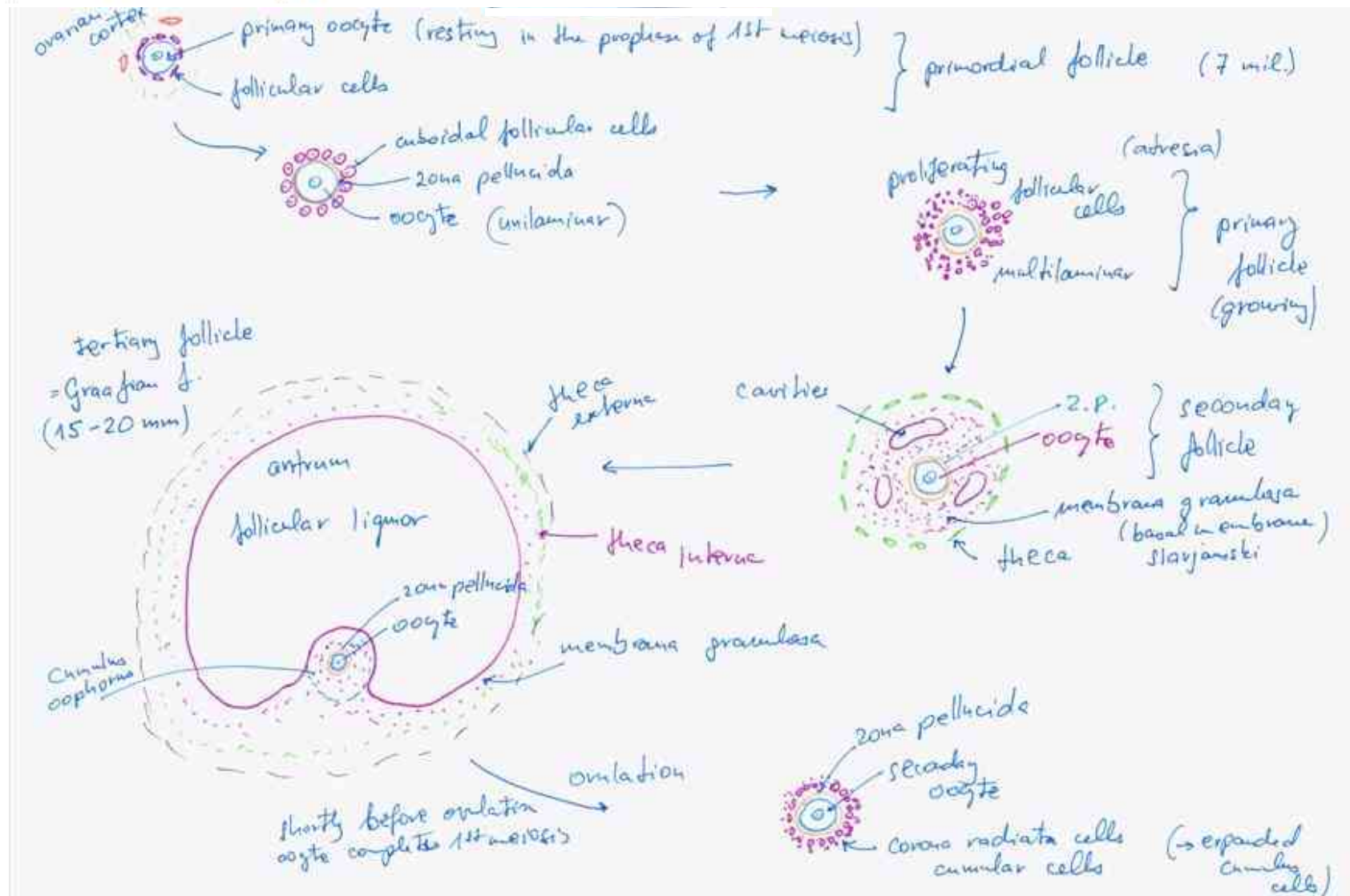


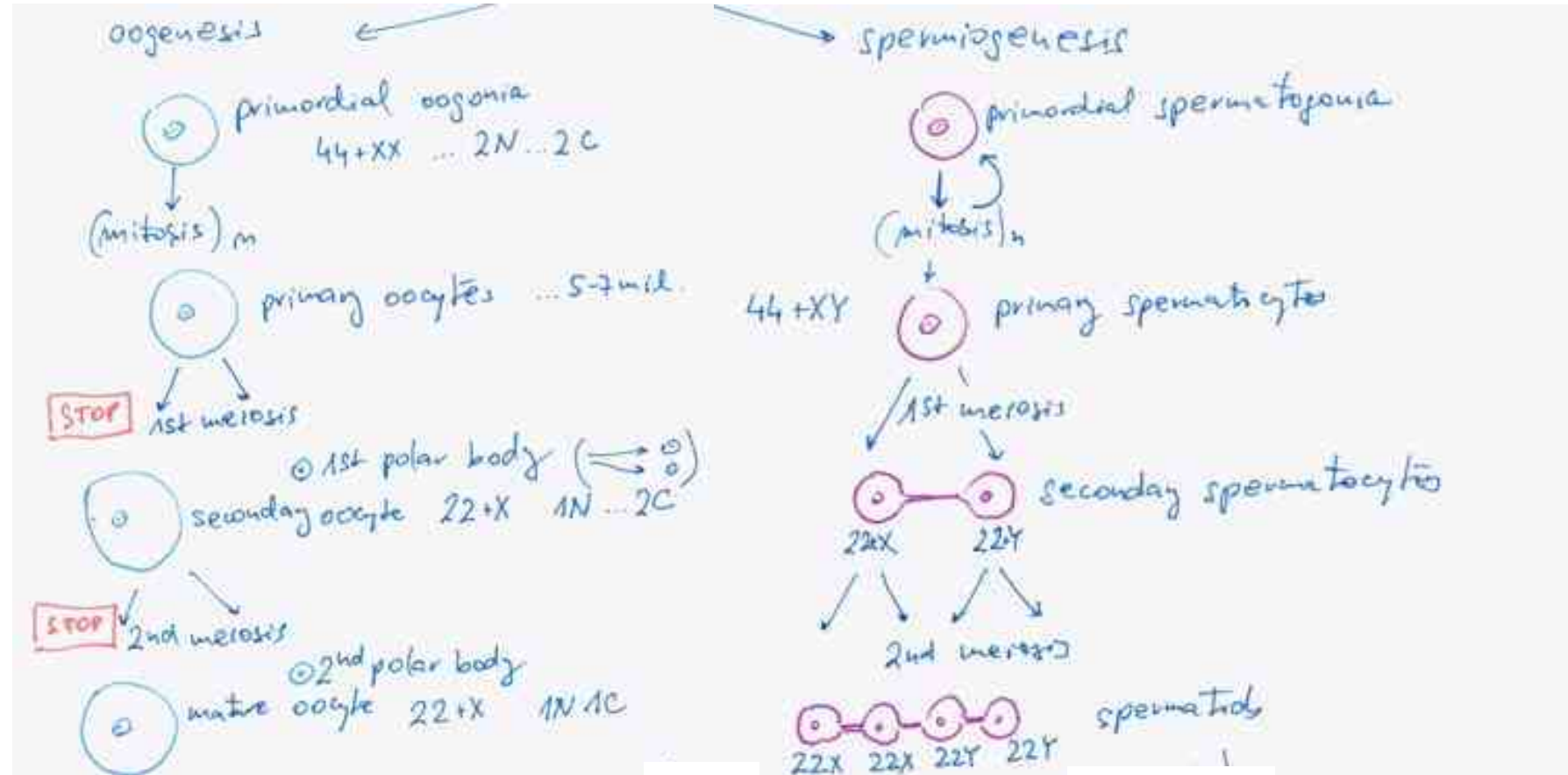
Embryology

54. Draw and label folliculogenesis:

- primordial ovarian follicle with primary oocyte and follicular cells,
- primary unilaminar and multilaminar follicle,
- secondary follicle, forming cavities, growing oocyte with zona pellucida,
- tertiary (Graafian) follicle, antrum folliculi, theca folliculi, granulosa membrane, cumulus oophorus, corona radiata,
- ovulation with free oocyte surrounded by zona pellucida and cumulus oophorus.

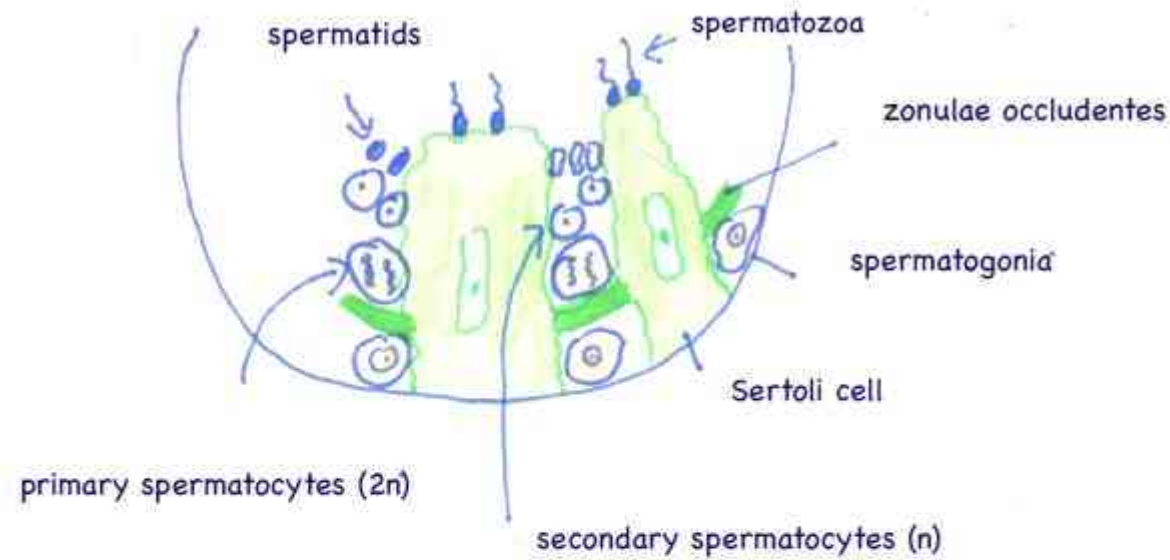


55. Draw and label mitosis and meiosis during oogenesis and spermatogenesis; note control checkpoints with developmental arrest during oogenesis; state the ploidy of cells:
- mitotic division of oogonium, 1st meiotic division and 1st meiotic arrest (2n),
 - oocyte maturation: re-initiation of meiosis and 2nd meiotic arrest, matured oocyte (n) in metaphase II and extruded polar body,
 - mitotic division of spermatogonia, 1st spermatocytes (2n),
 - 1st meiosis leading to 2nd spermatocytes (n), 2nd meiosis and four haploid spermatids,
 - mark the asymmetry of division during oogenesis and the symmetry of division during spermatogenesis.

