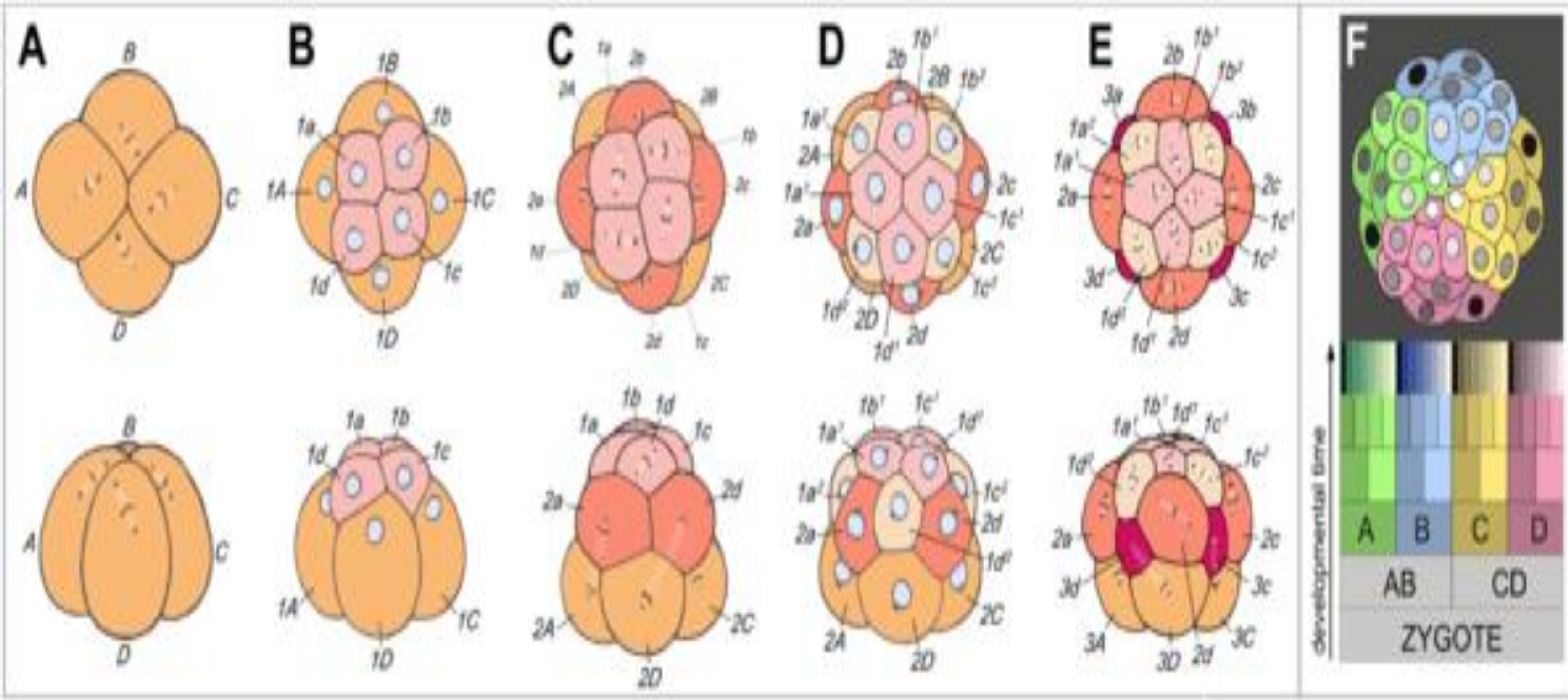
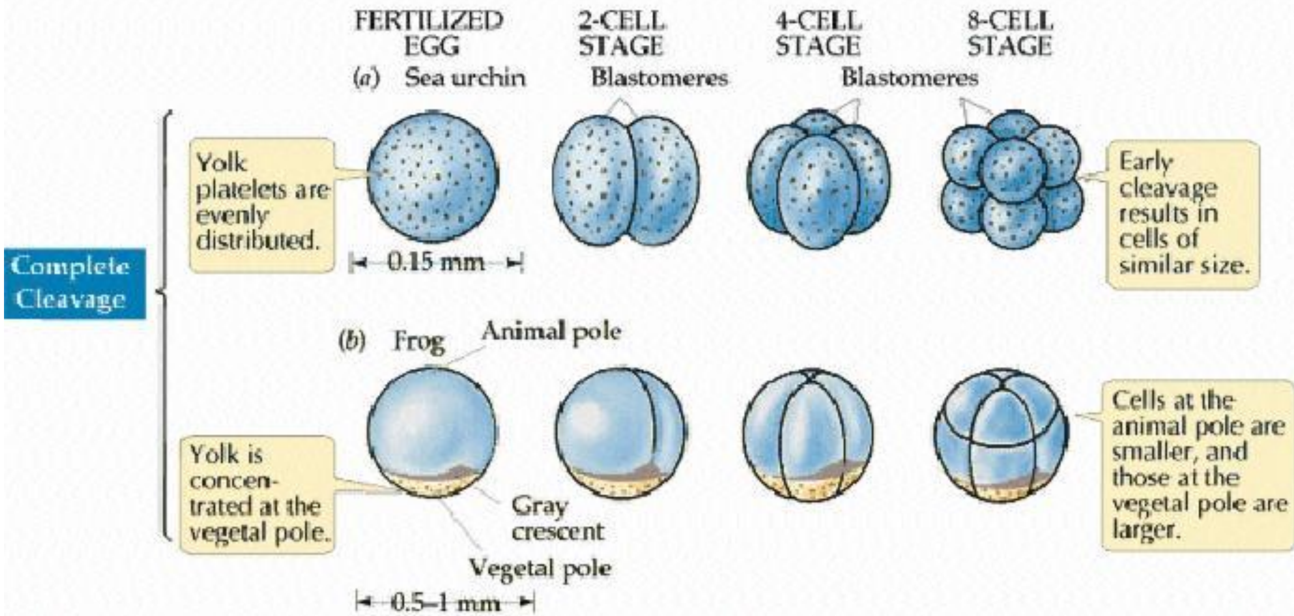
