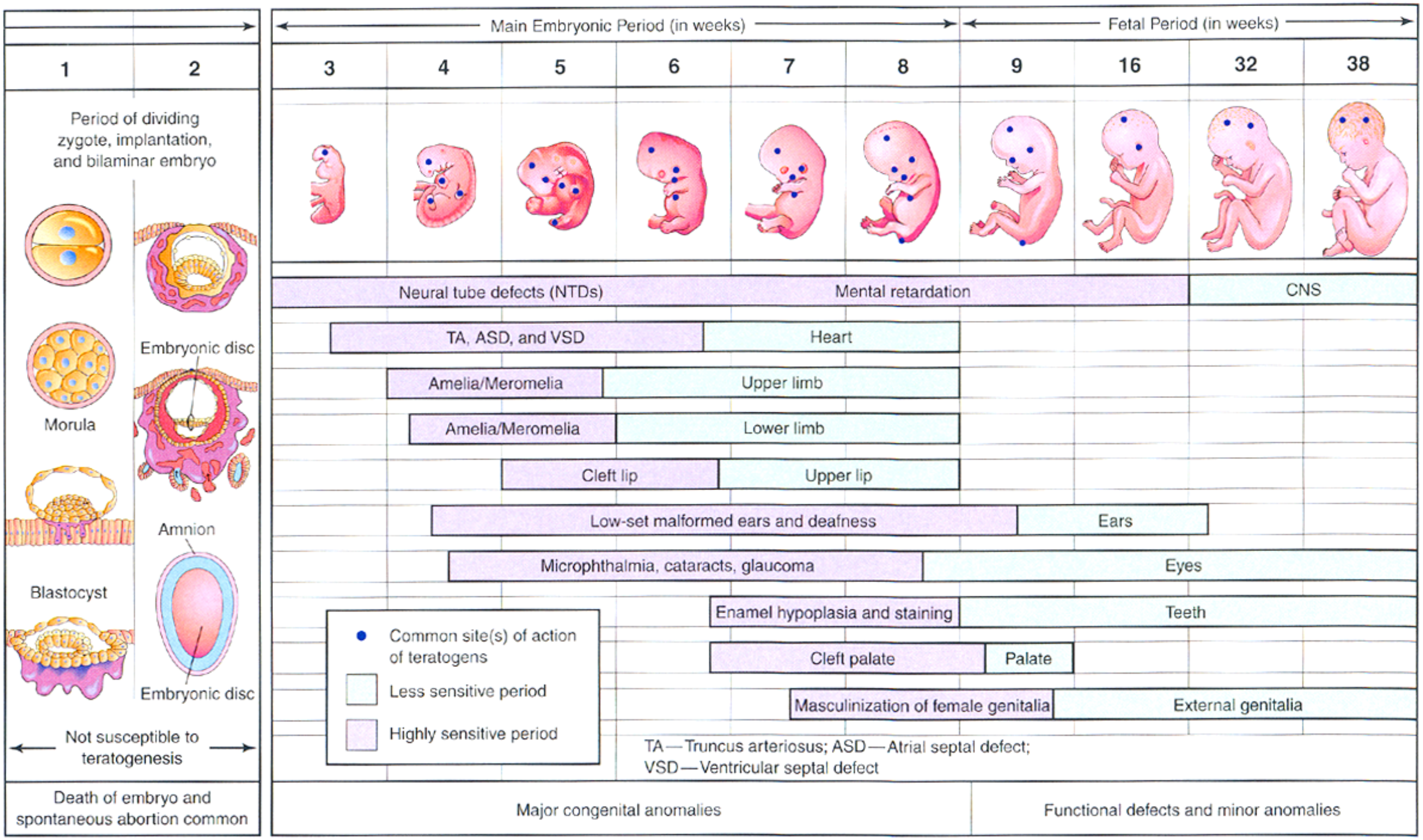
Introduction to Embryology I
A. From Cleavage to Gastrulation

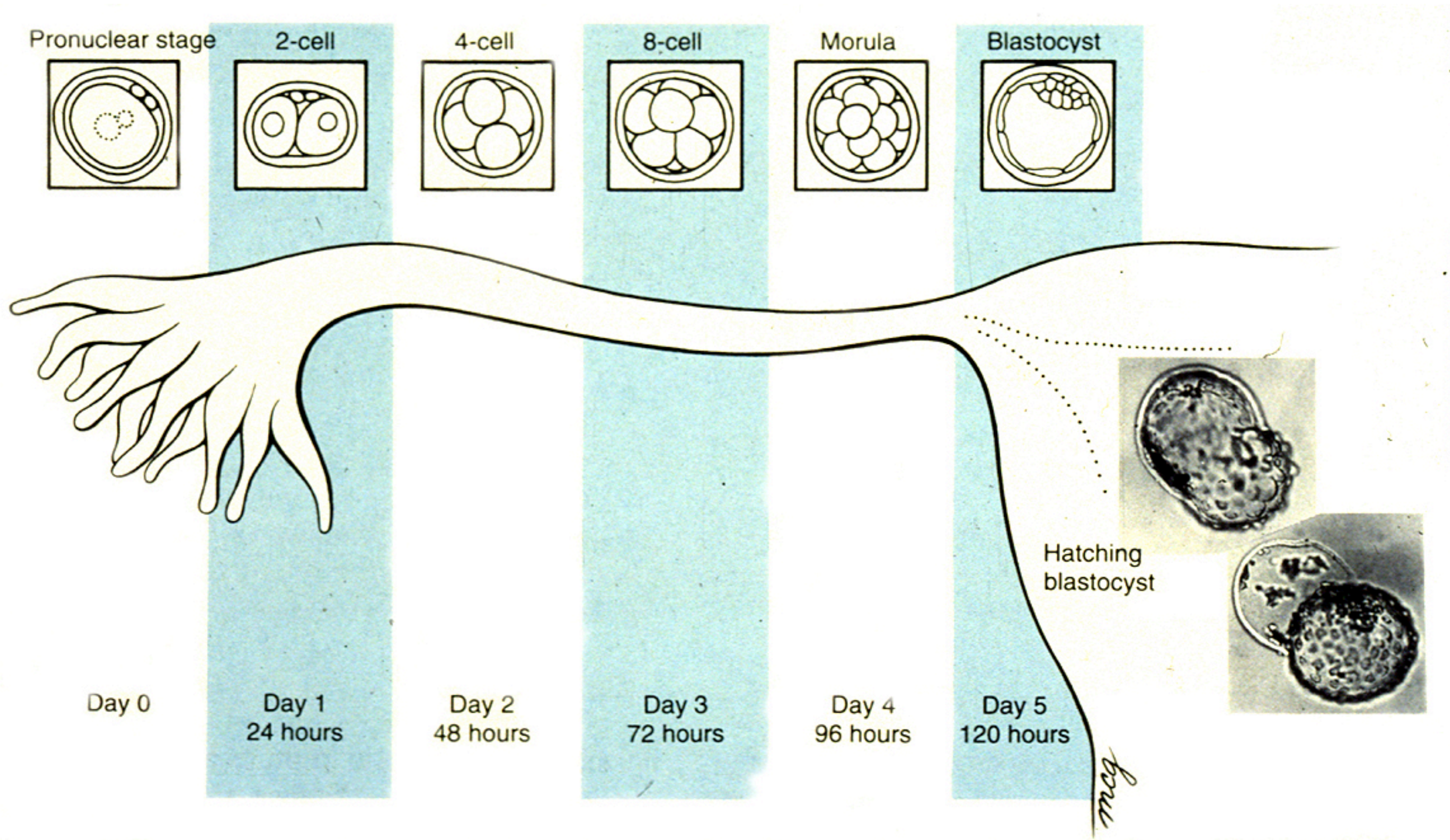
CRITICAL PERIODS IN HUMAN DEVELOPMENT*



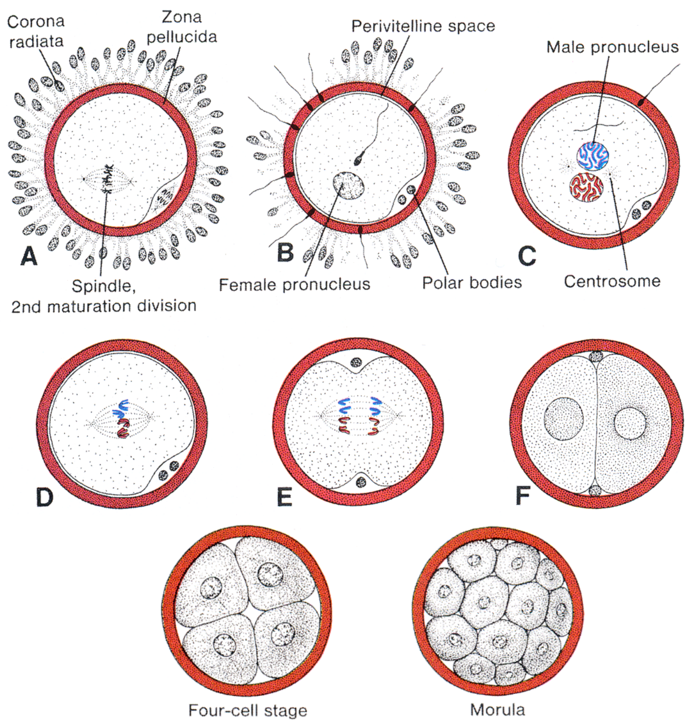
*Mauve denotes highly sensitive periods when major birth defects may be produced.

How do we begin? The first week following conception cell division takes place along the oviduct. At the end of that week the embryo "touches" down onto the uterine surface.

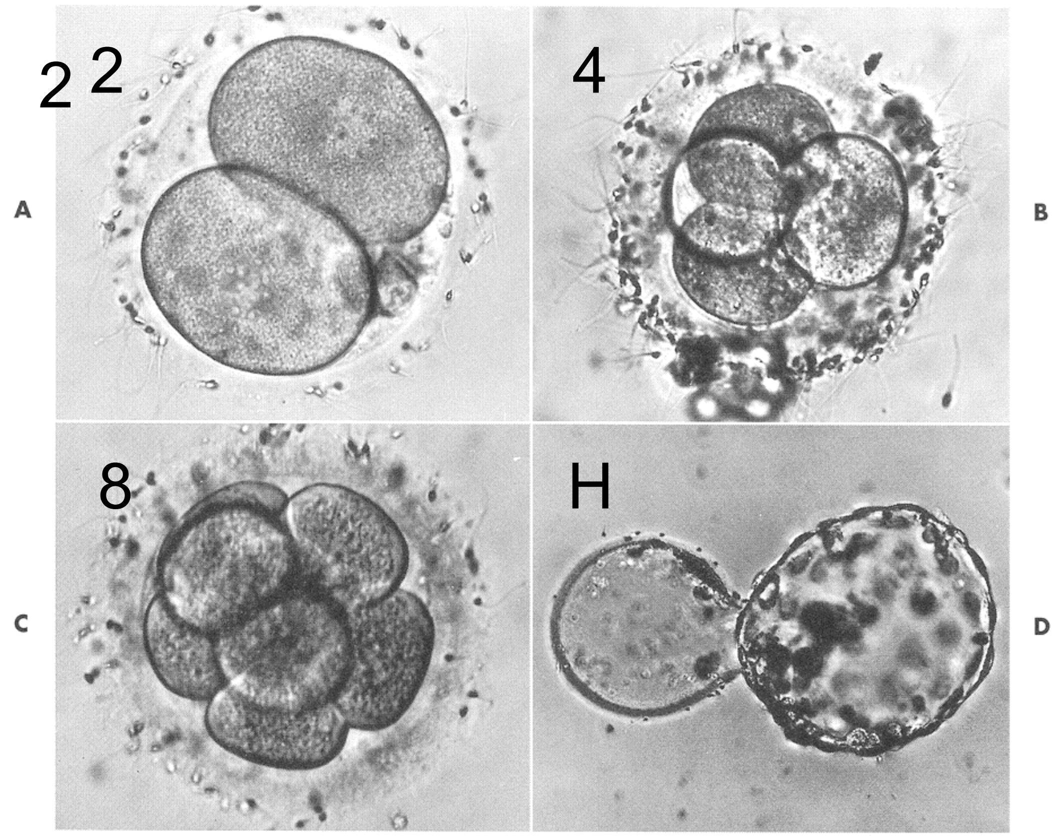
Cleavage divisions take place within the oviduct. Embryo hatches out of the zona pellucida in uterus



FROM ZYGOTE TO MORULA



Cleavage divisions



Compaction: establishment of inner and outer lineages

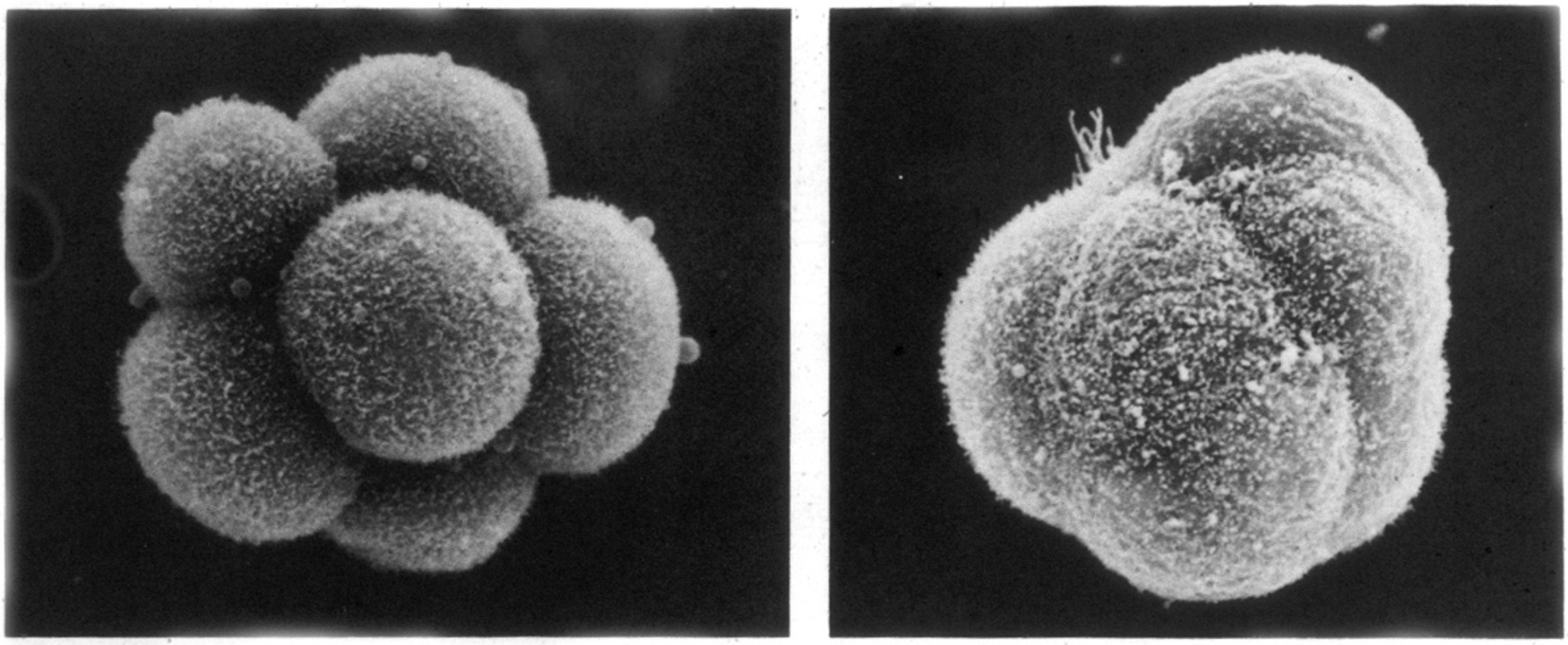
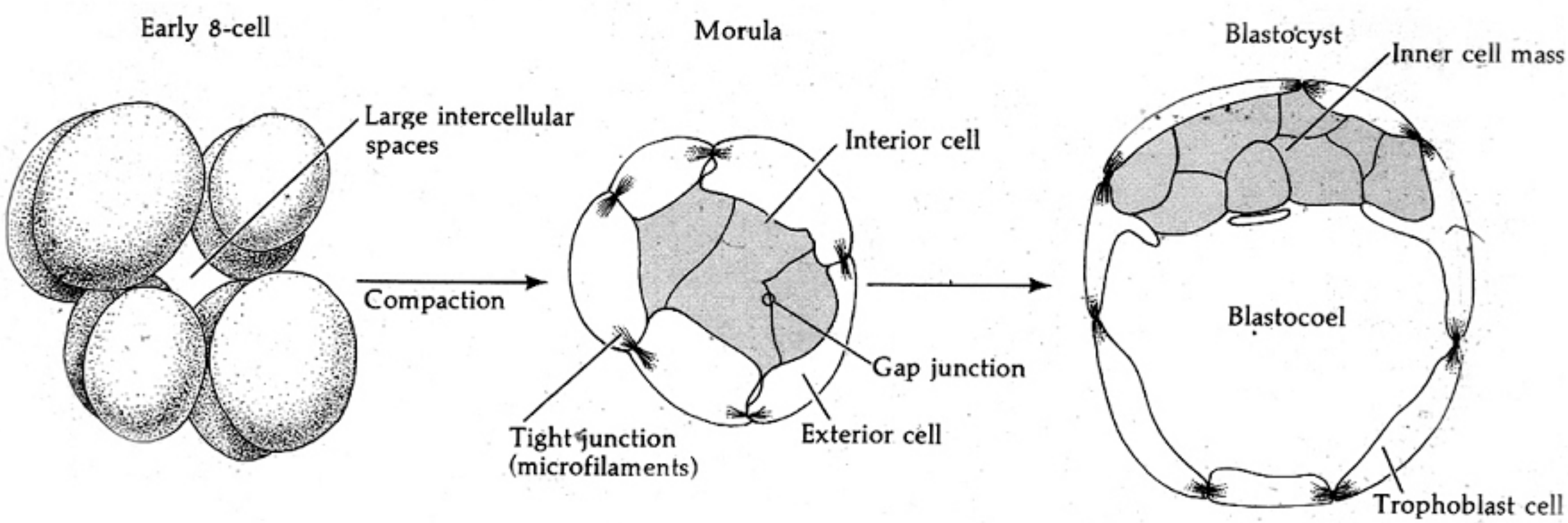