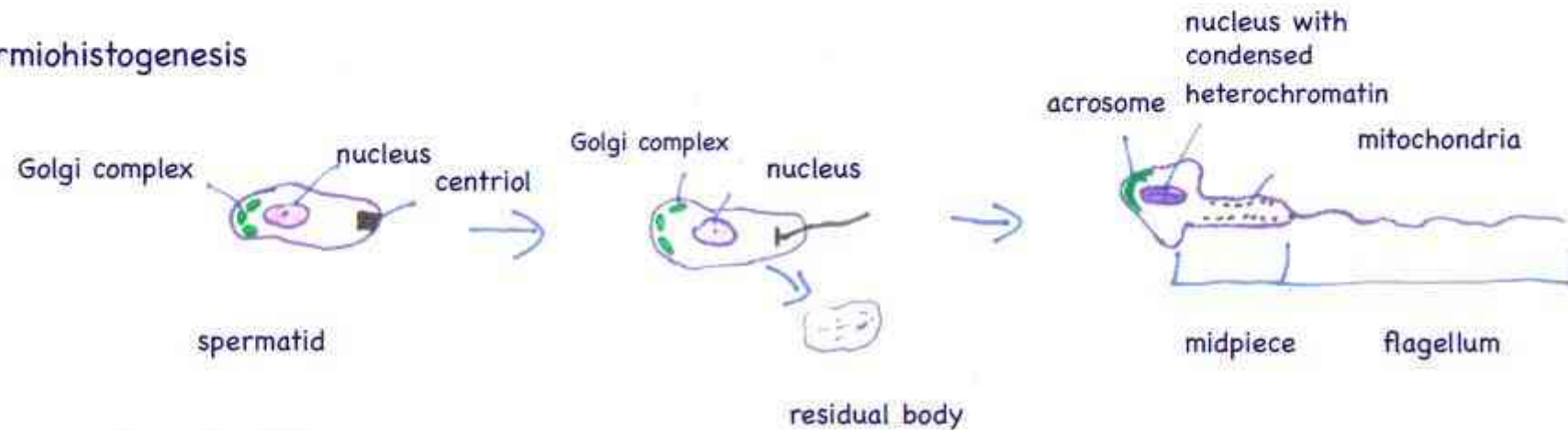


56. Draw and label spermatogenesis including spermiogenesis; note ploidy of cells:

- spermatogonia in testicular seminiferous tubules, adjacent Sertoli cells,
- mitotic division of spermatogonia leading to primary spermatocytes ($2n$),
- first meiotic division giving rise to secondary spermatocytes (n),
- second meiotic and spermatids,
- spermiogenesis – morphological transformation of spermatids into spermatozoa,
- Spermatozoon: flagellum, midpiece, condensed heterochromatin, acrosome.

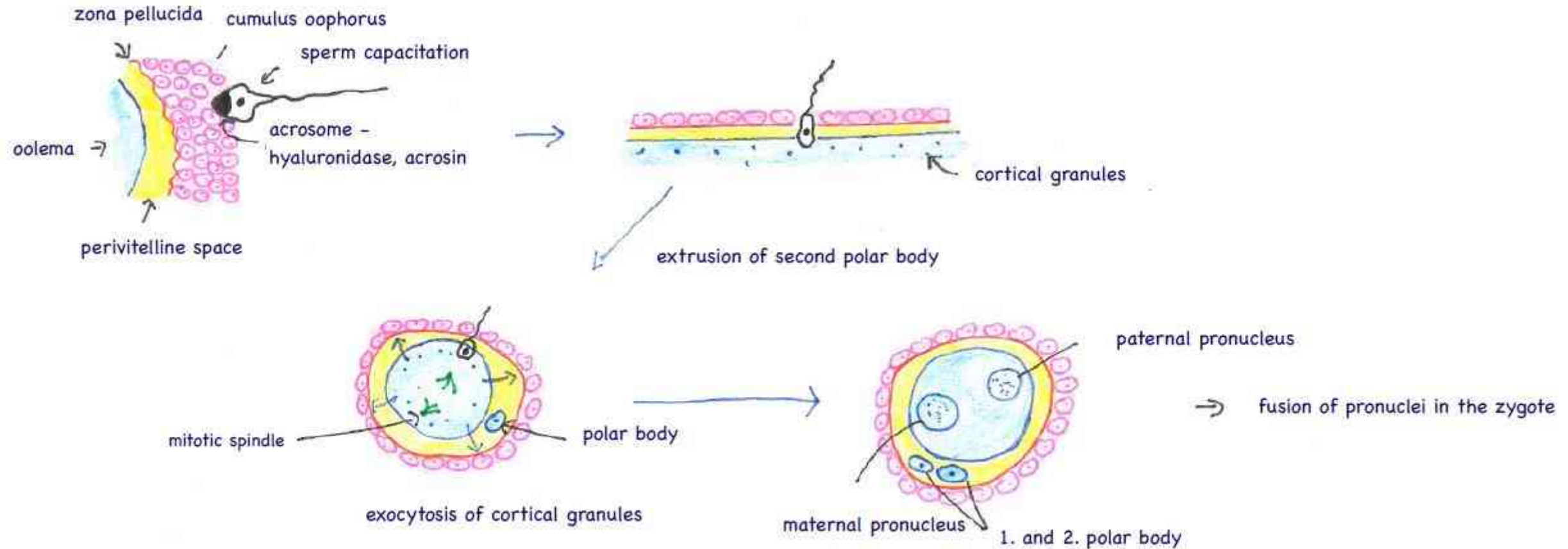


Spermiogenesis



57. Draw and label the fertilization, acrosomal and cortical reactions, genesis of a zygote:

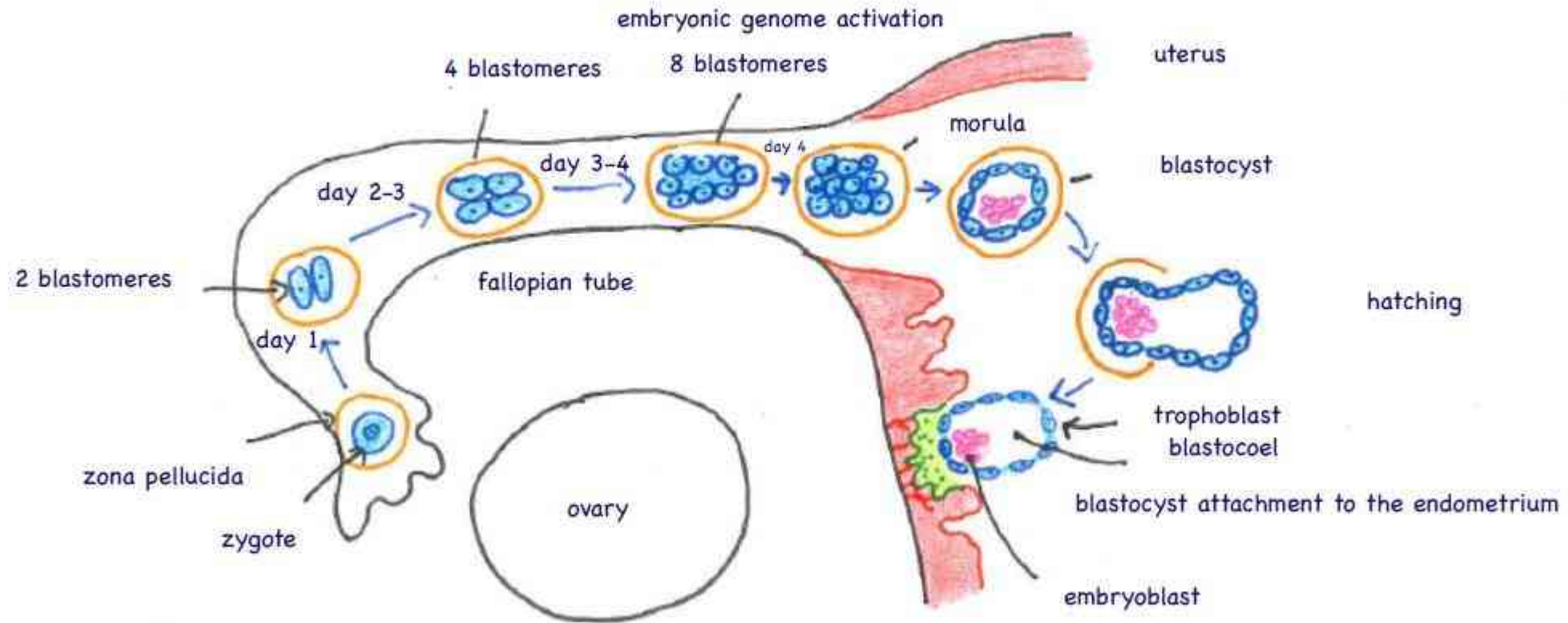
- sperm capacitation, spermatozoa penetrating through the cumulus oophorus, corona radiata, and zona pellucida,
- polyspermy block: exocytosis of cortical granules, zona hardening, perivitelline space extension,
- extrusion of 2nd polar body as a mark of the fertilization,
- genesis of maternal and paternal pronucleus, fusion of pronuclei in the zygote.