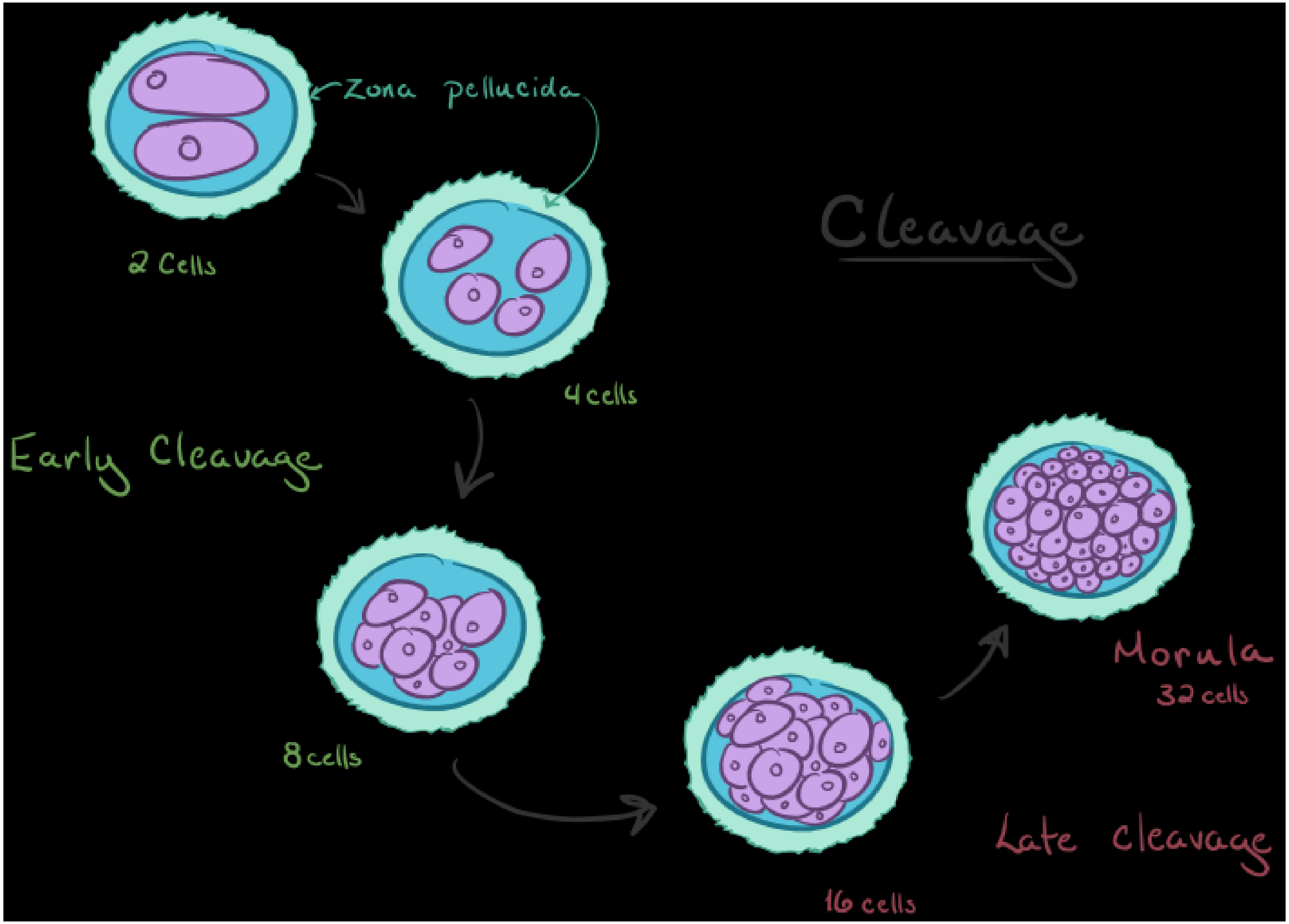


