Embryology

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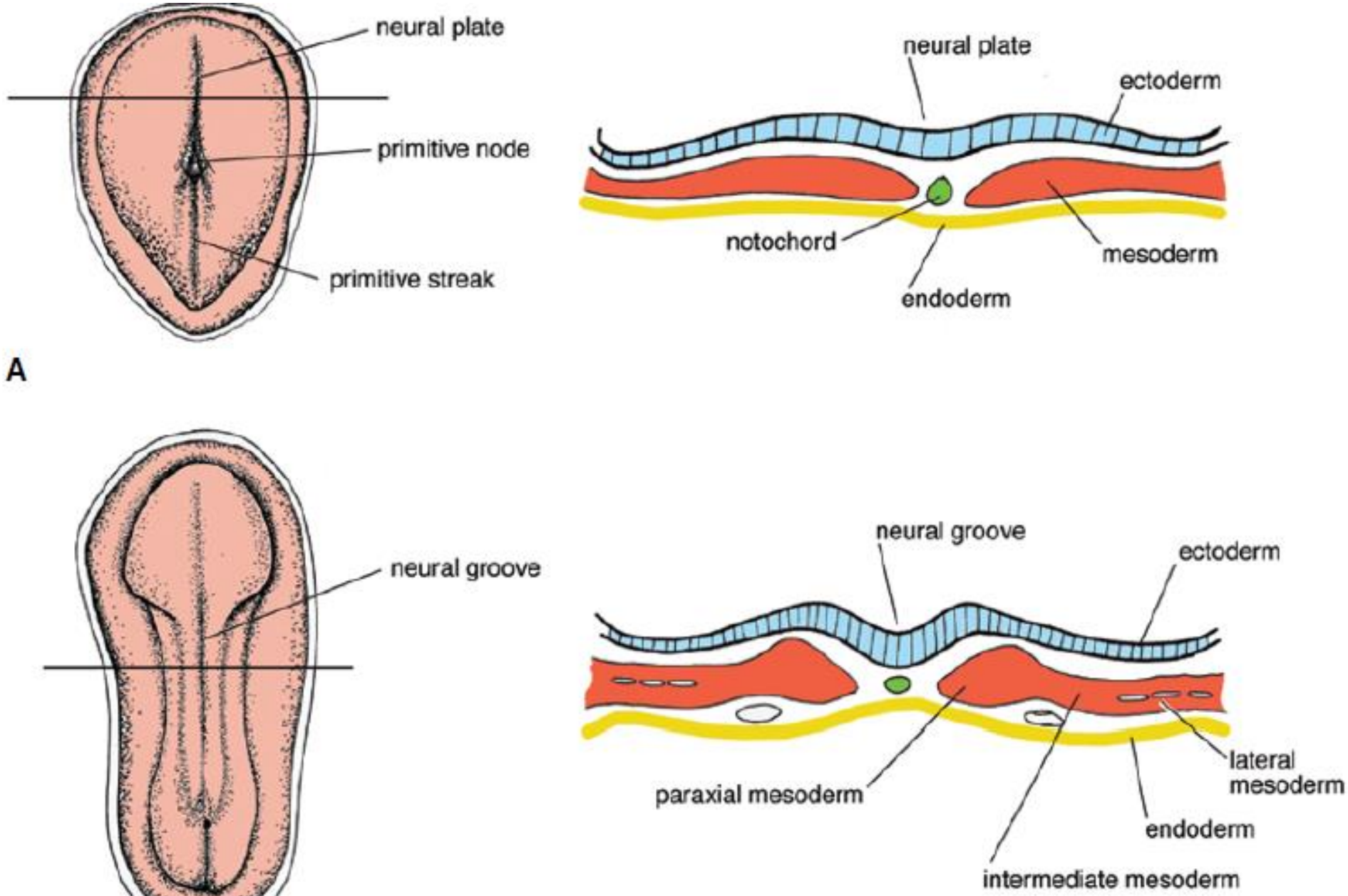
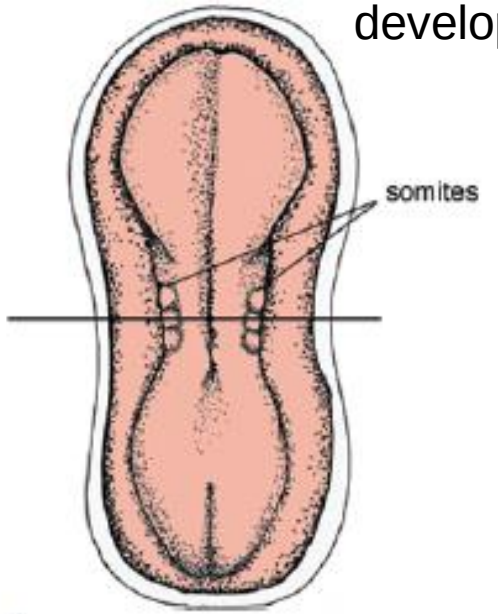
Year 2

