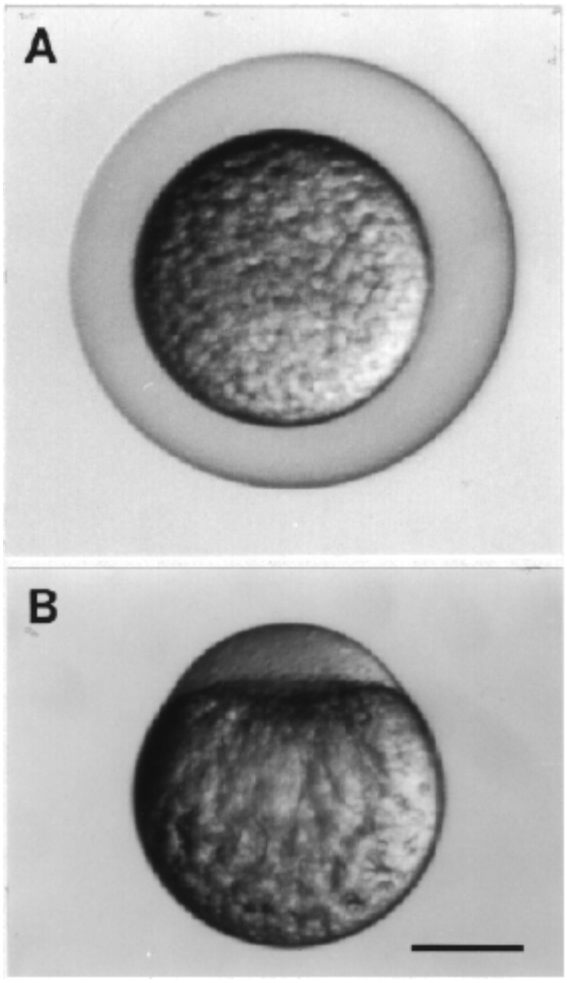

A: The zygote within its uplifted chorion, a few minutes after fertilization. **B**. The dechorionated zygote with the animal pole to the top, about 10 min after fertilization. Yolk-free cytoplasm has begun to segregate to the animal pole. Scale bar: 250 μm.

Fig. 4. Embryos during the cleavage period. Face views, except for **B**, which shows the embryo twisted about the animal-vegetal axis, roughly 45 degrees from the face view. **A**: 2-cell stage (0.75 h). **B**: 4-cell stage (1 h). **C**. 8-cell stage (1.25 h). **D**: 16-cell stage (1.5 h). **E**: 32-cell stage (1.75 h). **F**. 64-cell stage (2 h). Scale bar: 250 µm.