A
B
C
D
E
F
developmental time
A
B
C
D
AB
CD
ZYGOTE


FERTILIZED EGG
2-CELL STAGE
4-CELL STAGE
8-CELL STAGE
(a) Sea urchin
Blastomeres
Blastomeres
Yolk platelets are evenly distributed.
0.15 mm
Early cleavage results in cells of similar size.
Complete Cleavage
(b) Frog
Animal pole
Yolk is concen-trated at the vegetal pole.
Gray crescent
Vegetal pole
0.5–1 mm
Cells at the animal pole are smaller, and those at the vegetal pole are larger.


Cleavage
Zona pellucida
2 Cells
4 cells
Early Cleavage
8 cells
16 cells
Morula
32 cells
Late cleavage

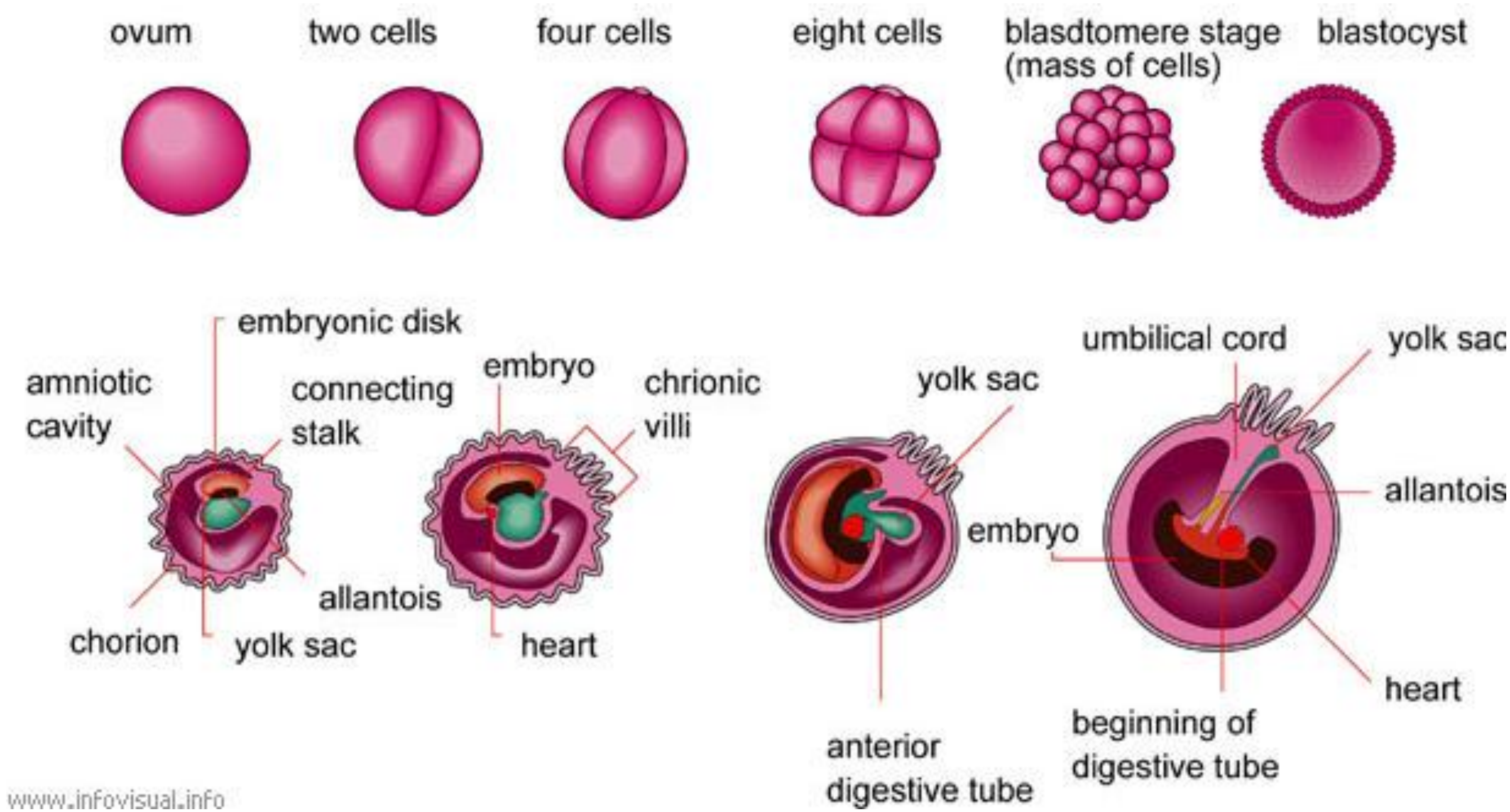
Types of cleavage:

in embryology, **cleavage** is the division of cells in the early embryo

the zygote undergoes rapid cell cycles with no significant growth, producing a cluster of cells that is the same size as the original zygote

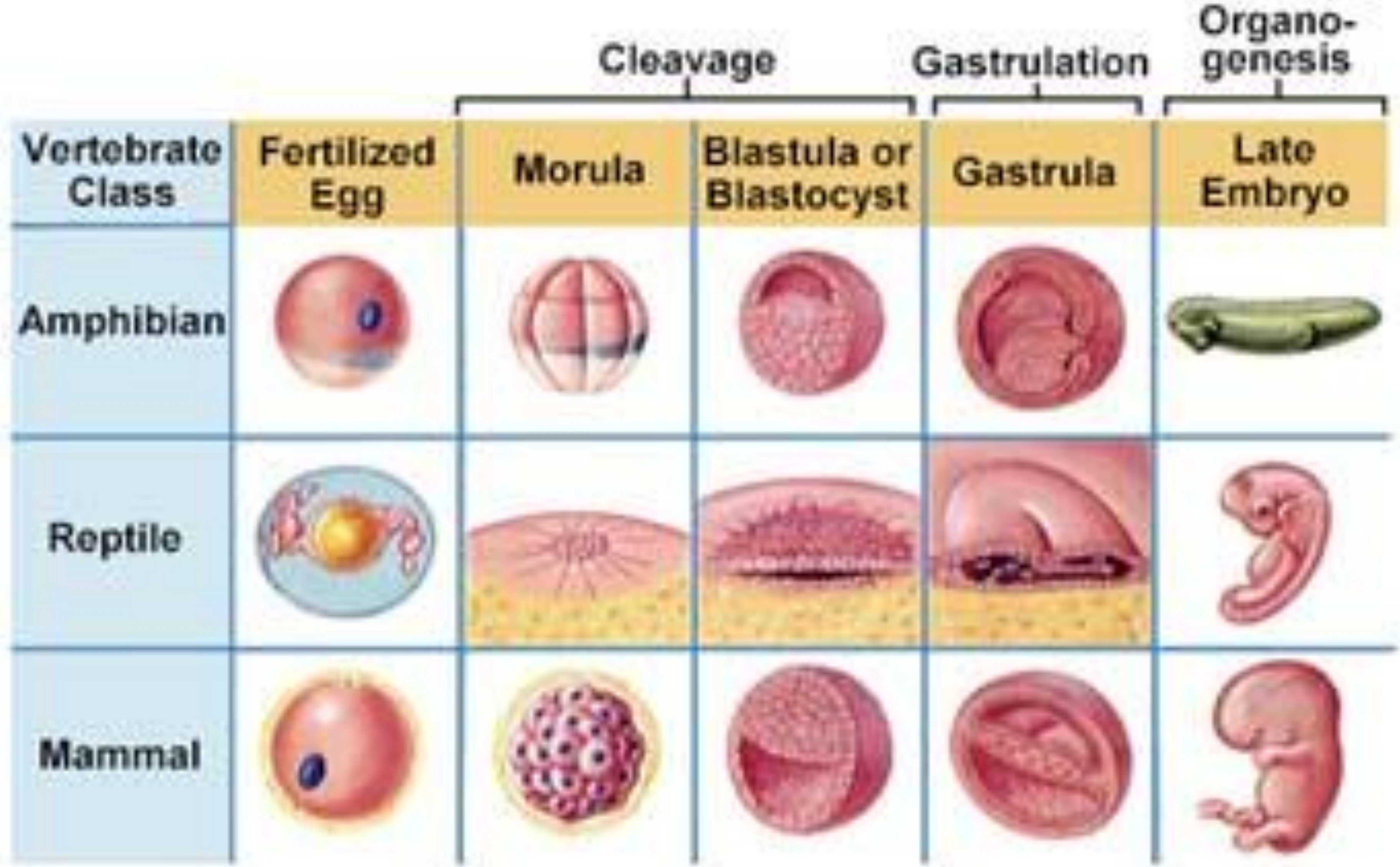
depending mostly on the amount of yolk in the egg, the cleavage can be **holoblastic** (total) or **meroblastic** (partial)