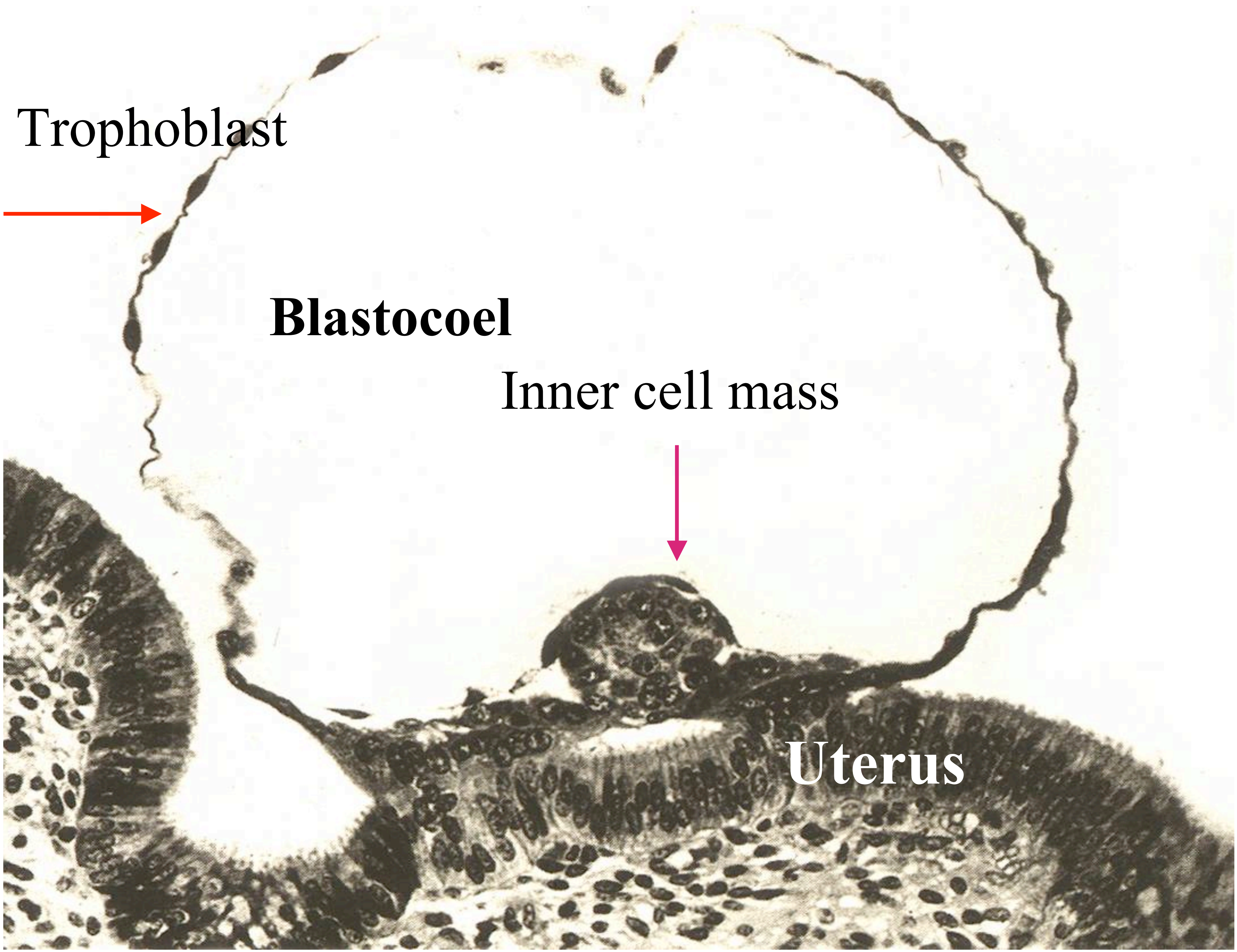
FIGURE 21
Scanning electron micrograph of uncompacted (left) and compacted (right) 8-cell mouse embryo. (Photographs courtesy of C. Žiomek.)

their behavior. They suddenly huddle together, maximizing their contact with the other blastomeres and forming a compact ball of cells (Figure 21). This tightly packed arrangement is stabilized by tight junctions that form between the outside cells of the ball, sealing off the

Fate:
Potency:
Commitment:
Differentiation:

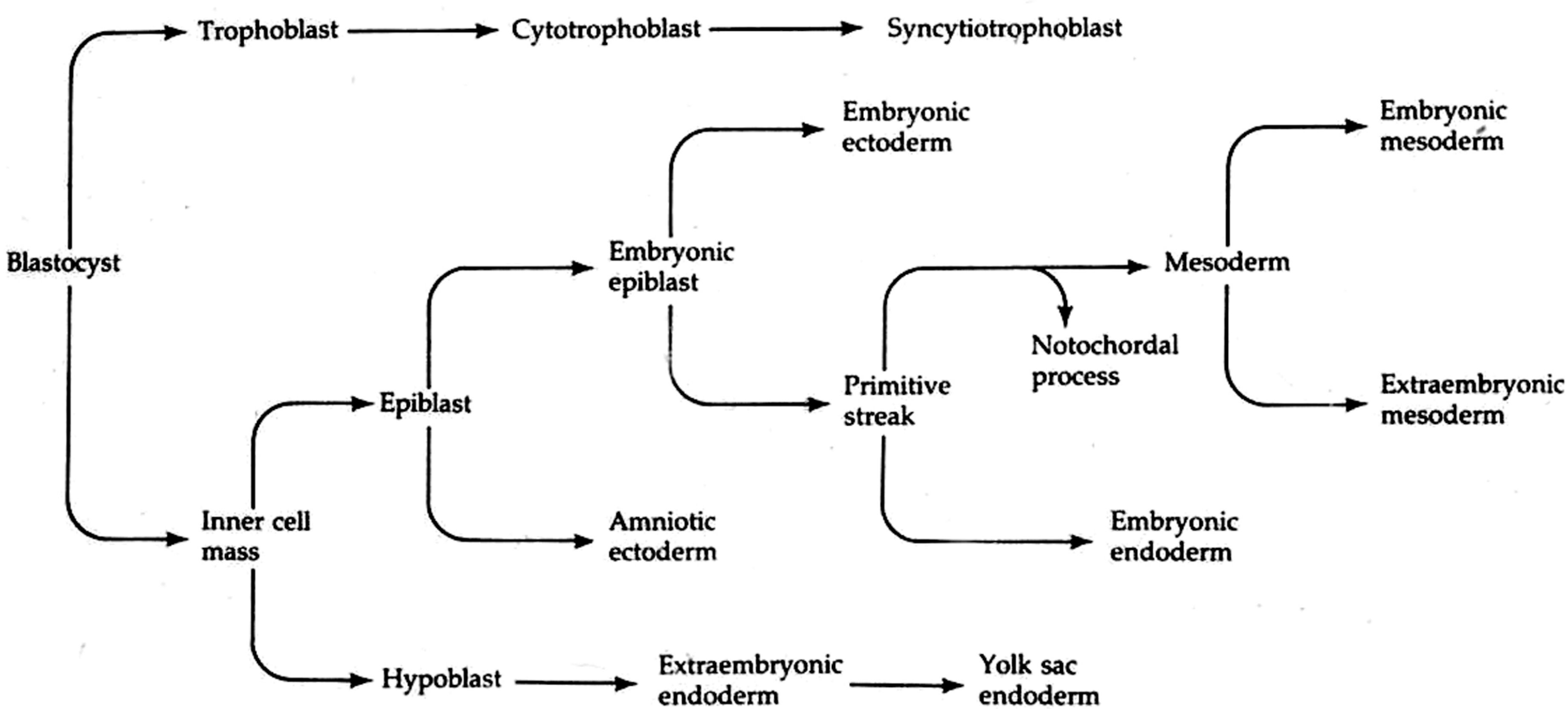


All cells contact the outside | Outer cell Inner Cells | Trophoblasts (O) Inner cell mass (I)


Trophoblast
Blastocoel
Inner cell mass
Uterus

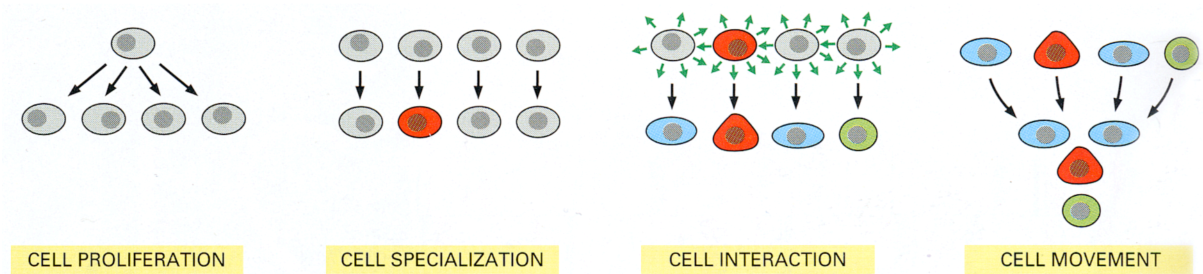
Lineages from the cells of the blastocyst

FIGURE 31
Scheme illustrating the derivation of tissues in human and rhesus monkey embryos. (After Luckett, 1978.)

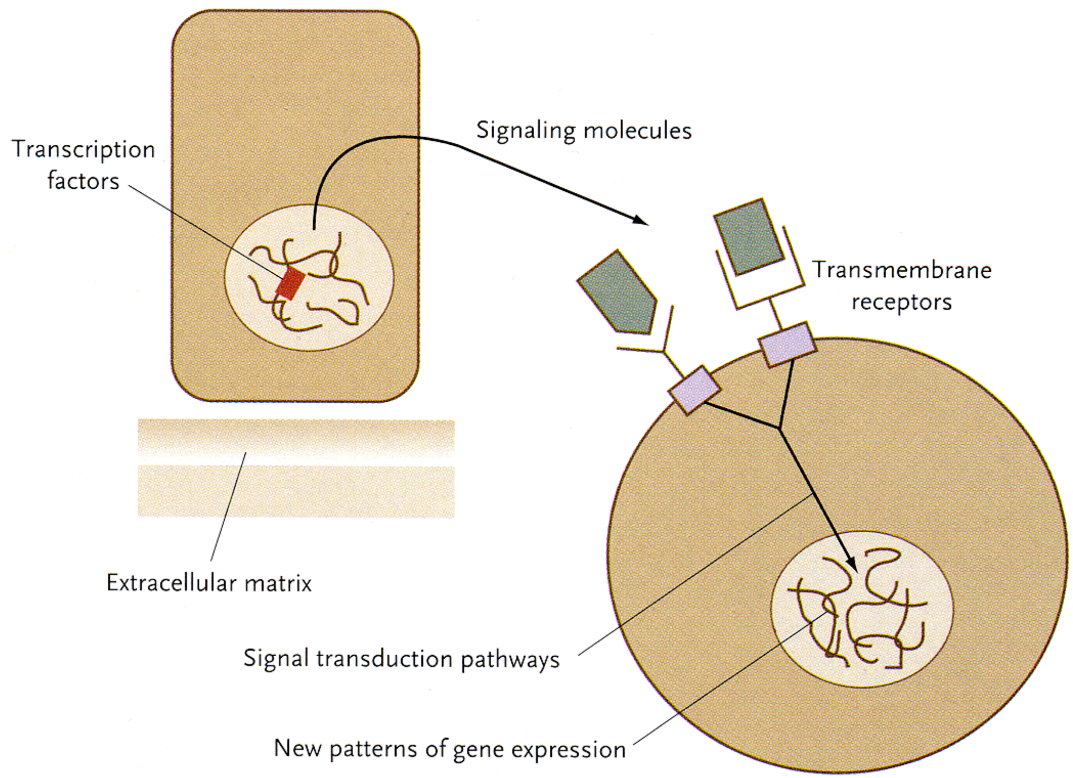


UNIVERSAL MECHANISMS OF ANIMAL DEVELOPMENT

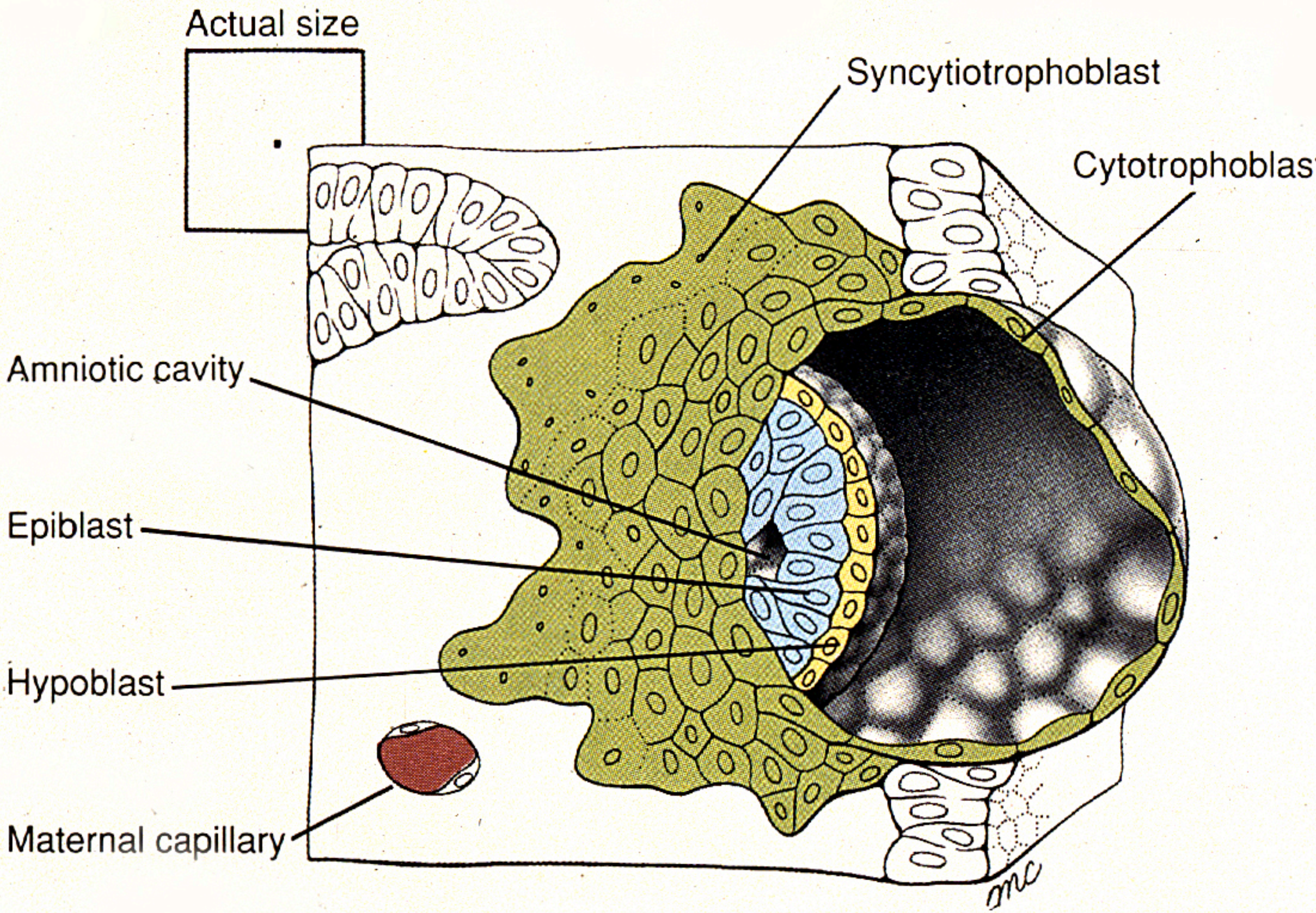
The five essential processes by which a multicellular organism is made



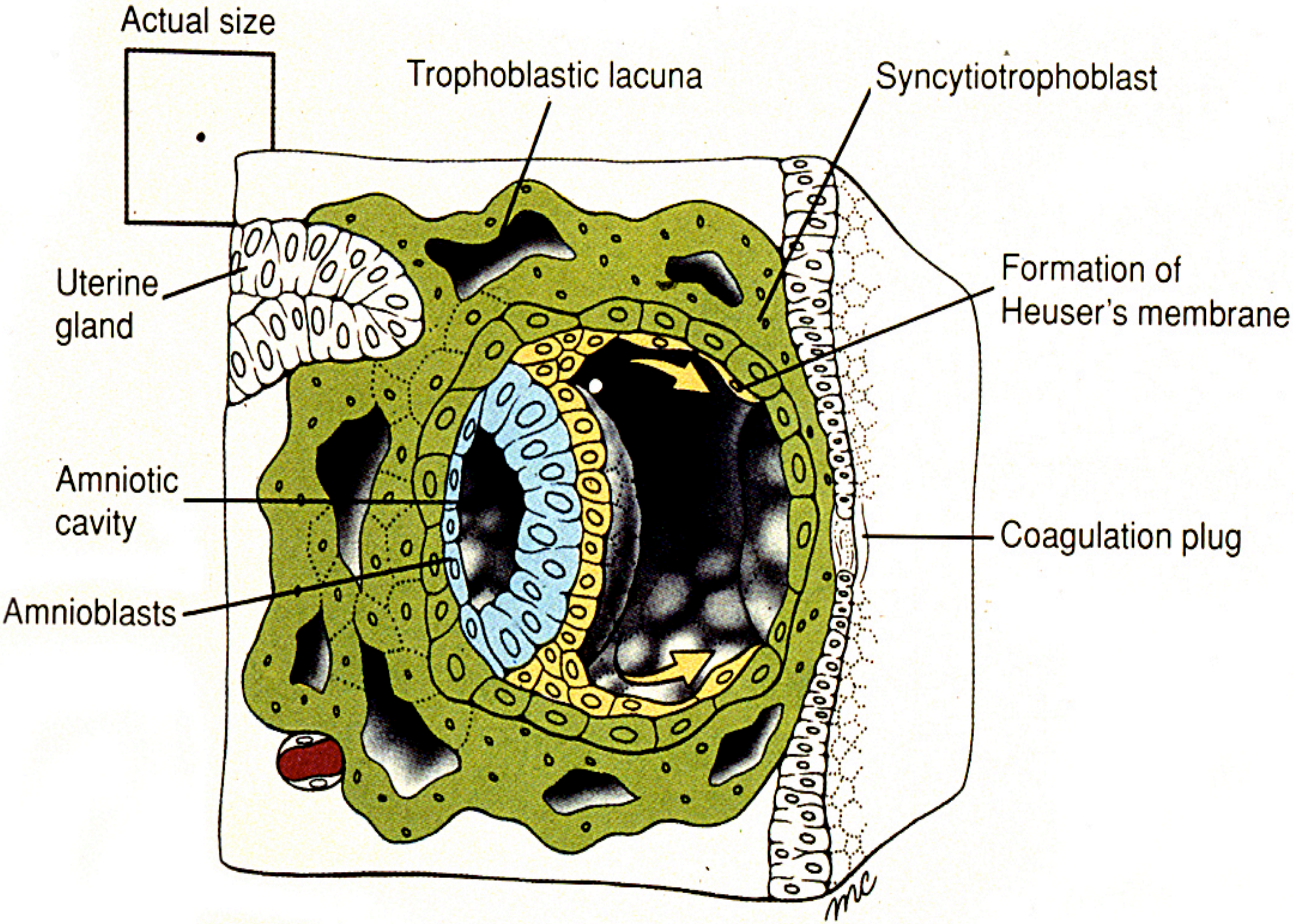
and programmed cell death (apoptosis)



Schematic representation of types of developmentally important molecules and their sites of action

