Premedical
21 Biology

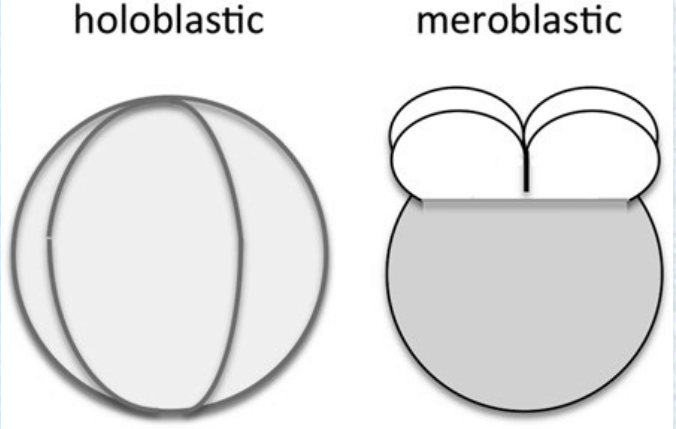
Individual human development

Zygote and **embryonal development**

Human zygote develops into embryo by mitotic **division**,

It has been described

as a **holoblastic cleavage**.



Zygote has genetic information for all cells of organism.

Zygote from the one cell stage to the morula stage consists of **totipotent cells**

Responsible for early differentiation and early development are:

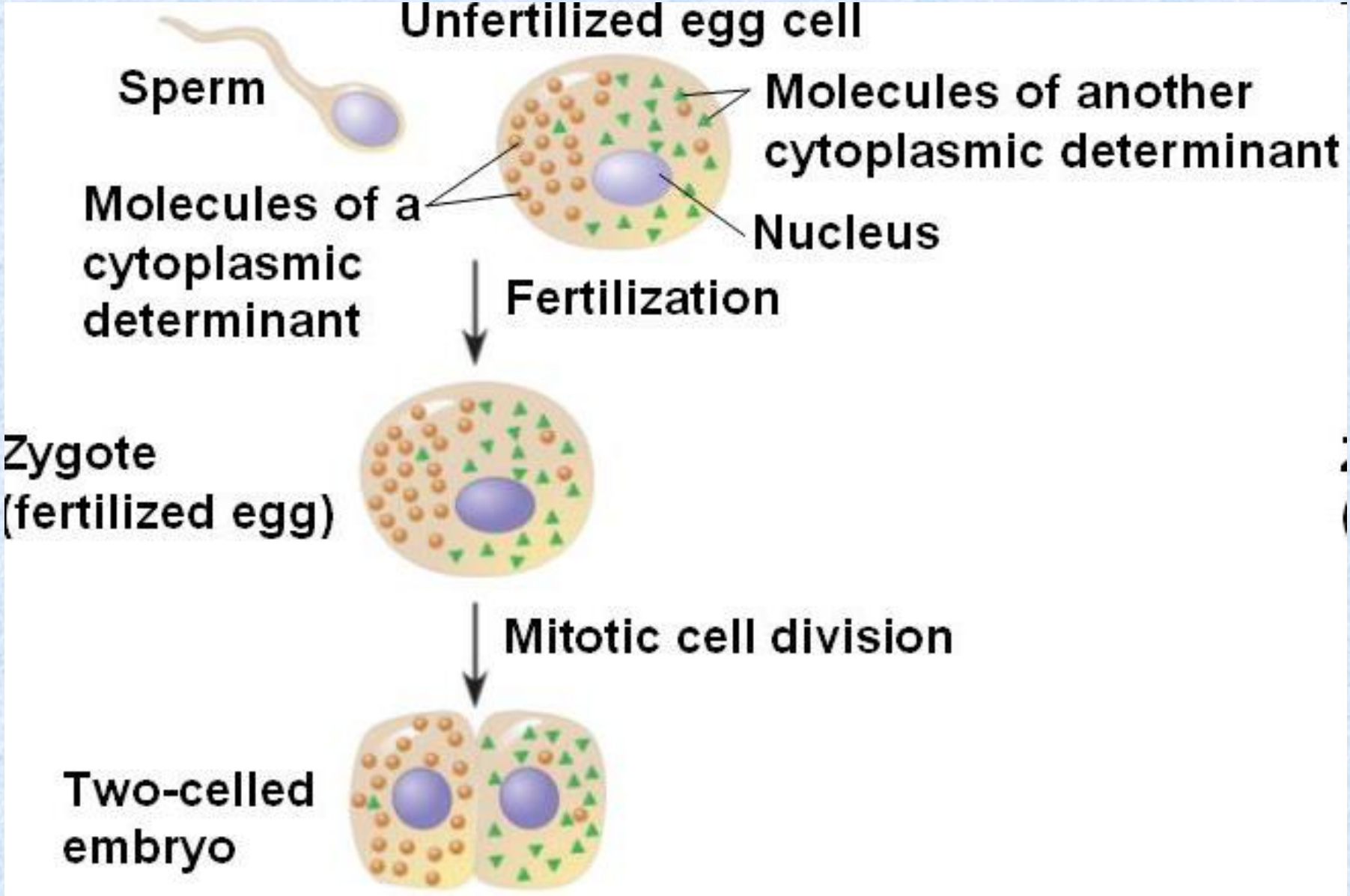
1. **Maternal determinants in egg:**

protein molecules, RNA, mRNA….

= cytoplasmic information molecules,

cytoplasmic determinants

A presence of certain cytoplasmic determinants in the embryo cell and the position of these cells during early development determine three dimensional structure


Unfertilized egg cell
Sperm
Molecules of another cytoplasmic determinant
Molecules of a cytoplasmic determinant
Nucleus
Fertilization
Zygote (fertilized egg)
Mitotic cell division
Two-celled embryo

2. Signal molecules/ Induction

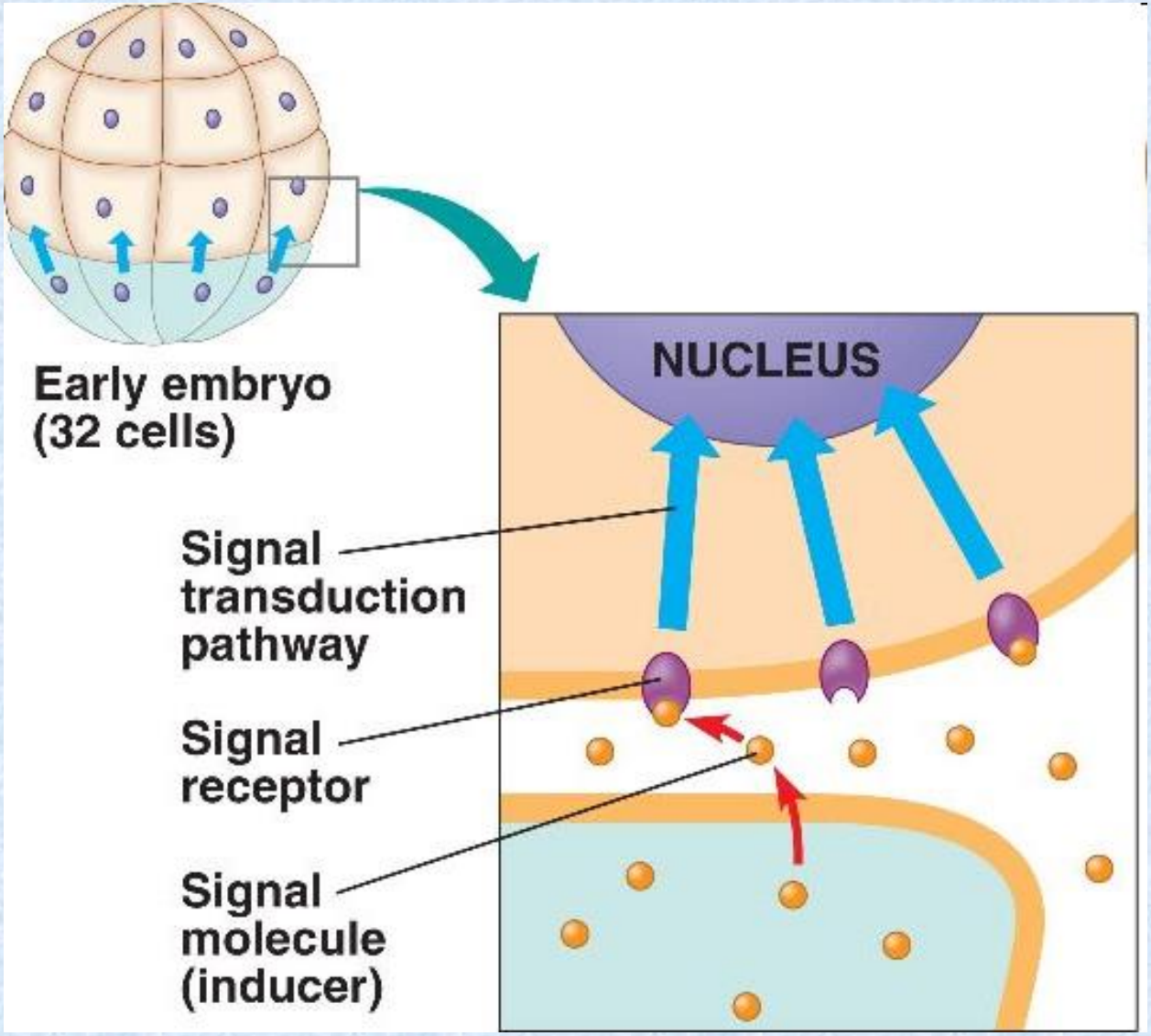
Signal molecules are products of a offspring genome.