the different cells derived from cleavage (up to the blastula stage) are called **blastomeres**



Cleavage: cell resulting from fertilization in dividing, egg becomes a new being
Ovum: female reproductive cell.
Two cells: part of its intrauterine growth when the ovule consists of two cells.
Four cells: part of its intrauterine growth when the ovule consists of four cells.
Eight cells: part of its intrauterine growth when the ovule consists of eight cells.
Blastomere stage (mass of cells): part of its intrauterine growth when the ovule consists of more than eight cells.
Blastocyst: part of development of the egg where the dividing cells form a sac.
Amniotyc cavity: pocket filled with amniotic fluid.

Embryonic disk: round, flat form related to the embryo.
Connecting stalk: tissue that holds the embryo in place.
Embryo: organism in midst of development.
Chrionic villi: velvety surface of the placenta.
Yolk sac: pocket containing the vitellus.
Umbilical cord: cord connecting the fetus to the placenta.
Allantois: one of three accessory parts of the embryo.
Heart: blood-pumping organ.
Digestive tract developing: the beginning of the development of the digestive tract.
Anterior disgestive tube: terminal part of the cloaqua.
Chorion: external embryonic menbrane.


Cleavage
Gastrulation
Organo-
genesis
Vertebrate
Class
Fertilized
Egg
Morula
Blastula or
Blastocyst
Gastrula
Late
Embryo
Amphibian
Reptile
Mammal

cleavage is first step in development of all multicelled organisms

cleavage converts a single-celled zygote into a multicelled embryo

usually, zygotic cytoplasm is divided among newly formed cells

frog embryos divide to produce 37,000 cells in a little over 40 hours

blastula is produced by mitosis of the zygote, and is a ball of cells surrounding a fluid-filled cavity (the blastocoel)

decreasing size of cells increases their surface to volume ratio, allowing for more efficient oxygen exchange between cells and their environment

RNA and information carrying molecules are distributed to various parts of the blastula, and this molecular differentiation sets the stage for the layering of body in next phases of development

pattern of cleavage

1. Holoblastic

1.1 Radial	sea urchin, amphioxus
1.2 Bilateral	tunicates, amphibians
1.3 Spiral	annelids, mollusks
1.4 Rotational	mammals

2. Meroblastic

2.1 Discoidal	fish, birds, reptiles
2.2 Superficial	insects

Holoblastic [Gr. *holos* - whole, entire]

pattern of cleavage in which entire ovum is divided into cells

also known as complete cleavage and is usually found in embryos with little to moderate amounts of yolk

in the absence of a large concentration of yolk, four major cleavage types can be observed in isolecithal cells - radial holoblastic, spiral holoblastic, bilateral holoblastic, and rotational holoblastic cleavage

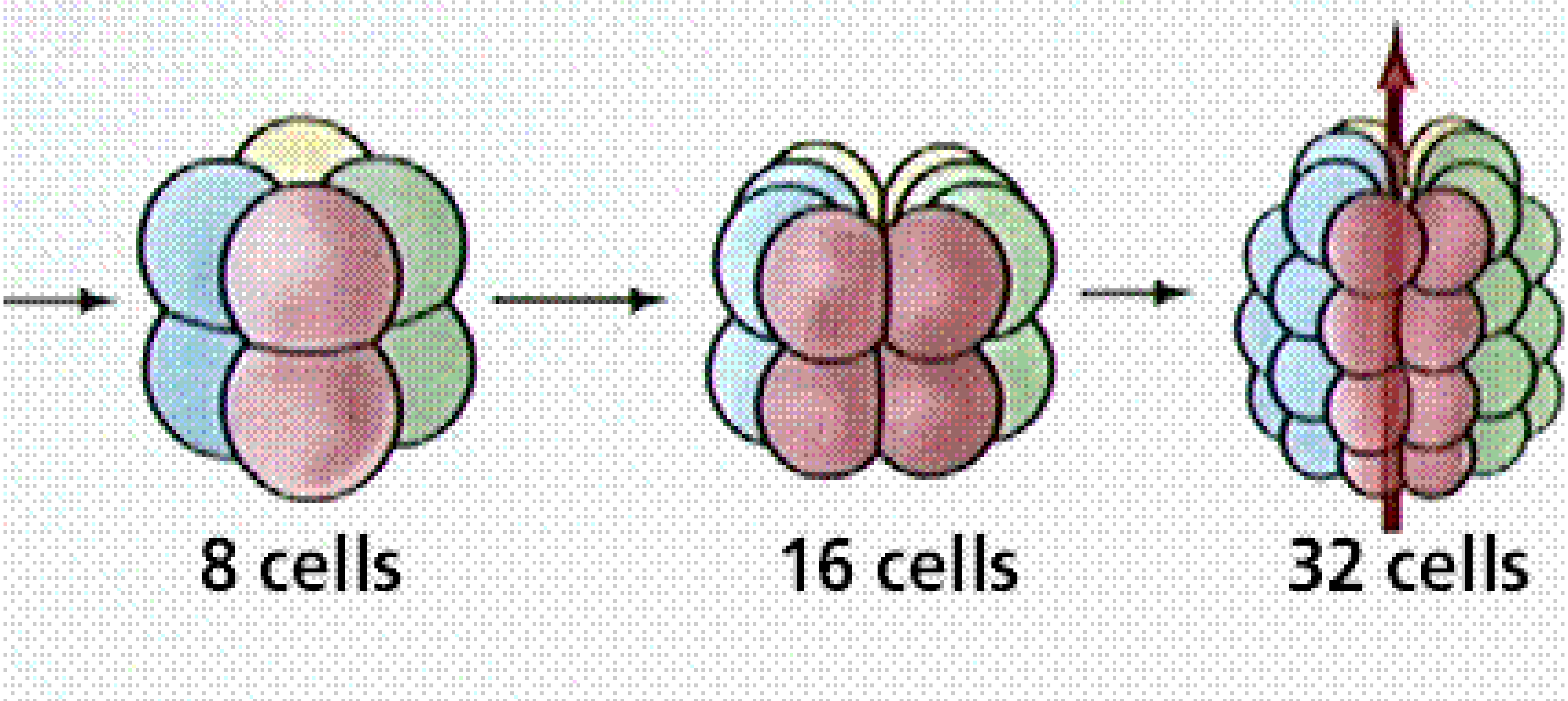
these holoblastic cleavage planes pass all the way through isolecithal zygotes during the process of cytokinesis