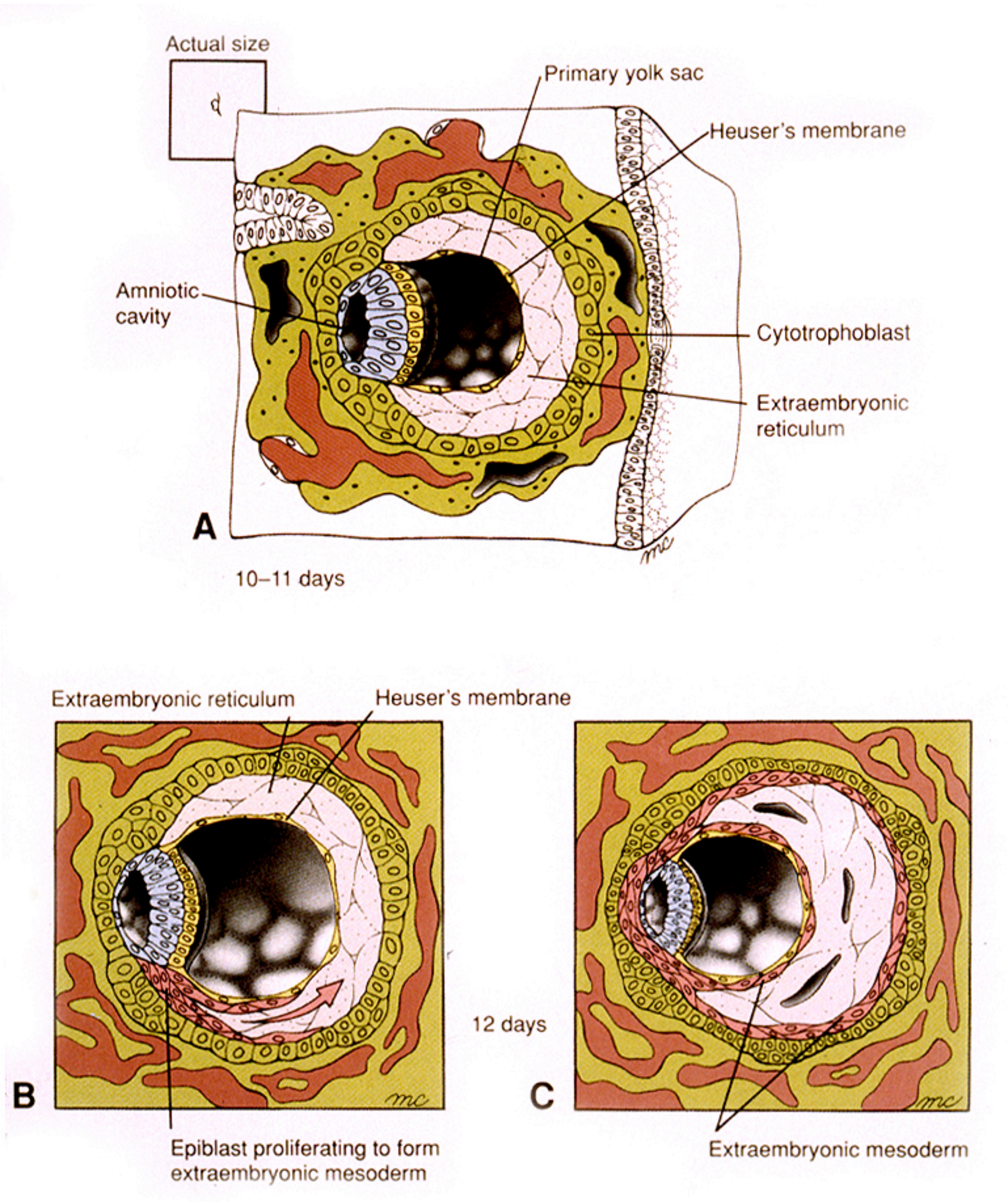

Actual size
Syncytiotrophoblast
Cytotrophoblast
Amniotic cavity
Epiblast
Hypoblast
Maternal capillary

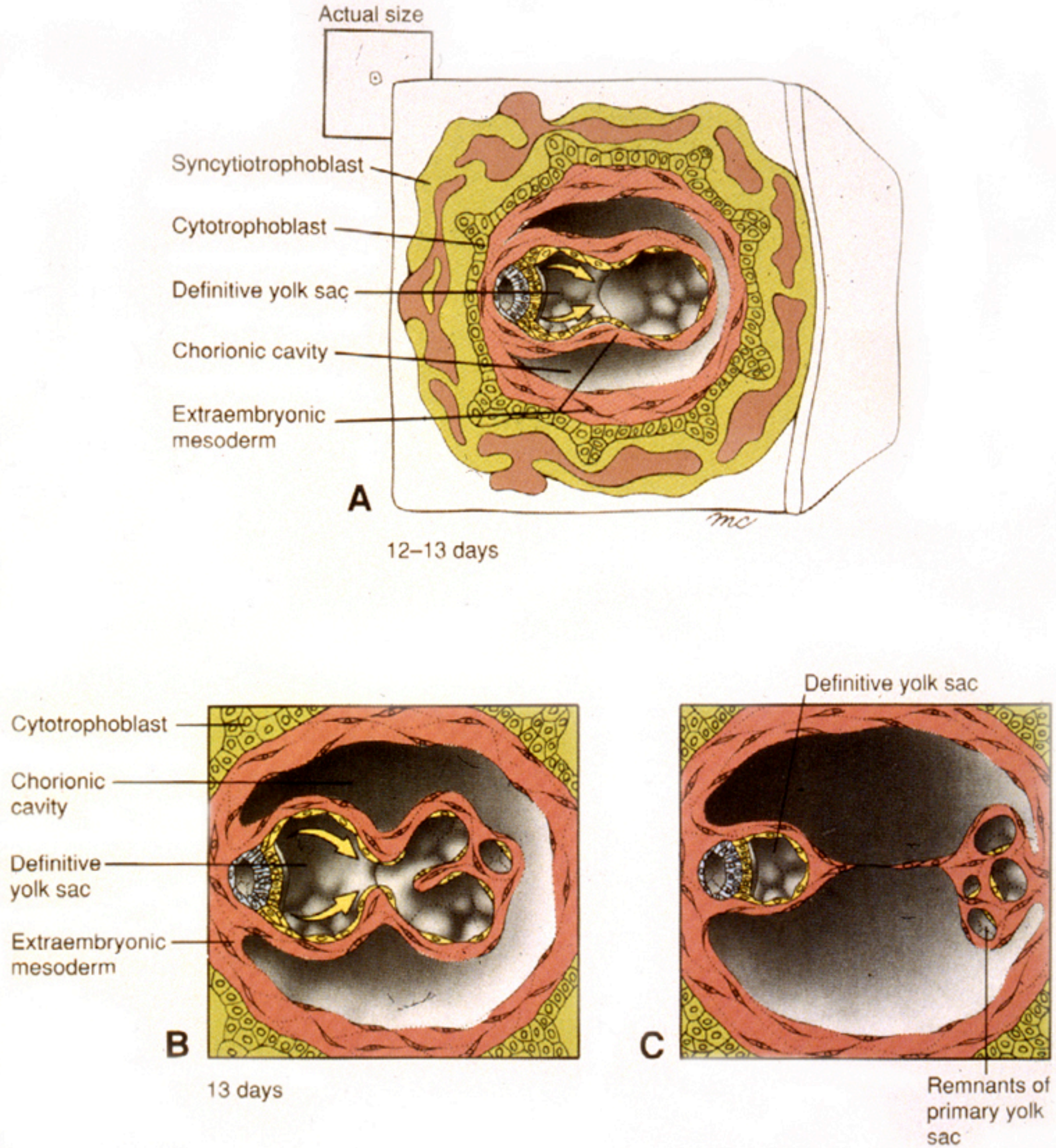
8 days

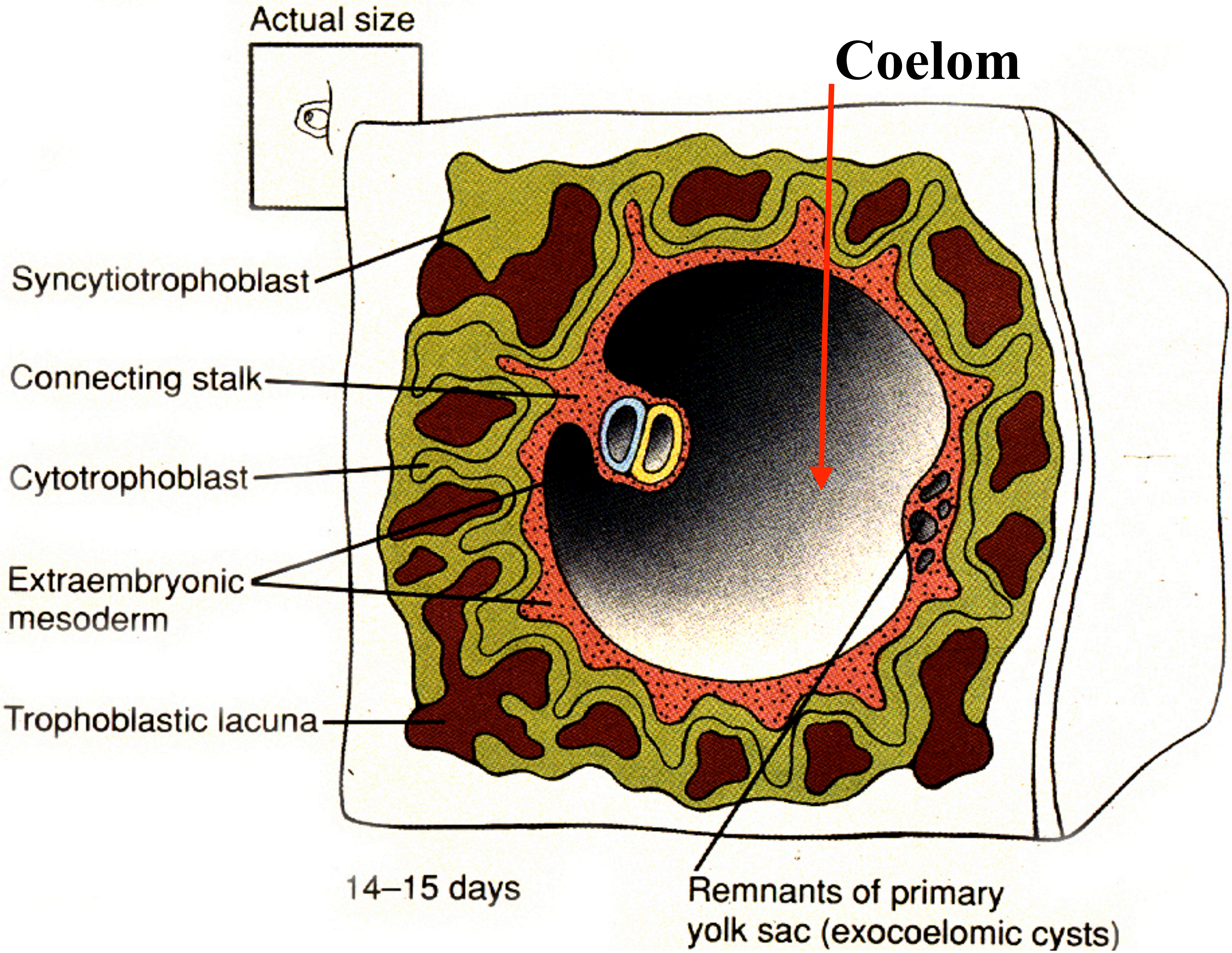


Actual size
Trophoblastic lacuna
Syncytiotrophoblast
Uterine gland
Formation of Heuser's membrane
Amniotic cavity
Amnioblasts
Coagulation plug
mc

9 days


Actual size
Primary yolk sac
Heuser's membrane
Amniotic cavity
Cytotrophoblast
Extraembryonic reticulum
A
10–11 days
Extraembryonic reticulum
Heuser's membrane
12 days
B
C
Epiblast proliferating to form extraembryonic mesoderm
Extraembryonic mesoderm


Actual size
Syncytiotrophoblast
Cytotrophoblast
Definitive yolk sac
Chorionic cavity
Extraembryonic mesoderm
A
12–13 days
Cytotrophoblast
Chorionic cavity
Definitive yolk sac
Extraembryonic mesoderm
B
13 days
Definitive yolk sac
C
Remnants of primary yolk sac


Actual size
Coelom
Syncytiotrophoblast
Connecting stalk
Cytotrophoblast
Extraembryonic mesoderm
Trophoblastic lacuna
14–15 days
Remnants of primary yolk sac (exocoelomic cysts)

Gastrulation

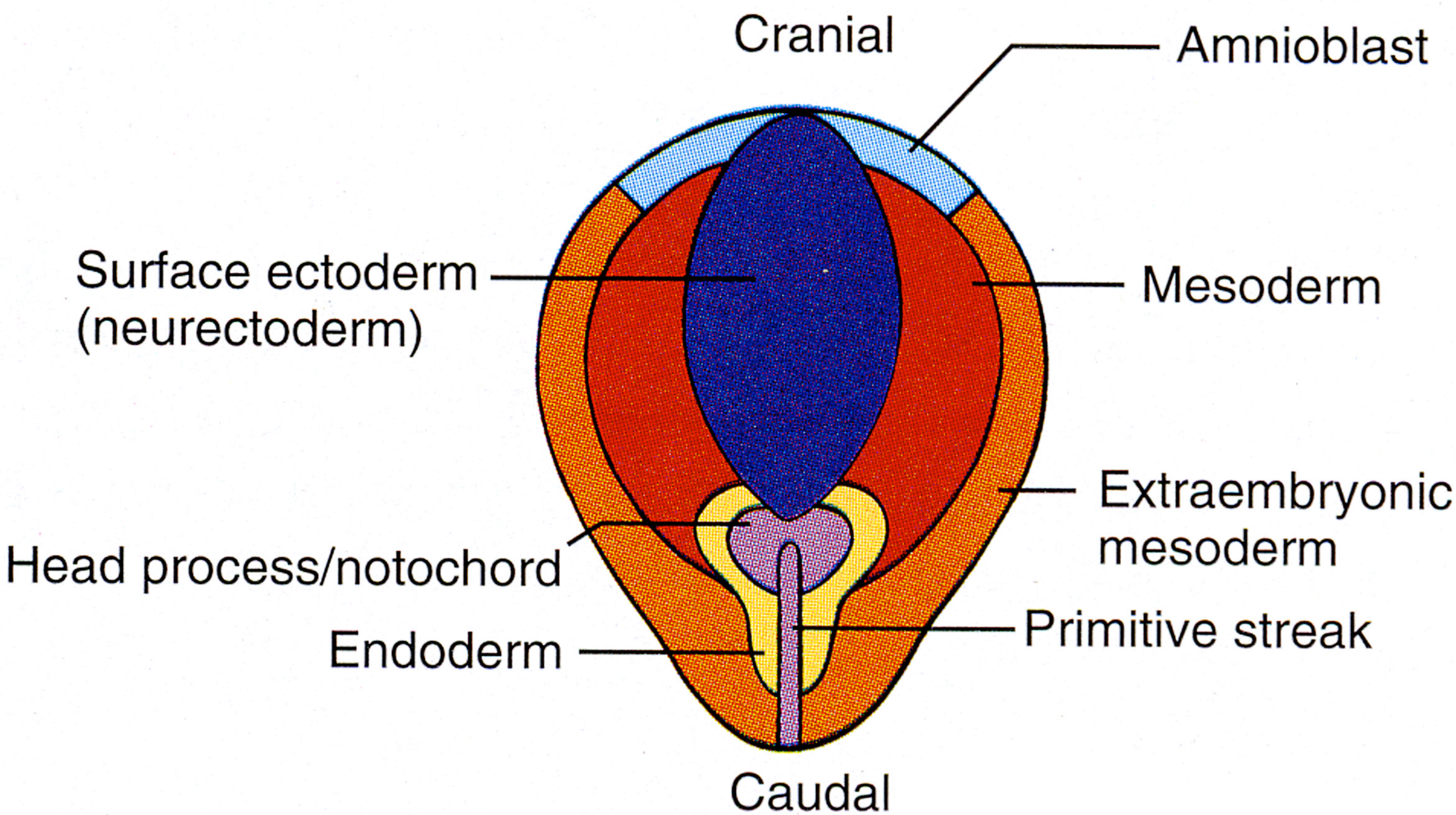
Formation of the 3 germ layers

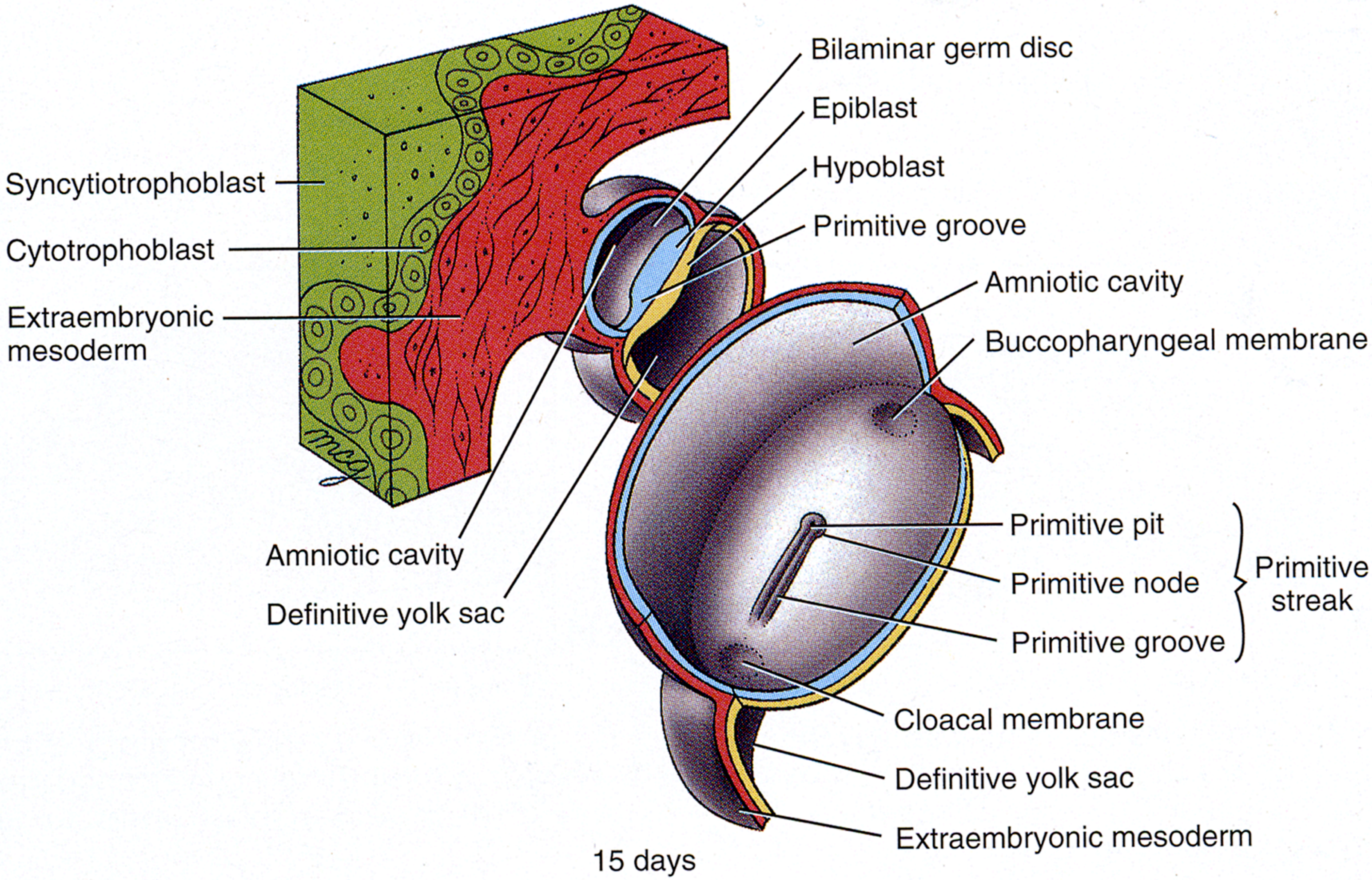
Ectoderm: Epidermis, neural tissue, neural crest