cortical reaction - prevents polyspermia
 -> increased perivitelline space
 -> loss of permeability of oolemma

58. Draw and label the cleavage till blastocyst hatching, including the implantation; state where and when the embryo in different stages of development occurs:

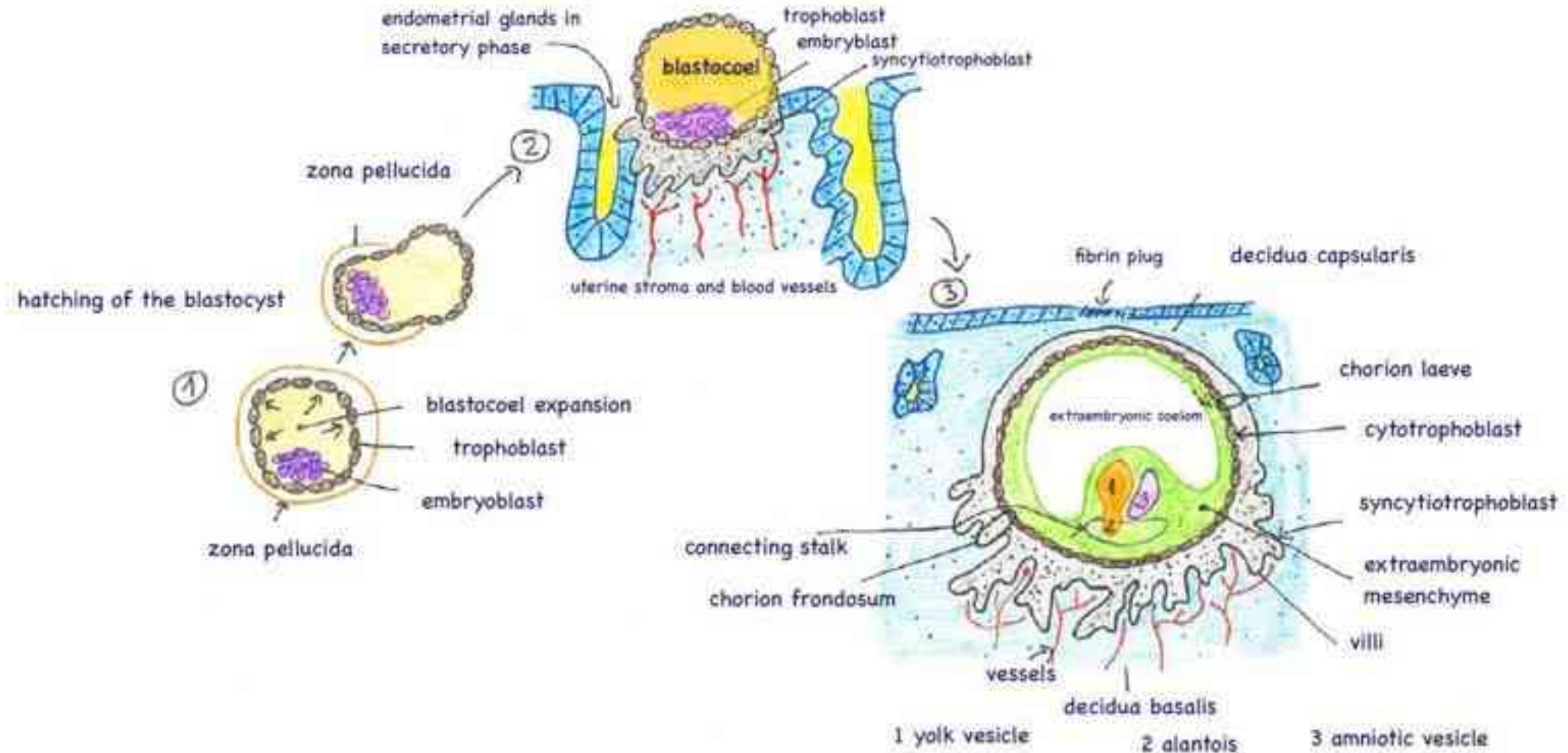
- day 1: mitotic division of the zygote (1st cleavage) toward blastomeres enclosed in zona pellucida, fallopian tube,
- day 2-3: mitotic division of blastomeres, embryonic genome activation (eight-cell), passing through the fallopian tube,
- day 3-4: morula formation, descending down the fallopian tube,
- day 4: blastocyst formation and hatching out of the zona pellucida in uterus,
- day 5: blastocyst attachment to the endometrium.



59. Draw and label blastocyst formation and the implantation in three schemes – free

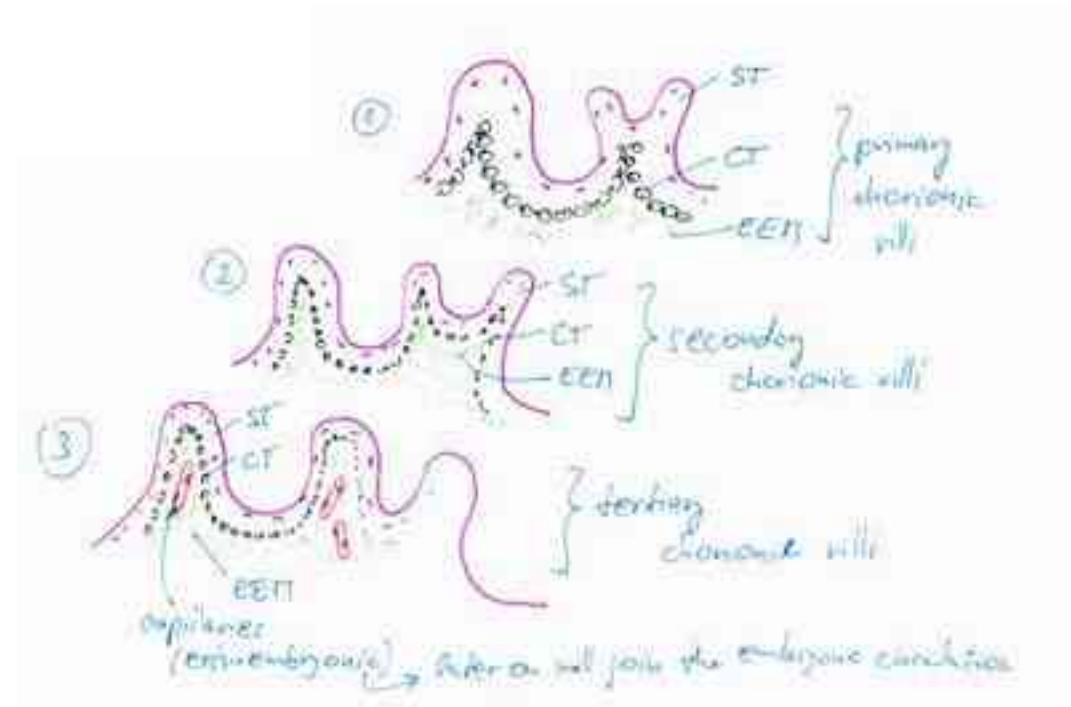
blastocyst, onset of implantation, and finalized implantation:

- formation of blastocoel and blastocyst expansion, hatching, free blastocyst,
- nidation of blastocyst into the endometrium, differentiation of trophoblast and embryoblast,
- syncytiotrophoblast formation and the invasion into the endometrium, vascular lacunae in the endometrium, chorion laeve et frondosum, operculum.