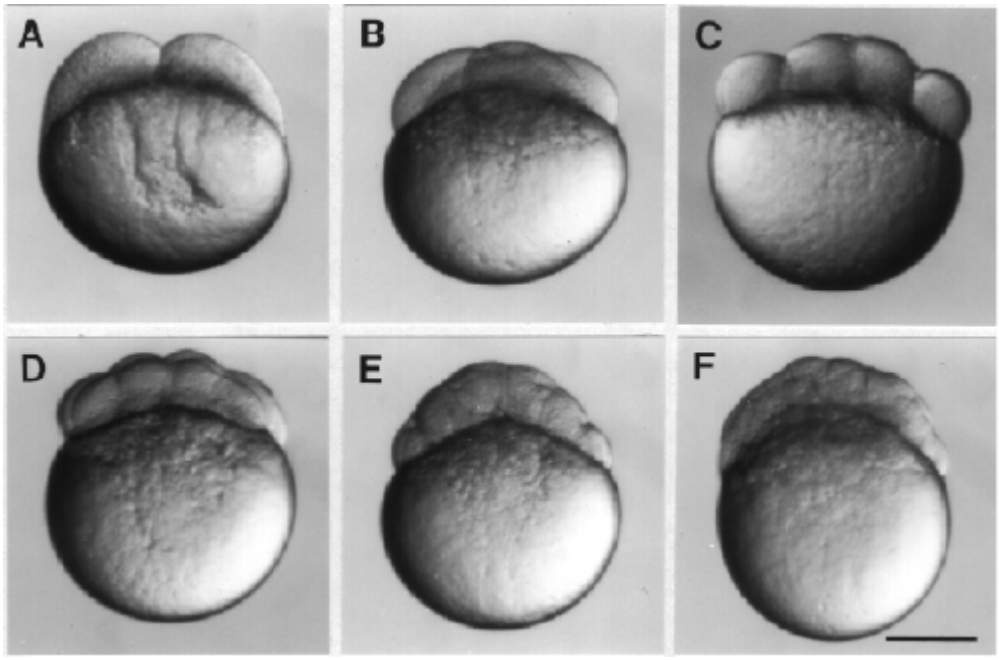

Fig. 8. Face views of embryos during the blastula period. **A**: 256-cell stage (2.5 h). **B**: high stage (3.3 h). **C**. transition between the high and oblong stages (3.5 h). **D**. transition between the oblong and sphere stages (3.8 h). **E**: dome stage (4.3 h). **F**. 30%-epiboly stage (4.7 h). Scale bar: 250 µm.

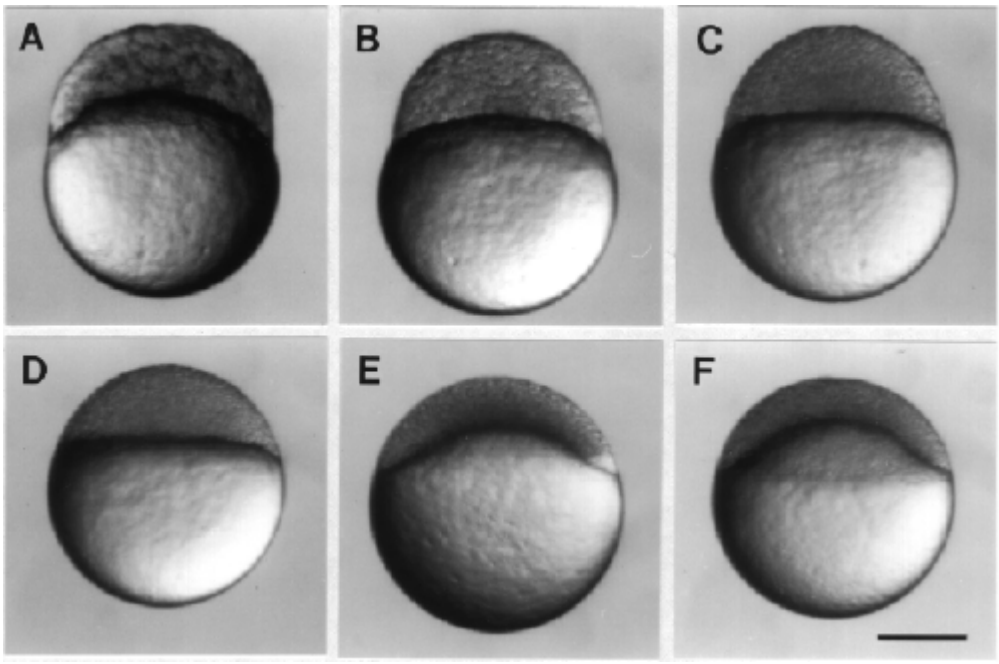

Fig. 11. Development during the gastrula period. Left side views, except where noted, with anterior up and dorsal to the left. **A**: 50%-epiboly stage (5.25 h). **B**. Germ ring stage (5.7 h). **C**. Animal pole view of the germ ring stage; the arrow indicates the germ ring; the embryonic shield will probably developed from the flattened region of the ring at the lower right. **D**: Shield stage (6 h). The embryonic shield, marking the dorsal side is visible as a thickening of the germ ring to the left. **E**: Animal pole view of the shield stage; the arrow indicates the embryonic shield. **F**: 70%-epiboly stage (7.7 h). The dorsal side of the blastoderm, to the left, is thicker than the ventral side, to the right. The anterior axial hypoblast, or prechordal plate, (arrow) extends nearly to the animal pole. **G**: 70%-epiboly stage, ventral view, but tipped slightly forwards anteriorly to reveal the now well delineated axial hypoblast (arrow) of the prechordal plate. **H**: 75%-epiboly stage (8 h). The arrow indicates the thin evacuation zone on the ventral side. **I**: 80%-epiboly stage (8.4 h), dorsal view. The arrows indicate the boundaries between axial mesoderm in the midline, and the paraxial mesoderm flanking to either side. **J**: 90%-epiboly stage (9 h). The tail bud (arrow) becomes visible in some embryos at this stage. **K**: 90%-epiboly stage, ventral view. The anterior prechordal plate (compare with G) enlarges as the polster. **L**: Bud stage (10 h). The arrow shows the polster, and the arrowhead shows the tail bud. A distinctive region just ventral to the tail bud (i.e. just to the left in this view) shows where the yolk disappears as epiboly ends. Scale bar: 250 µm.