Mesoderm: axial, paraxial, intermediate and lateral plate

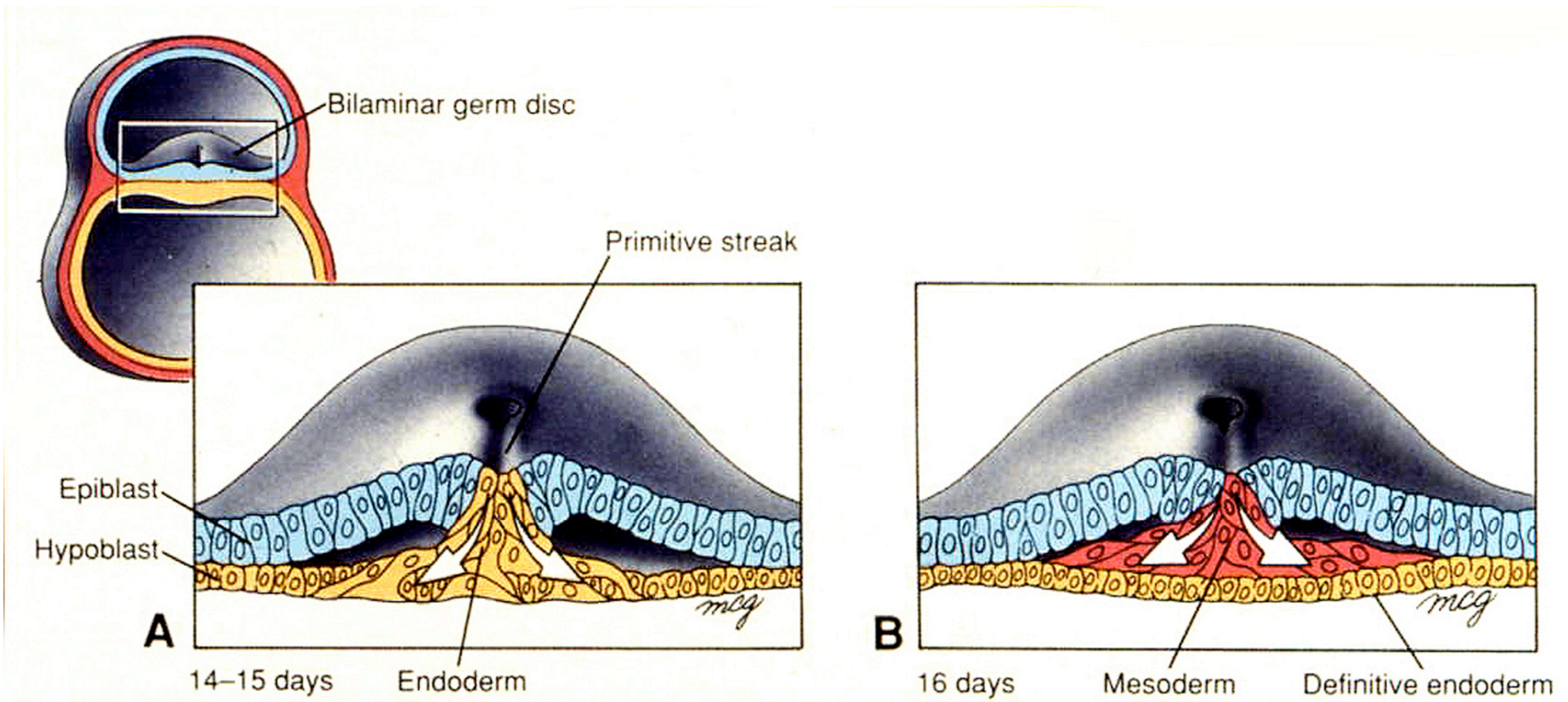
Endoderm: lining of gut and respiratory tract

Fate map of epiblast prior to gastrulation.



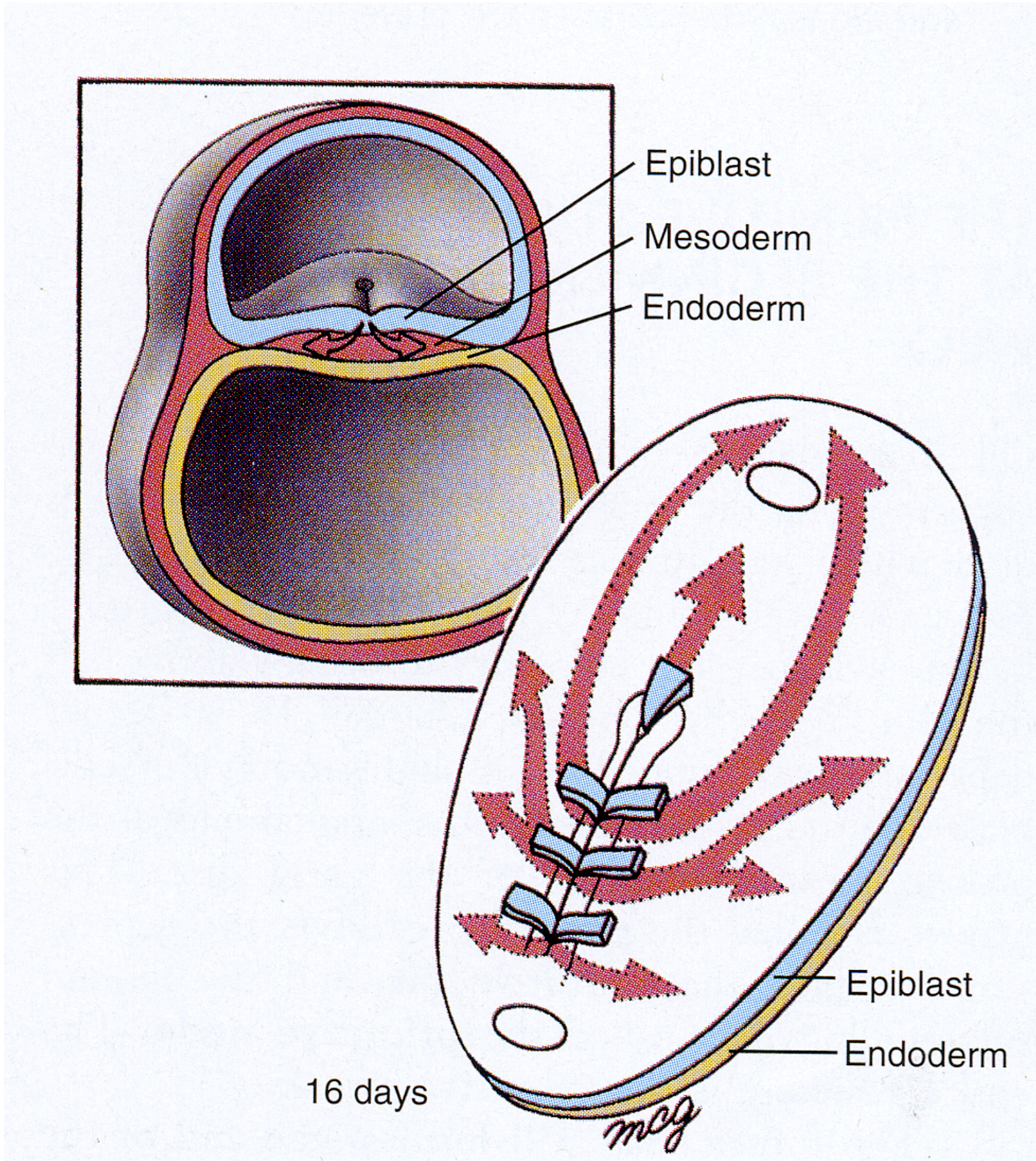


First sign of gastrulation
is the formation at midline of primitive streak.
Formation of streak defines cranial and caudal axes.

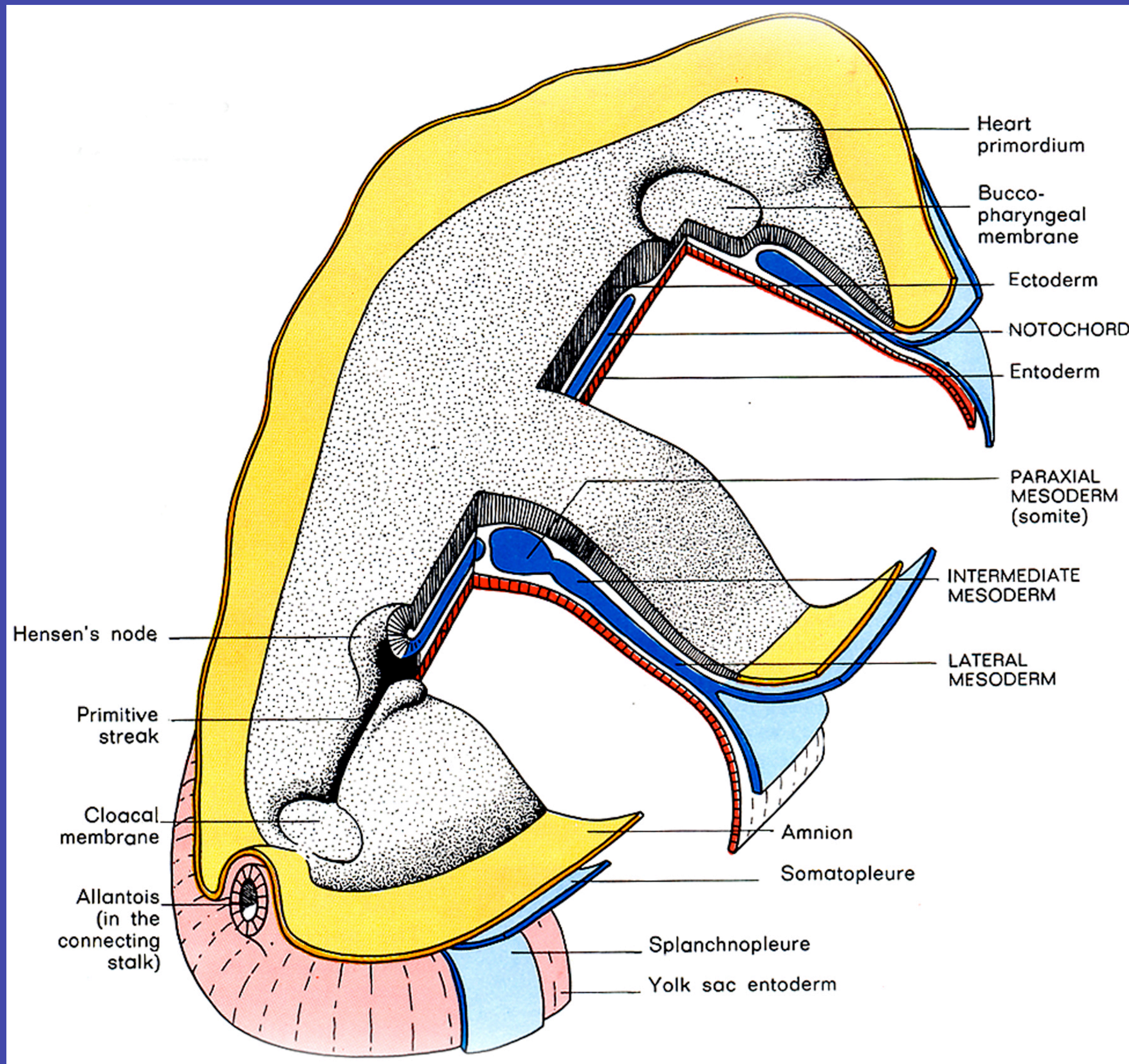


Cells of the epiblast gain access to the interior via primitive node and streak. Hypoblast is replaced by true endoderm.

Where and when epiblast cells enter the node or streak determines their fate.



At the end of gastrulation the 3 primary germ layers are present. The 3 axes of the embryo are established.
The embryo still touches extra-embryonic tissue on all edges.



Gamete production and fertilization – re-establishment of the 2N state.

Cleavage divisions: setting aside embryonic vs. extra-embryonic lineages

Initial stages of implantation and formation of extra-embryonic spaces.

Gastrulation: place and time of migration determines fate. Formation of 3 germ layers.

Introduction to Embryology I

B. Neural induction

What is induction?

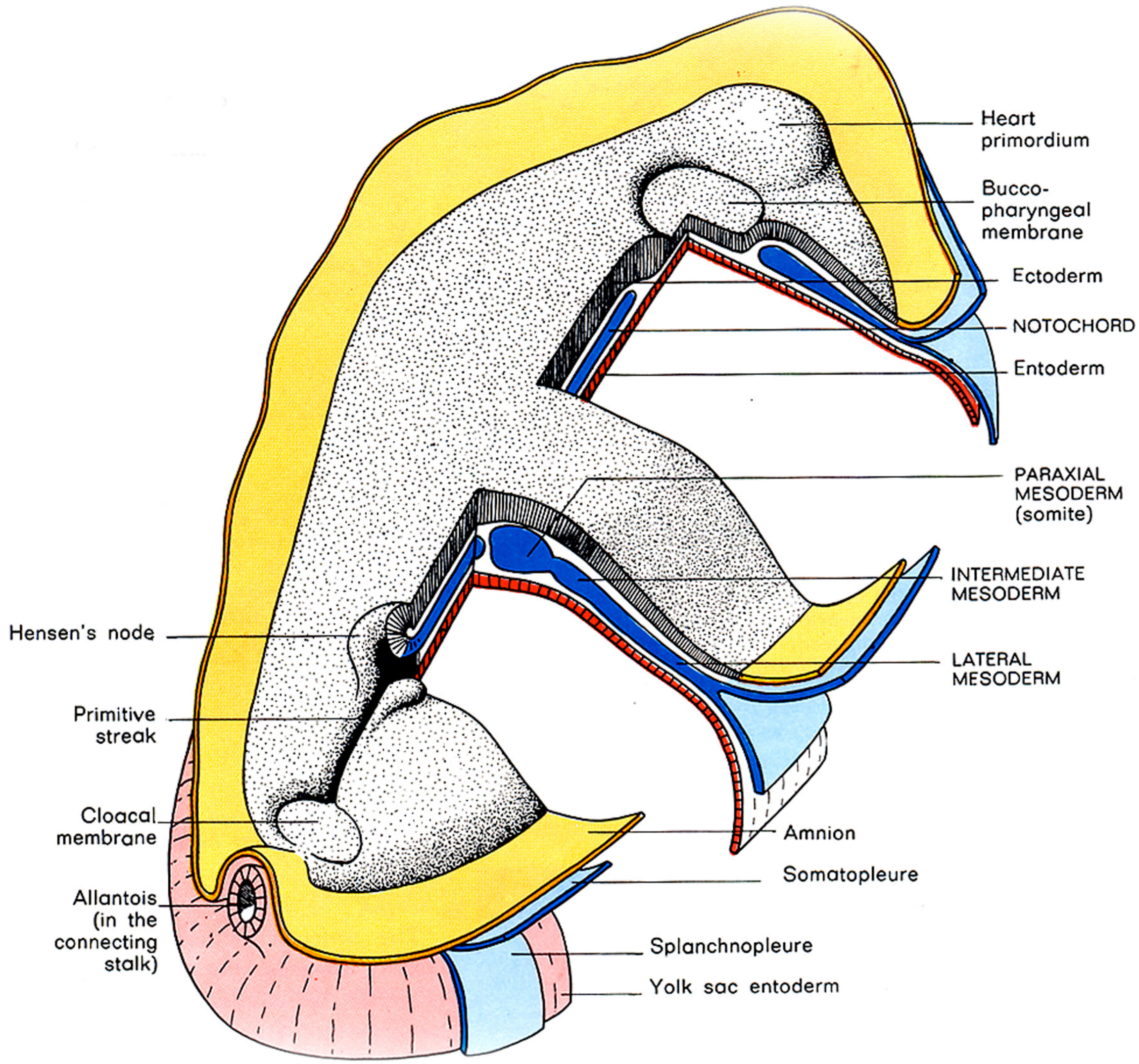
It is the interaction of two cells/tissues which leads to a change in fate of (at least) one of them. Responding tissue must show competence. Competence can change over time.

What are the mechanisms of induction:

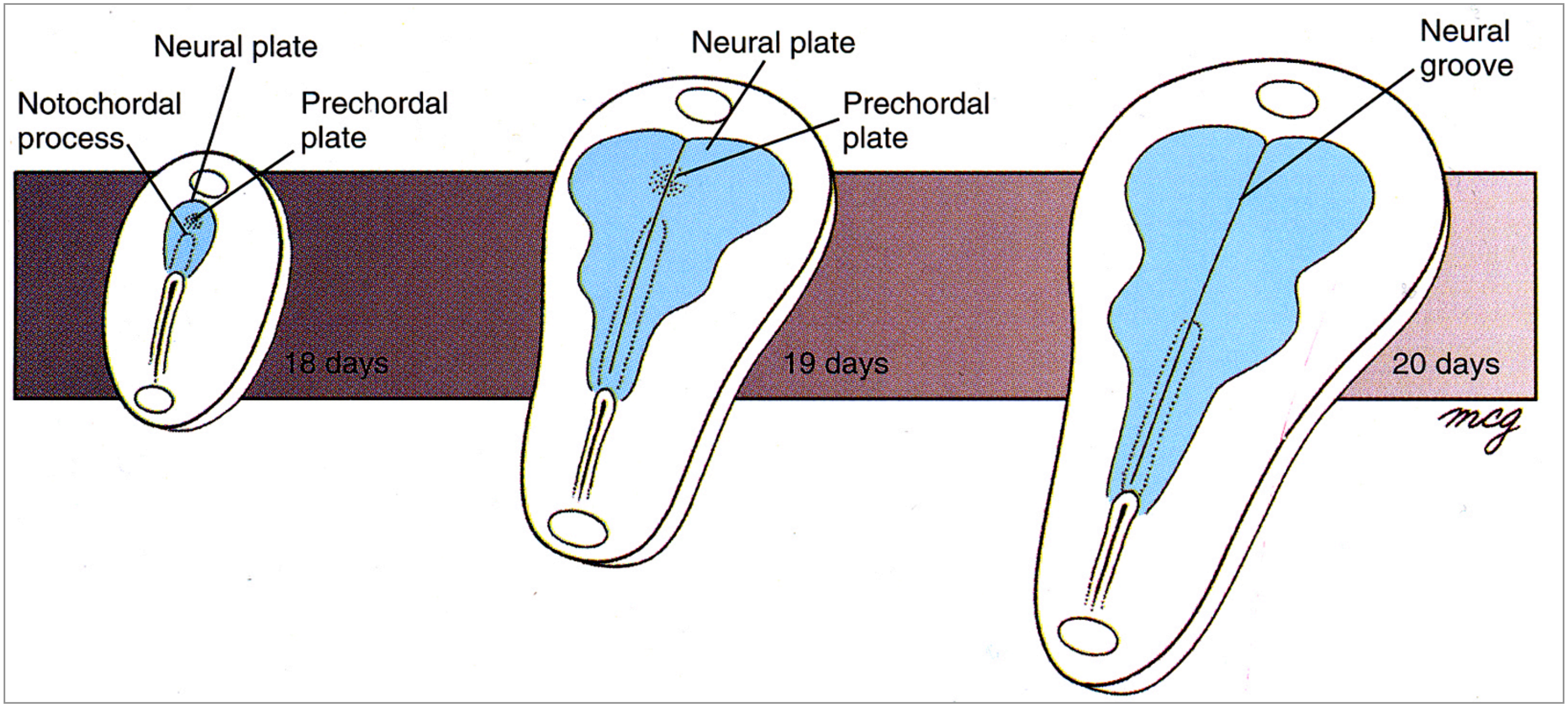
1. Diffusible signals referred to as morphogens. Cells/ tissues that “see” the morphogen take on a new fate. For many morphogens both the biochemistry and the concentration of the morphogen carry information. Gradients are stabilized by restrictions on diffusion.
2. ECM
3. Cell-Cell

In all cases the tissue with altered fate had to have been competent to respond.