in holoblastic eggs the first cleavage always ocurrs along the vegetal-animal axis of the egg, the second cleavage is perpendicular to the first

from here, spatial arrangement of blastomeres can follow various patterns, due to different planes of cleavage, in various organisms

radial holoblastic cleavage

radial cleavage is characteristic of some animal groups, for instance, echinoderms, in which the spindle axes are parallel or at right angles to the polar axis of the oocyte



bilateral holoblastic cleavage

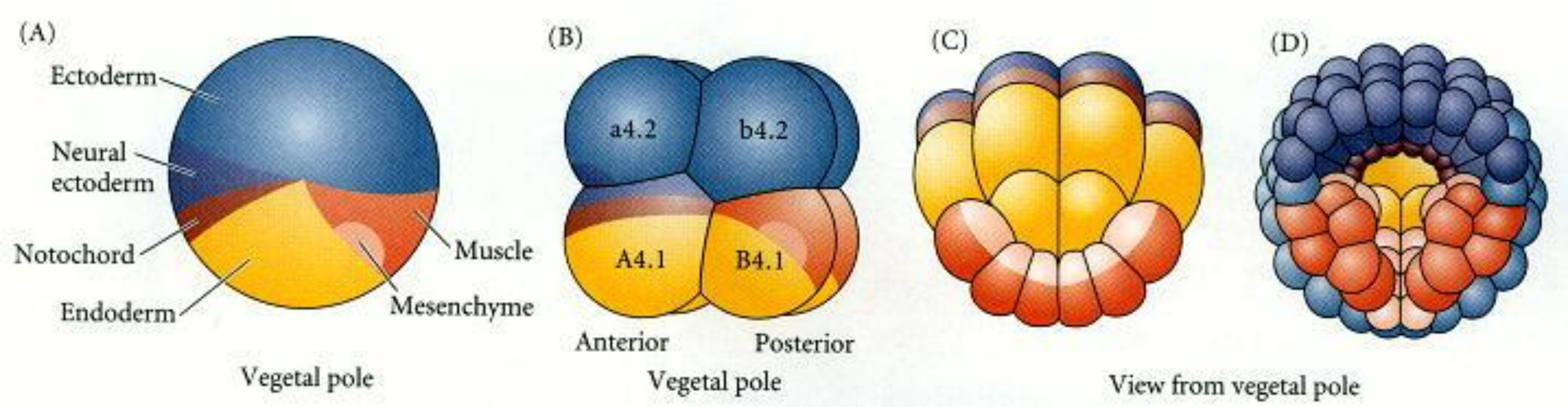
the most striking phenomenon in this type of cleavage is that the first cleavage plane establishes the earliest axis of symmetry in the embryo, separating the embryo into its future right and left sides.

each successive division orients itself to this plane of symmetry, and the half-embryo formed on one side of the first cleavage plane is the mirror image of the half-embryo on the other side.

the second cleavage is meridional, like the first, but unlike the first division, it does not pass through the center of the egg.

rather, it creates two large anterior cells (the A and D blastomeres) and two smaller posterior cells (blastomeres B and C).

each side now has a large and a small blastomere. During the next three divisions, differences in cell size and shape highlight the bilateral symmetry of these embryos. At the 32-cell stage, a small blastocoel is formed, and gastrulation begins



Bilateral symmetry in the egg of the tunicate *Styela partita.* (A) Uncleaved egg. The regions of cytoplasm destined to form particular organs are labeled here and coded by color throughout the diagrams. (B) 8-cell embryo, showing the blastomeres and the fates of various cells. The embryo can be viewed as two 4-cell halves; from here on, each division on the right side of the embryo has a mirror-image division on the left. (C, D) Views of later embryos from the vegetal pole. (A after Balinsky 1981.)

spiral holoblastic cleavage

pattern of early cleavage found in molluscs and annelids (both mosaic eggs)