Establishment of the basic body plan

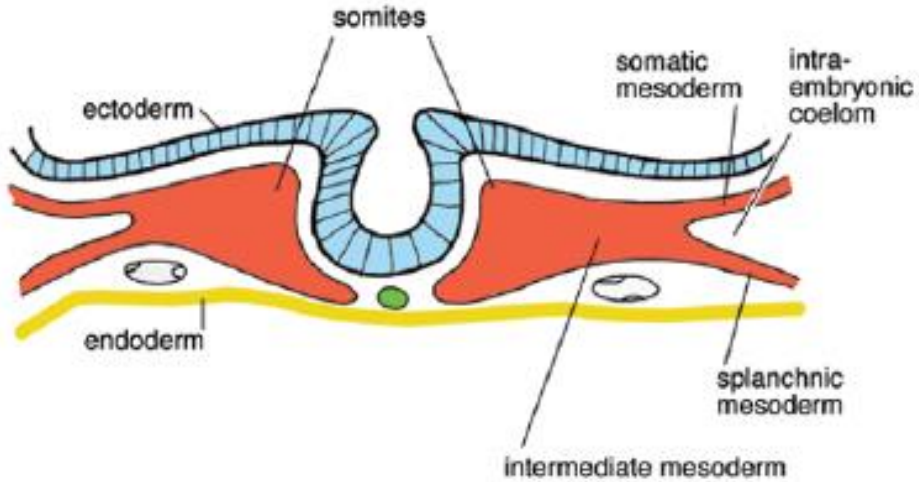
- At the end of gastrulation, the typical mammalian embryo has a pear-shaped outline and is composed of an outer ectodermal layer, a middle mesodermal layer and an inner endodermal layer.
- A longitudinal column of mesoderm, the notochord, which arose from the primitive node, establishes the cranial–caudal axis of the developing embryo.
- The body plan of mammalian species is directed by a genomic regulatory program.
- Complex gene regulatory networks (GRNs) which have evolved through modularization, duplication and specialization of simple regulatory motifs have enabled both subtle and large morphological changes to take place throughout evolution.

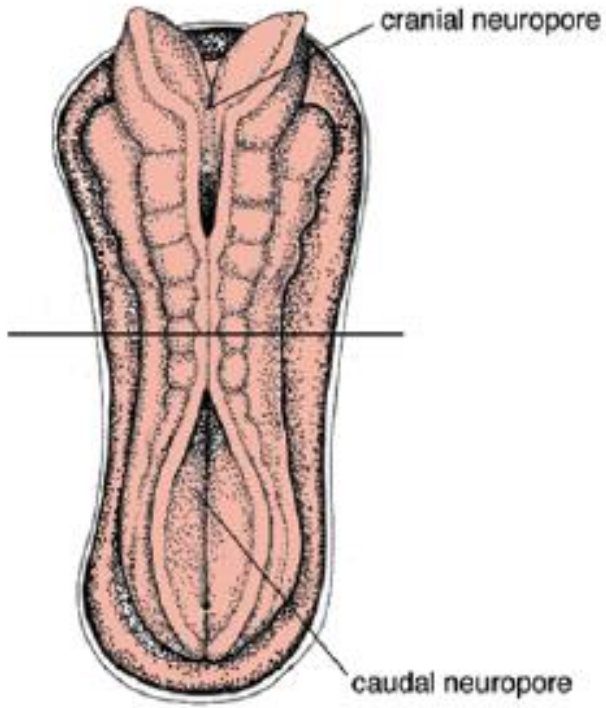

neural plate
primitive node
primitive streak
A
neural plate
ectoderm
notochord
mesoderm
endoderm
neural groove
B
neural groove
ectoderm
paraxial mesoderm
lateral mesoderm
endoderm
intermediate mesoderm

Dorsal views and cross-sections through an early mammalian embryo illustrating progressive developmental changes from formation of the primitive streak to neurulation (A to D).