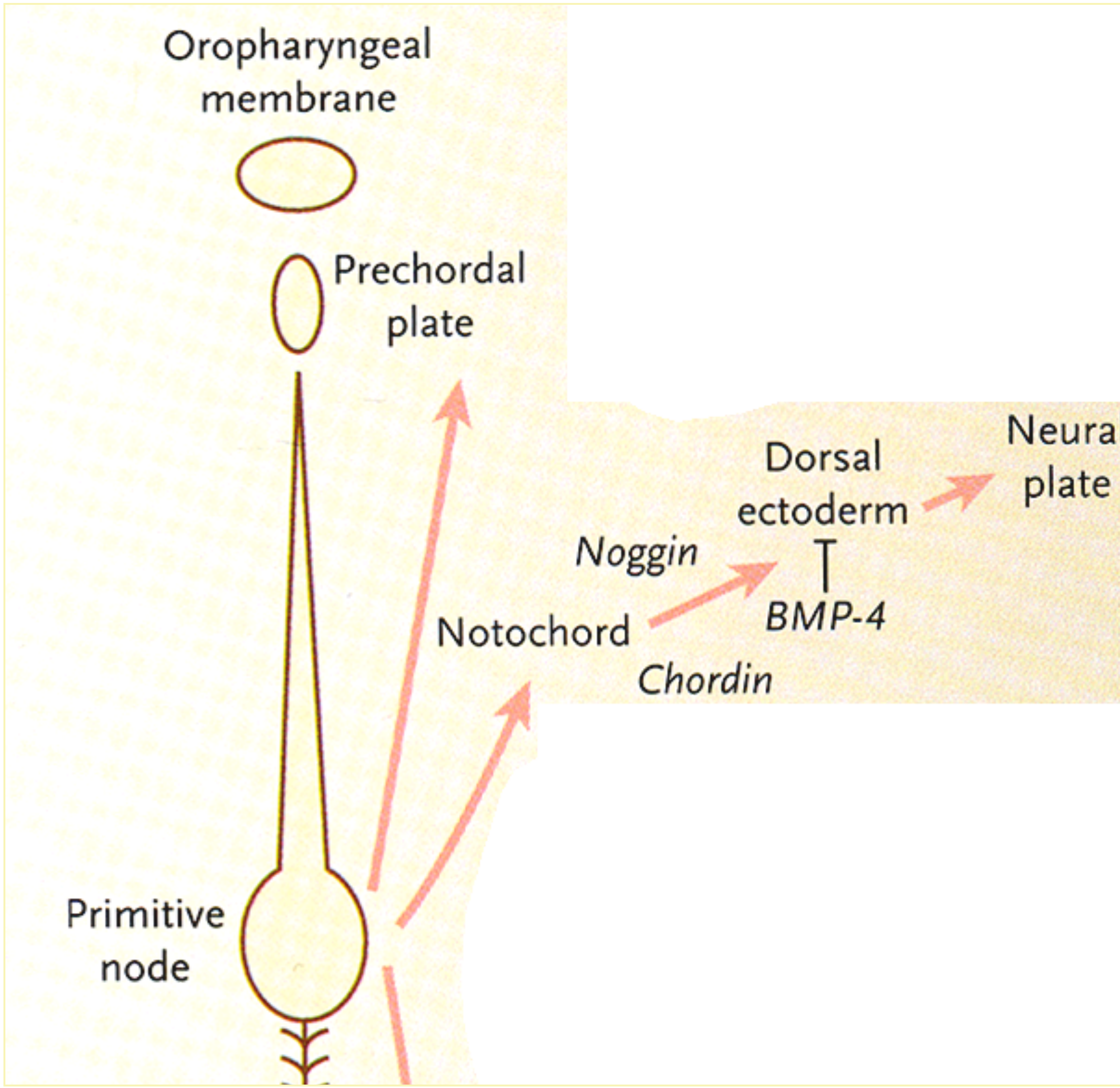
Note the midline position of the notochord vis-á-vis dorsal ectoderm.



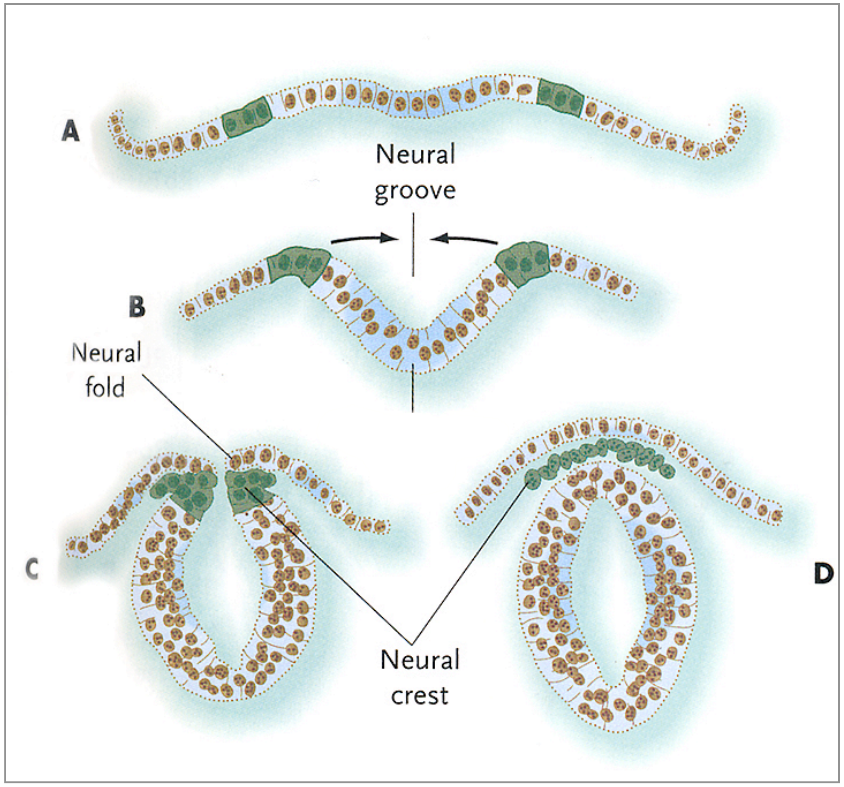
Shaping the neural plate

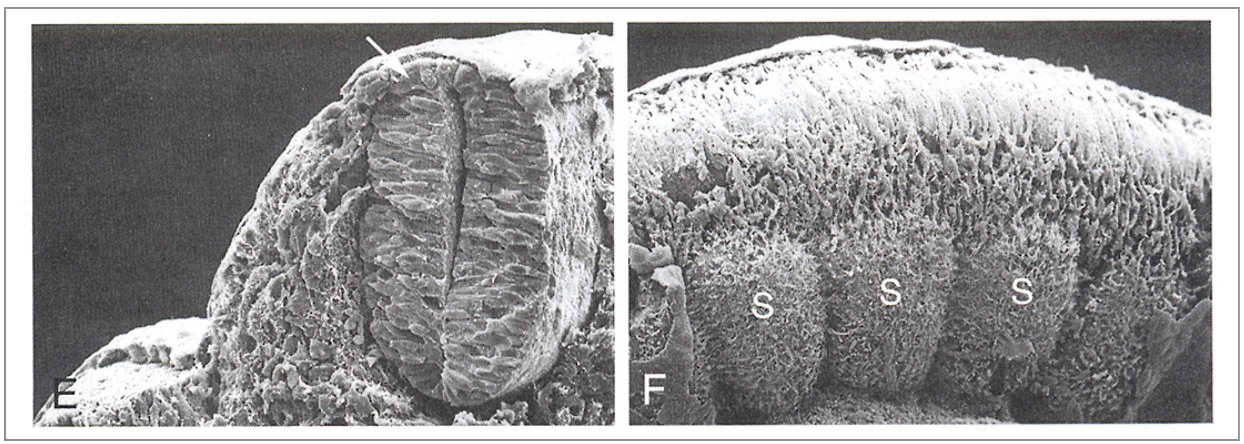


“Negative” induction of neural plate.

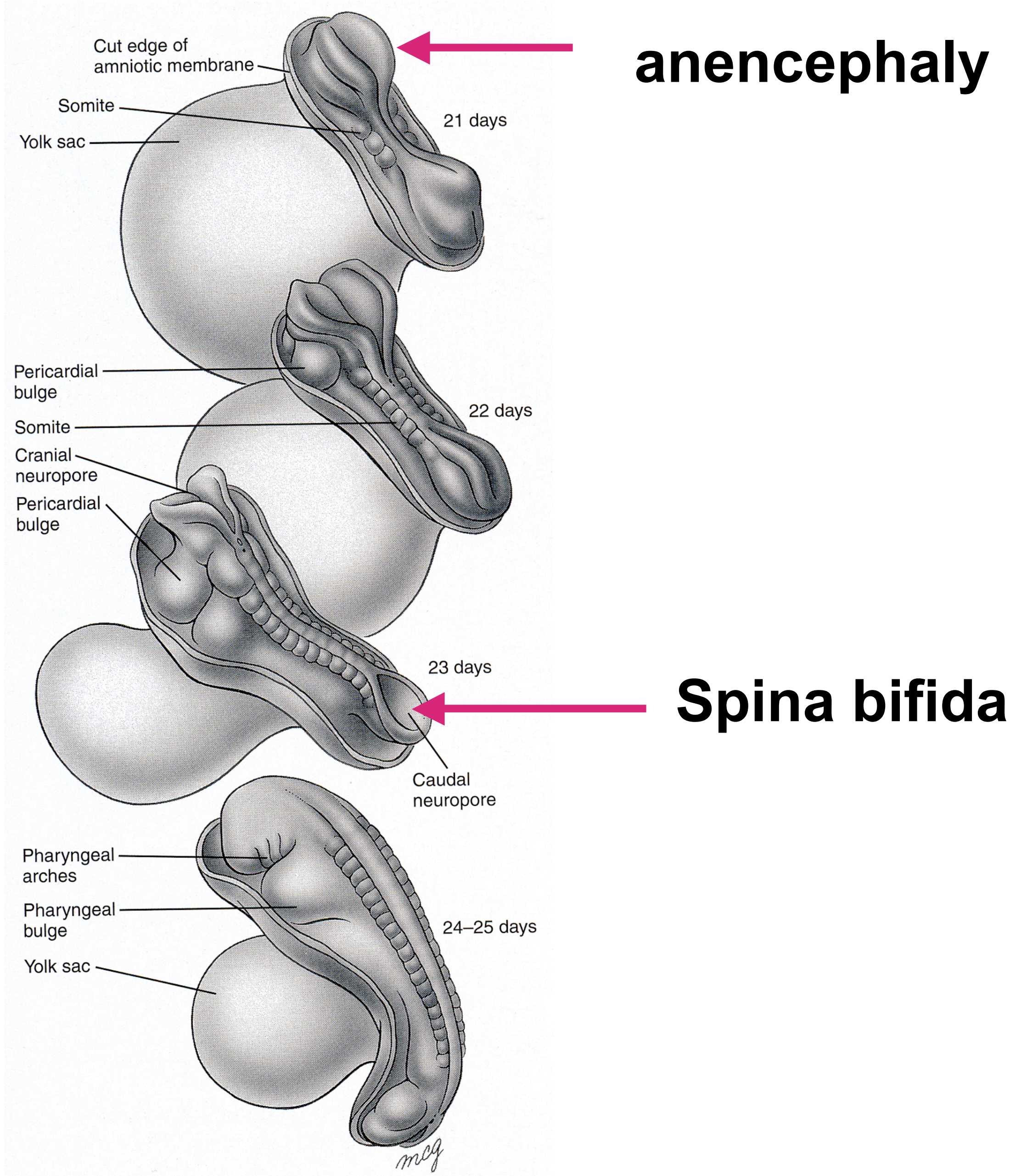


The neural crest





Closing of neuropores



Neural tube –

“induced” by inhibition of signals (morphogens) coming from dorsal ectoderm (block BMP-4) by secretions from notochord and prechordal plate (noggin).

neural plate folds into a tube

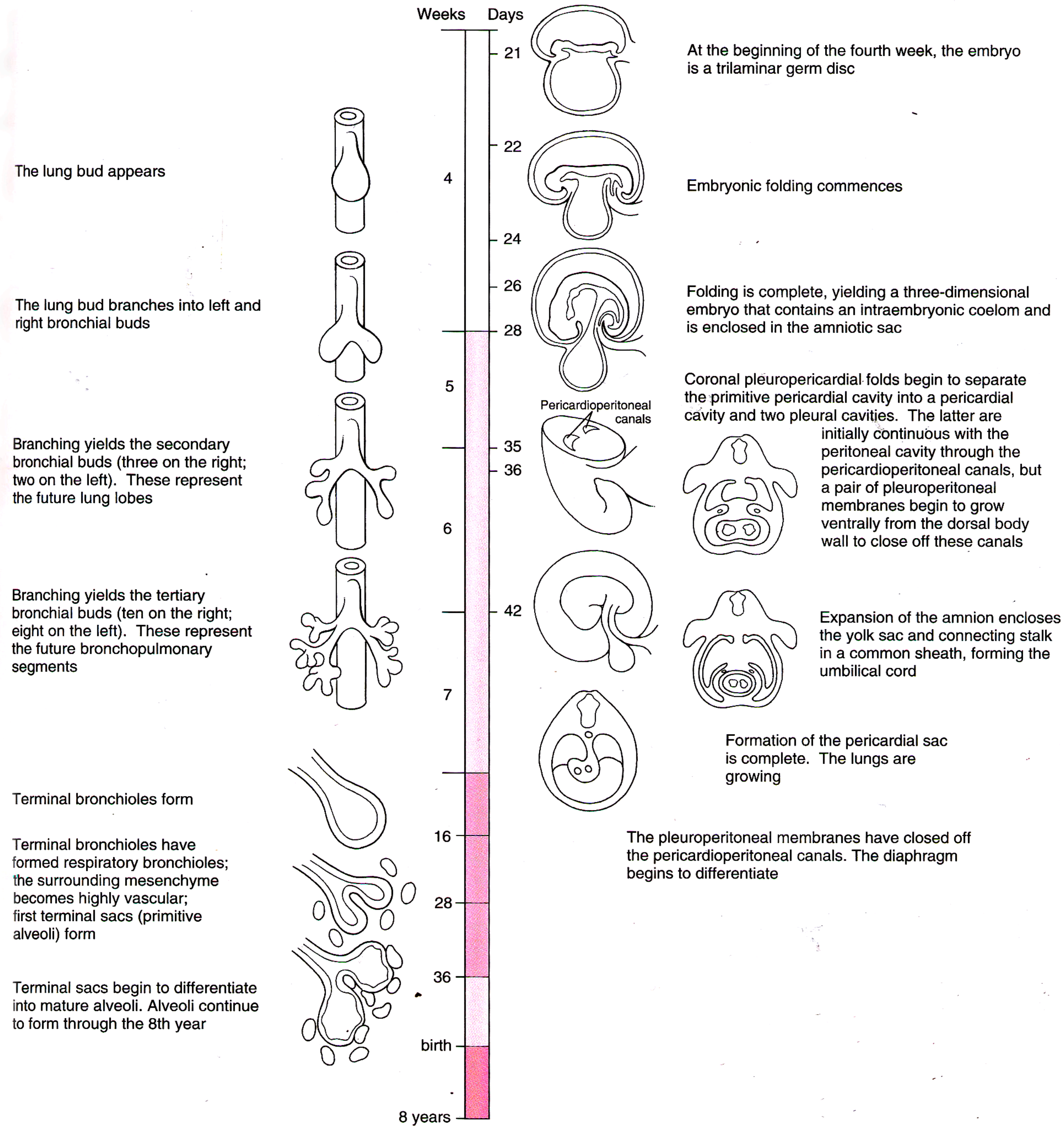
central canal of tube is maintained.