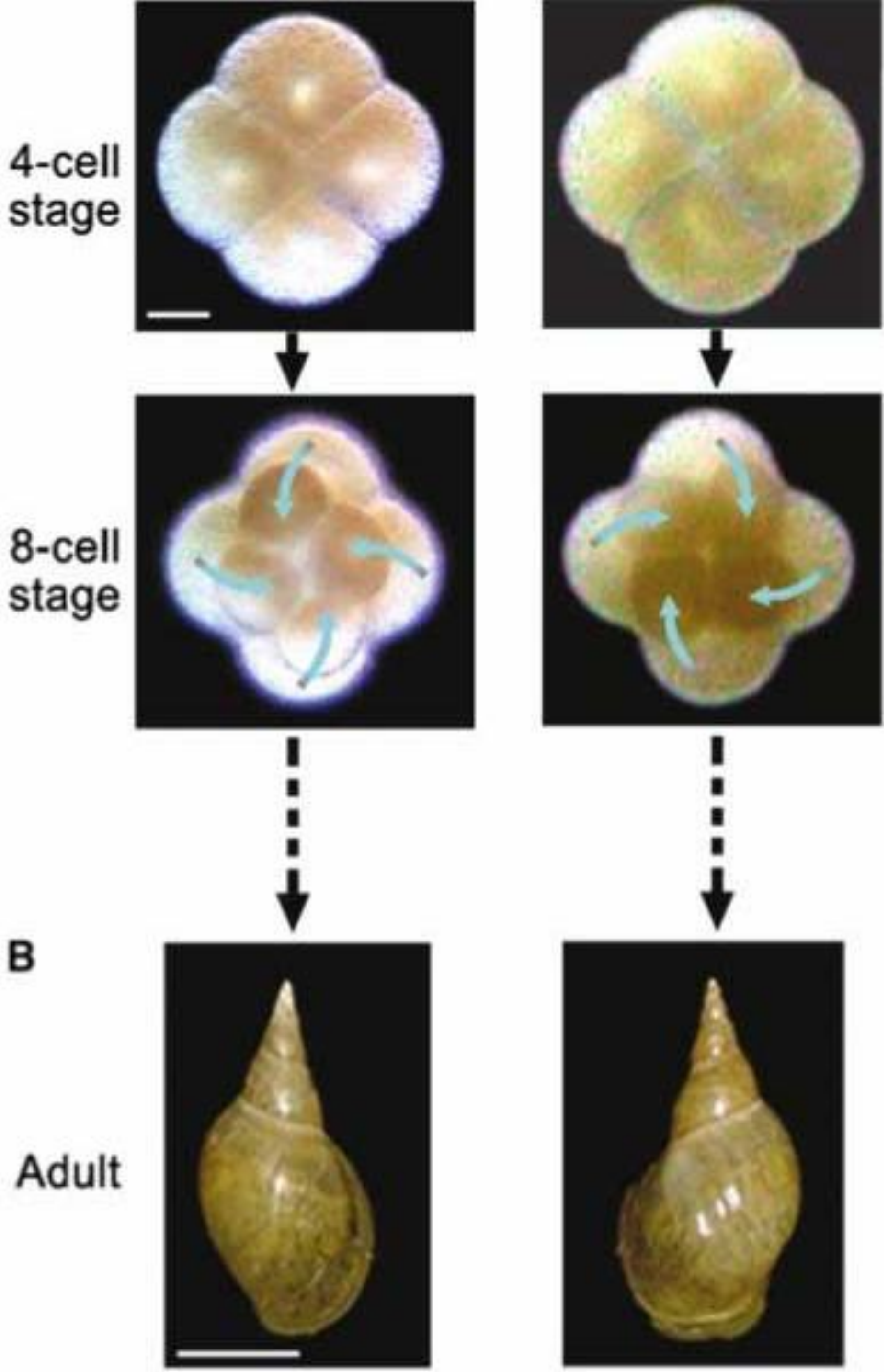
in spiral cleavage, the cleavage planes are oriented obliquely to the polar axis of the oocyte

at the third cleavage the halves are oblique to the polar axis and typically produce an upper quartet of smaller cells that come to be set between the furrows of the lower quartet