Cells communicate with each other via the signal molecules and through cell-cell surface contacts, which result in a change of transcription/regulation of gene expression.

Signals molecules have target cells with receptors.

The **position of specific molecules** in the cell, c**ontact of cells and interaction between signalling molecules and target cells** determine the morphogenetic development.

Animal pole
Vegetative pole



Induction / signalling / regulation of gene expression

Morphogenes

= genes involved directly or indirectly in the control of embryo growth and morphogenesis. They produce transcription factors.

Transcription factors are products of **regulatory genes** and their gradient create **anteriorposterior and dorsoventral axes** They are proteins, which interact with DNA. They activate or deactivate the transcription of other genes. At the end of the regulatory cascade molecules control cellular development.

They have positional information, determine the location relative to body axes

Positional information have groups of genes

Egg-polarity genes, maternal - *bicoid*

Segmentation genes, embryonic:

- Gap genes – division alongside the axis
- Pair-rule genes – segmentation (every second)
- Segment polarity genes
- Homeotic genes

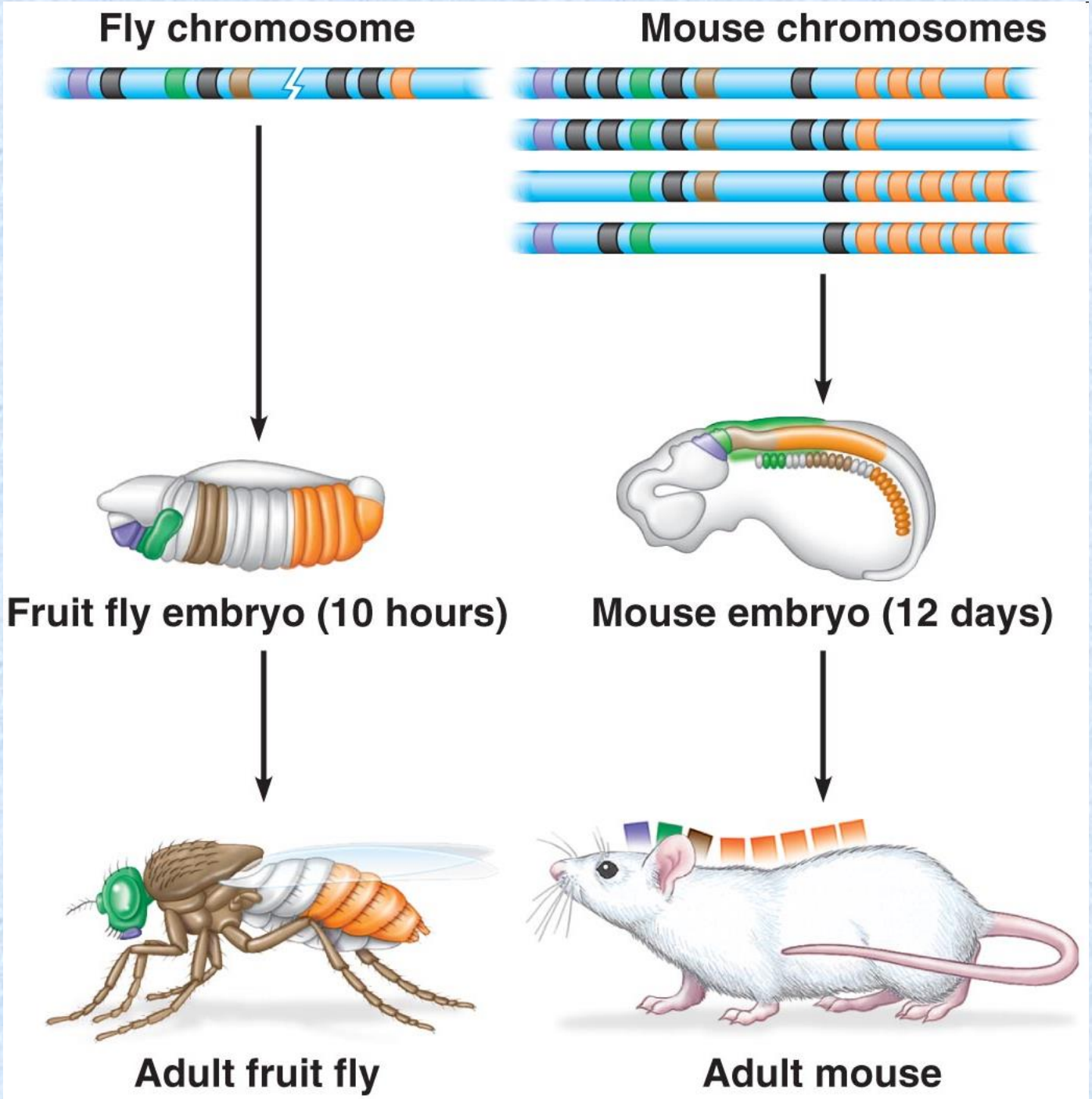
Homeotic genes / Homeobox

are evolutionarily highly conserved. They are master regulatory genes that direct the development of particular body segments and direct an identity of body parts. Their mutations lead to the formation of the structures in the wrong parts.

HOX genes:

encode transcription factors with **homeodomain**, which is able to bind to DNA / **switch on or off**