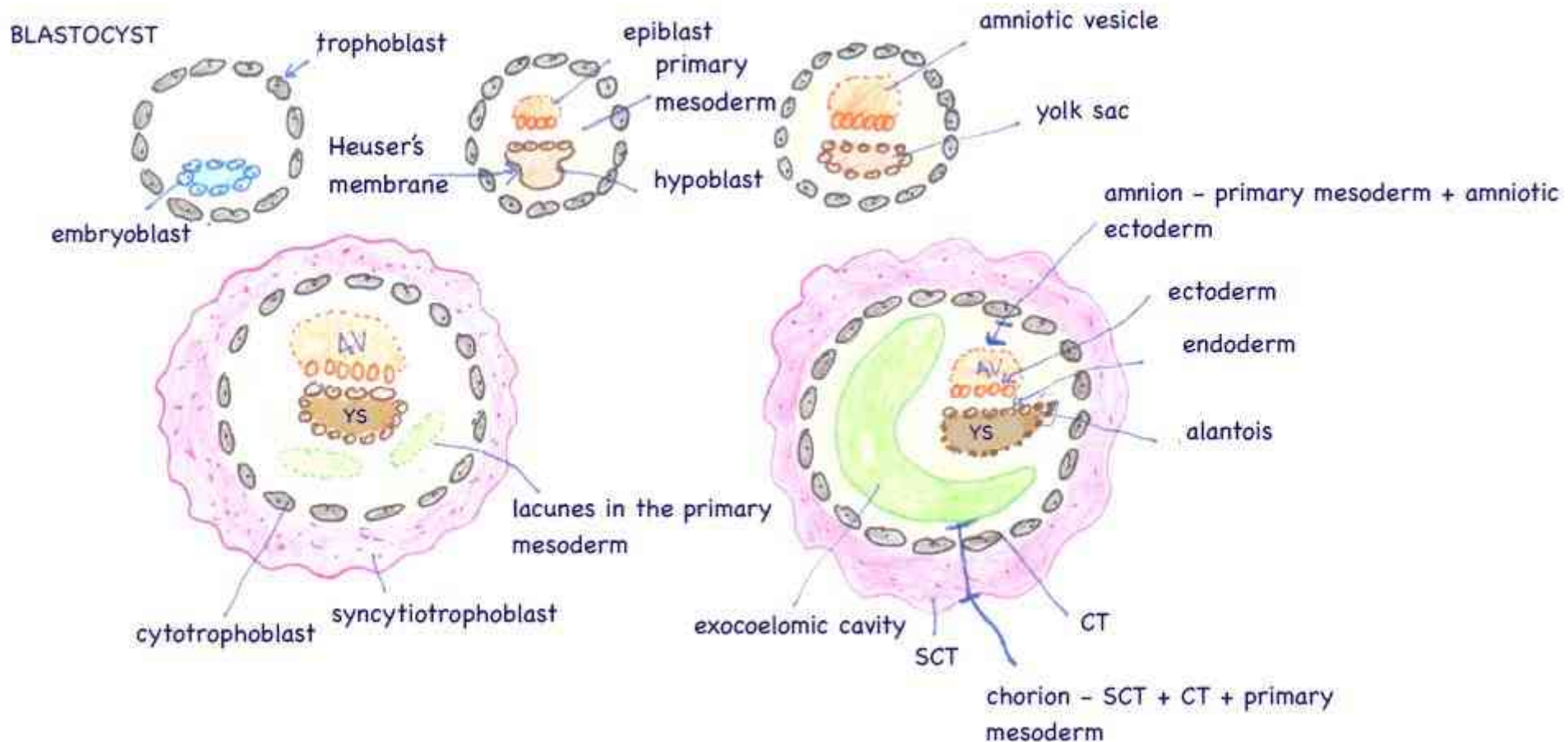
60. Draw and label the development of chorionic villi – primary to tertiary villi. Describe differences between villi of the mature and immature placenta:

- differentiation of trophoblast: cytotrophoblast and syncytiotrophoblast, primary chorionic villi,
- secondary chorionic villi with extraembryonic mesenchyme,
- tertiary villi equipped with fetal capillaries and the extraembryonic mesenchyme,
- tertiary villi of the mature placenta.



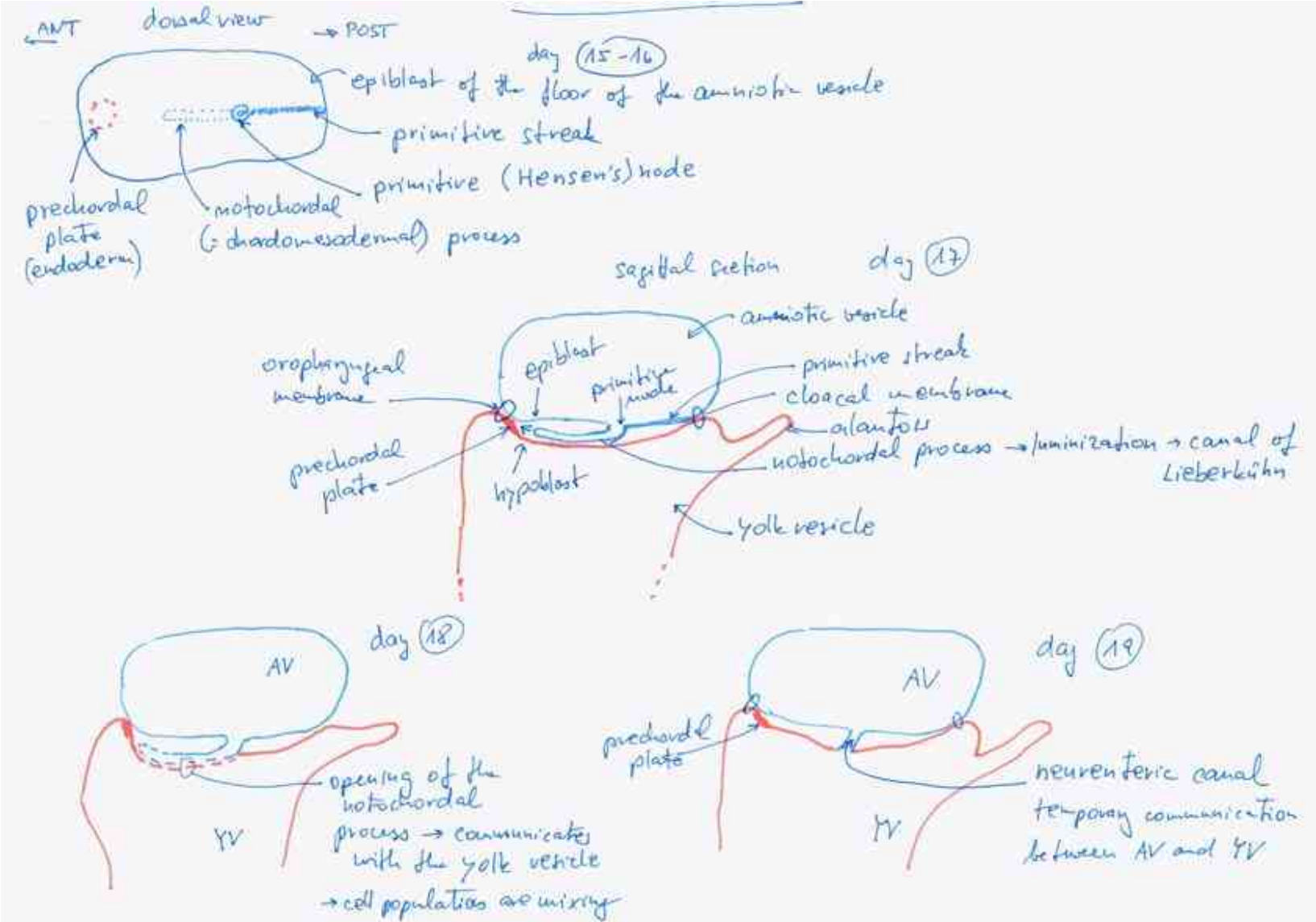
61. Draw and label the development of implanted blastocyst; amniotic vesicle and yolk sac, layers of amnion and chorion:

- blastocyst with embryoblast and trophoblast,
- syncytio- and cytotrophoblast, epiblast and hypoblast, primary mesoderm, Heuser's membrane,
- amniotic vesicle, yolk sac and their mutual contact; origin of exocoelomic cavity,
- chorion (primary mesoderm + cytotrophoblast + syncytiotrophoblast),
- amnion (primary mesoderm + amniotic ectoderm).



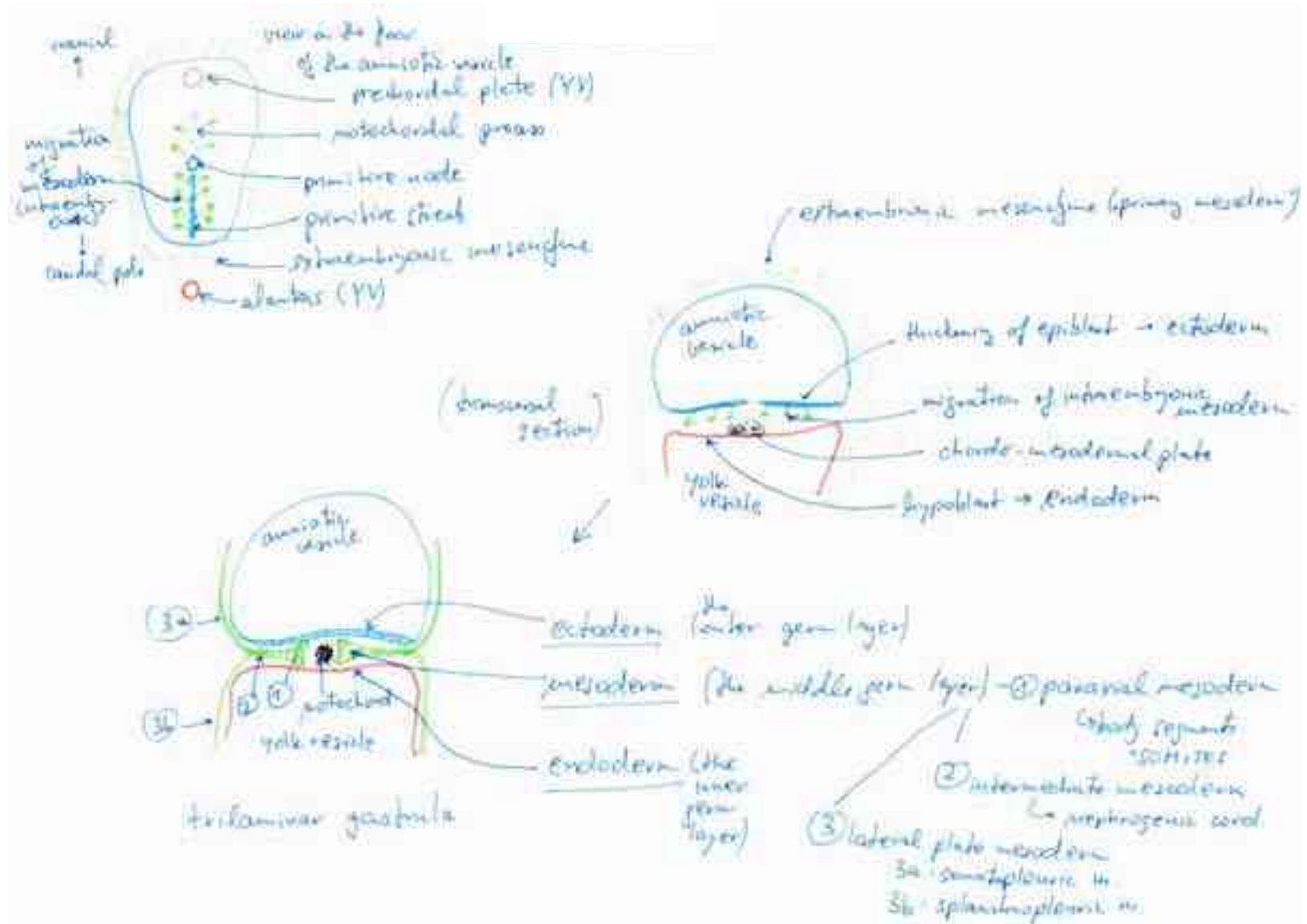
62. Draw and label embryonic disc – dorsal view and sagittal sections:

- ectodermal primitive streak and primitive (Hensen's) node,
- notochordal process,
- luminization of the notochordal process along with the origin notochordal canal,
- entodermal prechordal plate,
- neurenteric canal, oropharyngeal and cloacal membranes, allantois.



