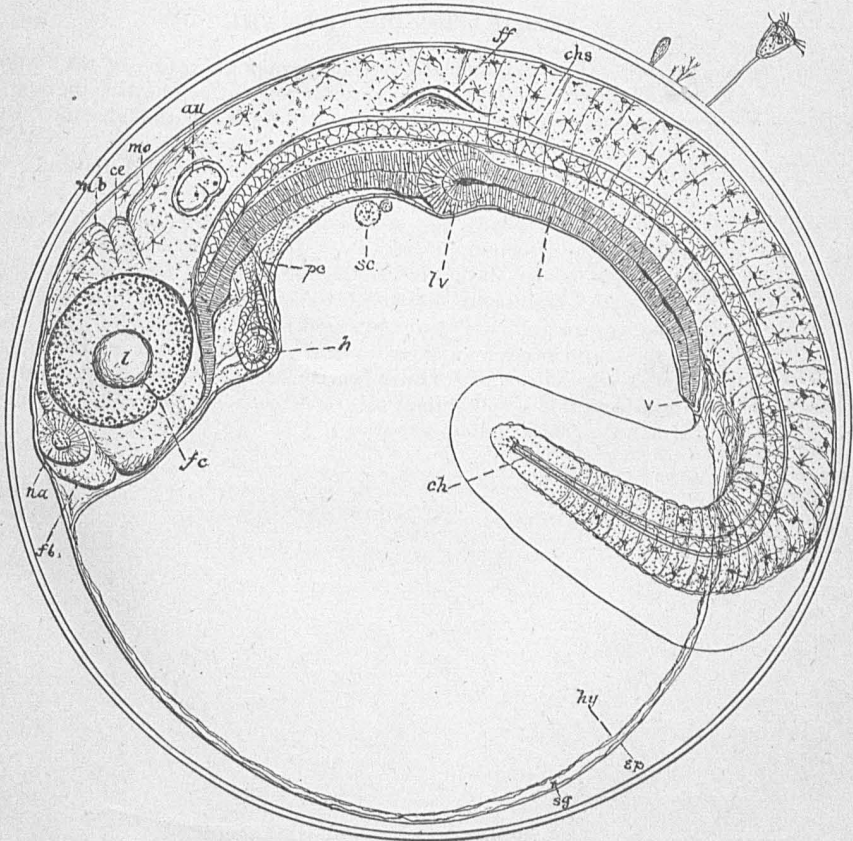
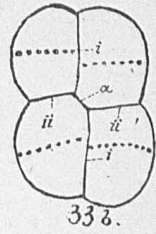
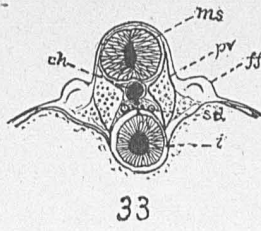
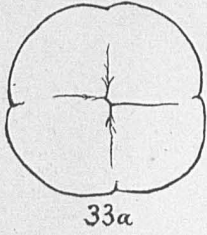
EXPLANATION OF PLATE VII.

- FIG. 31. Embryo cod fourteen days after impregnation, seen from the side in section, showing the optic cup *op*, with the choroid fissure *fo* entering it below. The rudimental intestine is already clearly defined, and the hinder extremity of the chorda dorsalis *ch* is enlarged, and composed of small cells, while the anterior portion is hyaline, inclosing transversely placed lenticular nuclei. Kupffer's vesicle is present, and stellate pigment cells have made their appearance. x 55.
- FIG. 32. Embryo cod sixteen days after impregnation, viewed from the side in section. The tail has become free and is twisted over to one side, lying with one of its sides against the yolk and the other against the vitelline membrane. The rudiment of the liver has made its appearance as a thickening of the ventral wall of the primitive intestine, at the hinder extremity of which the position of the vent has been defined. The lateral fin-fold *f* is now distinctly developed as a short longitudinal ridge. x 55.



EXPLANATION OF PLATE VIII.