Introduction to Embryology II

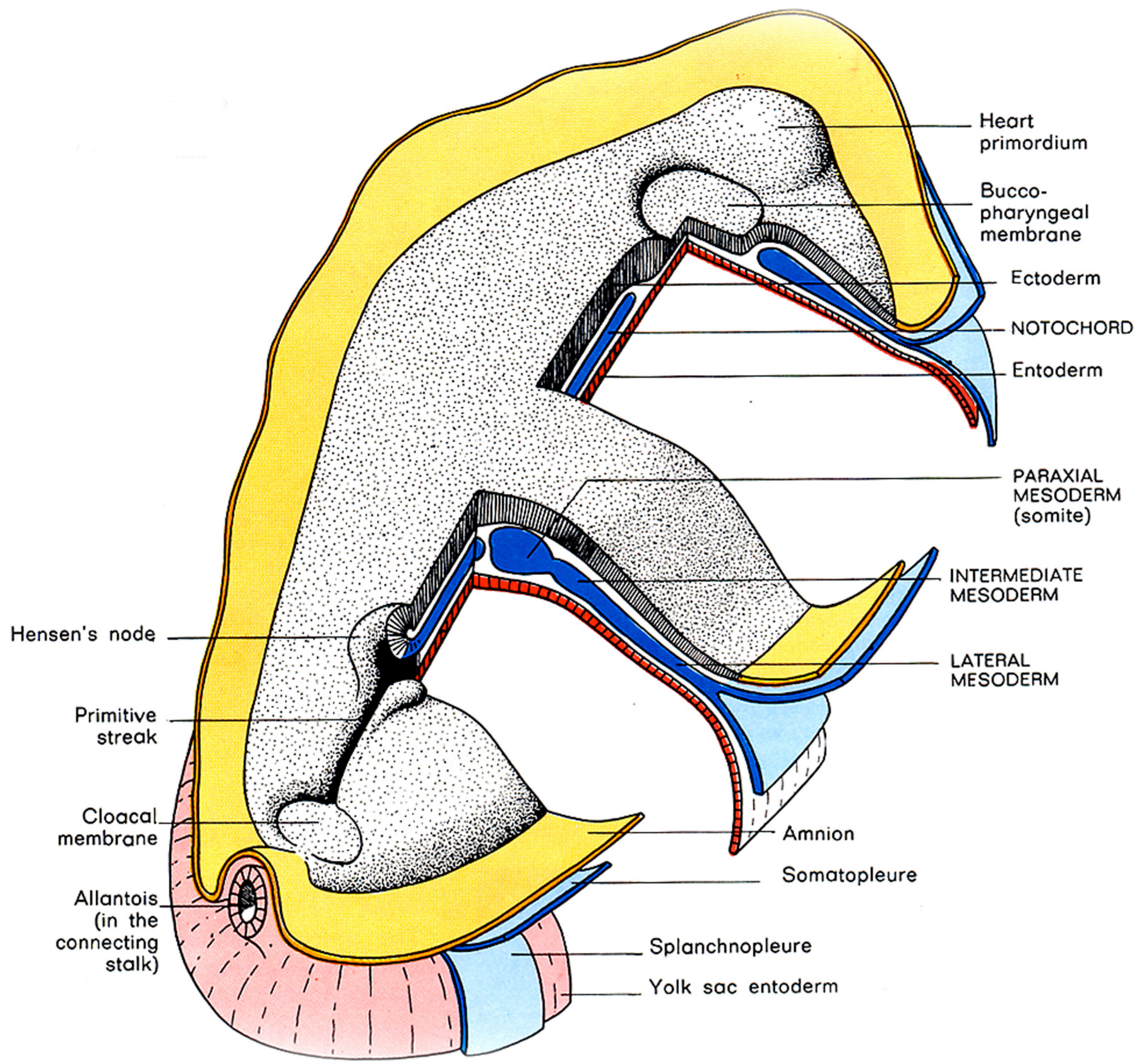
II. FLEXION AND FOLDING

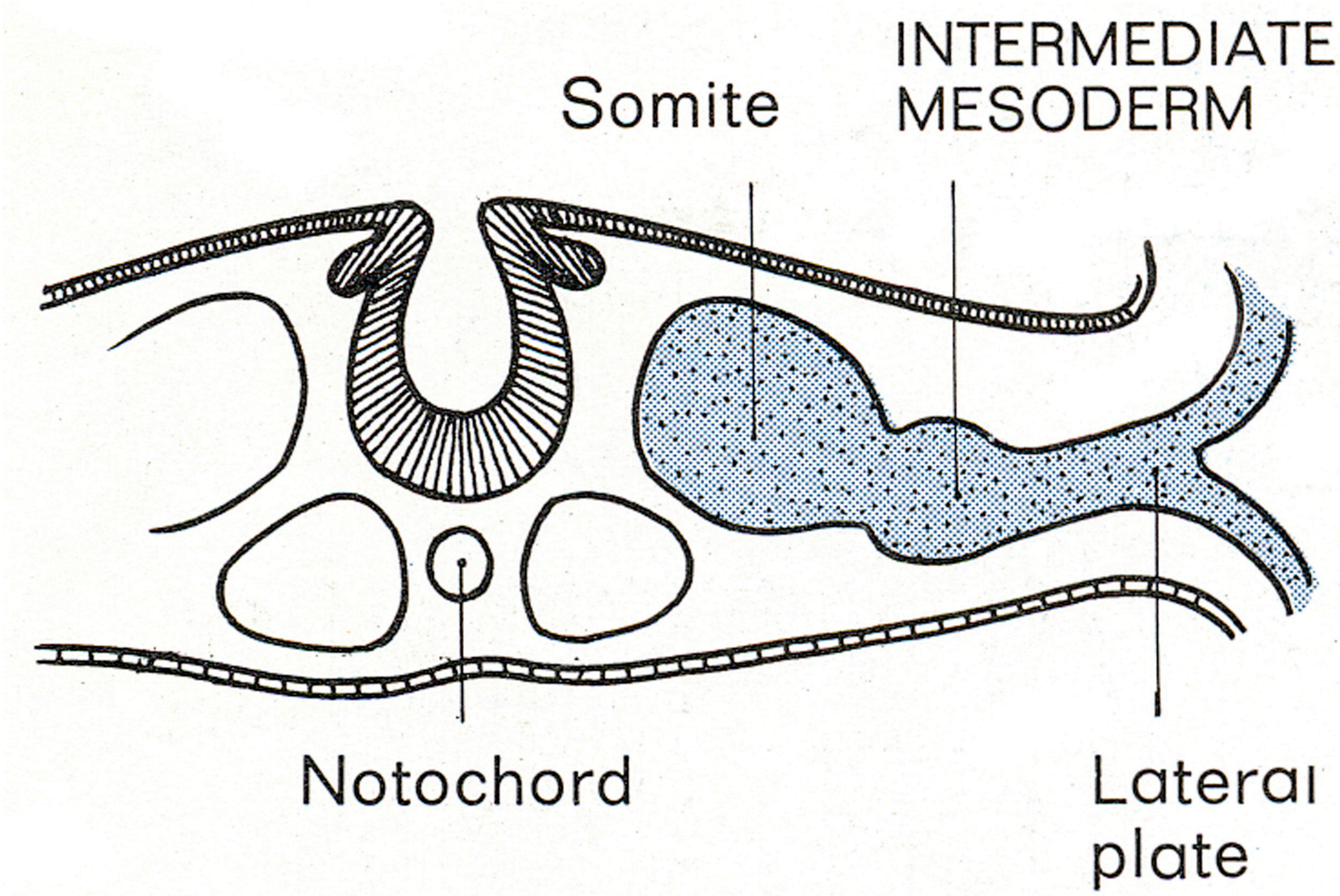
Formation of the body cylinder or how to turn a flat structure into a tube.

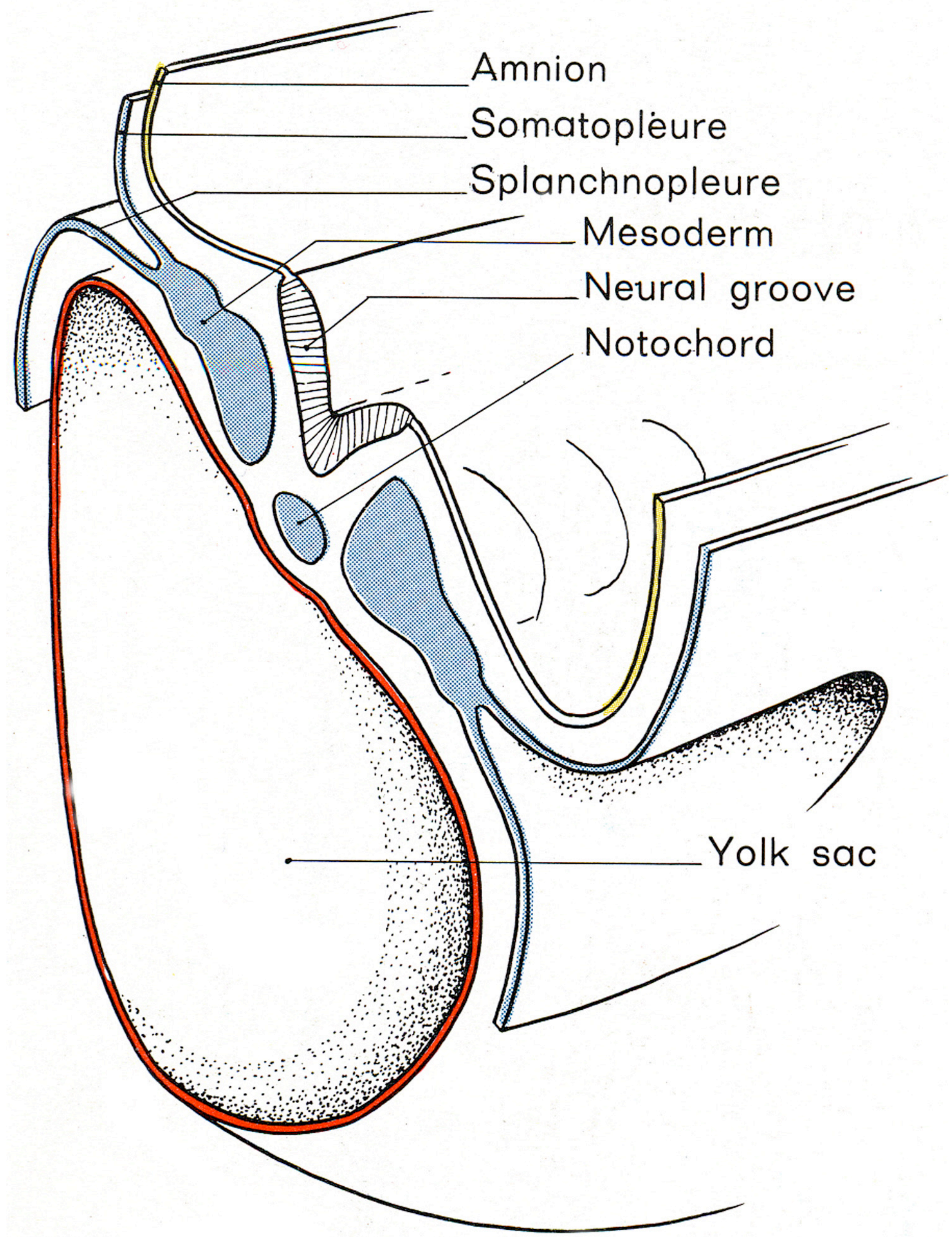
A Movie

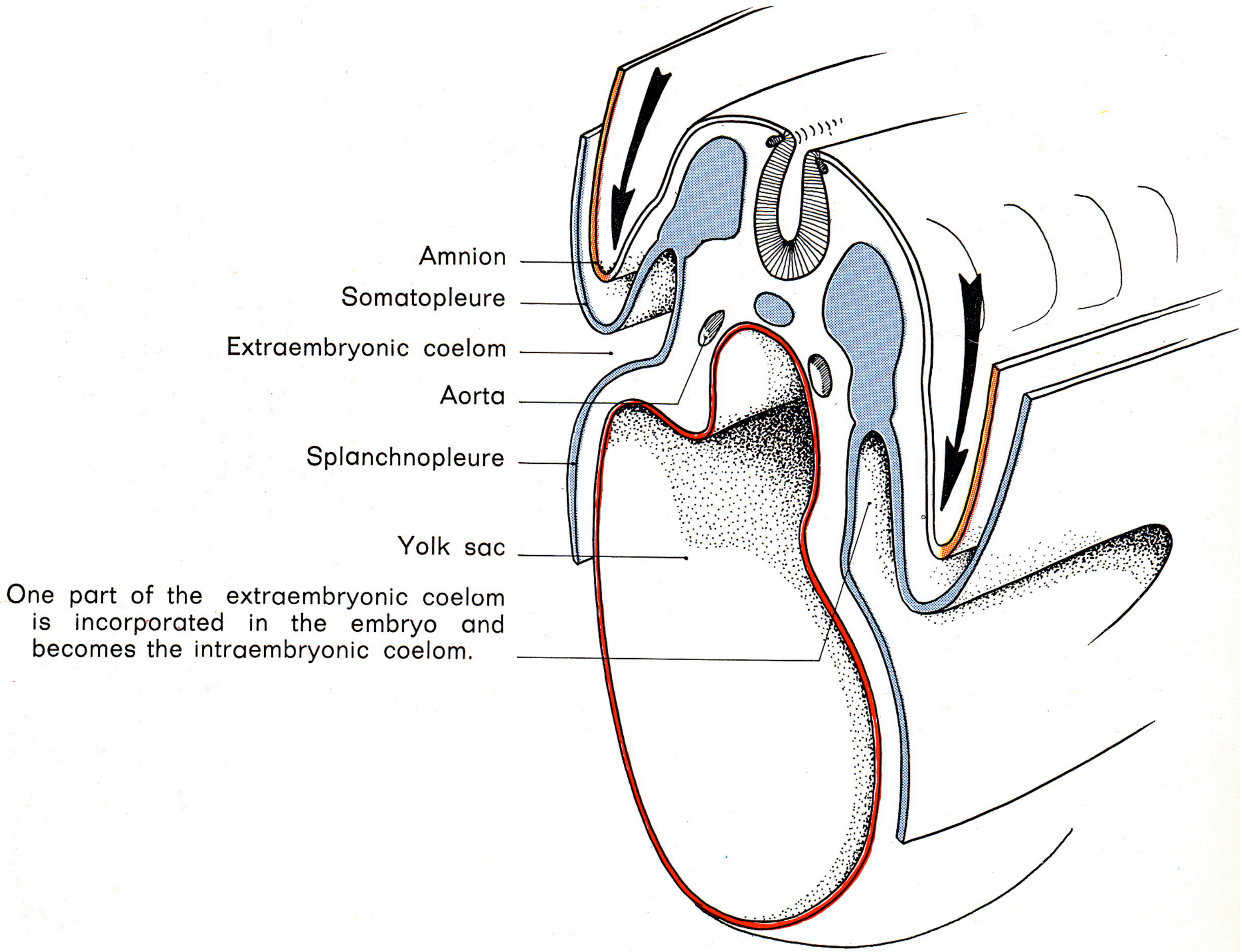


Timeline. Embryonic folding; development of the pericardial, pleural, and peritoneal cavities; and development of the lungs.

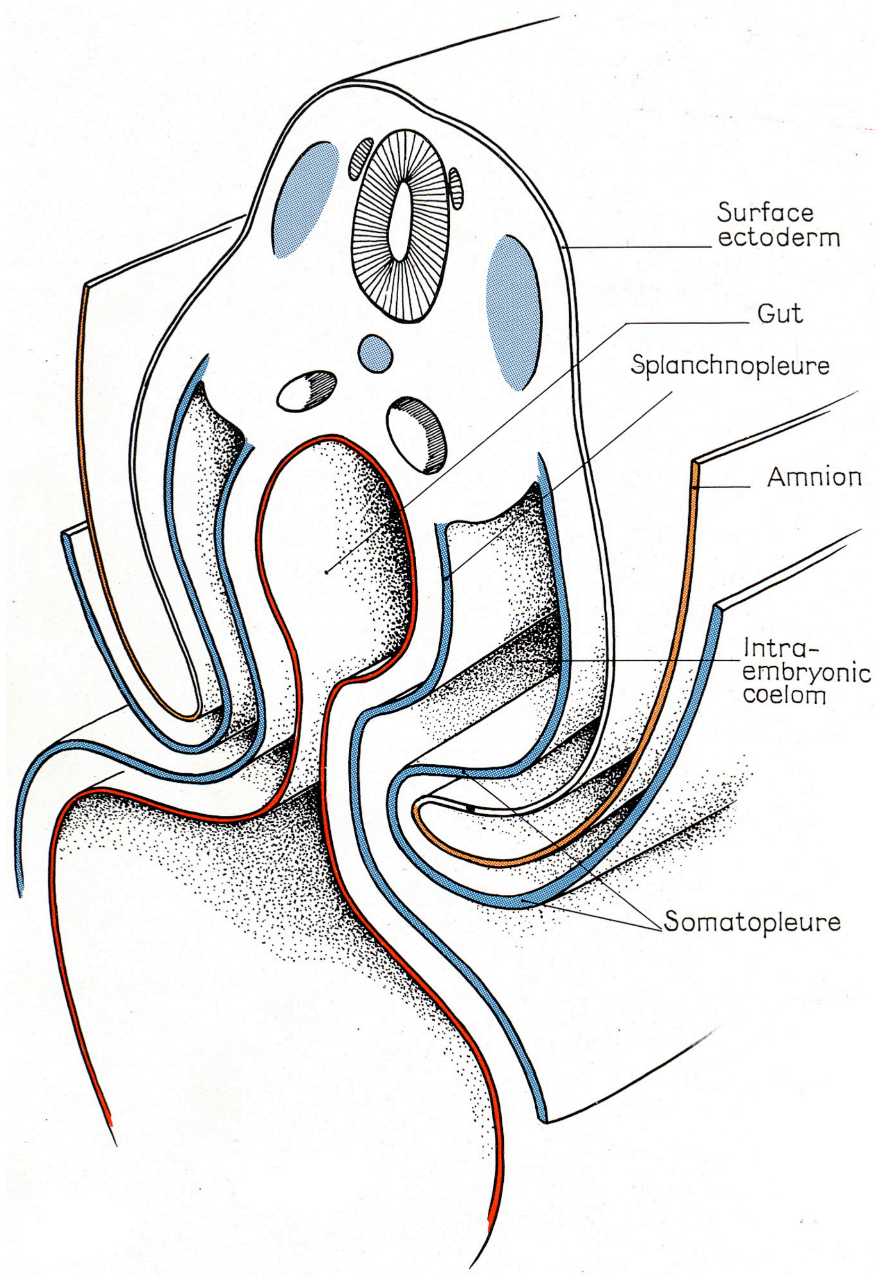

Heart primordium
Bucco-pharyngeal membrane
Ectoderm
NOTOCHORD
Entoderm
PARAXIAL MESODERM (somite)
INTERMEDIATE MESODERM
LATERAL MESODERM
Hensen's node
Primitive streak
Cloacal membrane
Allantois (in the connecting stalk)
Amnion
Somatopleure
Splanchnopleure
Yolk sac entoderm