63. Draw and label the formation of mesoderm and chorda dorsalis – dorsal view and transversal sections:

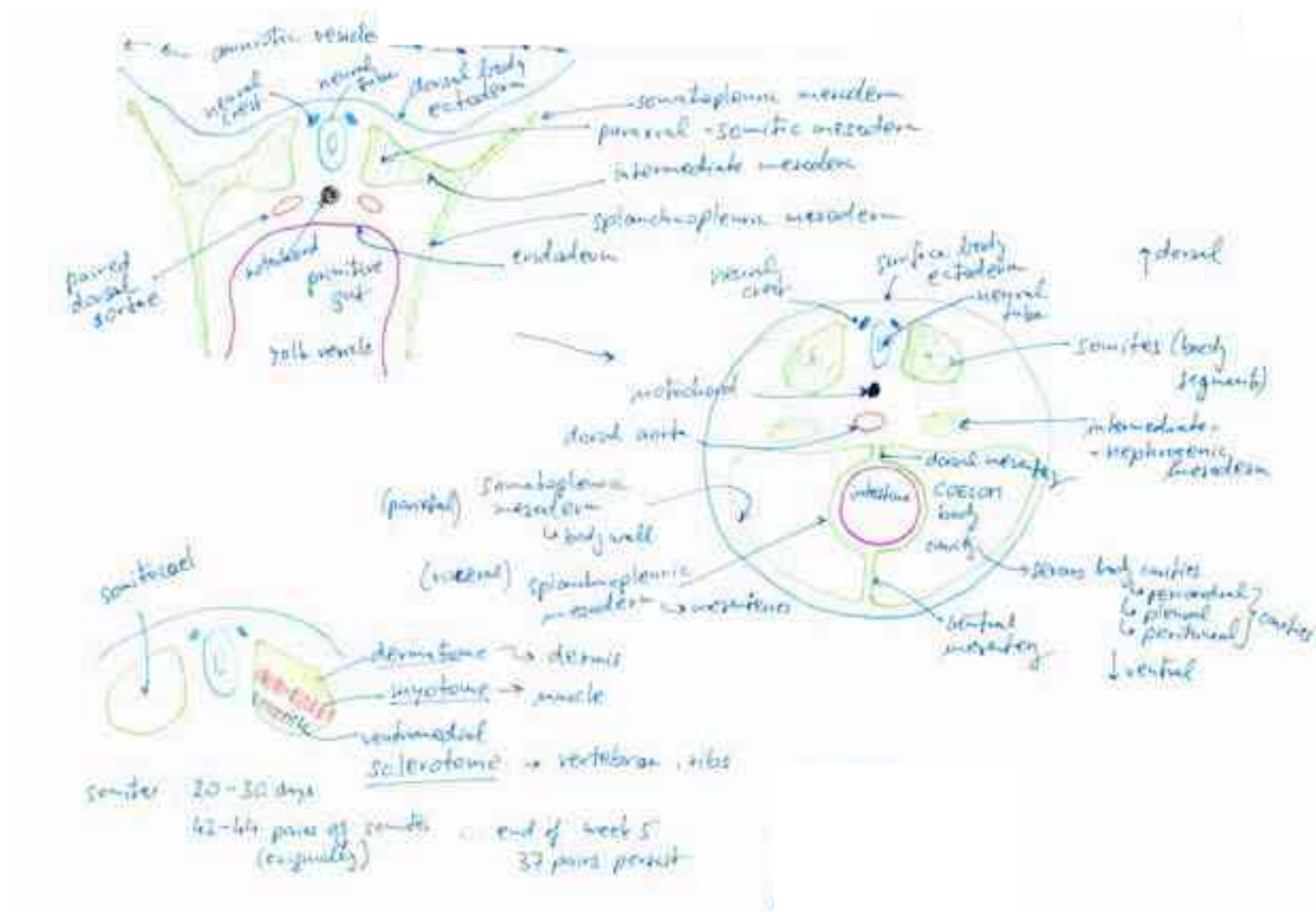
- dorsal view: primitive streak and primitive node,
- transversal section: migration of ectodermal cells and origin of mesoderm,
- differentiation of paraxial mesoderm, intermediate mesoderm, and lateral mesoderm.



64. Draw and label origin of somites and intraembryonic coelom in gastrula, basic

segmentation of mesoderm – transversal views:

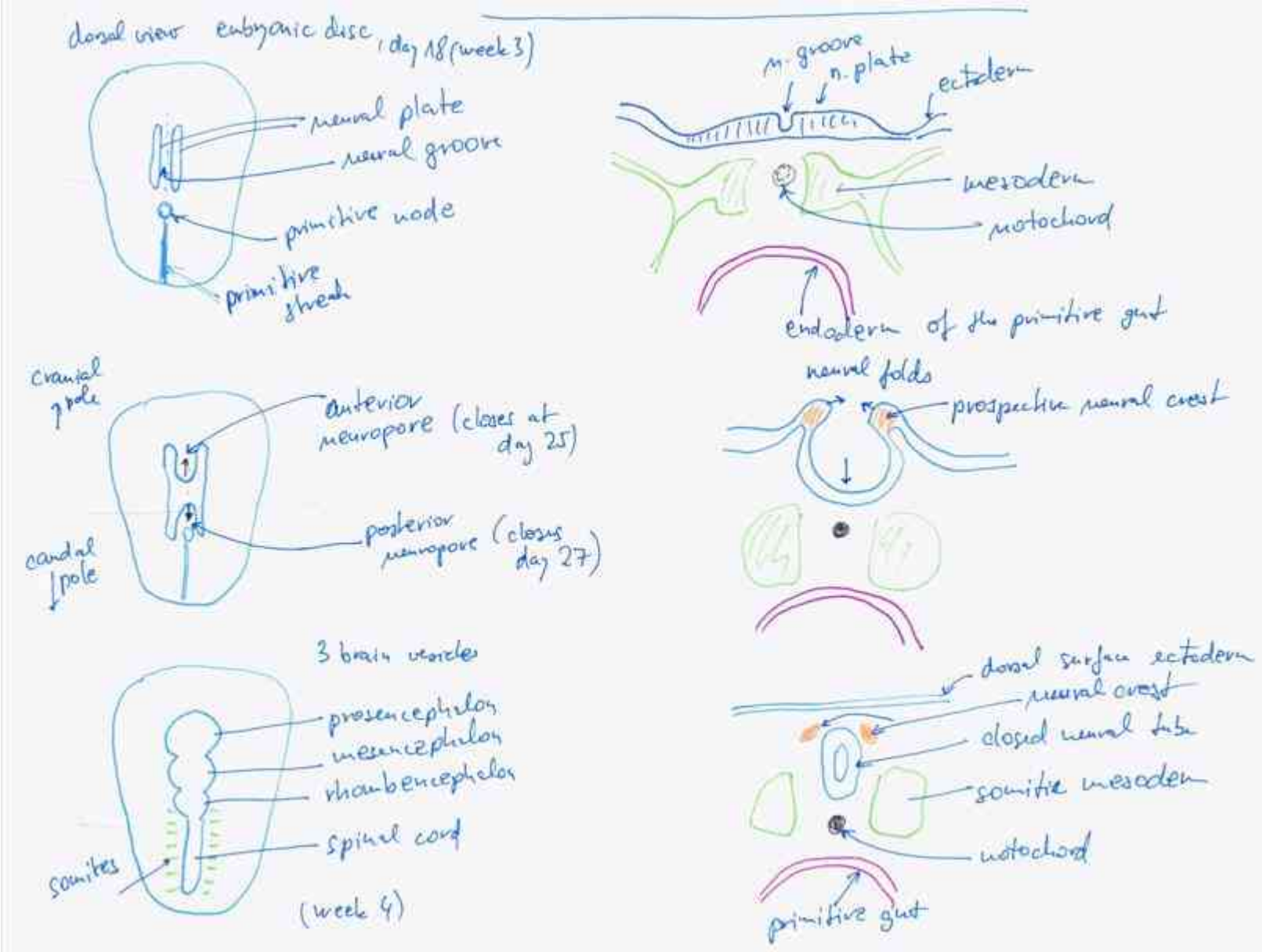
- fate of paraxial mesoderm and origin of somites,
- intermediary mesoderm, lateral mesoderm with somatopleura and sp coelom,
- relation of somites to the neural tube, neural crest, chorda dorsalis, and paired aortae;
- relation to the nephrogenic cord.