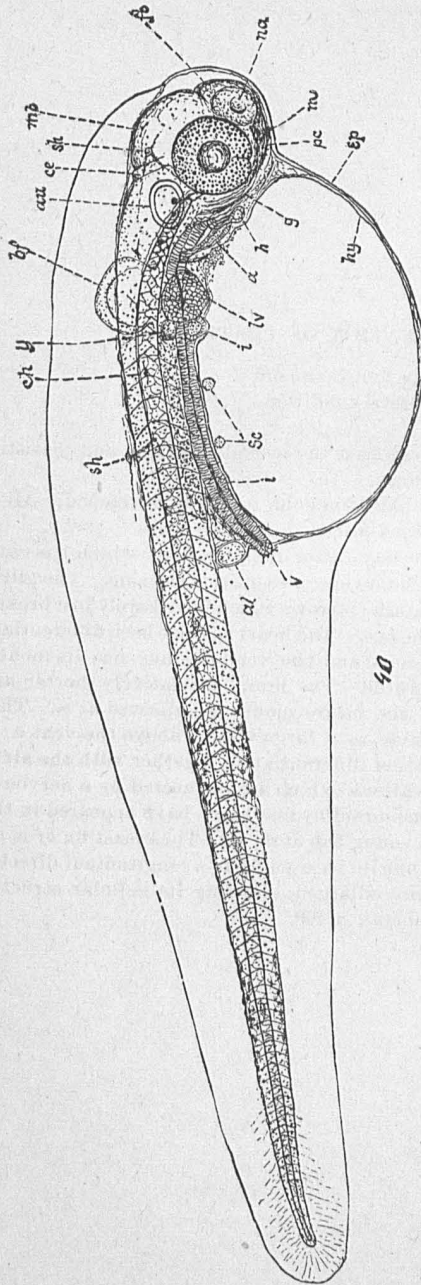
- FIG. 33. Transverse optical diagrammatic section through the region of the fin-folds of an embryo cod eighteen days after impregnation, showing the relation of the spinal chord *ms* to the chorda dorsalis *ch* and the intestine *i*, with the muscle plates *pr* and segmental ducts *sd* on either side. x 55.
- FIG. 33 *a*. Germinal disk of cod's egg divided into four segments, and showing dislocation of the second cleavage furrow. x 32.
- FIG. 33 *b*. Germinal disk of shad's egg of two hours, divided like the preceding, and with the second and third cleavage furrows dislocated. x 18.
- FIG. 34. Embryo cod nineteen days after impregnation. The liver, heart, tail, fin-fold, brain, and intestine have made important progress. The heart now pulsates regularly, but there are as yet no blood corpuscles. The eye is beginning to develop an outer layer of pigment, the lamina fusca. The muscle segments or plates have become more numerous. At the upper right-hand side a bell-animalcule, some monads, and an alga are shown attached to the vitelline membrane. x 55.



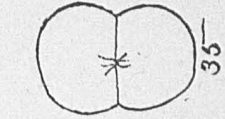
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EXPLANATION OF PLATE IX.

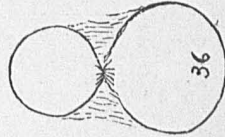
- FIG. 35. Germinal disk of cod's egg four hours old.
- FIG. 36. A similar disk in an abnormal condition.
- FIG. 37. Another abnormal form.
- FIG. 38. Germinal disk of cod's egg past the second cleavage, and consisting of four cells; an abnormal form.
- FIG. 39. A similar disk six and a half hours old, normally developed. All of the five preceding figures are magnified thirty-two times.
- FIG. 40. Embryo cod twenty-two days after impregnation, which has escaped from the egg twenty-four hours since, seen from the side. The gill clefts now show distinctly as parallel furrows which have barely just broken through behind and below the eye. The heart has also been differentiated into its four principal divisions, and the venous sinus has its mouth directed upwards and backwards. The brain is relatively shorter and deeper, and the position of the future mouth is indicated at *m*. The allantois *al* is now clearly visible as a large vesicle above the vent *v*. The liver *lv* has been still further differentiated, together with the air bladder *y*. Lateral sensory elevations, which are connected by a nervous thread to the spinal cord, surmounted by fine hairs, have appeared in the epiblast or epithelium of the young fish at *sh, sh*. The breast fin *bf* is now nearly circular in outline, but its base still has a longitudinal direction. $\times 40$.
- FIG. 41. Heart of the above, more enlarged, showing its cellular structure and its four principal chambers. $\times 100$.