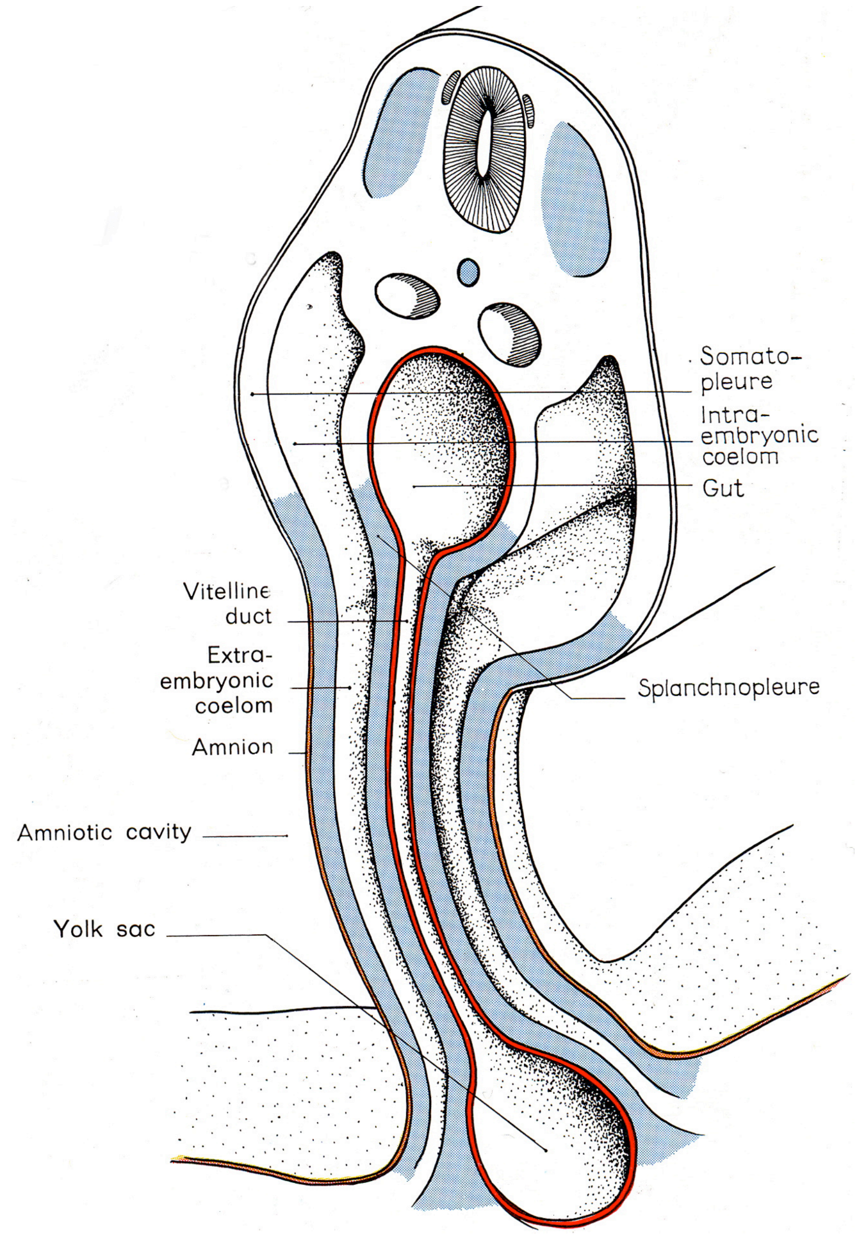

INTERMEDIATE MESODERM
Somite
Notochord
Lateral plate


Amnion
Somatopleure
Splanchnopleure
Mesoderm
Neural groove
Notochord
Yolk sac

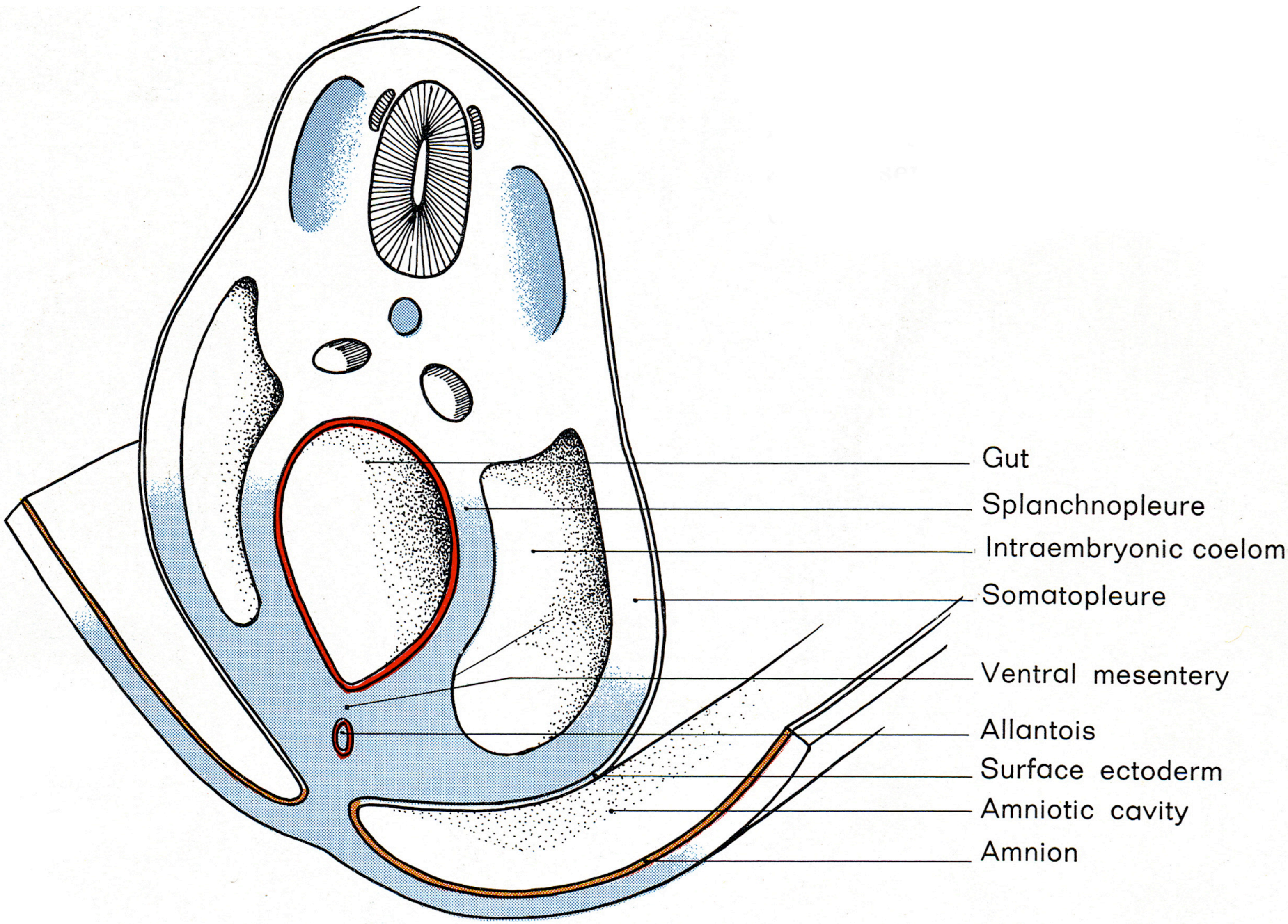


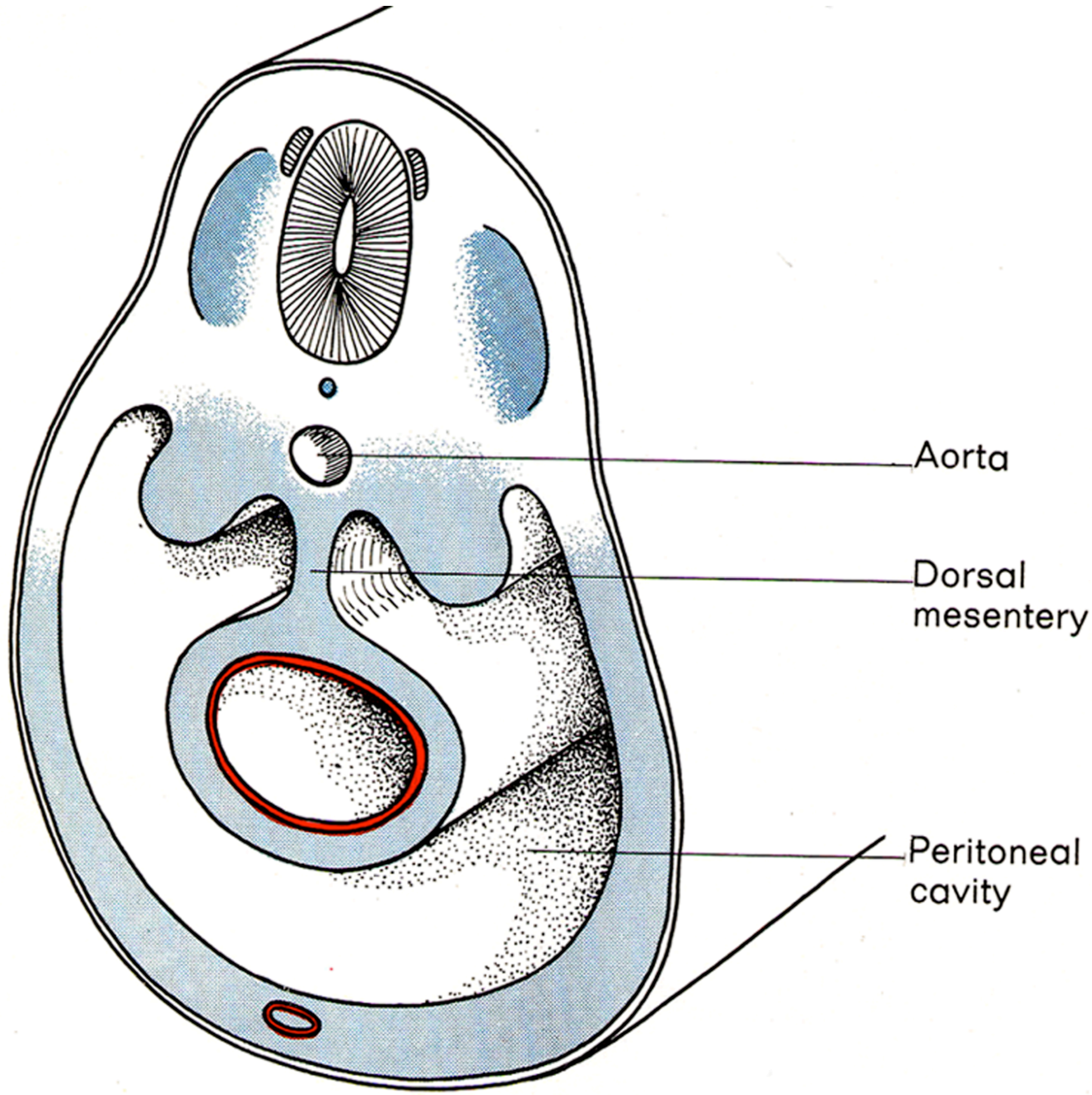
Amnion
Somatopleure
Extraembryonic coelom
Aorta
Splanchnopleure
Yolk sac
One part of the extraembryonic coelom is incorporated in the embryo and becomes the intraembryonic coelom.

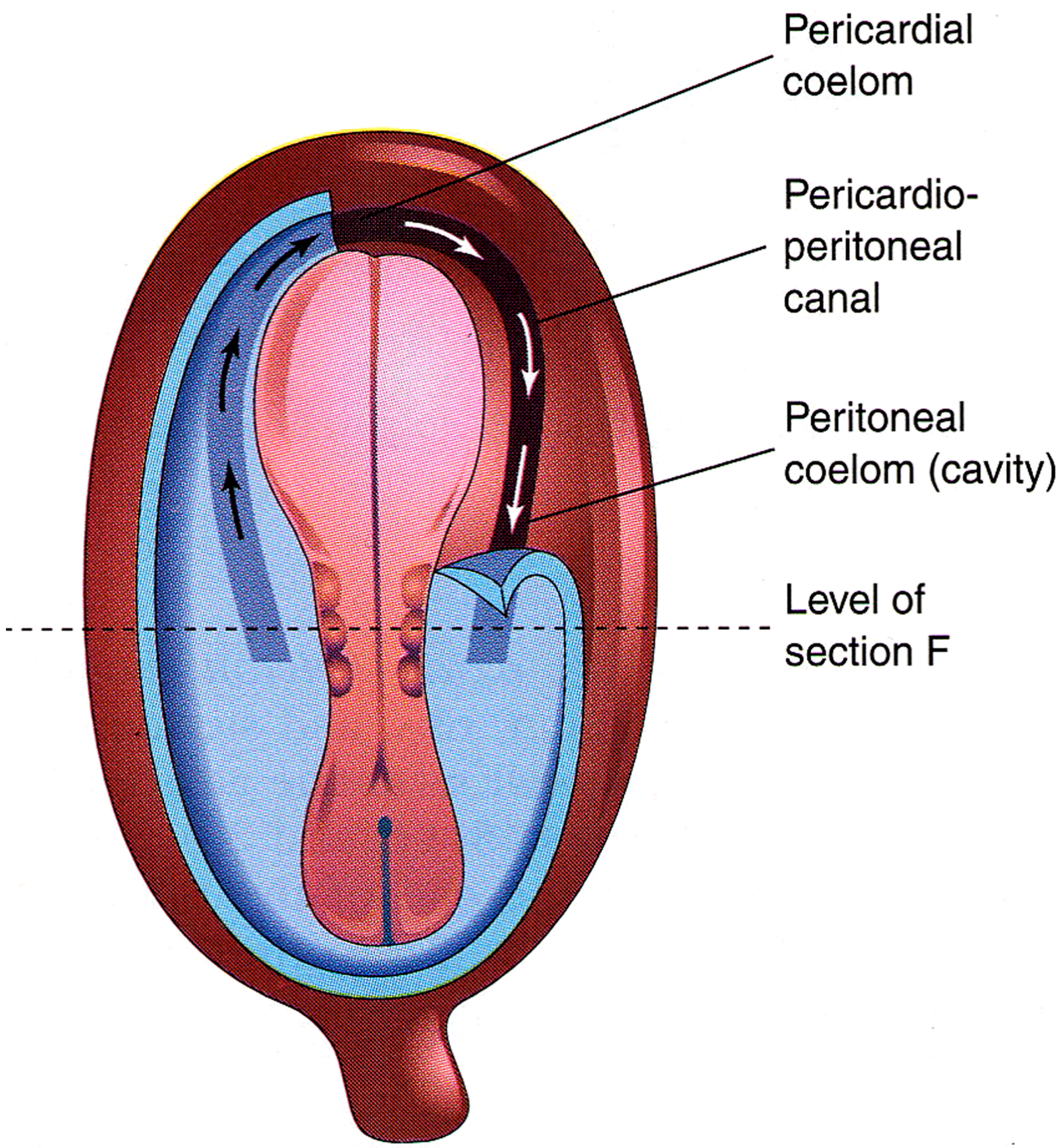

Surface ectoderm
Gut
Splanchnopleure
Amnion
Intra-embryonic coelom
Somatopleure

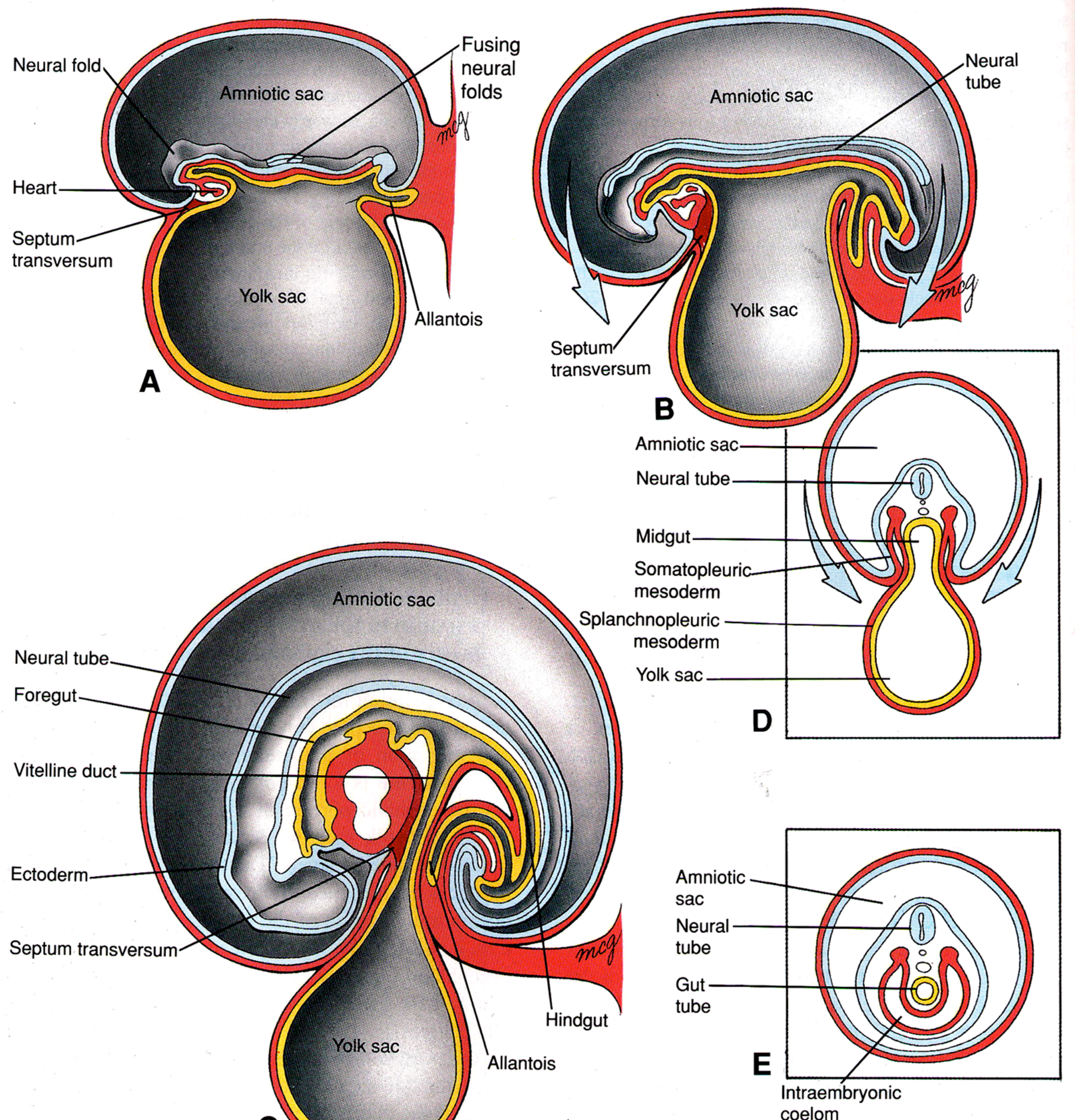


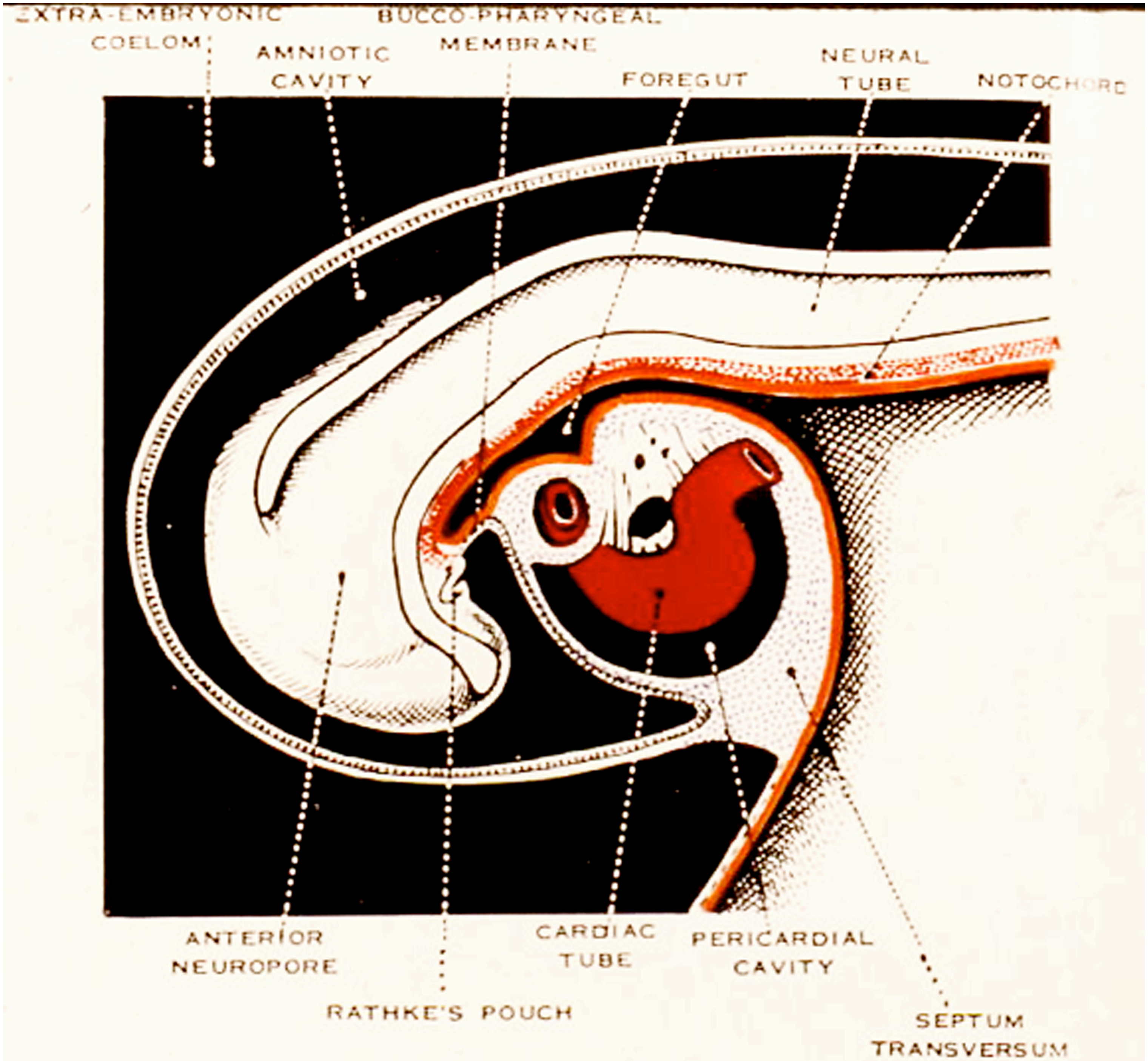
Somato-
pleure
Intra-
embryonic
coelom
Gut
Vitelline
duct
Extra-
embryonic
coelom
Amnion
Amniotic cavity
Yolk sac
Splanchnopleure