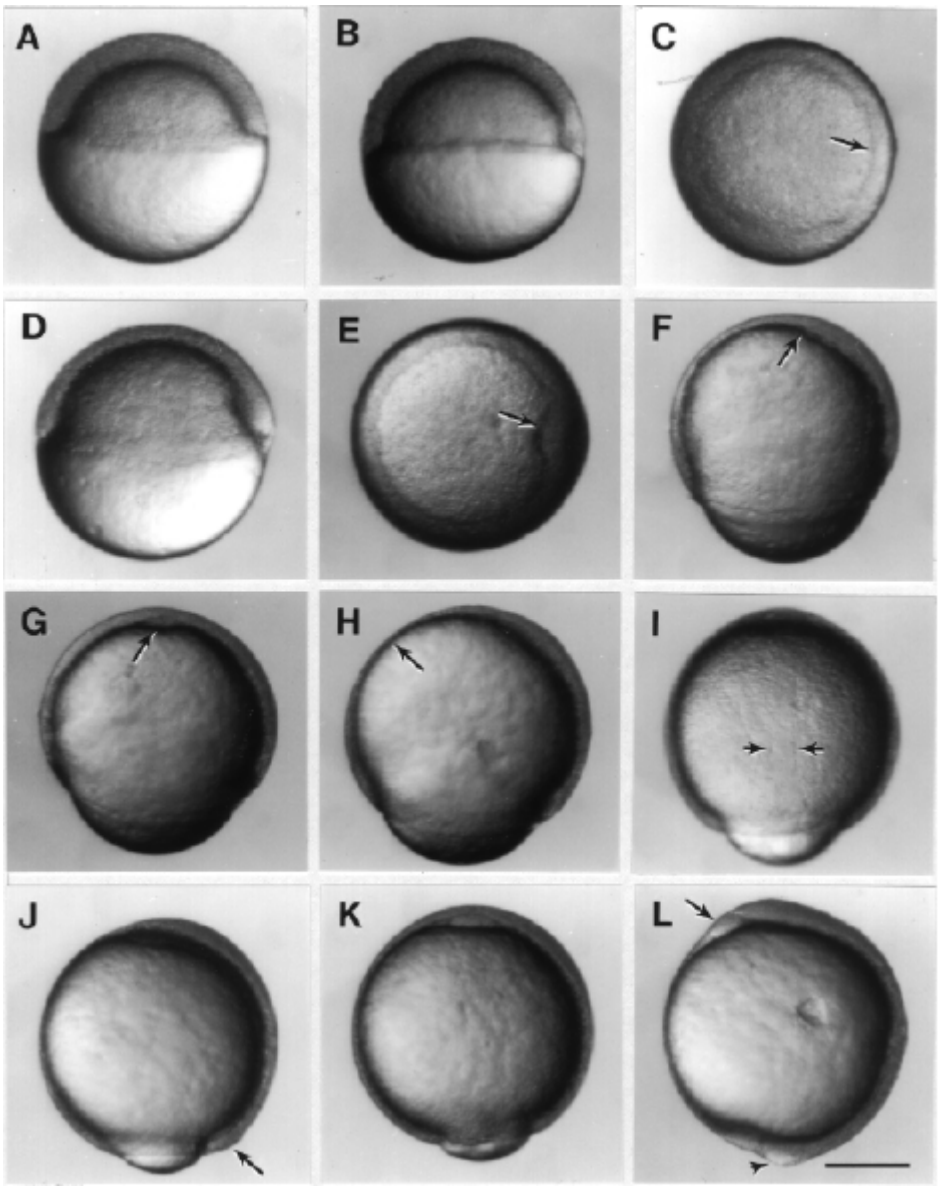

Fig. 15. Development during the segmentation period. Left side views, except where noted, with anterior up and dorsal to the left. **A**: 2-somite stage (10.7 h). Somite 2 is the only one entirely pinched off at this time, the arrow indicates its posterior boundary; somite 1 is just developing a clear anterior boundary at this stage. **B**: 2-somite stage, dorsal view. The notochord rudiment shows between the arrows, just anterior to the level of somite 1. **C**: 2-somite stage, ventral view. The arrow indicates the polster. **D**: 4-somite stage (11.3 h). Somite 1 now has an anterior boundary. The optic primordium begins to show (arrow). **E**: 4-somite stage, dorsal view, focus is on the notochord at the level of the boundary between somites 2 and 3. Note at the top how the brain rudiment and underlying axial mesoderm prominently indent the yolk cell in the midline. **F**: 5-somite stage (11.7 h), ventral view, focus is on the newly forming Kupffer's vesicle (arrow). **G**: 8-somite stage (13 h). The optic primordium has a prominent horizontal crease (arrow). The midbrain rudiment lies just dorsal and posterior to optic primordium. The segmental plate, developing paraxial mesoderm posterior to the somite row, is clearly delineated. **H**: 13-somite stage (15.5 h). Somites begin to take on a chevron shape. The yolk cell begins to look like a kidney-bean, heralding formation of the yolk extension. The tail bud becomes more prominent and Kupffer's vesicle shows from the side (arrow). **I**: 14-somite stage (16 h), dorsal view, and positioned so that the first somite pair is at the center. Note at the top the shape of the brain primordium, at the level of the midbrain. **J**: 15-somite stage (16.5 h). The arrow shows Kupffer's vesicle. **K**:

15-somite stage from a dorsal-view to show the optic primordia. Kupffer's vesicle is also nearly in focus. **L**: 17-somite stage (17.5 h). The otic placode begins to hollow. The yolk extension is now clearly delimited from the yolk ball as the tail straightens out. **M**: 20-somite stage (19 h). The arrow indicates the otic vesicle. **N**: 25-somite stage (21.5 h). The telencephalon is prominent dorsally, at the anterior end of the neuraxis. **O**: 25-somite stage, dorsal view. The hindbrain's fourth ventricle shows at the top. Scale bars: 250 µm.