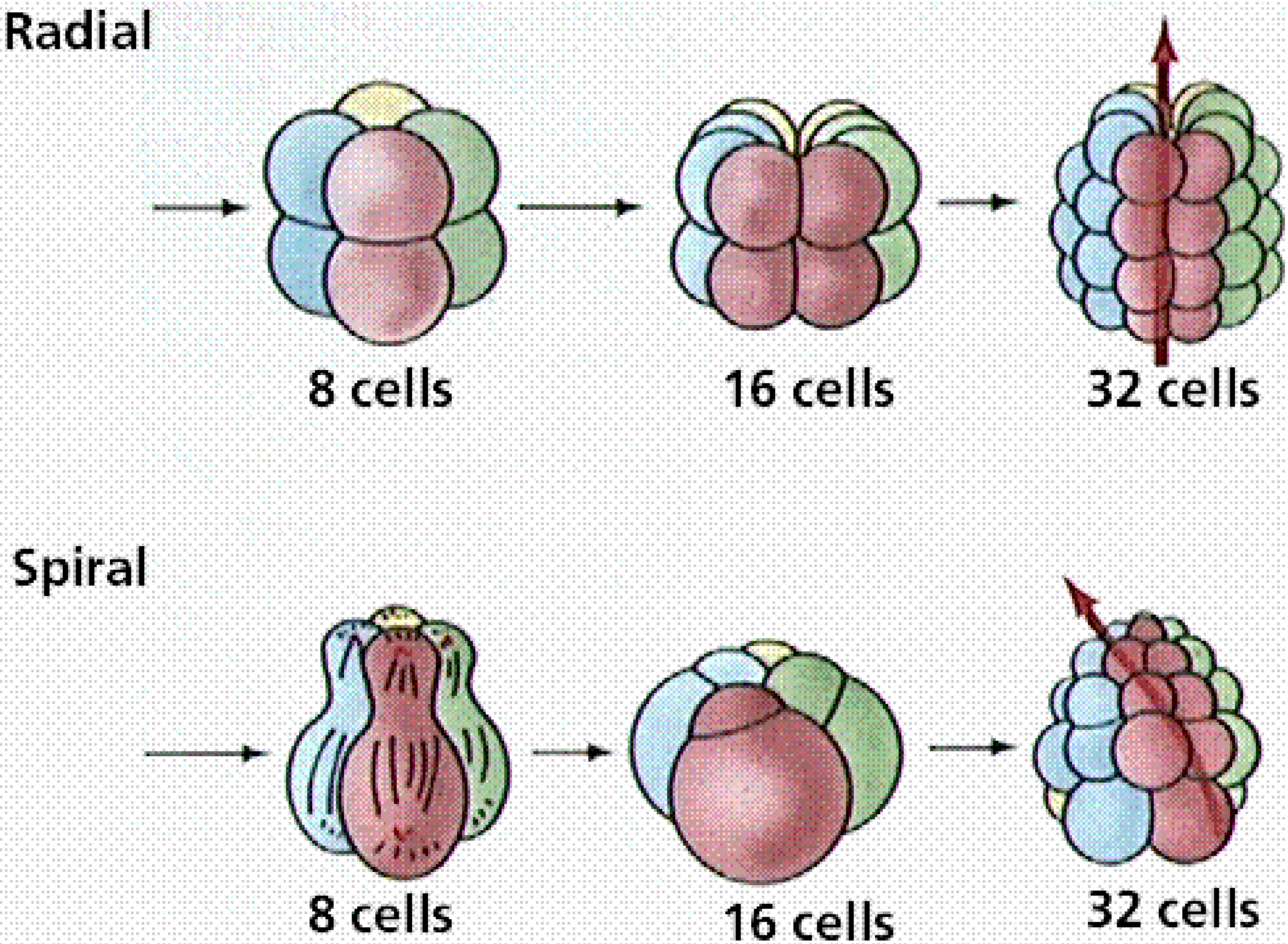
all groups showing spiral cleavage are protostomia, such as annelids and mollusks

the animal pole blastomeres are rotated with respect to those of the vegetal pole

in some molluscs, the handedness of the spiral twist is maternally inherited



Spiral

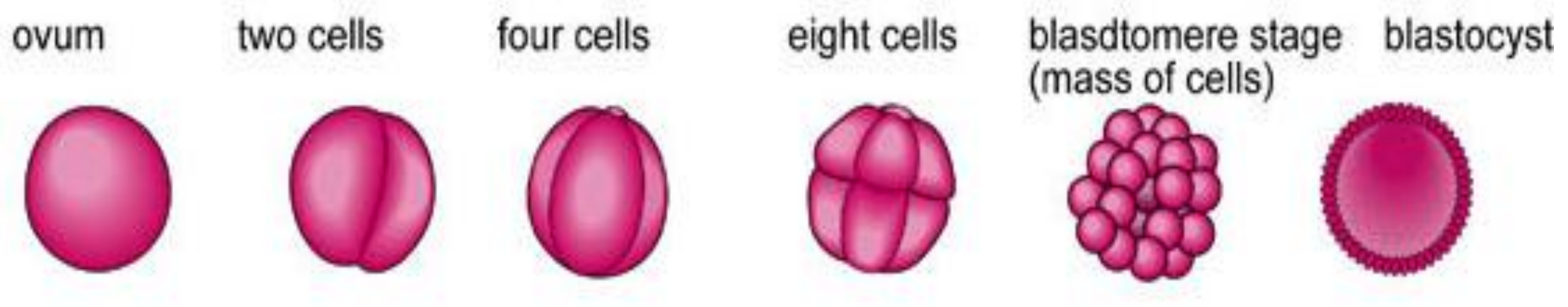


Radial
8 cells
16 cells
32 cells
Spiral
8 cells
16 cells
32 cells

rotational holoblastic cleavage

mammals display rotational cleavage, and an isolecithal distribution of yolk

Because the cells have only a small amount of yolk, they require immediate implantation onto the uterine wall in order to receive nutrients