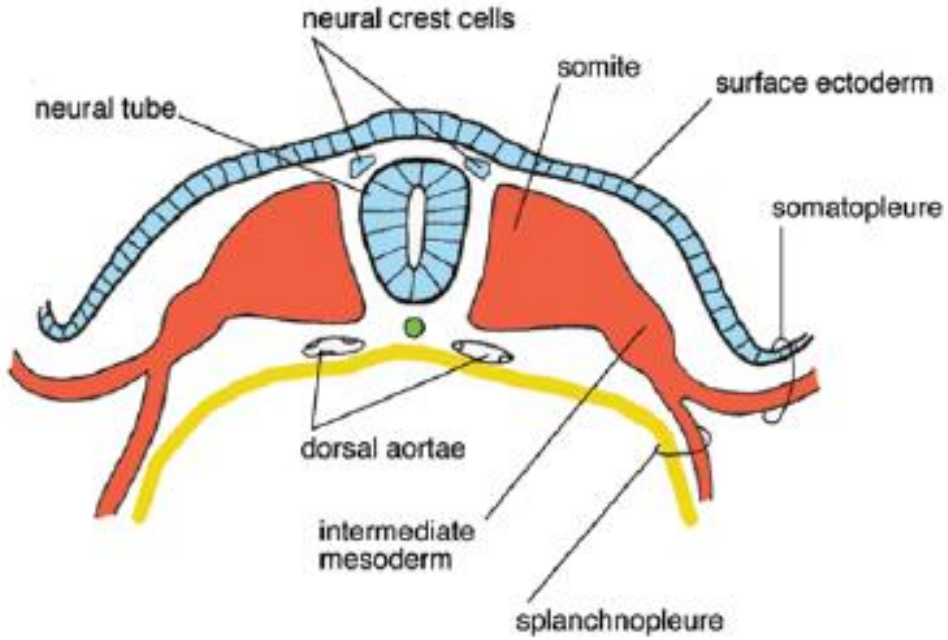


C



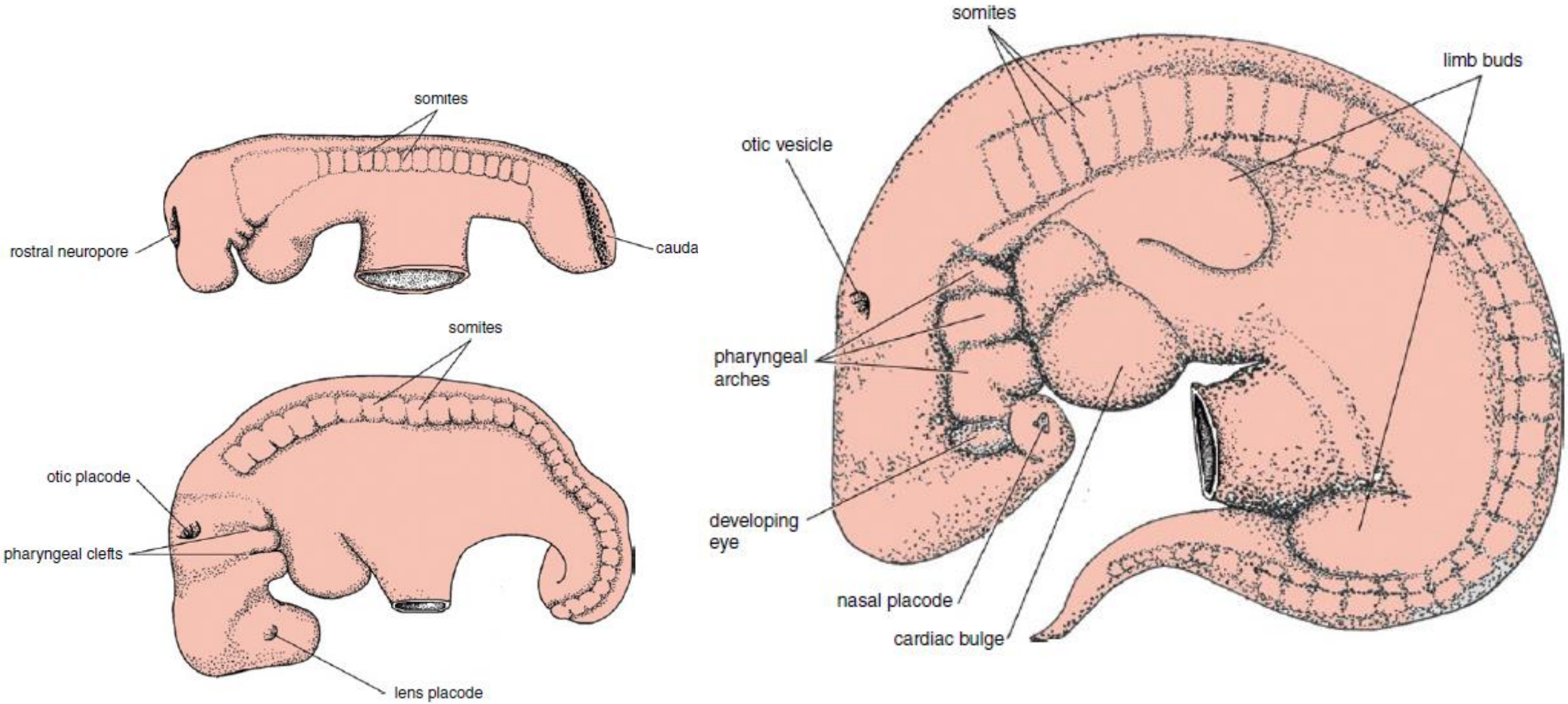


D

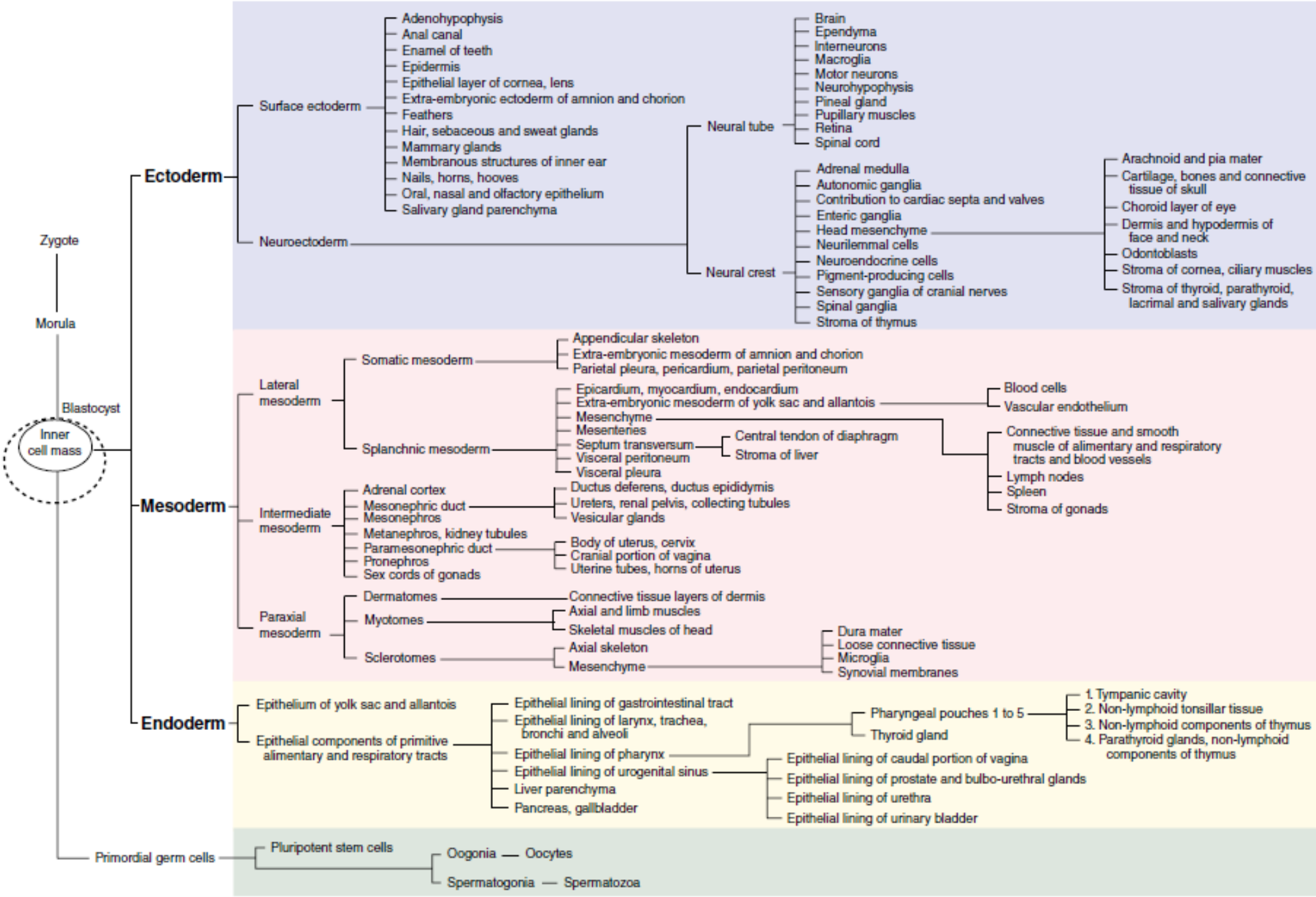


- **Ectoderm** dorsal to the notochord proliferates in response to factors originating from the notochord, giving rise to the neural plate, a layer of ectoderm referred to as neuroectoderm.
- Some neuroectodermal cells migrate from the lateral margins referred to as neural crest cells.
- The central nervous system (brain and spinal cord) arise from the neural tube; the peripheral nervous system develops from both the neural tube and the neural crest.
- Some surface ectodermal cells in the cephalic region form discrete thickenings known as placodes. These placodes include the nasal, lens and otic placodes, which give rise to the nasal chambers, lens and inner ear respectively.
- In the cephalic region, a small number of neurogenic placodes develop which contribute to the formation of the sensory components of some cranial nerves.
- **The endoderm** gives rise to the epithelial lining of the primitive gut and respiratory tract and their associated mural glands.
- The epithelial lining of the bladder, middle ear and auditory tube also develop from endoderm.