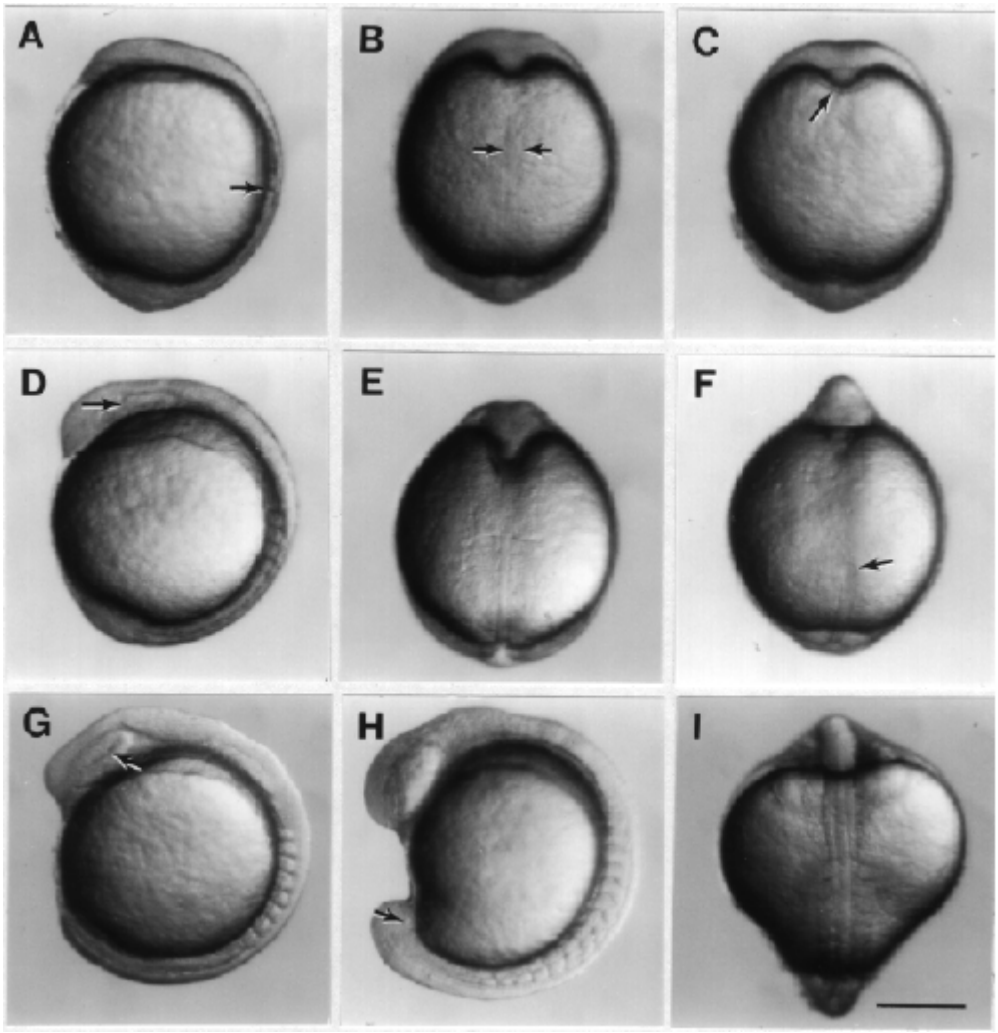

Figure 15A-I

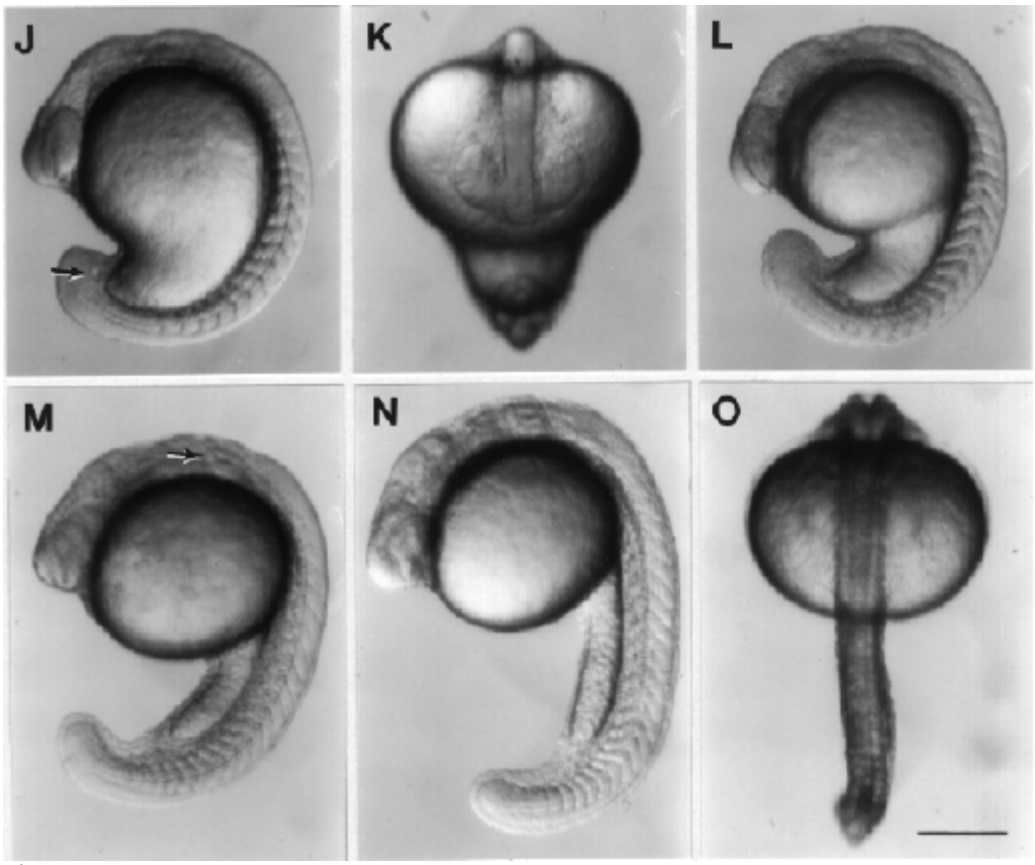

Figure 15J-O

Fig. 29. Development during the pharyngula period. Left side and dorsal views (except for the prim-5 stage) of the same embryat the given stage. **A**: Left side view at the prim-5 stage (24 h). The brain is prominently sculptured (see Fig. 23 for a key tthe brain subdivisions). Melanogenesis has begun, but is not yet evident at this low magnification. **B, C**: The prim-12 stage (28 h). Melanophores extend from the level of the hindbrain tabout the middle of the yolk ball. **D, E**: The prim-20 stage (33 h). A few pigment cells are now present along the axis dorsal tthe yolk extension and on the dorsal part of the yolk ball. **F, G**: The prim-25 stage (36 h). Pigment extents almost to the end of the tail. The arrow in F indicates the ventral horn of melanophores. **H, I:** The high-pec stage (42 h). Pigment now extends the whole length of the embryo. The dorsal and ventral pigment body stripes are filled in, but not so neatly as they will be later. The lateral stripe is not yet evident. Scale bars: 250 µm.