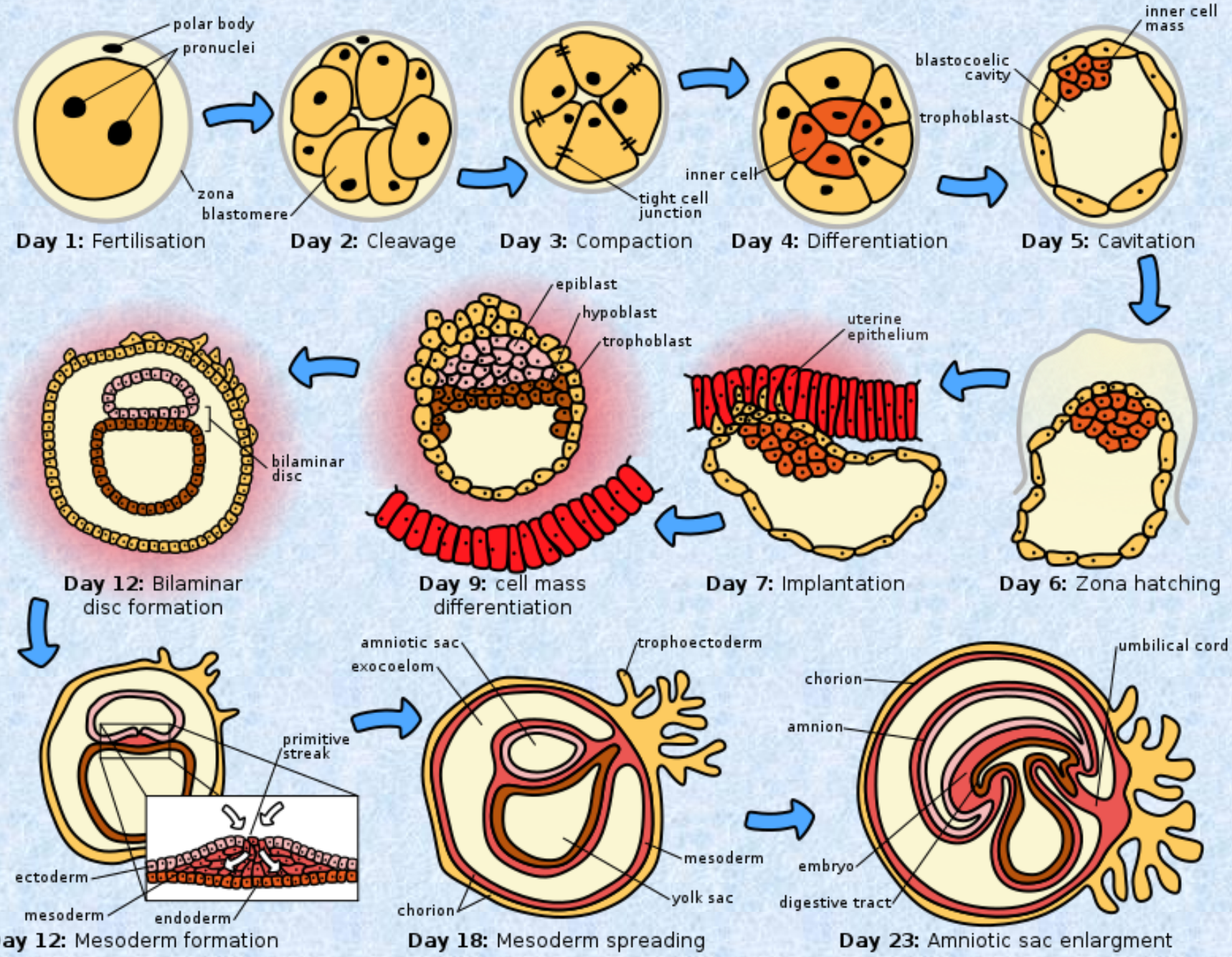
Clusters of homeotic genes



Development stages of embryo

1. **Zygote –** totipotent cell
2. **Morula – blastomers** = totipotent cells
3. **Blastula / blastocoel / blastocyst** = pluripotent cells,
   7 days, **more than 100 cells**
4. **Gastrula – gastrulation for primitive tract, archenteron**
   Organogenesis – primitive organs

Human embryo carries out a slow rate division between 12 and 24 hours

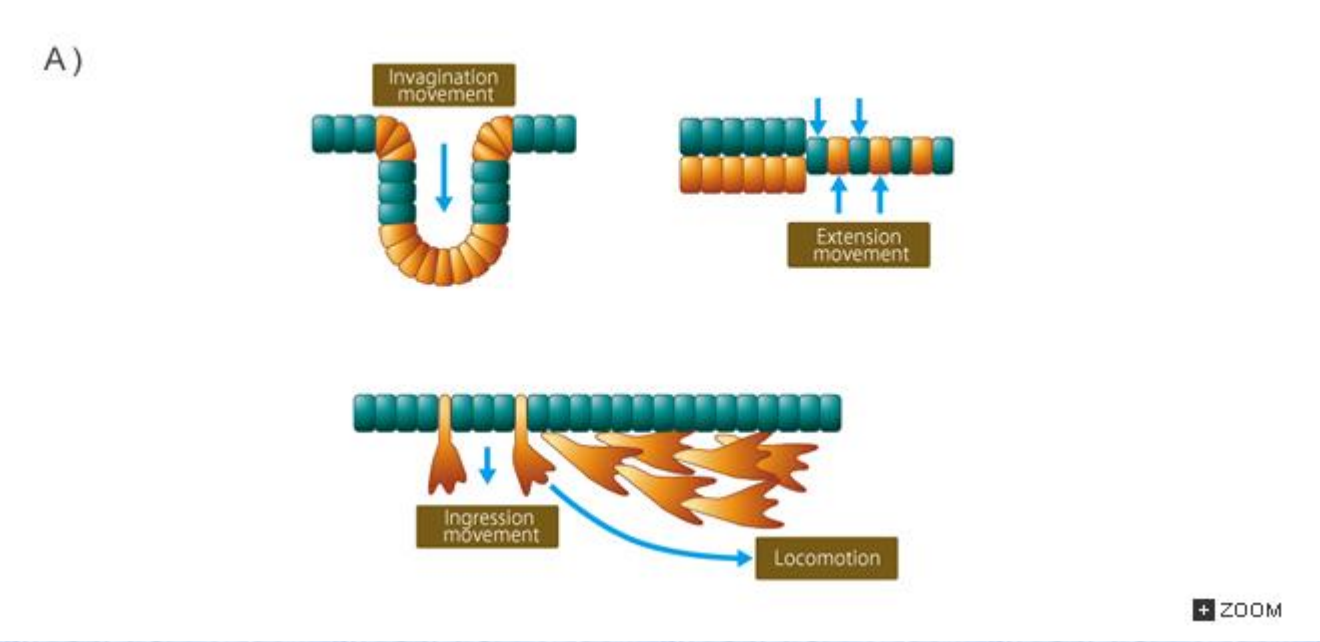


https://en.wikipedia.org/wiki/Human_embryonic_development#/media/File:HumanEmbryogenesis.svg

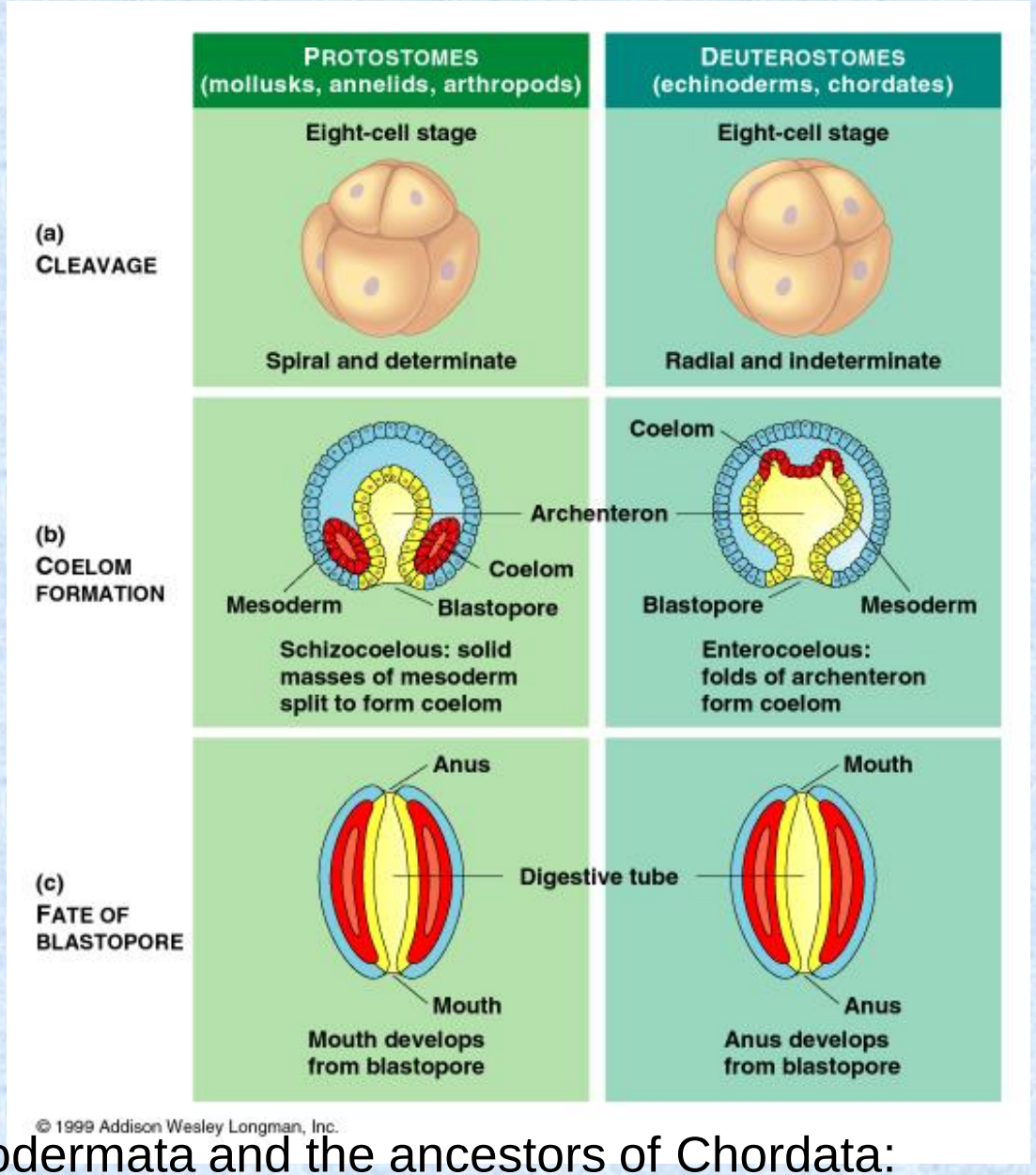
Morphogenetic movements

Movements of epithelial embryo cells:

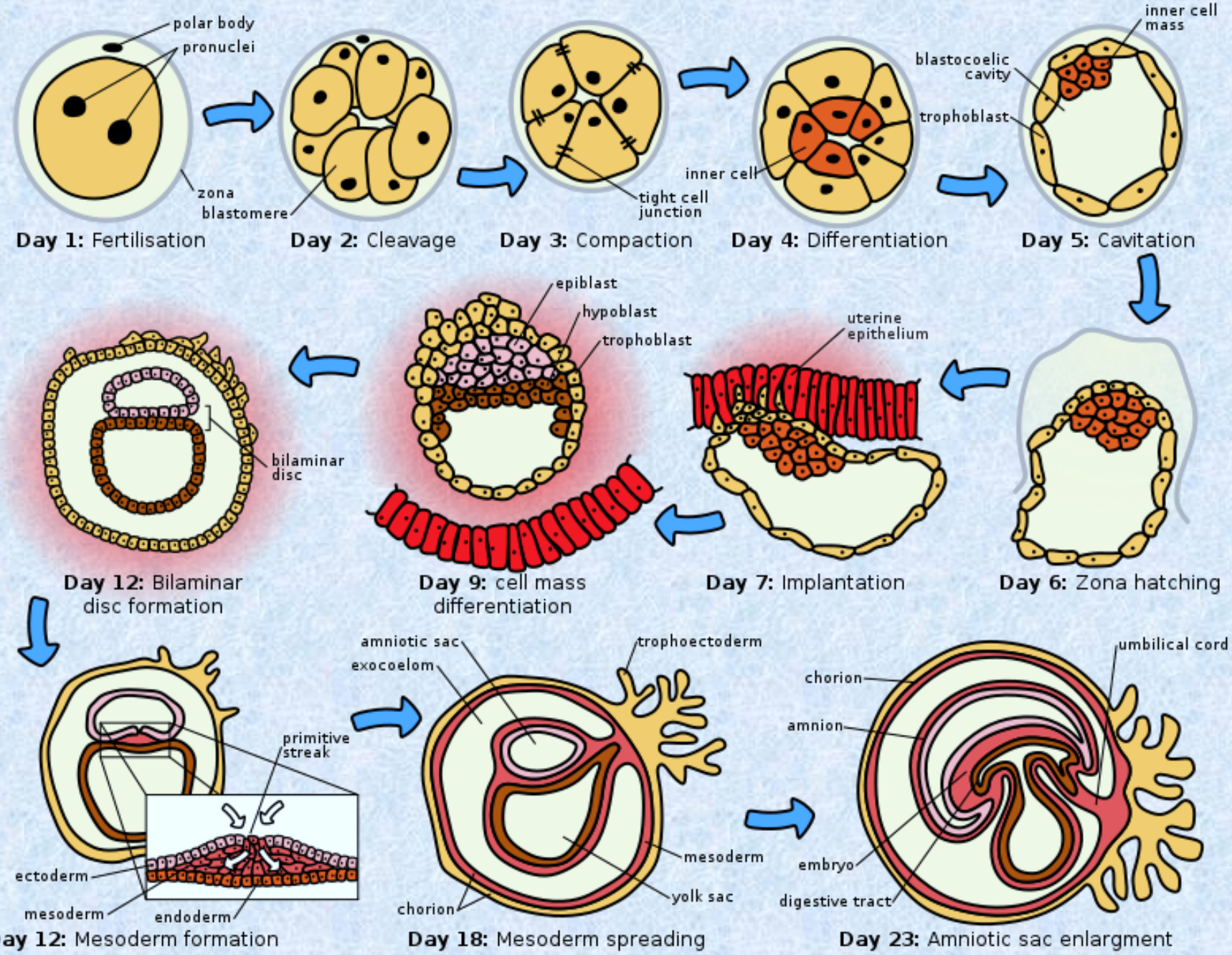
- an invagination movement of epithelium
- an extension movement caused by rearrangement
- a locomotive movement - migration



Origin of blatoporus and coelom and three germ layers



Deuteronomy, including Echinodermata and the ancestors of Chordata: the oral end develops from the second opening on the dorsal surface of the body; the blastopore becomes the anus.



https://en.wikipedia.org/wiki/Human_embryonic_development#/media/File:HumanEmbryogenesis.svg

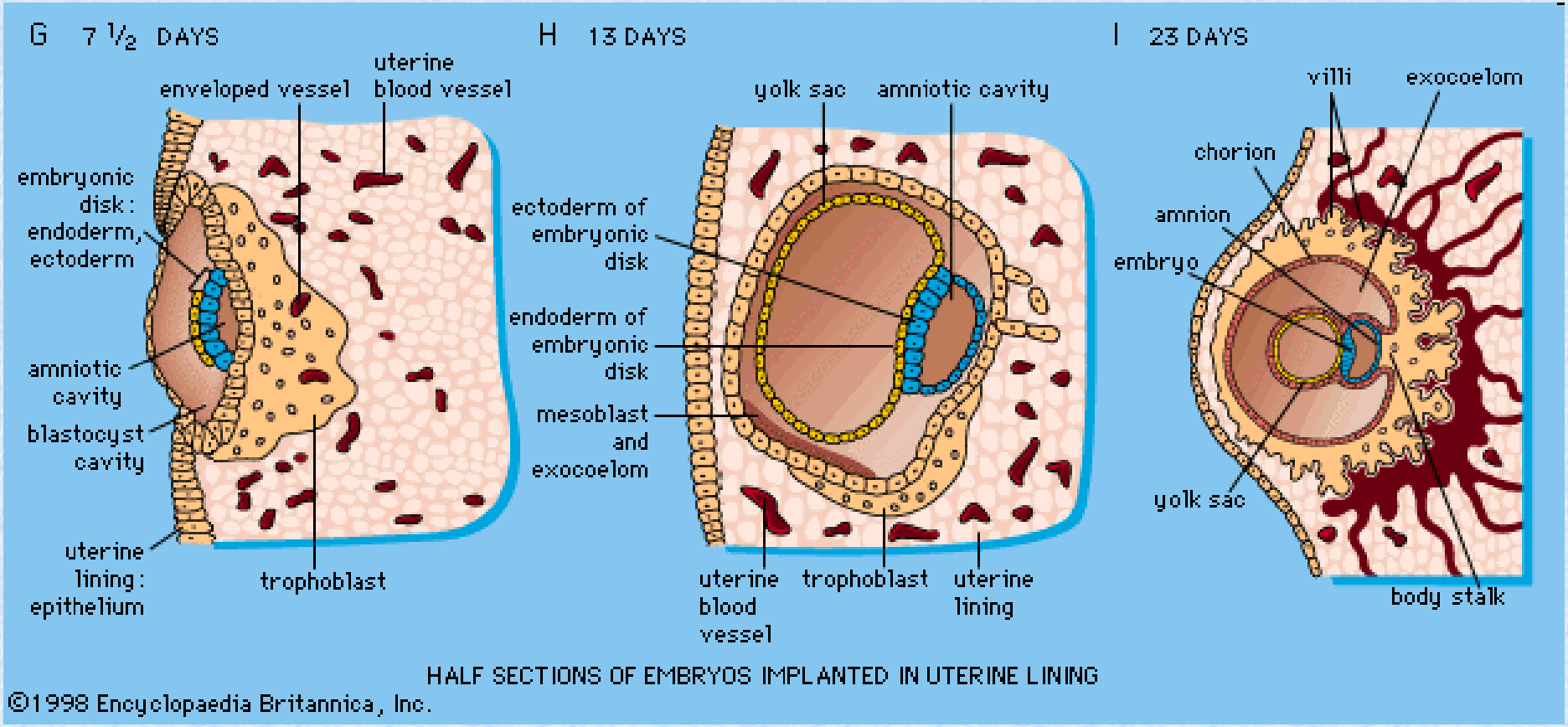
Gastrulation in chicken, mammals

At first, the cells differentiate into **epiblast** – blue cell line and **hypoblast** - yellow cells line = **bilaminar disk formation**

primitive streak = “blastoporus”

a rapidly proliferating mass of cells that spreads between the **ectoderm and endoderm**, giving rise to the **mesoderm layer.**

Cells separate from the central part of the ectoderm and move into the interior of the embryo, and become endoderm and mesodermal cells.