- The parenchymal cells of the liver, pancreas, thyroid and parathyroid glands arise from endoderm.
- **The mesoderm**, which arises from the primitive streak, forms a sheet of cells which spreads laterally and cranially between the epiblast and the hypoblast.
- Mesoderm adjacent to the developing tube forms a thickened column of cells, termed the paraxial mesoderm.
- A chord of cells which extends along the length of the embryo lateral to the paraxial mesoderm forms the intermediate mesoderm. Cells of the paraxial mesoderm form whorl-like aggregations called somitomeres.
- The majority of components of the axial skeleton, associated musculature and overlying dermis are derived from somites. Mesoderm lateral to the somites forms a column of cells referred to as intermediate mesoderm.

- The space between the somatopleure and splanchnopleure is referred to as the embryonic coelom and from this space the body cavities, namely the pleural, pericardial and peritoneal cavities arise.
- From the mesoderm which lines the coelomic cavity a simple squamous epithelium, the mesothelium, develops.
- Mesothelium forms the serous membranes which line body cavities.
- After gastrulation, the trilaminar embryonic disc is transformed into a three-layered tube by the formation of head, tail and lateral folds.
- The inner endodermal layer forms the lining of the embryonic gut,
- The ectoderm gives rise to the nervous system and the epidermis of the skin and its derivatives, and from the mesodermal layer structural and connective tissue components of the body are formed.
- The embryo becomes C shaped with a prominent row of somites located on either side of the midline.
- Six paired segmental mesenchymal blocks of neural crest origin, the pharyngeal arches, develop in the cephalic region in a cranio-caudal sequence, between the foregut and surface ectoderm.
- The endoderm of the foregut evaginates between the arches, forming five pharyngeal pouches.
- At this stage of embryological development, a well-defined cardiac bulge in the thoracic region is associated with the developing heart.
- From the third week onwards the fore and hind limb buds are recognizable.
- The cephalic region exhibits precocious growth and differentiation associated with brain development.
- Subsequently, balance is established between the growth rate in the cephalic region and other regions of the developing embryo