65. Draw and label the development of neural plate, neural groove, and neural tube – dorsal

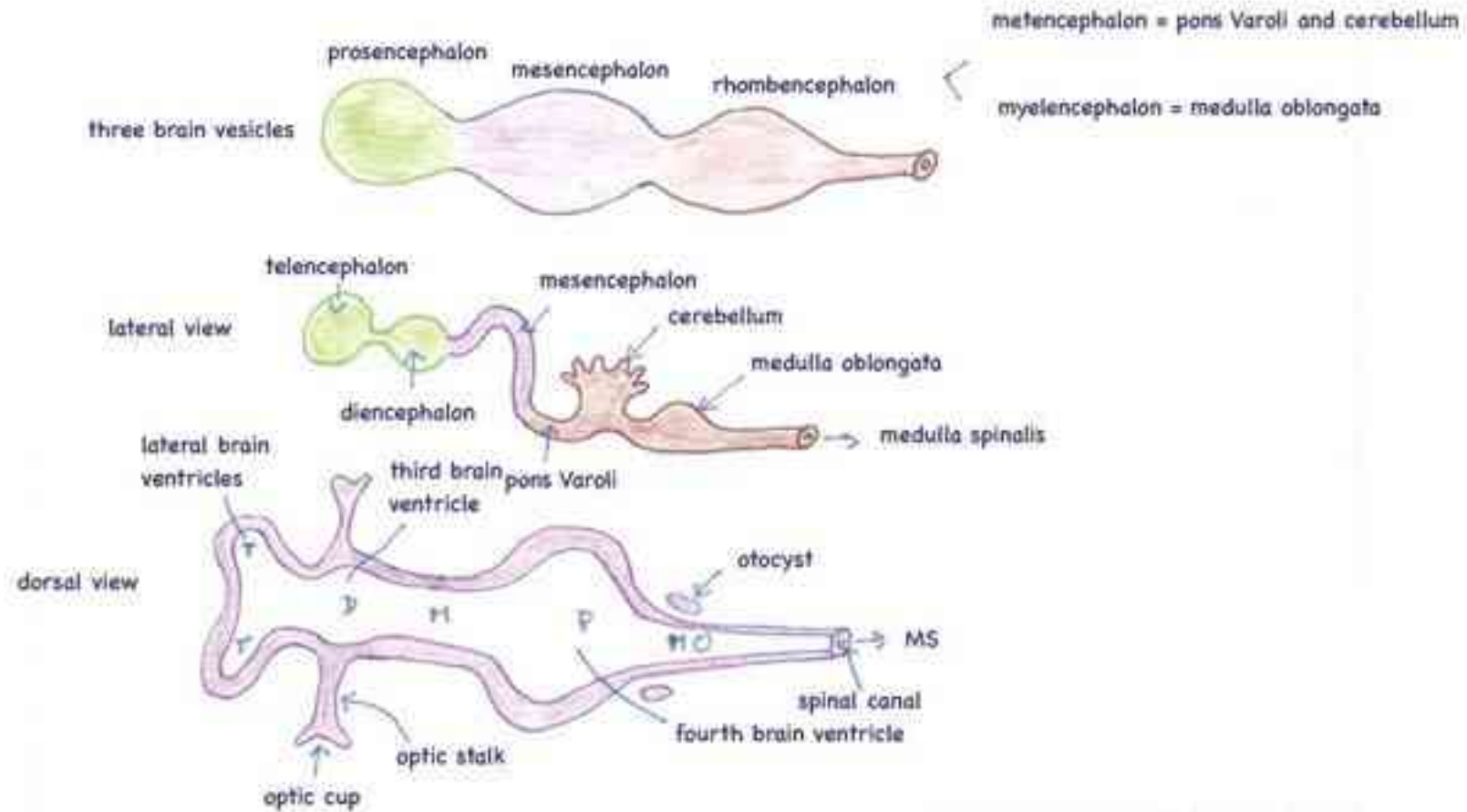
view and transverse sections:

- the relation of primitive streak and neural plate, anterior and posterior neuropores,
- ectoderm, coelom, prechordal plate, and neural plate,
- neural folds, neural groove, basis of neural crest,
- neural tube related to chorda dorsalis, neural crest, and somites.



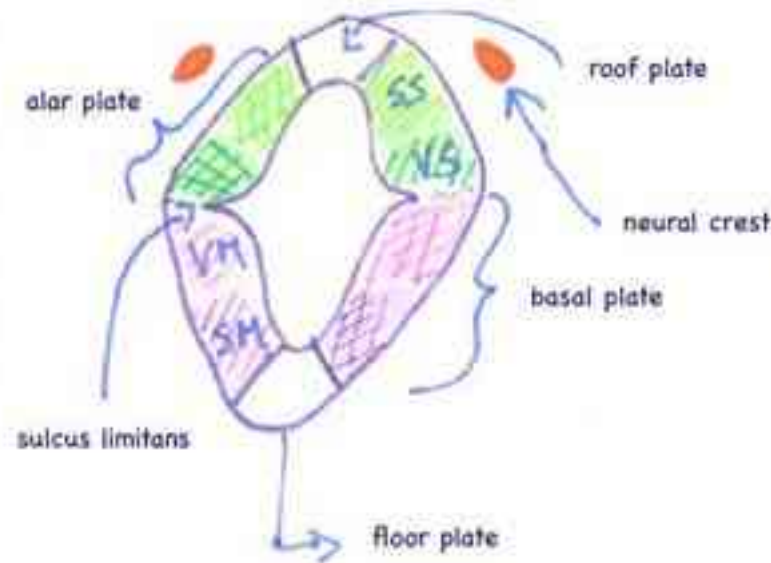
66. Draw and label head part of neural tube, division to brain vesicles, describe further development of vesicles:

- the stage of three brain vesicles: prosencephalon, mesencephalon, rhombencephalon,
- prosencephalon divided to telencephalon and diencephalon,
- rhombencephalon divided to metencephalon (future pons Varoli and cerebellum) and myelencephalon (future medulla oblongata),
- lateral brain vesicles (telencephalon), 3rd (diencephalon) and 4th (metencephalon) brain vesicle.



67. Draw and label a cross-section of the neural tube including general localization of sensitive and motor functions. Draw and label the spinal nerve roots:

- neural tube: alar (dorsal) plate and basal (ventral) plate, sulcus limitans, neural crest, roof and floor plate,
- somatosensitive, viscerosensitive, visceromotor, and somatomotor areas,
- dorsal (afferent) and ventral (motoric) spinal root, spinal ganglia, interneuron, sensitive and motor neurons.