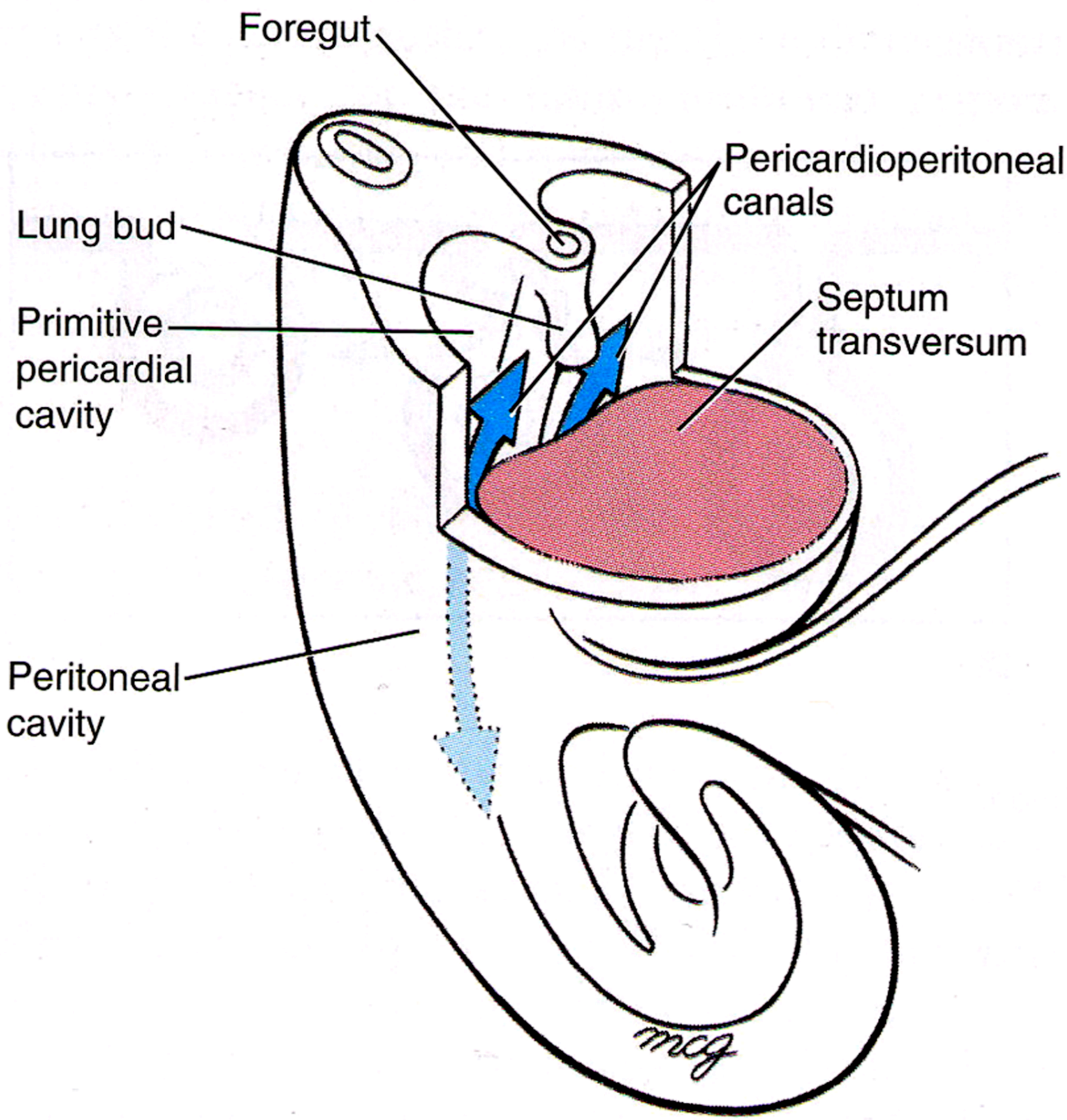

Gut
Splanchnopleure
Intraembryonic coelom
Somatopleure
Ventral mesentery
Allantois
Surface ectoderm
Amniotic cavity
Amnion


Aorta
Dorsal
mesentery
Peritoneal
cavity

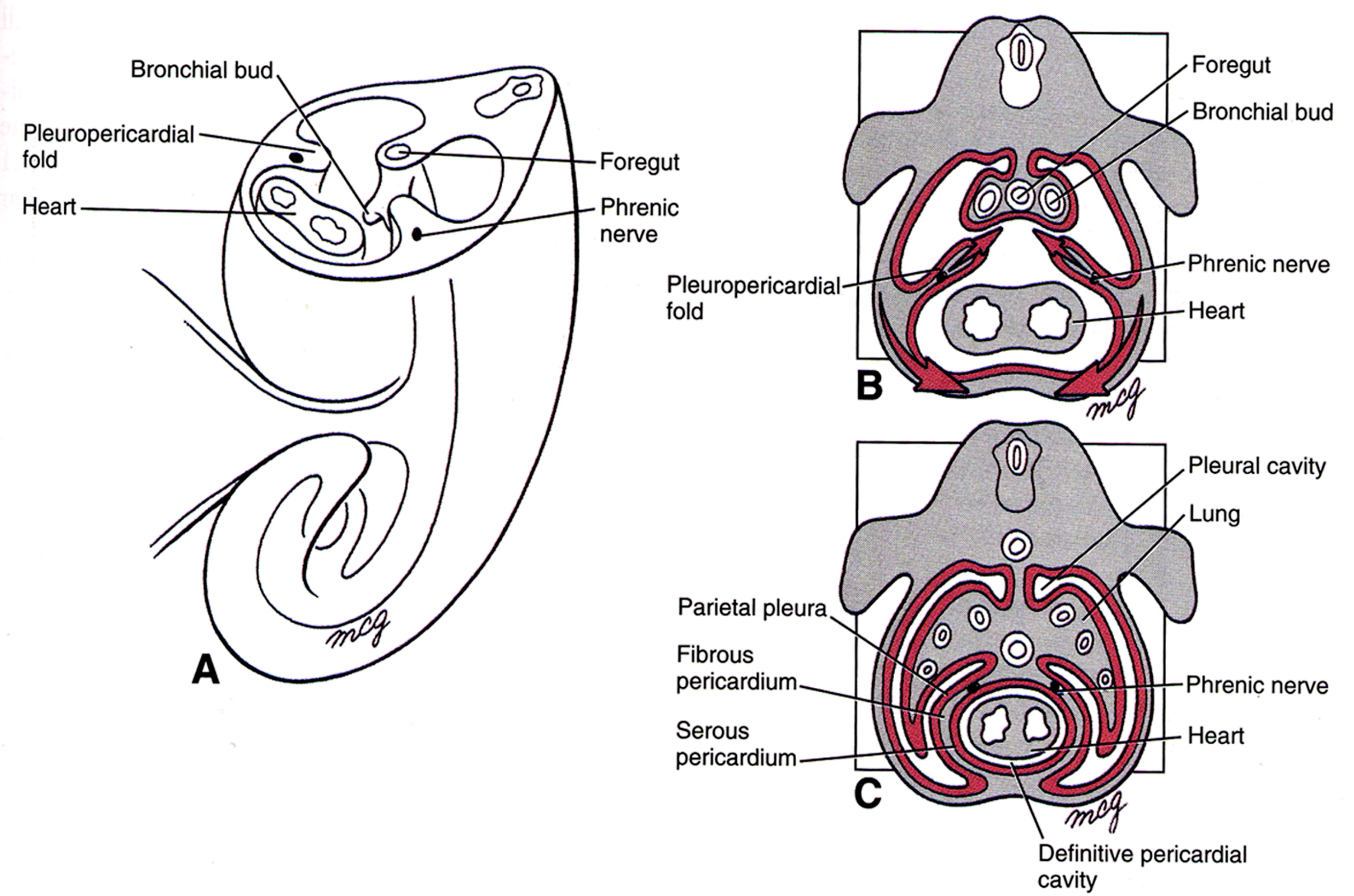

Pericardial
coelom
Pericardio-
peritoneal
canal
Peritoneal
coelom (cavity)
Level of
section F

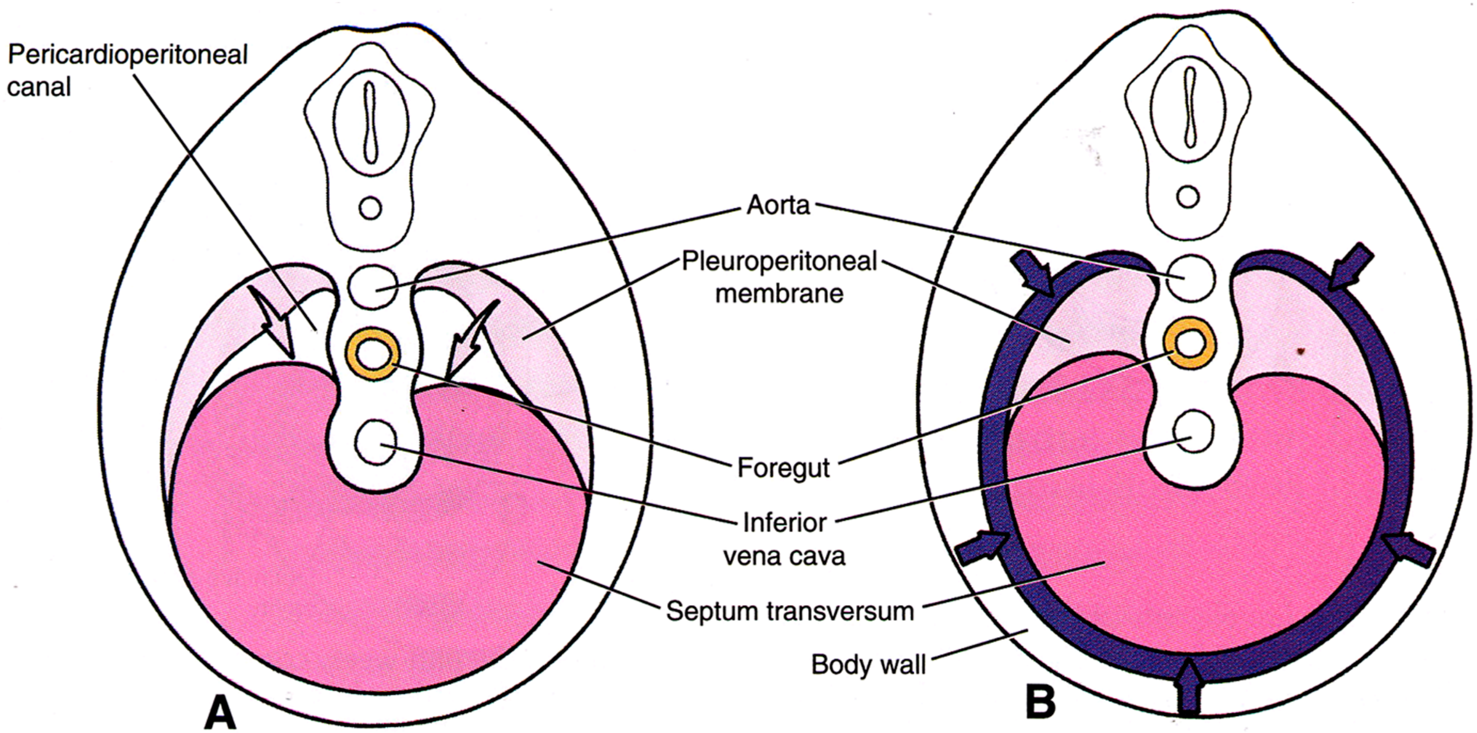

Neural fold
Amniotic sac
Fusing neural folds
Heart
Septum transversum
Yolk sac
Allantois
A
Amniotic sac
Neural tube
Yolk sac
Septum transversum
B
Amniotic sac
Neural tube
Midgut
Somatopleuric mesoderm
Splanchnopleuric mesoderm
Yolk sac
D
Amniotic sac
Neural tube
Foregut
Vitelline duct
Ectoderm
Septum transversum
Yolk sac
Allantois
Hindgut
C
Amniotic sac
Neural tube
Gut tube
Intraembryonic coelom
E

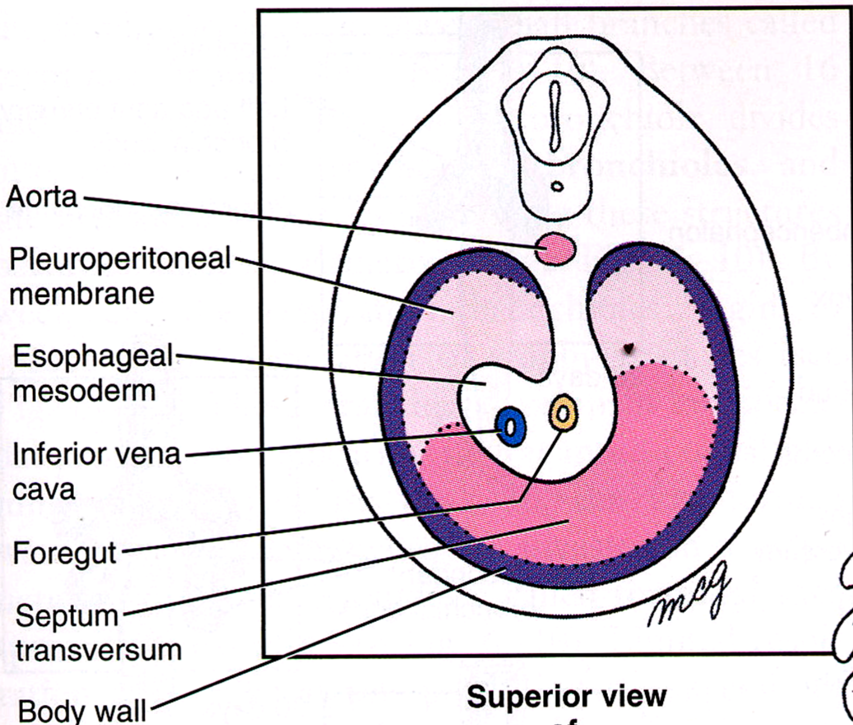

EXTRA-EMBRYONIC
COELOM
BUCCO-PHARYNGEAL
MEMBRANE
AMNIOTIC
CAVITY
FOREGUT
NEURAL
TUBE
NOTOCHORD
ANTERIOR
NEUROPORE
CARDIAC
TUBE
PERICARDIAL
CAVITY
RATHKE'S POUCH
SEPTUM
TRANSVERSUM



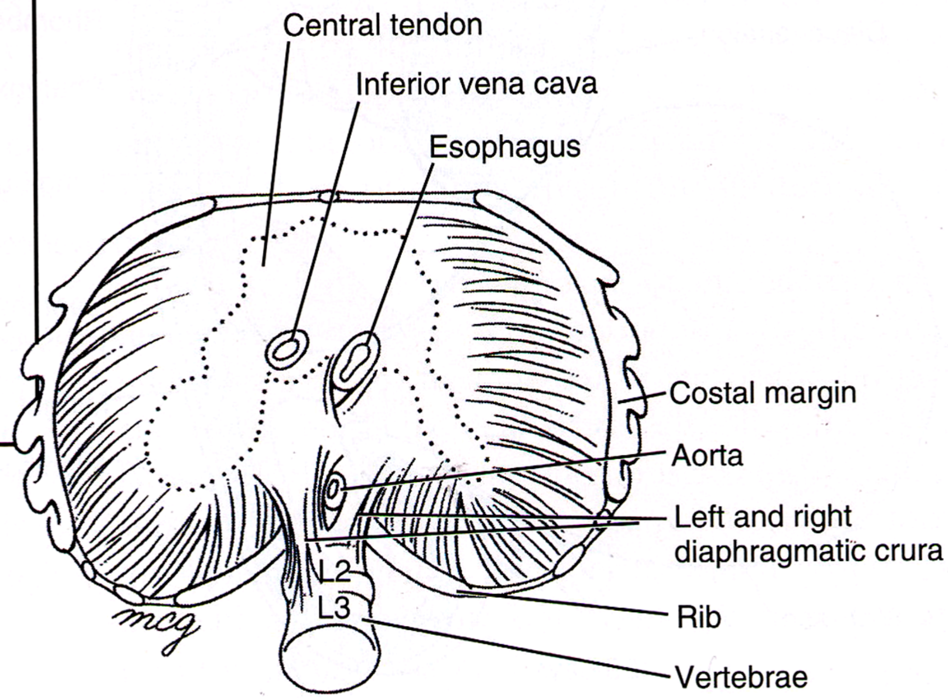
Foregut
Pericardioperitoneal canals
Lung bud
Primitive pericardial cavity
Septum transversum
Peritoneal cavity
mcg


Bronchial bud
Pleuropericardial fold
Heart
Foregut
Phrenic nerve
A
Foregut
Bronchial bud
Pleuropericardial fold
Phrenic nerve
Heart
B
Pleural cavity
Lung
Parietal pleura
Fibrous pericardium
Serous pericardium
Phrenic nerve
Heart
C
Definitive pericardial cavity


Pericardioperitoneal canal
Aorta
Pleuroperitoneal membrane
Foregut
Inferior vena cava
Septum transversum
Body wall
A
B



Superior view of developing diaphragm



Inferior view of diaphragm