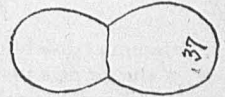
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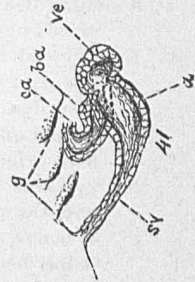
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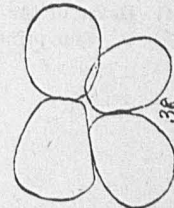
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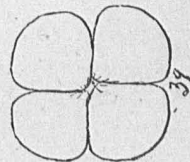
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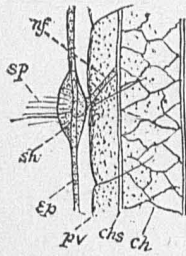
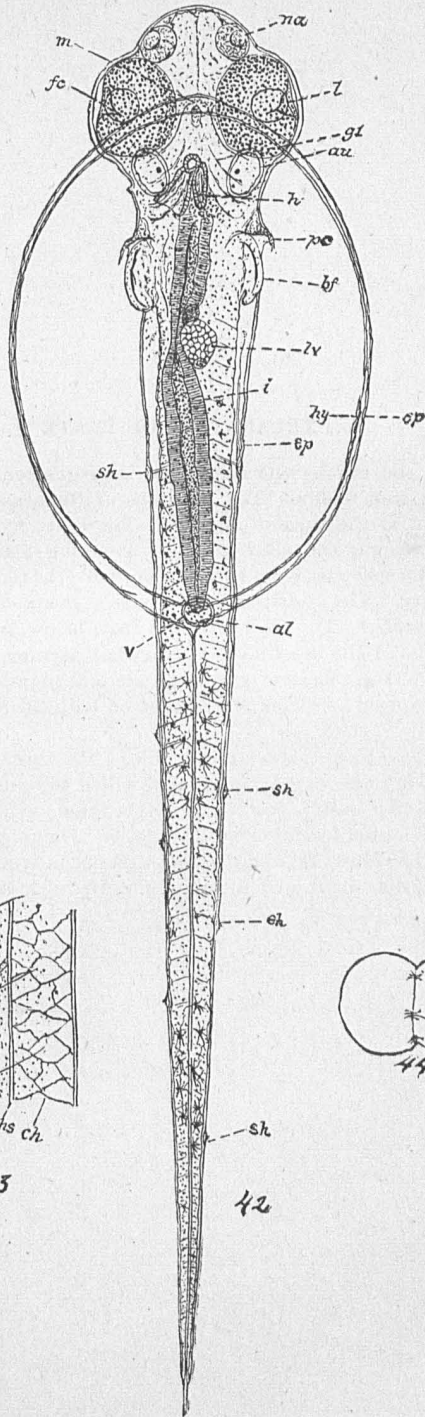
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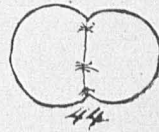
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EXPLANATION OF PLATE X.

- FIG. 42. Embryo cod twenty-one days after impregnation, one day out of the egg, seen from below. The positions of the sensory elevations *sh* are indicated at the sides of the tail. The inner hypoblastic covering of the yolk *hy* and the outer epiblastic covering *ep* are shown in optic section, with a space between them all around—the remains of the segmentation cavity. The position of the mouth *m* is indicated as well as that of the gill arches *g* 1. The heart, seen from below, is bent upon itself, and the course of the intestine *i* is somewhat asymmetrical. The vent lies just below the allantoic sac. The stellate pigment cells have aggregated in two patches behind the vent on both the ventral and dorsal sides of the tail. x 45.
- FIG. 43. One of the lateral sensory elevations of the preceding specimen in section showing the nerve filament *nf*, which joins it to the spinal cord. The elevation itself is seen to be only a thickened portion of the epiblast *ep*, surmounted by sensory filaments *sp*. The relations of the muscle plates *pr*, the chorda *ch*, and its sheath *chs* are also shown. x 120.
- FIG. 44. Germinal disk in the condition of the first cleavage of cod's egg four hours old. x 32.