HALF SECTIONS OF EMBRYOS IMPLANTED IN UTERINE LINING

Gastrulation

Germ layers:

Ectoderm

Endoderm

Mesoderm

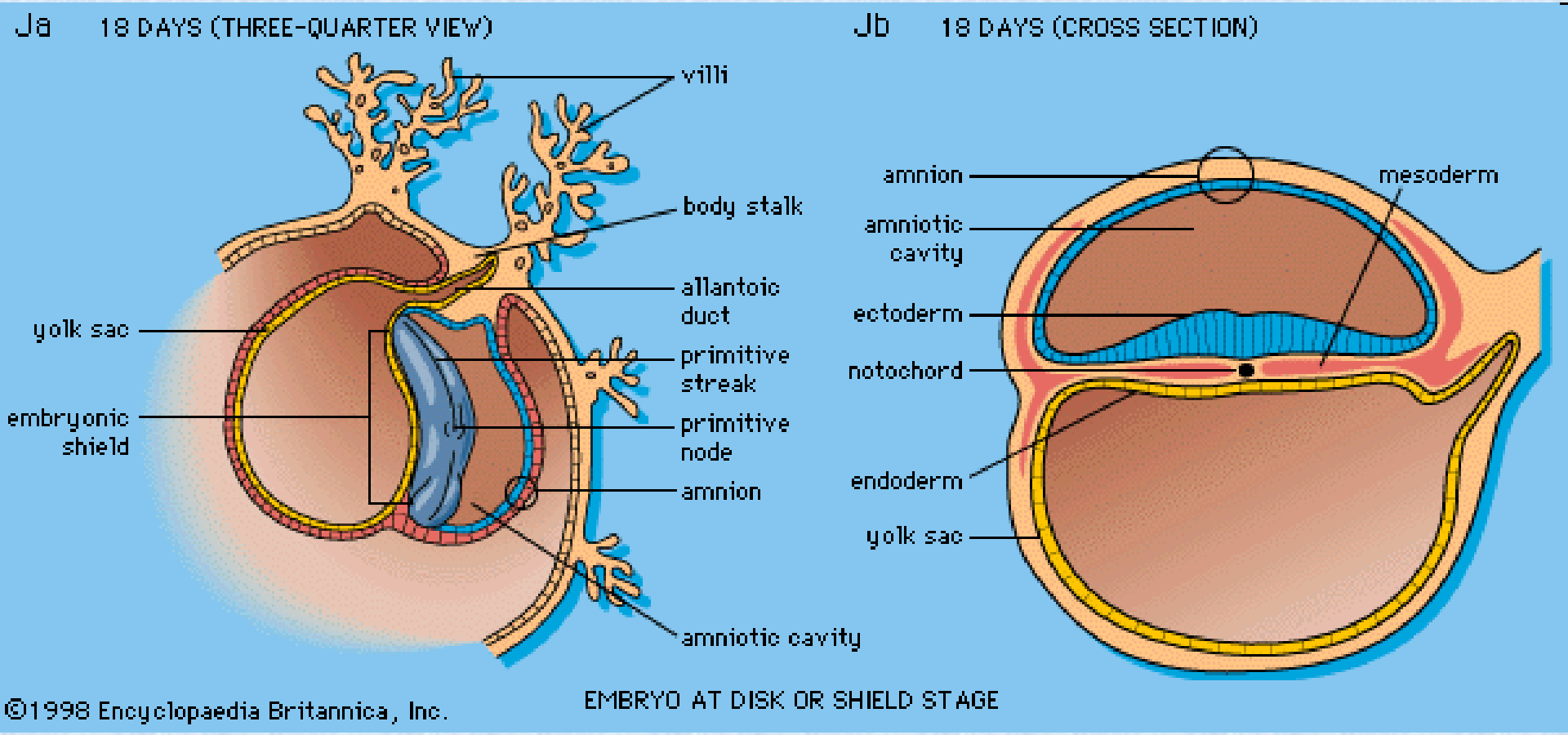
ectoderm forms the outer layer of gastrula (blue)

endoderm lines the digestive tract (yellow) and

mesoderm fills the space between the ectoderm and

endoderm (red)

https://www.khanacademy.org/test-prep/mcat/cells/embryology/v/early-embryogenesis-cleavage-blastulation-gastrulation-and-neurulation



EMBRYO AT DISK OR SHIELD STAGE

Amniotic egg / reptiles, birds and mammals

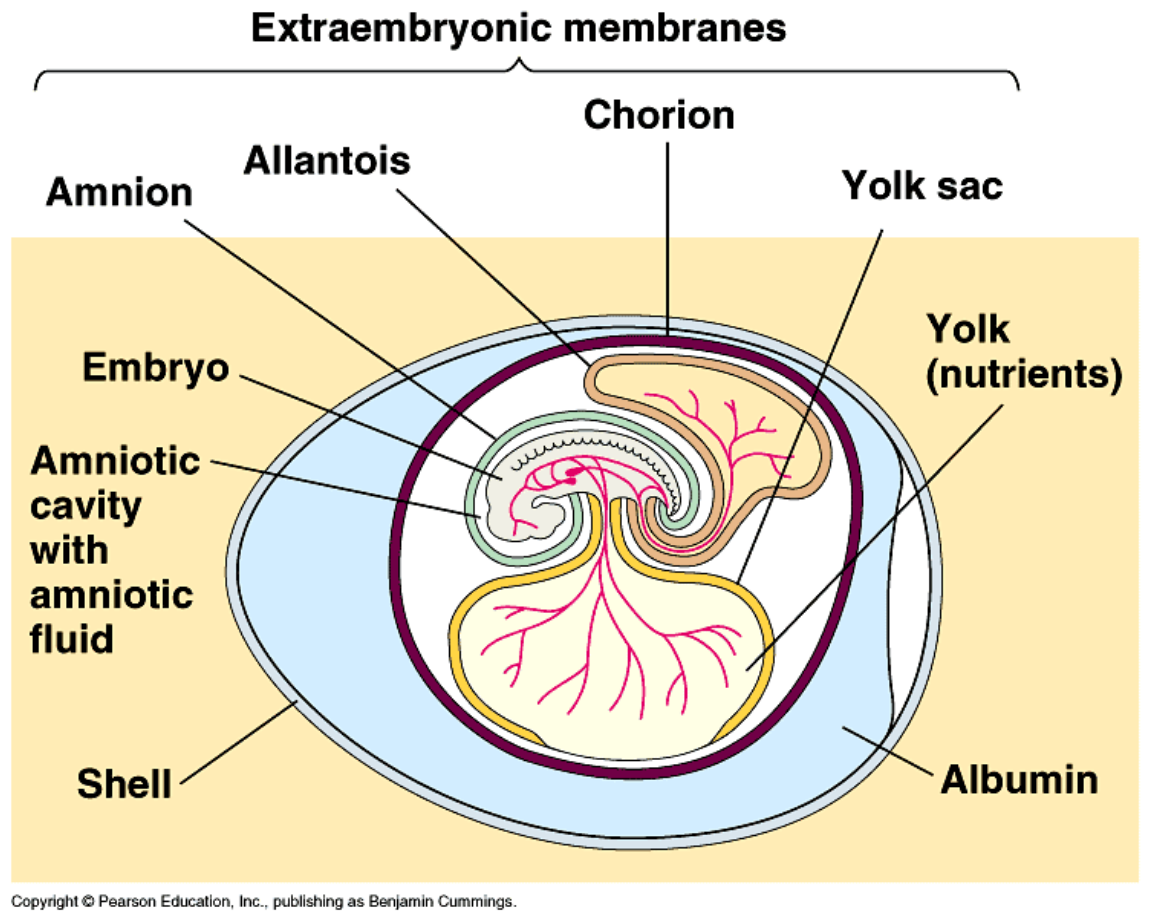
Extraembryonic membranes:

Amnion / protection

Allantois / wastes and gas exchange

Chorion / gas exchange

Yolk sac



Organogenesis - chordata

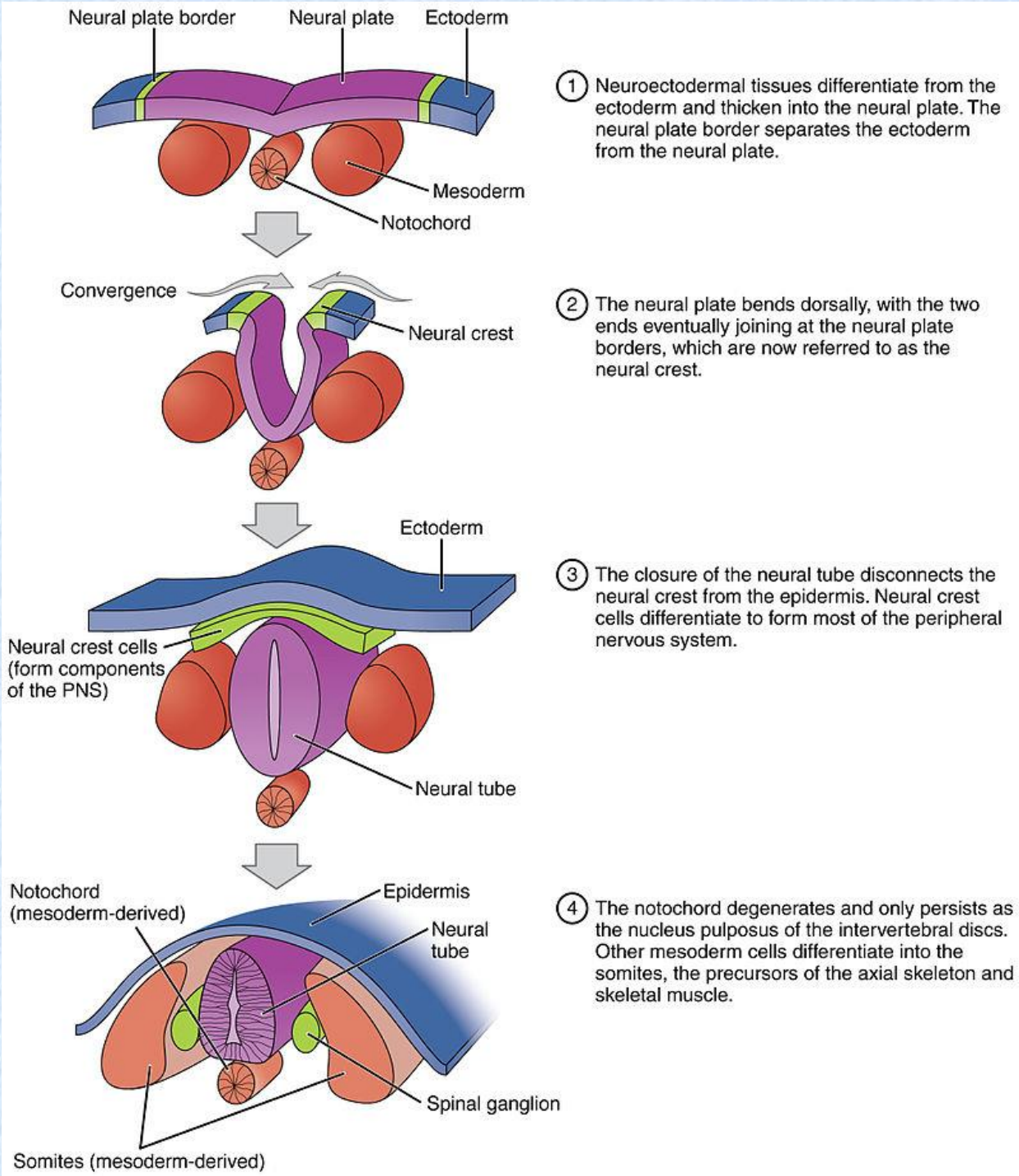
Germ layers form primitive organs

by an origin of folds, clefts, dense clumps

Neural tube - from ectoderm – a centre of nerve system, brain and spinal cord

Notochord – from mesoderm – future backbone

Somites – from **mesoderm** - the segments arranged along side of notochord



1. Neuroectodermal tissues differentiate from the ectoderm and thicken into the neural plate. The neural plate border separates the ectoderm from the neural plate.

2. The neural plate bends dorsally, with the two ends eventually joining at the neural plate borders, which are now referred to as the neural crest.

3. The closure of the neural tube disconnects the neural crest from the epidermis. Neural crest cells differentiate to form most of the peripheral nervous system.

4. The notochord degenerates and only persists as the nucleus pulposus of the intervertebral discs. Other mesoderm cells differentiate into the somites, the precursors of the axial skeleton and skeletal muscle.

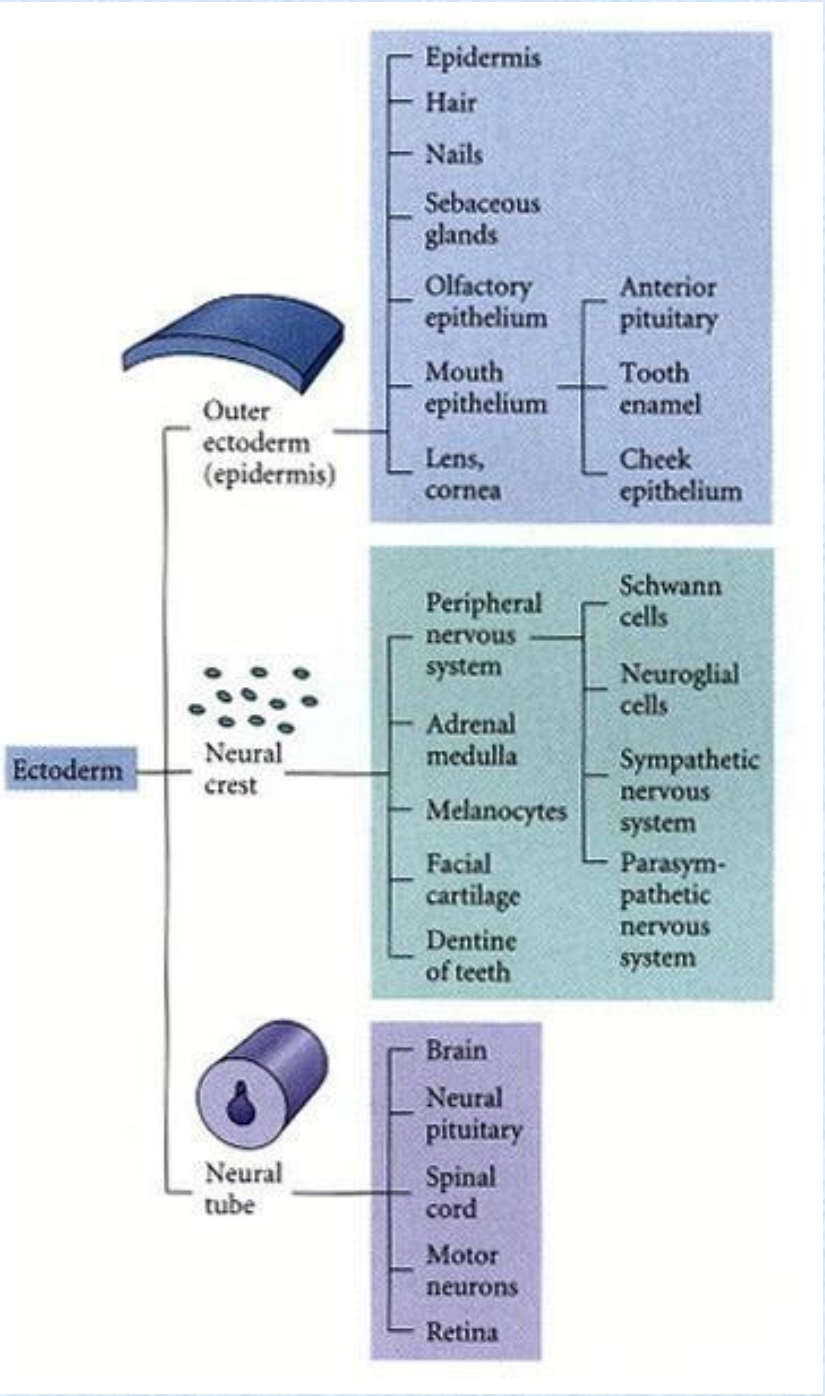
Formation of primitive organs

Illustration from Anatomy & Physiology, Connexions Web site. http://cnx.org/content/col11496/1.6/, Jun 19, 2013.

In vertebrates, the **ectoderm** has three parts:

an external ectoderm (also known as surface ectoderm), **neural crest** and **neural tube**.

The latter two are known as neuroectoderm.