Lateral views of a mammalian embryo at different stages of development showing recognizable structures


Zygote
Morula
Blastocyst
Inner cell mass
Ectoderm
Surface ectoderm
Adenohypophysis
Anal canal
Enamel of teeth
Epidermis
Epithelial layer of cornea, lens
Extra-embryonic ectoderm of amnion and chorion
Feathers
Hair, sebaceous and sweat glands
Mammary glands
Membranous structures of inner ear
Nails, horns, hooves
Oral, nasal and olfactory epithelium
Salivary gland parenchyma
Neuroectoderm
Neural tube
Brain
Ependyma
Interneurons
Macroglia
Motor neurons
Neurohypophysis
Pineal gland
Pupillary muscles
Retina
Spinal cord
Neural crest
Adrenal medulla
Autonomic ganglia
Contribution to cardiac septa and valves
Enteric ganglia
Head mesenchyme
Neurilemmal cells
Neuroendocrine cells
Pigment-producing cells
Sensory ganglia of cranial nerves
Spinal ganglia
Stroma of thymus
Arachnoid and pia mater
Cartilage, bones and connective tissue of skull
Choroid layer of eye
Dermis and hypodermis of face and neck
Odontoblasts
Stroma of cornea, ciliary muscles
Stroma of thyroid, parathyroid, lacrimal and salivary glands
Mesoderm
Lateral mesoderm
Somatic mesoderm
Appendicular skeleton
Extra-embryonic mesoderm of amnion and chorion
Parietal pleura, pericardium, parietal peritoneum
Splanchnic mesoderm
Epicardium, myocardium, endocardium
Extra-embryonic mesoderm of yolk sac and allantois
Blood cells
Vascular endothelium
Mesenchyme
Mesenteries
Septum transversum
Central tendon of diaphragm
Stroma of liver
Visceral peritoneum
Visceral pleura
Connective tissue and smooth muscle of alimentary and respiratory tracts and blood vessels
Lymph nodes
Spleen
Stroma of gonads
Intermediate mesoderm
Adrenal cortex
Mesonephric duct
Mesonephros
Ductus deferens, ductus epididymis
Ureters, renal pelvis, collecting tubules
Vesicular glands
Metanephros, kidney tubules
Paramesonephric duct
Pronephros
Sex cords of gonads
Body of uterus, cervix
Cranial portion of vagina
Uterine tubes, horns of uterus
Paraxial mesoderm
Dermatomes
Connective tissue layers of dermis
Myotomes
Axial and limb muscles
Skeletal muscles of head
Sclerotomes
Axial skeleton
Mesenchyme
Dura mater
Loose connective tissue
Microglia
Synovial membranes
Endoderm
Epithelium of yolk sac and allantois
Epithelial components of primitive alimentary and respiratory tracts
Epithelial lining of gastrointestinal tract
Epithelial lining of larynx, trachea, bronchi and alveoli
Epithelial lining of pharynx
Pharyngeal pouches 1 to 5
Thyroid gland
1. Tympanic cavity
2. Non-lymphoid tonsillar tissue
3. Non-lymphoid components of thymus
4. Parathyroid glands, non-lymphoid components of thymus
Epithelial lining of urogenital sinus
Epithelial lining of caudal portion of vagina
Epithelial lining of prostate and bulbo-urethral glands
Epithelial lining of urethra
Epithelial lining of urinary bladder
Liver parenchyma
Pancreas, gallbladder
Primordial germ cells
Pluripotent stem cells
Oogonia — Oocytes
Spermatogonia — Spermatozoa