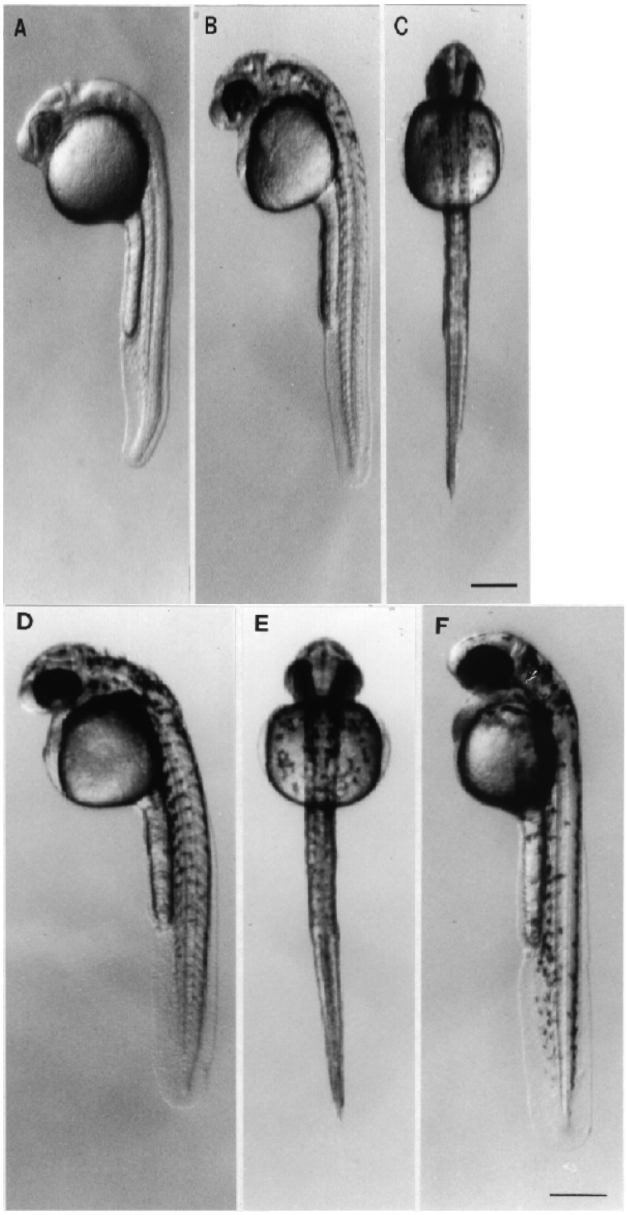

Figure 29 A-F

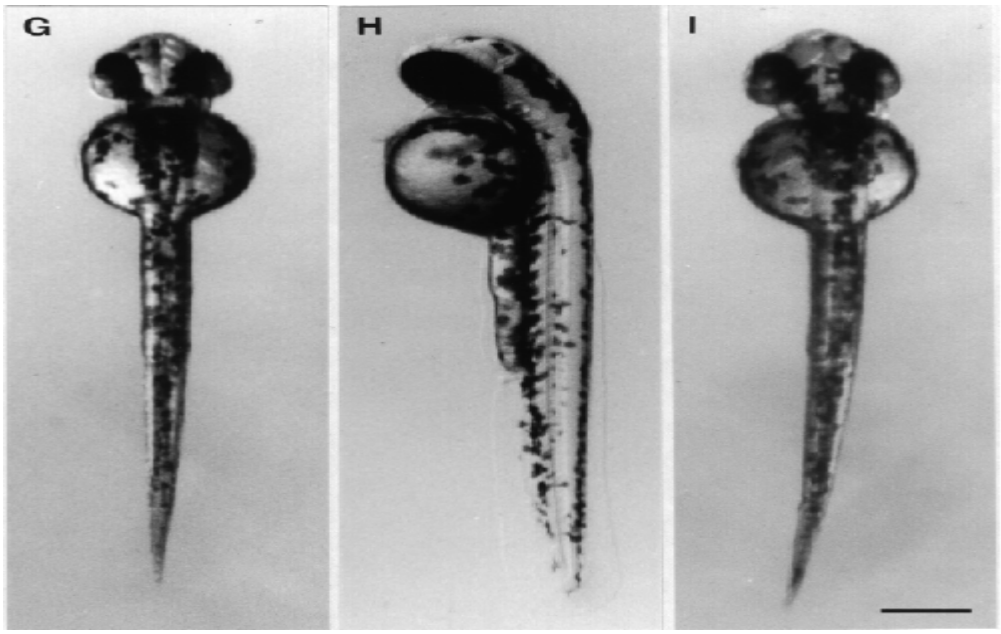

Figure 29 G-I

Fig. 39. Development during the hatching period of embryogenesis (A-F), and the early larva (G, H). Left side and dorsal views of the same embryo are paired for each time point. **A, B**: Long-pec stage (48 h). **C, D**: Pec-fin stage (60 h). **E, F**: Protruding-mouth stage (72 h). Note the progressive increase dorsally in yellow pigmentation due to xanthophore development, and the progressive filling of melanophores into the lateral stripe. **G, H**: The early larva (120 h) is photographed with a combination of transmitted and incident illumination, the latter revealing reflective iridophores. The swim bladder is inflated at this stage. Continued development of the lower jaw, protruding it more anteriorly, brings the lower and upper jaws close together in front of the eyes. Scale bars: 250 µm.