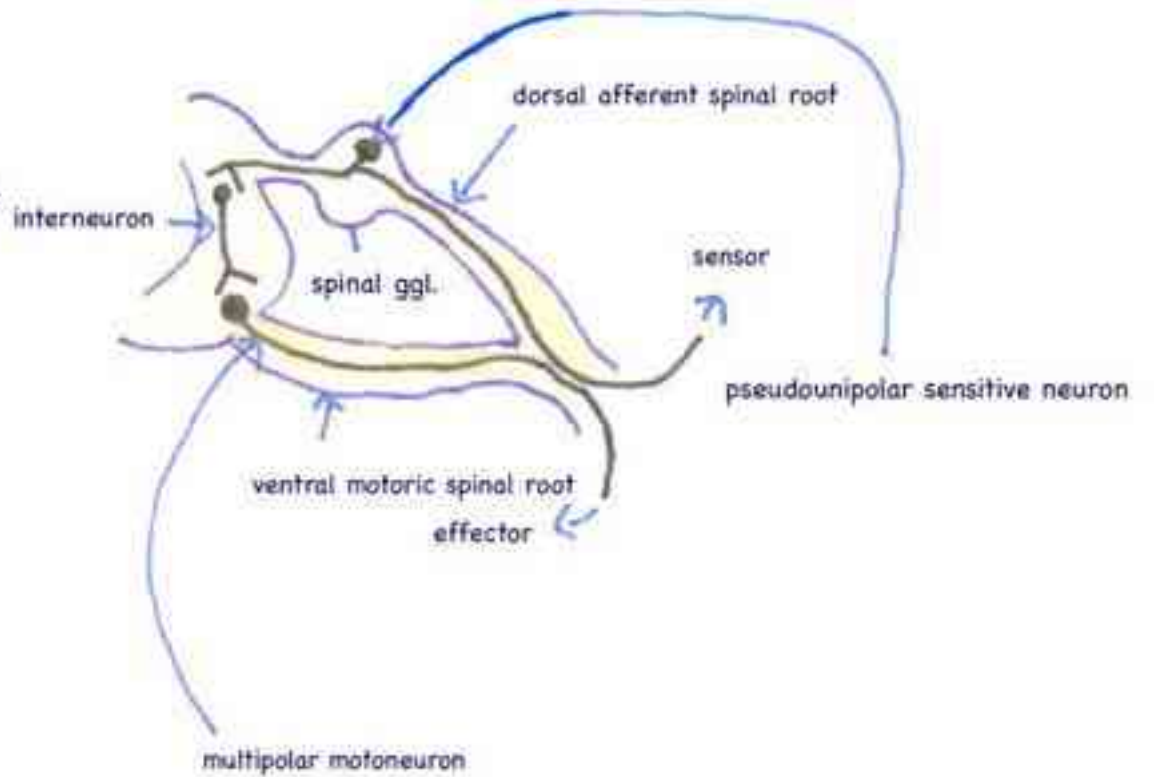


SS - somatosensitive

SM - somatomotor

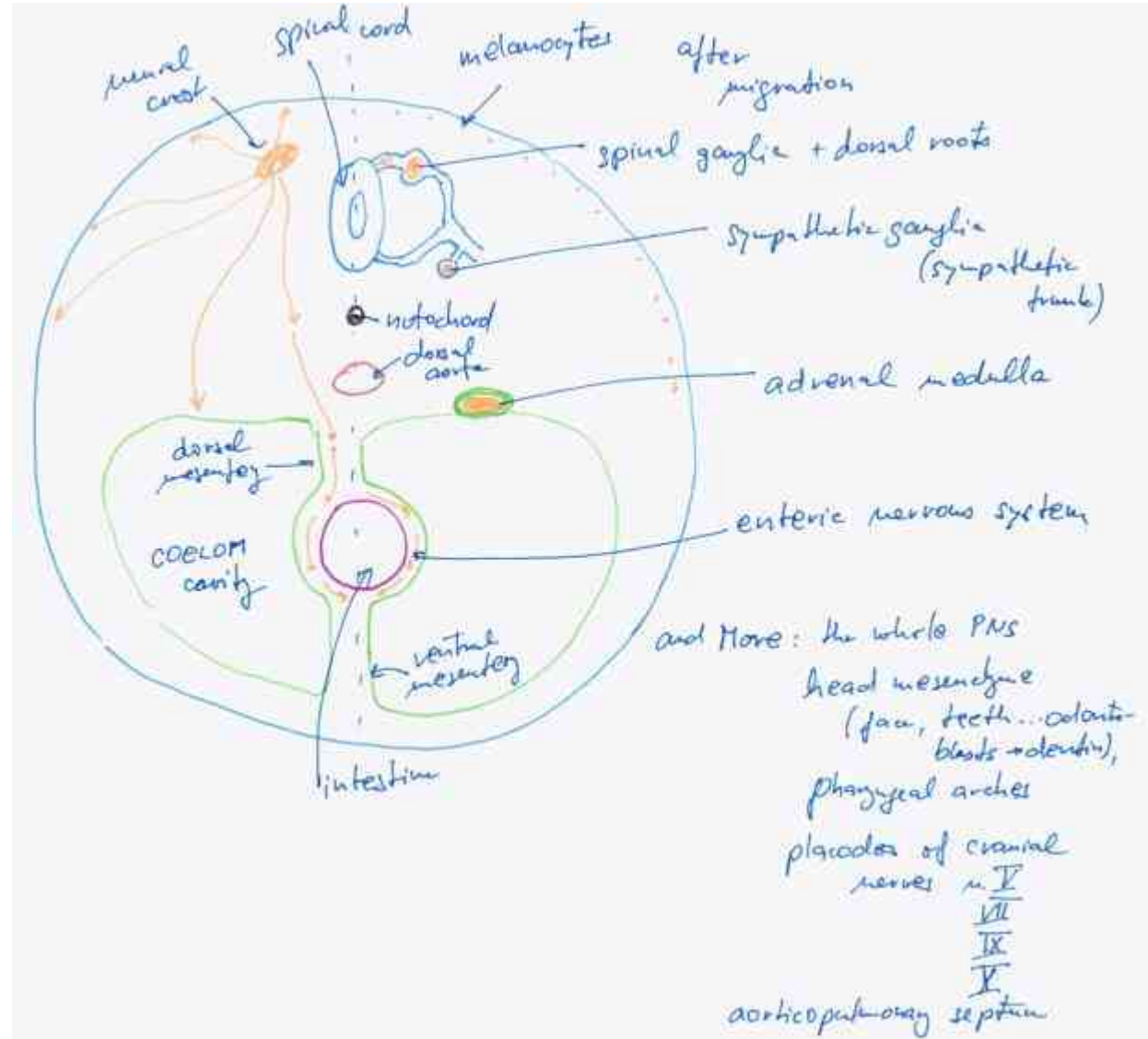
VS - viscerosensitive

VM - visceromotor



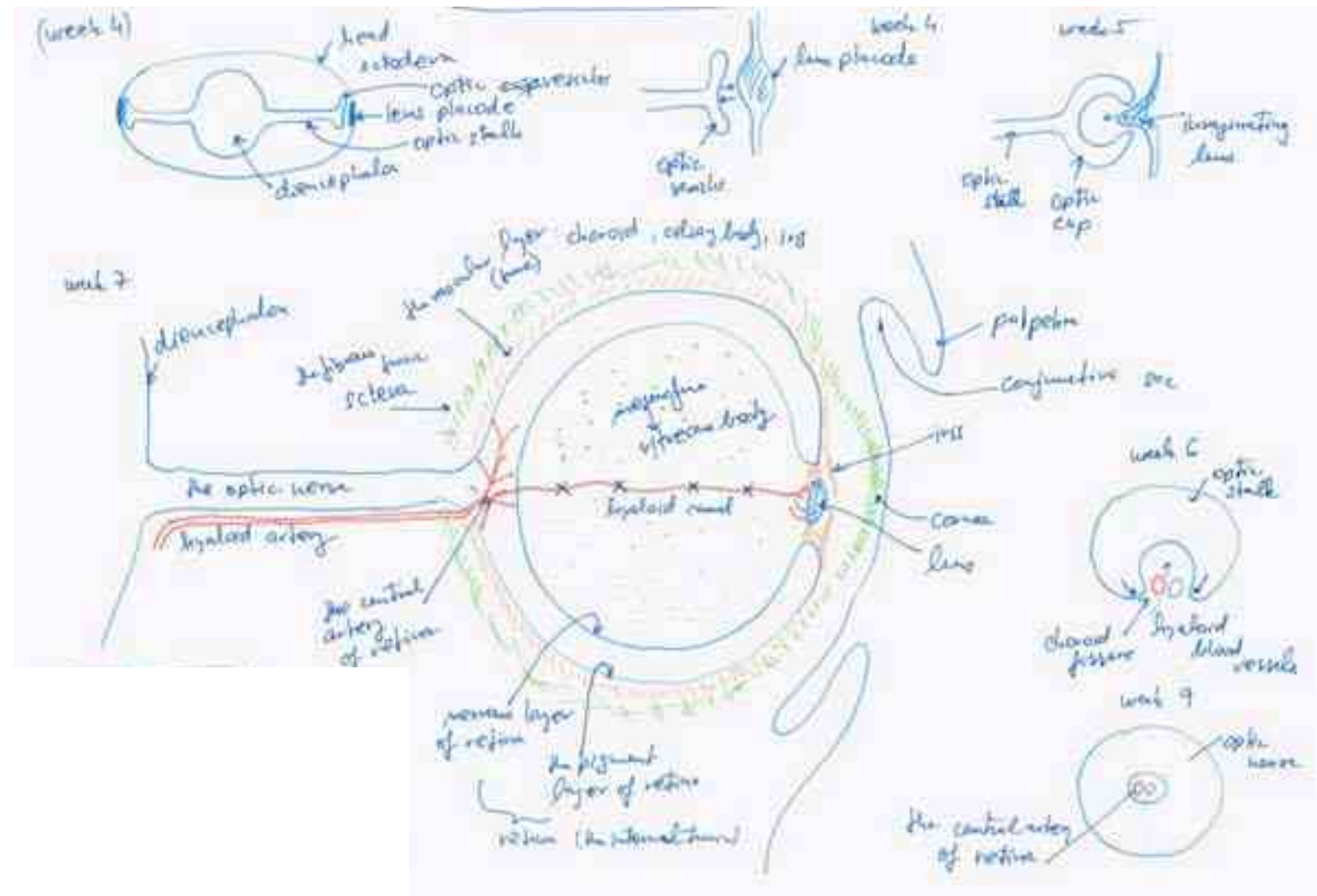
68. Draw and label neural crest and its derivatives:

- neural crest and the relation to the neural tube,
- division of neural crest, cells migrating from the crest, melanocytes,
- spinal ganglia, ganglia of the autonomic nervous system, the enteric nervous system, and medulla suprarenalis,
- placodes of the cranial nerves.

