Premedical Biology

Individual development in humans
Zygote and embryonal development

Zygote develops into embryo by cell division (mitosis). Cell differentiate and create a three-dimensional form = morphogenesis

Zygote has genetic information for all cells of organism, body.

Zygote is totipotent cell
Responsible of early differentiation and early development are:

1. Maternal determinants in egg:

   protein molecules, RNA, mRNA…. = cytoplasmatic information molecules, cytoplasmatic determinants
Sperm

Molecules of a cytoplasmic determinant

Molecules of another cytoplasmic determinant

Nucleus

Fertilization

Zygote (fertilized egg)

Mitotic cell division

Two-celled embryo
2. Signal molecules/ Induction

Signal molecules are determined by offspring genome. It is a type of local signaling between cells in early embryo. Process is accomplished by chemical signals. Signals (molecules) have target cells (with receptors) and cell-cell surface interactions results in a change of transcription/regulation of gene expression.

Target cell has an ability to respond to signals
Induction / signalling / regulation of gene expression
Anteriorposterior and dorsoventral axe is done by gradients of products of maternal regulatory genes = transcription factors

..........morphogenes proteins, which interact with DNA. They activate or deactivate the transcription of other genes. At the end of regulatory cascade molecules control cellular behaviors. **Positional information** determine the location relative to body axes
Positional information

groups of genes

Egg-polarity genes, maternal - *bicoid*

Segmentation genes, embryonic:

Gap genes – division alongside the axe

Pair-rule genes – segmentation (every second)

Segment polarity genes

Homeotic genes
Homeotic genes / Homeobox

are evolutionarily highly conserved. They are responsible for a formation of specific anatomical structures of each body part, for an identity of body parts. Mutations lead to formation of these structures in the wrong parts.

HOX genes:
encode transcription factors with **homeodomain**, which is able to bind to DNA / **switch on or off**
Fly chromosome

Mouse chromosomes

Fruit fly embryo (10 hours)

Mouse embryo (12 days)

Adult fruit fly

Adult mouse
Animal kingdom

Porifera - sponges
Cnidaria – jellyfish, corals, anemones
Ctenophora – coma jellies
Platyhelminthes – flatworms
Rotifera
Nematoda – roundworms
Nemertea – ribbon worms
Bryozoa
Phoronida
Brachiopoda
Mollusca – clams, snails, octopuses
Annelida – segmented worms
Arthropoda – crustaceans, insects, spiders
Echinodermata – sea stars, sea urchins
Chordata – lancelets, tunicates, vertebrates

two germs layers
Radial

three germs layers
Schizocoelom
Bilateral
Protostomia / mouth from blastopore

Pseudocoelom

Coelom without segmentation
Coelom with segmentation
Segmentation homonomously
Sedmentation herenomously

Deuterostomia / anus from blastopore, mouth secondarily
Body cavity

Body cavity

Space between digestive tract and outer body wall
Development

Zygote - cleavage – division

Polarization / animal vegetal pole

Morula – blastomeres - totipotent

Blastula / blastocoel / blastocyst

Gastrula – gastrulation

Organogenesis – primitive organs

Specific changes of shape, position and adhesion
Morphogenetic movements
Movements of epithelial embryo cells:
- invagination movement of epithelium
- extension movement caused by rearrangement
- locomotive movement (migration)
Gastrulation

Epiblast – embryo + Hypoblast - yolk sac

Germ layers:

Ectoderm
Endoderm
Mesoderm

ectoderm forms the outer layer of gastrula
endoderm lines the digestive tract and
mesoderm fills the space between the ectoderm and endoderm
Gastrulation in chicken, mammals

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

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Amniotic egg / reptiles, birds and mammals

Extraembryonic membranes:
Amnion / protection

Allantois / wastes and gas exchange

Chorion / gas exchange

Yolk sac
Organogenesis - chordata

Primitive organs from germ layers
folds, clefts, dense clumps – mechanisms

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

**Notochord** – mesoderm – backbone

**Somites** - mesoderm - the muscle segments arrange along each 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.
In vertebrates, the **ectoderm** has three parts: external ectoderm (also known as surface ectoderm), the 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
- mesenchymum
- mesothelium
- muscles
- peritoneum (lining of the abdominal cavity)
- reproductive system
- spleen
- urinary system, including the kidneys
The following chart shows 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.
Thank you for your attention