The body organs, tissues and systems derived from the **mesoderm**:

- bones
- cartilage
- most of the circulatory system, including the heart and major blood vessels
- connective tissues of the gut and integuments
- mesenchyme
- mesothelium
- muscles
- peritoneum (lining of the abdominal cavity)
- reproductive system
- spleen
- urinary system, including the kidneys

The products produced by **the endoderm:**

Gastrointestinal tract

Respiratory tract

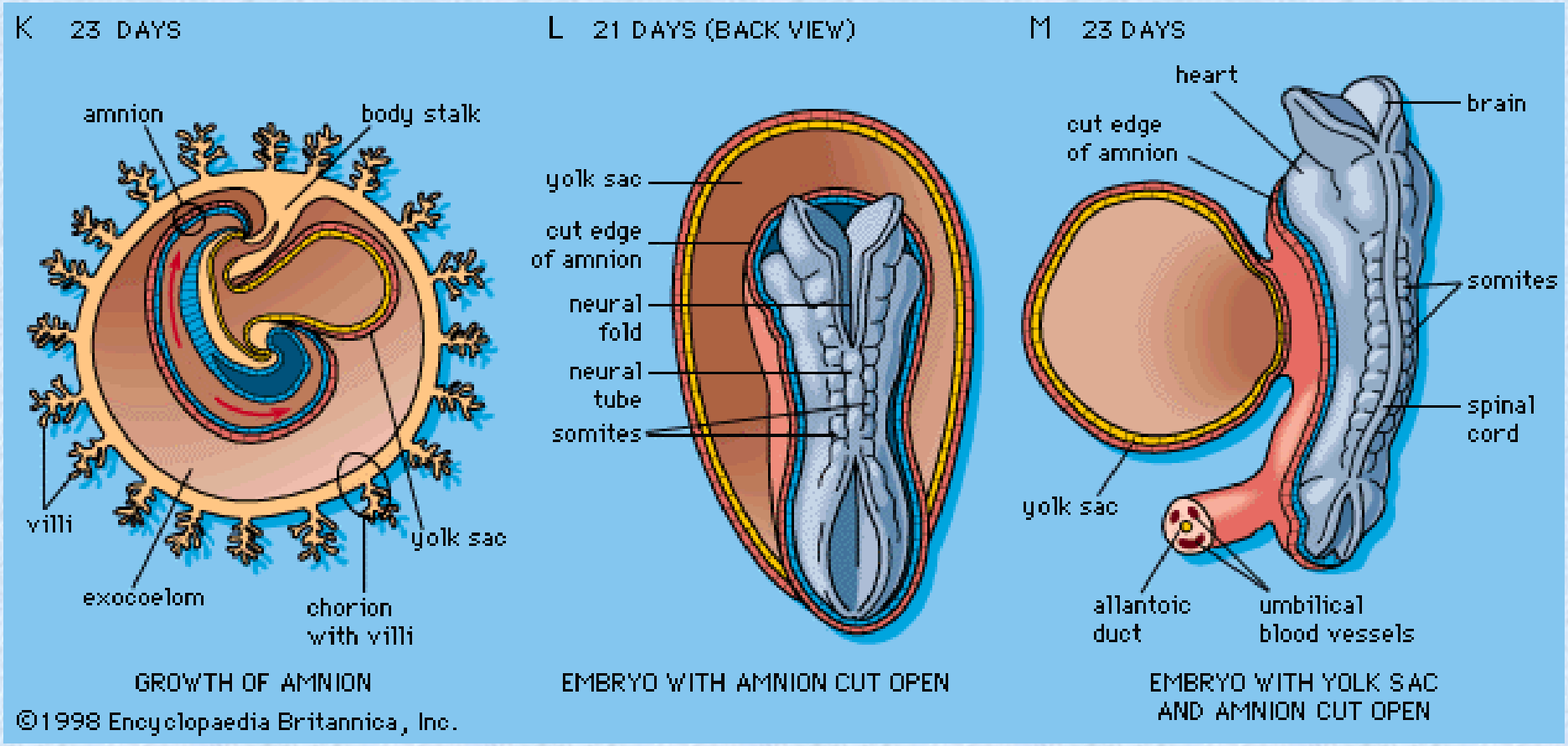
Endocrine glands and organs (liver and pancreas)

The endoderm

forms the epithelial lining of the entire alimentary canal **except part of the mouth, pharynx and the terminal part of the rectum,**

the lining cells of **all the glands which open into the digestive tube**, including those of the liver and pancreas,

the **epithelium of the auditory tube and tympanic cavity, of the trachea, bronchi, and alveoli of the lungs, of the urinary bladder and part of the urethra**, and that which lines the follicles of the **thyroid gland and thymus.**