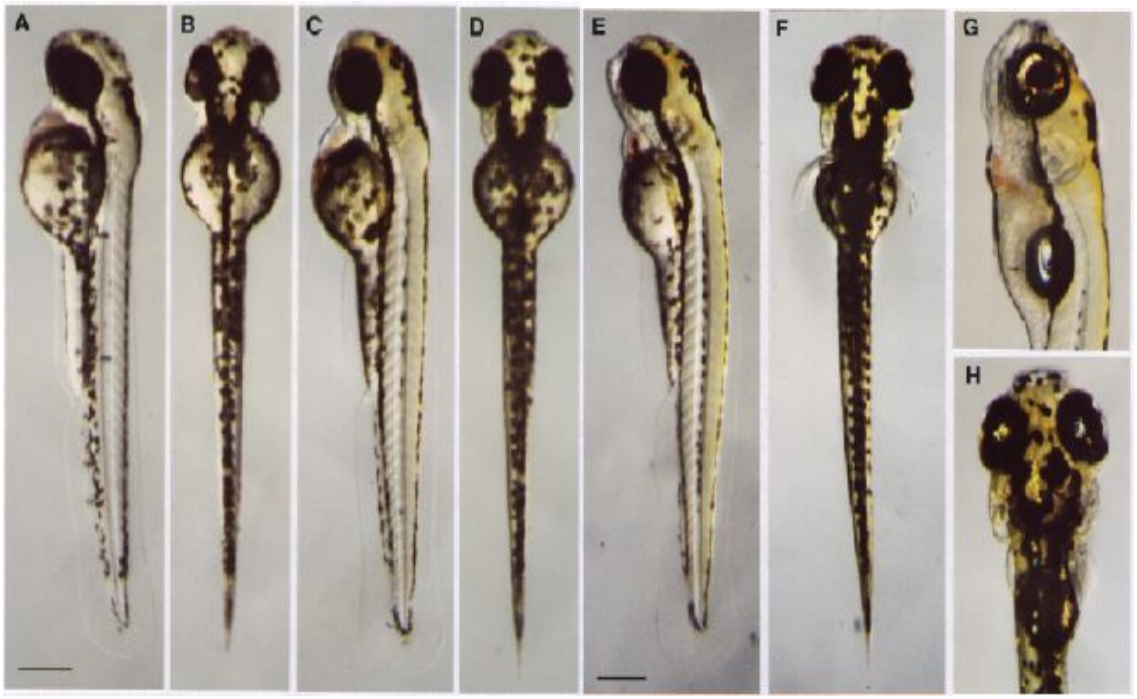

Figure 39A-H

Fig. 42. Branchial arches develop late in embryogenesis. Left side Nomarski views, dorsal to the top, anterior to the left, at the protruding-mouth stage (72 h). To avoid confusion, keep in mind that in fish (but not necessarily in tetrapod species that do not develop gills) branchial arch and pharyngeal arch numbering systems differ. By convention, branchial arch 1 is the same as pharyngeal arch 3 and contains ceratobranchial cartilage 1 and aortic arch 3. **A**: A superficial view of the four gill-bearing branchial arches (branchials 1-4) to show the clefts between them and developing buds of gill filaments (the arrowhead indicates a bud emerging from the posterior surface of branchial arch 2). The third aortic arch (3) is in focus within the first branchial arch. **B**: A deeper plane of focus reveals a gradient of cartilage development in branchial arches 1-3. To the left, branchial arch 1 includes a long stretch of differentiated cartilage (this cartilage being ceratobranchial 1). In the next arch, ceratobranchial 2 is less differentiated, and in branchial arch 3, to the right, the ceratobranchial is represented by only a row of precartilaginous mesenchymal cells. **C**: The posterior-most branchial does not follow the same gradient rule; ceratobranchial cartilage 5 (arrowhead), the last cartilage of the series, is further developed than the third or fourth ceratobranchials at the same stage. Aortic arches (numbered 4-6 in the figure) are in focus dorsally above the precartilage masses. The fifth branchial arch does not possess an aortic arch (that would be numbered aortic arch 7, were it to exist). Neither will the fifth branchial arch bear gills. Scale bar: 50 µm.

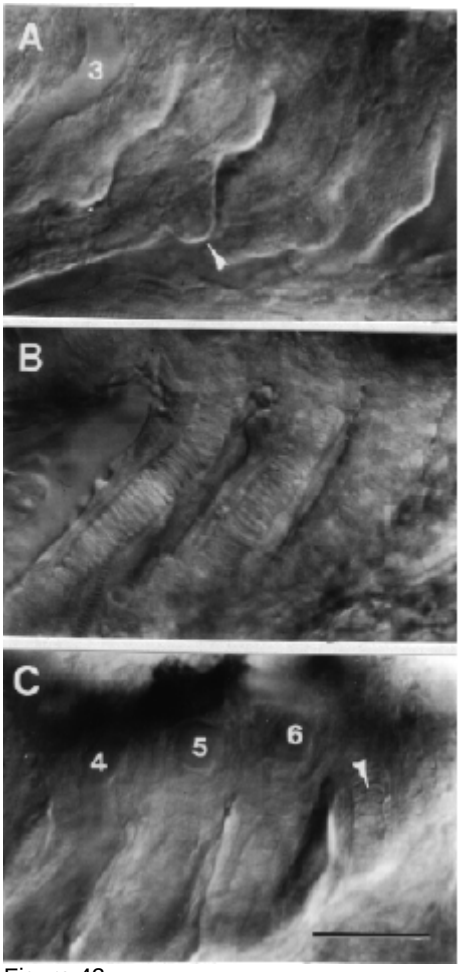

Figure 42