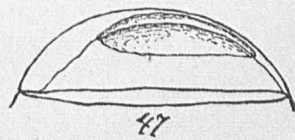
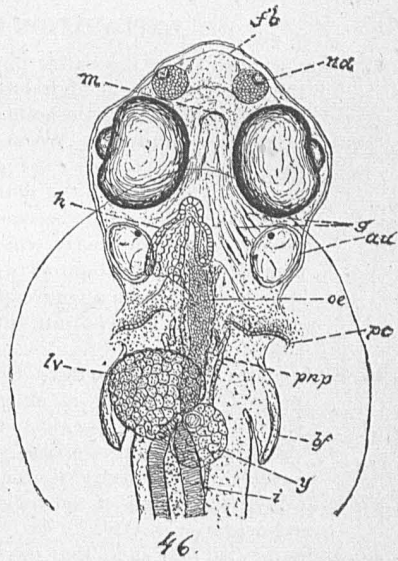
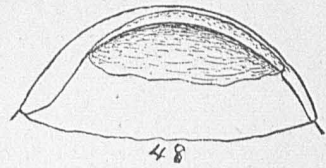
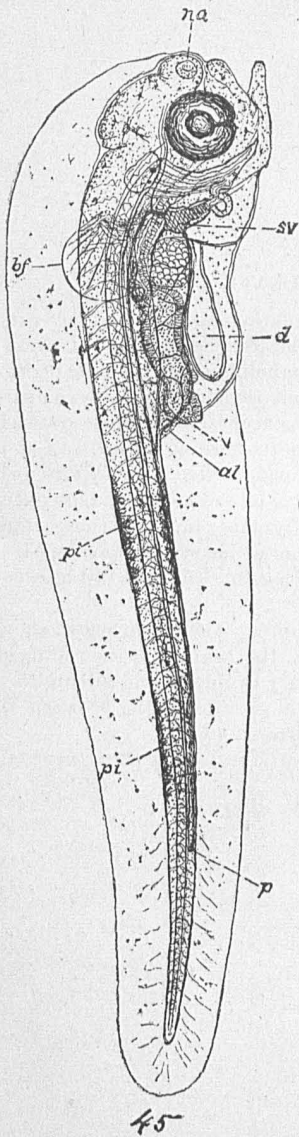
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EXPLANATION OF PLATE XI.

- FIG. 45.** Young codfish thirty days after impregnation and ten days after it has left the egg, showing the high dorsal natatory membrane or median fin-fold, of the forward part of the animal reminding one of the form of the dolphin of ancient sculptures. We note but little difference as compared with the younger stage, shown in Fig. 49, except that the blood system has been more fully developed, the dorsal aorta turning upon itself at *p* on the underside of the tail, to become the caudal vein, which splits up into cardinal branches anteriorly, which give off vessels which pass over the viscera in front of the allantois to finally empty into the venous sinus. At no time has there been a true omphalomeseraic system developed, since the heart does not even pulsate until some time after the tail begins to form. $\times 25$.
- FIG. 46.** Embryo cod twenty-three days after impregnation, from below, showing the pectoral folds *pf*, the oesophagus *o*, the heart, and the rudimentary gill clefts *g*. The mouth *m*, the maxillary hyoidean, and gill arches are indicated, while the pericardiac septum *pc*, intervening between the heart space and body cavity, is also shown. $\times 40$.
- FIG. 47.** Four days' blastoderm of cod's egg in optic section, to show the extent of the segmentation cavity. $\times 32$.
- FIG. 48.** A similar disk four and a half days old. $\times 32$.



EXPLANATION OF PLATE XII.

FIG. 49. Head of embryo cod on the twenty-seventh day after impregnation and one week after hatching, seen from the side. The breast fin has assumed a nearly vertical position. Meckel's cartilage forms the skeletal basis of the lower jaw, and the palatopterygoid cartilage and quadrate constitute the major portion of the sides of the upper jaw. The tongue *t* is supported by a glosso-hyal, followed by other hyal cartilages, to which are attached the curved cartilaginous rods which support the gills *g*. The mouth is now wide open, and the young fish snaps its jaws vigorously. The circulation has been established; a dorsal aorta and caudal vein now traverse the mesoblastic tissue *mes* below the chorda, and the blood corpuscles have acquired a reddish tinge. The yolk-sack *d* is being gradually emptied of its contained deutoplasm. The splanchnopleural covering of the forepart of the yolk-sack has been pushed upwards, and now forms the hinder wall of the pericardiac cavity *cc*. The liver *lv* is more distinctly developed than formerly, and occupies a lower position in the visceral cavity above it, and dorsad of the structure *y* has increased in size, and appears to represent the dorsad portion of the rudimentary liver, while in front of it lies the air-bladder proper, covered with pigment cells. In front of the air-bladder again a convoluted tubular organ *pn* may be distinguished, the pronephros. The allantois *al* has undergone little advancement, but the intestine can now be divided into three regions: that of the gullet from *a* to the liver, the mid-gut region from the liver to the constriction *ic*, and the hind-gut from *ic* to *v*. The auditory vesicle *au* has undergone further development, inasmuch as the semicircular canals are defined, the ingrowing ridges from the walls of the primitive vesicle having met and divided the cavity into the rudimentary ampullæ and canals, while the otoliths asterisk *as* and sagitta *s* are seen in place. The dermal sensory elevations *sh* are seen to have filamentous prolongations backwards and forwards which will probably connect them into a continuous lateral series, the rudiment of the lateral line system of the adult. The complicated stellate pigment cells *pi* have aggregated together in definite tracts on the tail and over the endothelium (peritoneum) of the visceral cavity. $\times 85$.