K 23 DAYS
amnion
body stalk
villi
exocoelom
chorion with villi
yolk sac
GROWTH OF AMNION
L 21 DAYS (BACK VIEW)
yolk sac
cut edge of amnion
neural fold
neural tube
somites
EMBRYO WITH AMNION CUT OPEN
M 23 DAYS
heart
brain
cut edge of amnion
somites
spinal cord
yolk sac
allantoic duct
umbilical blood vessels
EMBRYO WITH YOLK SAC AND AMNION CUT OPEN
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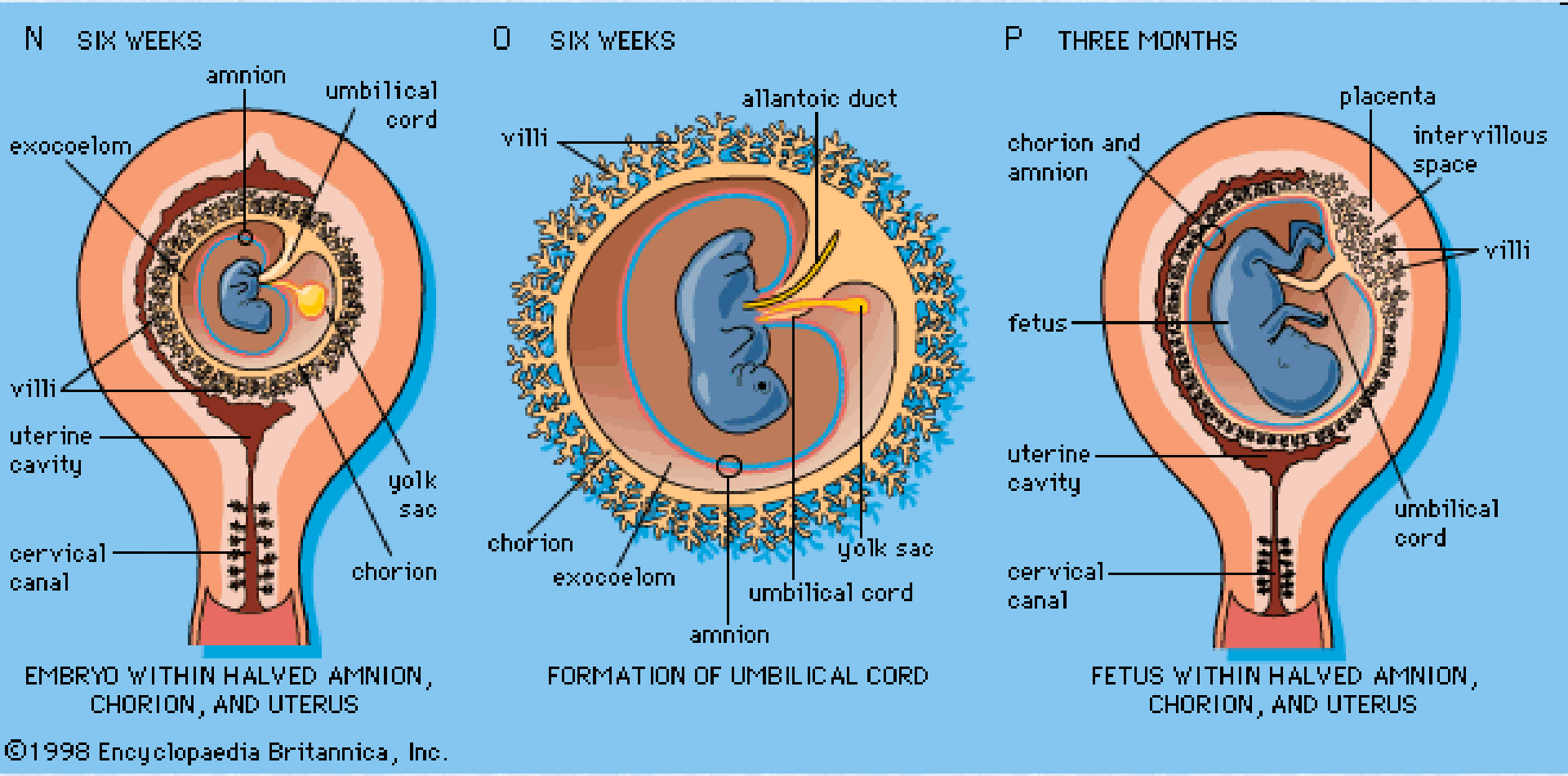
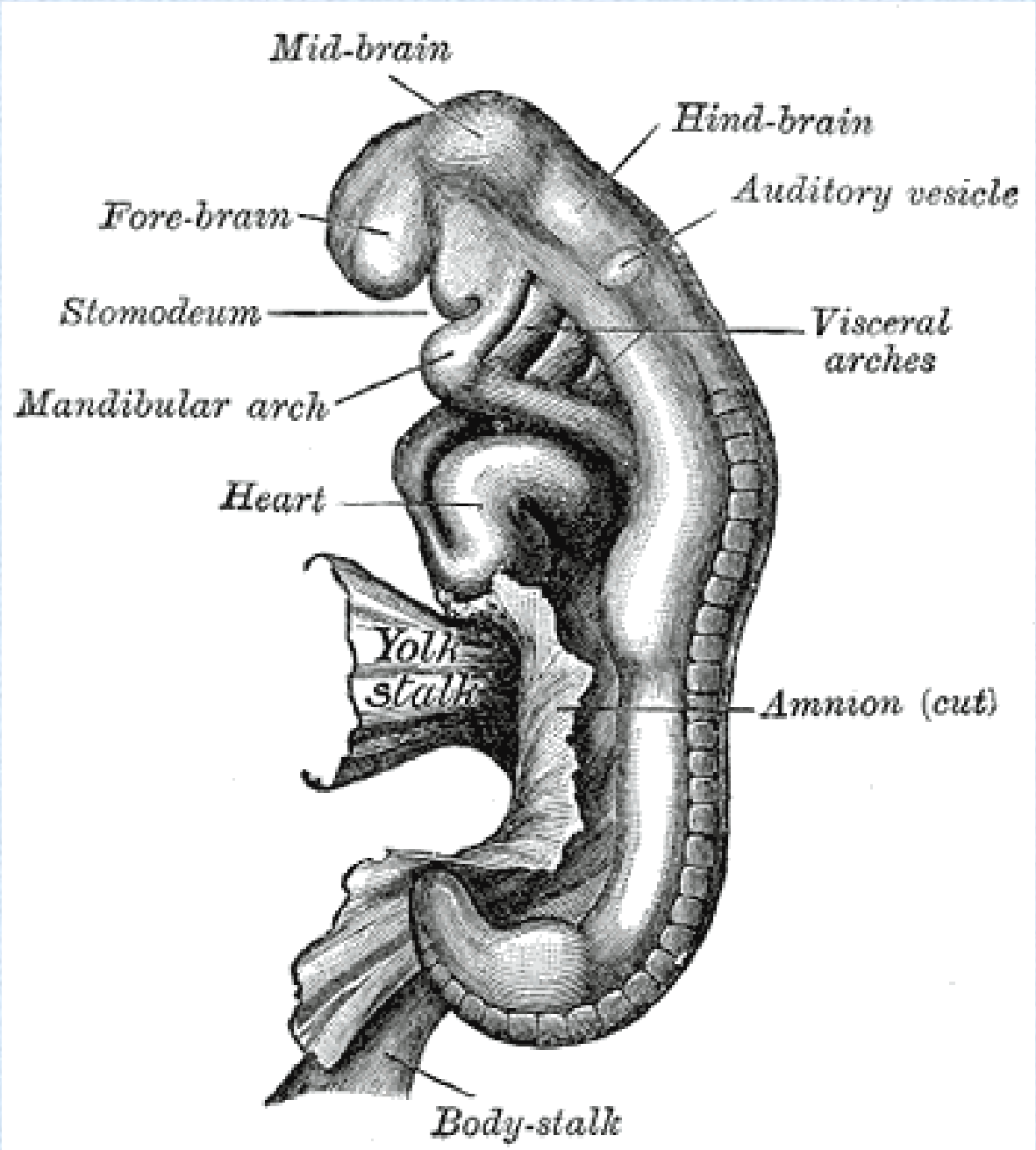
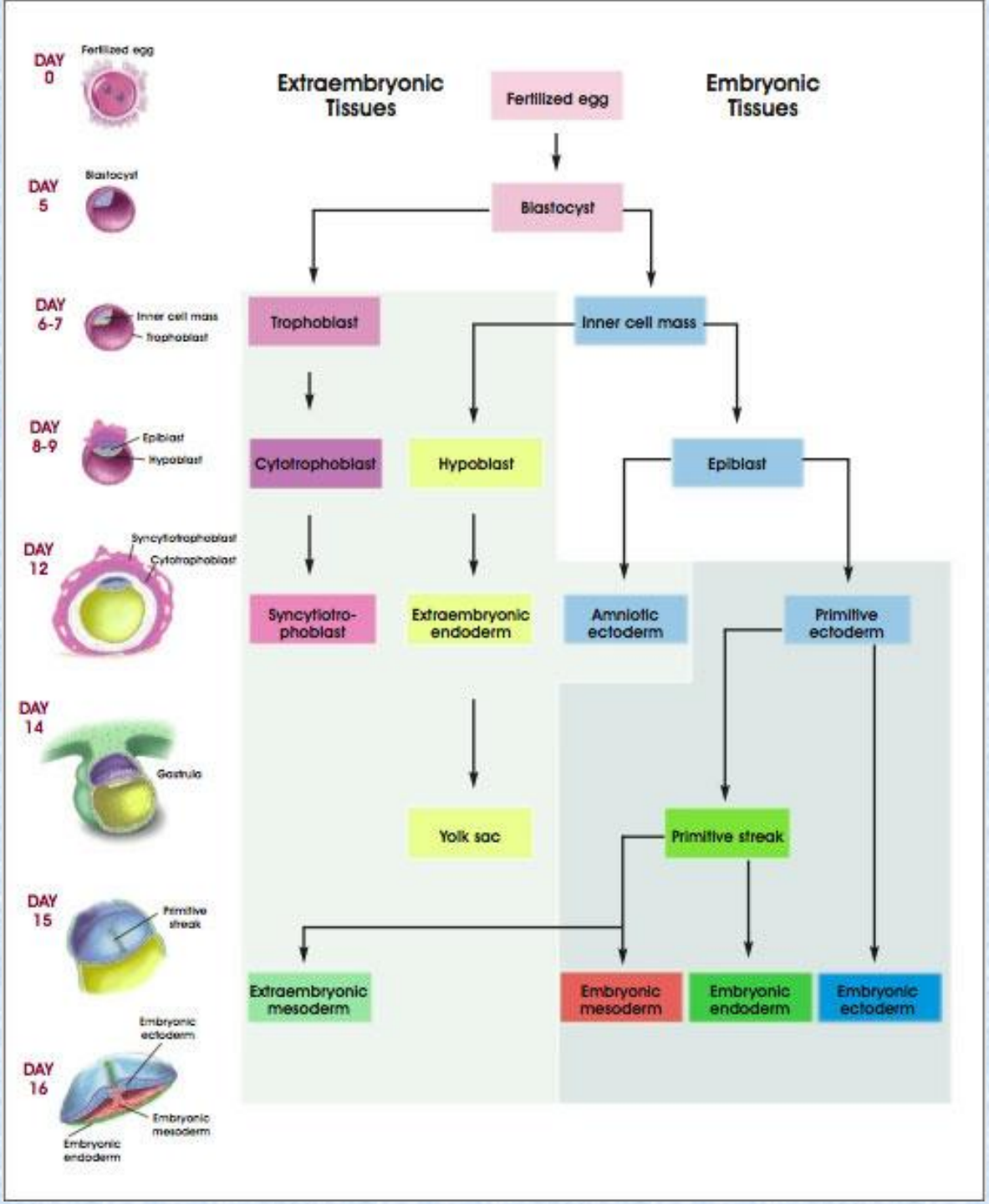



Mid-brain
Hind-brain
Auditory vesicle
Fore-brain
Stomodeum
Visceral arches
Mandibular arch
Heart
Yolk stalk
Amnion (cut)
Body-stalk



Development of Human Embryonic Tissues.

Thank you for your attention

https://www.khanacademy.org/test-prep/mcat/cells/embryology/v/early-embryogenesis-cleavage-blastulation-gastrulation-and-neurulation

Campbell, Neil A., Reece, Jane B., Cain Michael L., Jackson, Robert B., Minorsky, Peter V.**, Biology**, Benjamin-Cummings Publishing Company, 1996 –2010.