meroblastic

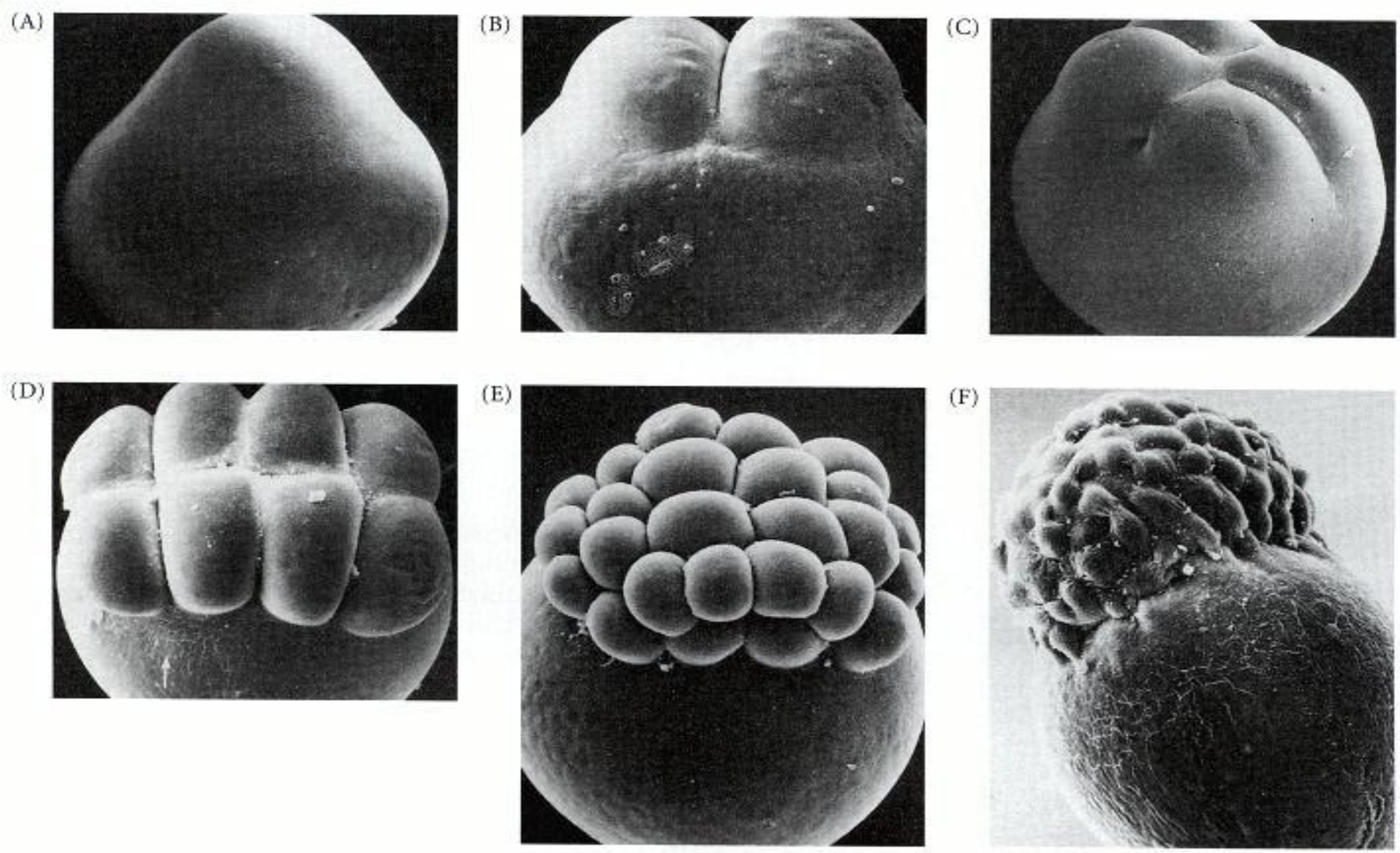
incomplete cleavage, characteristic of zygotes with large accumulations of yolk

discoidal meroblastic cleavage

in fish eggs, cleavage occurs only in the **blastodisc**, a thin region of yolk-free cytoplasm at the animal cap of the egg. Most of the egg cell is full of yolk.

the cell divisions do not completely divide the egg, so this type of cleavage is called **meroblastic** (Greek, *meros,* "part").

since only the cytoplasm of the blastodisc becomes the embryo, this type of meroblastic cleavage is called **discoidal**.



discoidal cleavage in a zebrafish egg. (A) 1-cell embryo. The mound atop the cytoplasm is the blastodisc region. (B) 2-cell embryo. (C) 4-cell embryo. (D) 8-cell embryo, wherein two rows of four cells are formed. (E) 32-cell embryo. (F) 64-cell embryo, wherein the blastodisc can be seen atop the yolk cell

superficial meroblastic cleavage

meroblastic cleavage, **partial cleavage**, a form in which only the protoplasmic portions of the oocyte participate; called also *incomplete cleavage*

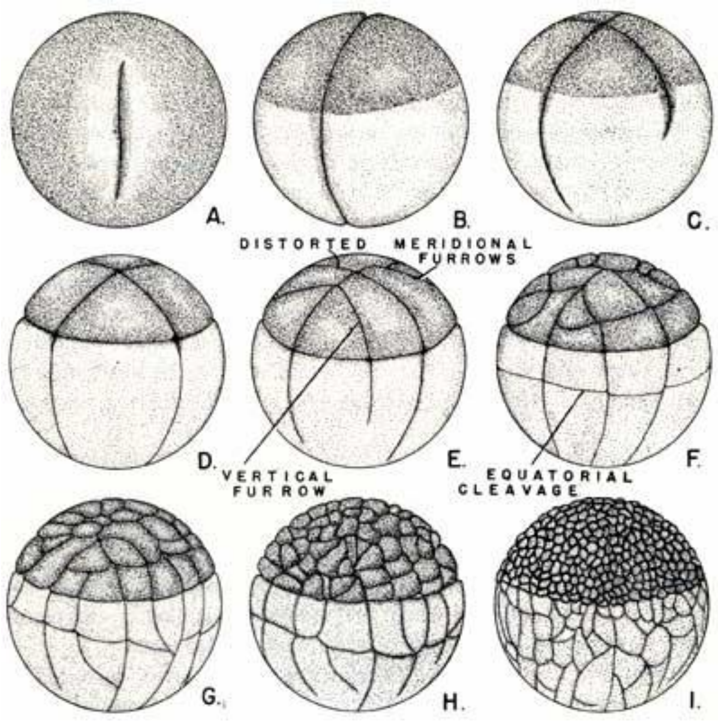
progressive cleavage, in the formation of spores within a sporangium, the production of a series of cleavage planes in succession, resulting first in formation of protospores and later in formation of sporangiospores

radial cleavage, a cleavage pattern characteristic of vertebrates and echinoderms, in which the spindle axes are parallel or at right angles to the polar axis of the oocyte.

spiral cleavage, a cleavage pattern characteristic of such invertebrates as annelids and mollusks, in which the cleavage planes are oriented obliquely to the polar axis of the oocyte.

superficial cleavage, a form in which only the surface region of centrolecithal oocytes participate

the first divisions in a salamander, Ambystoma maculatum



What's neat about it is that this is a transitional pattern. The first three divisions are fully holoblastic, with a complete separation of all of the cells. In subsequent divisions, though, you can see that cleavages are slower and tend to be incomplete within the vegetal, yolkier mass of the macromeres. In this one animal we see both holoblastic and meroblastic cleavage, and difference is clearly just a result of different quantities of yolk in the portion being divided.