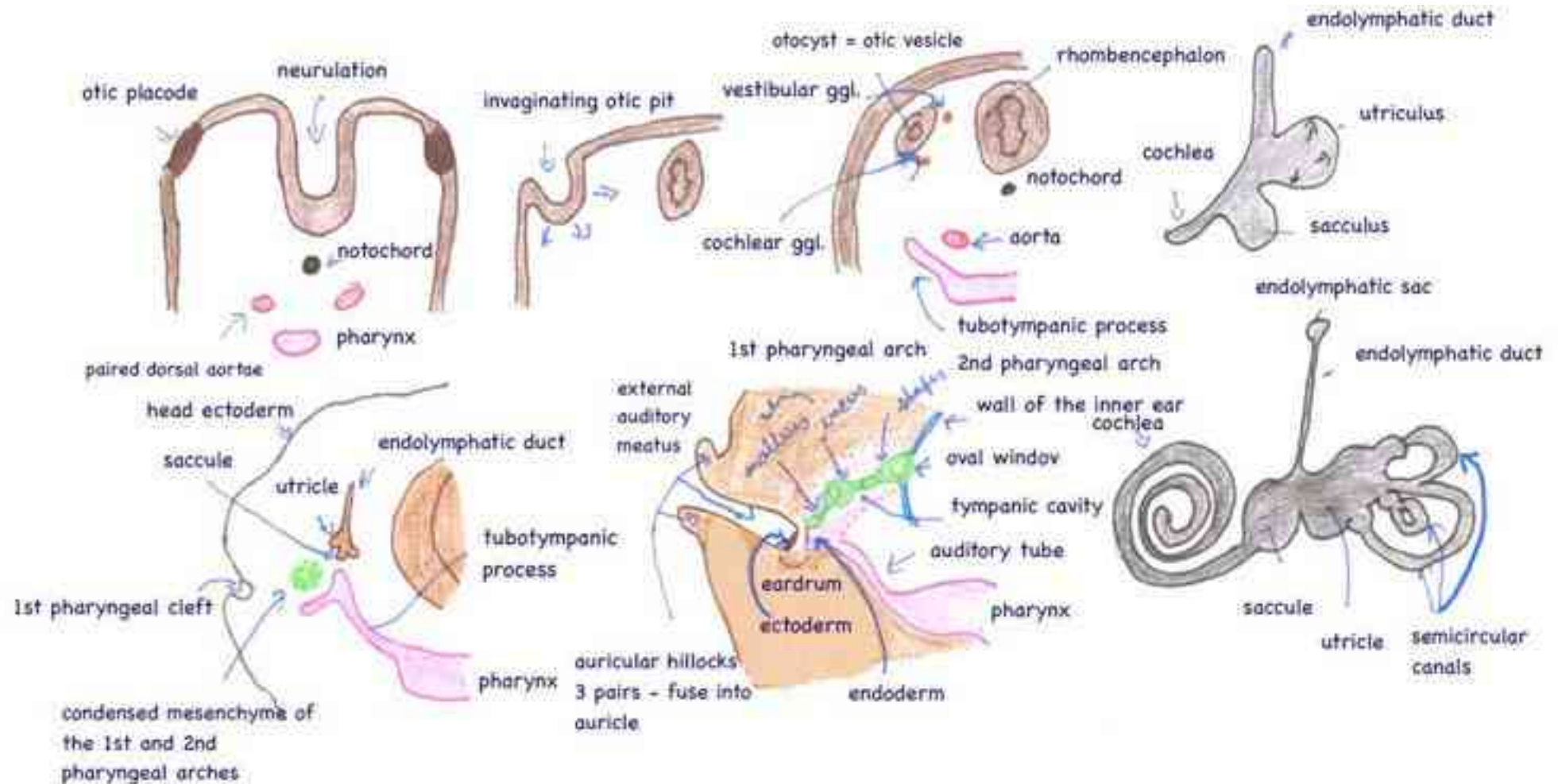


69. Draw and label development of the eye and nervus opticus:

- optic vesicle growing from the diencephalon, ectodermal lens placode,
- optic nerve and bilayered optic cup with inner neural layer and outer pigmented layer;
 invagination of the lens vesicle, cornea,
- eye mesenchyme: choroidea, corpus ciliare, iris, sclera,
- arteria hyaloidea, arteria centralis retinae,
- vasa centralia retinae enclosed in nervus opticus.

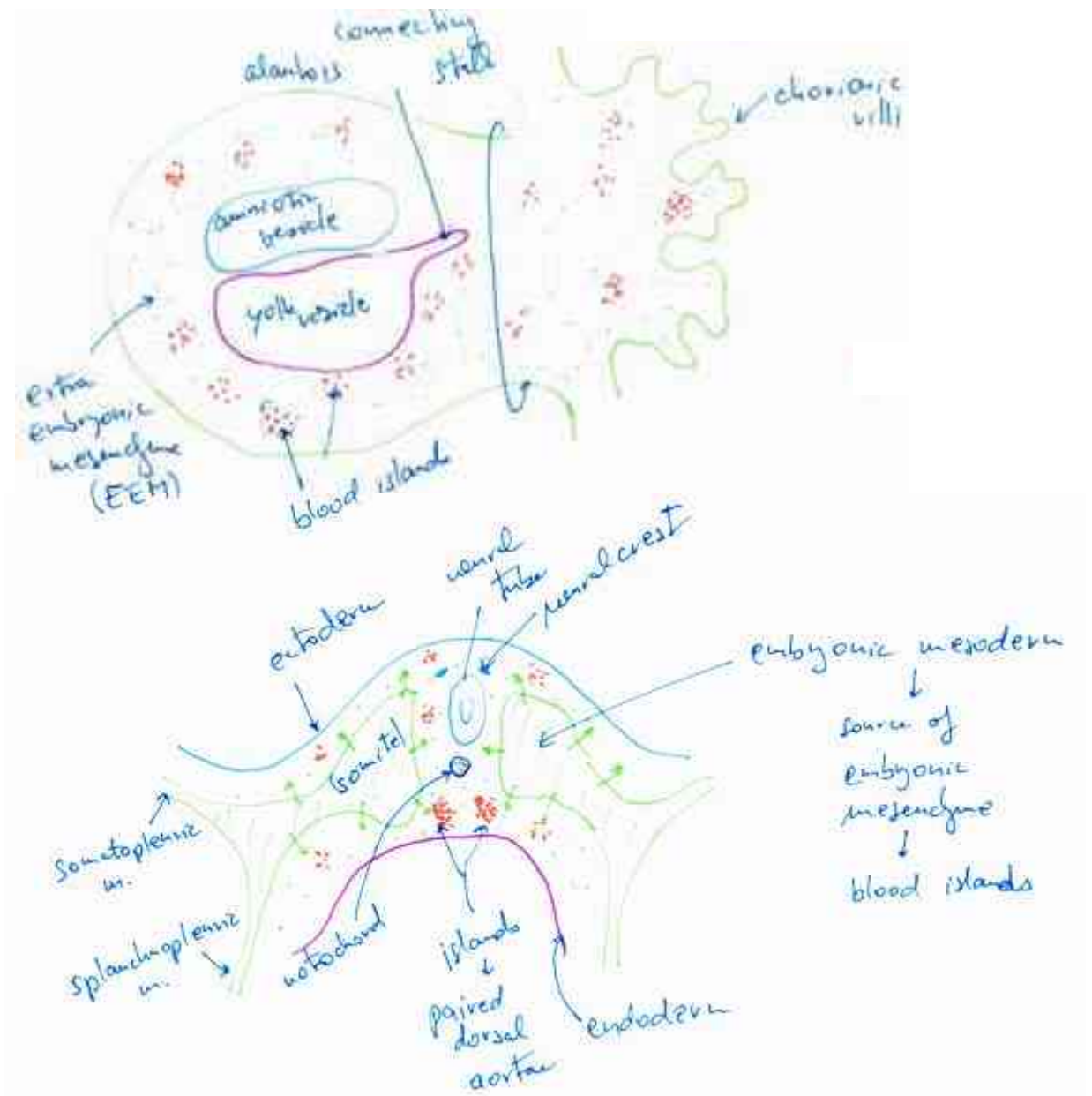
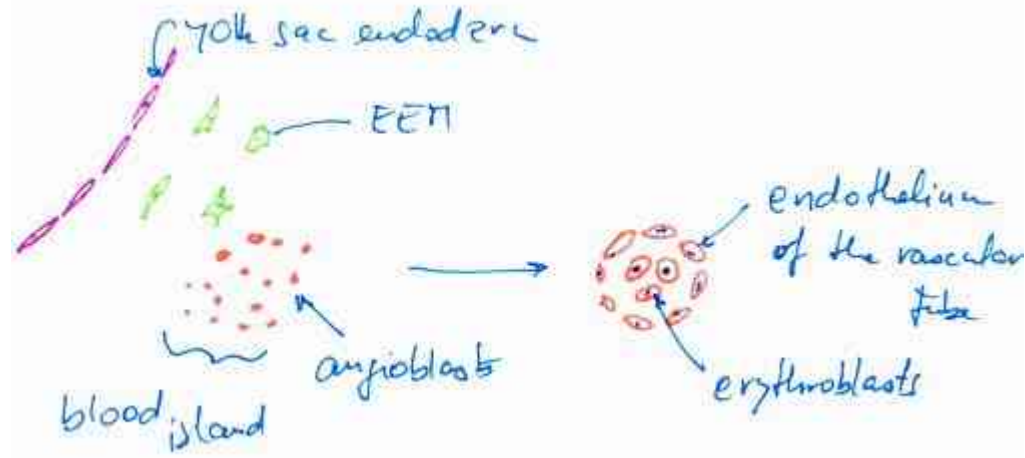


- inner ear: invagination of otic placode, otocyst, cochlea, primordial saccule, primordial utricle, endolymphatic duct, semicircular duct,
- middle ear cavity: originating from the 1st entodermal pharyngeal pouch; malleus, incus, and stapes originating from the mesenchyme of 1st and 2nd branchial arches,
- outer ear: external auditory meatus from the 1st ectodermal cleft, pinna from 3 auricular hillocks on the mandibular and 3 hillocks on the hyoid pharyngeal arch, eardrum.



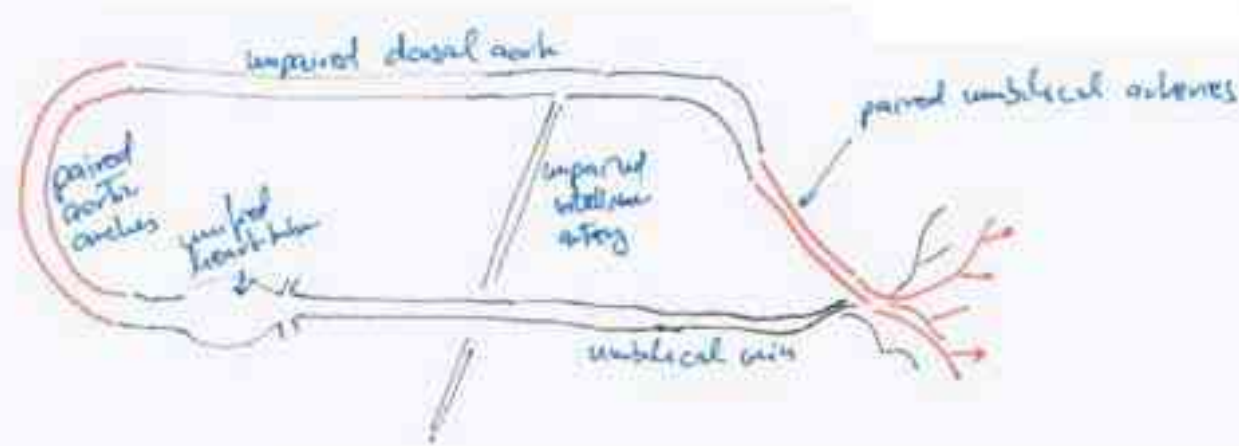
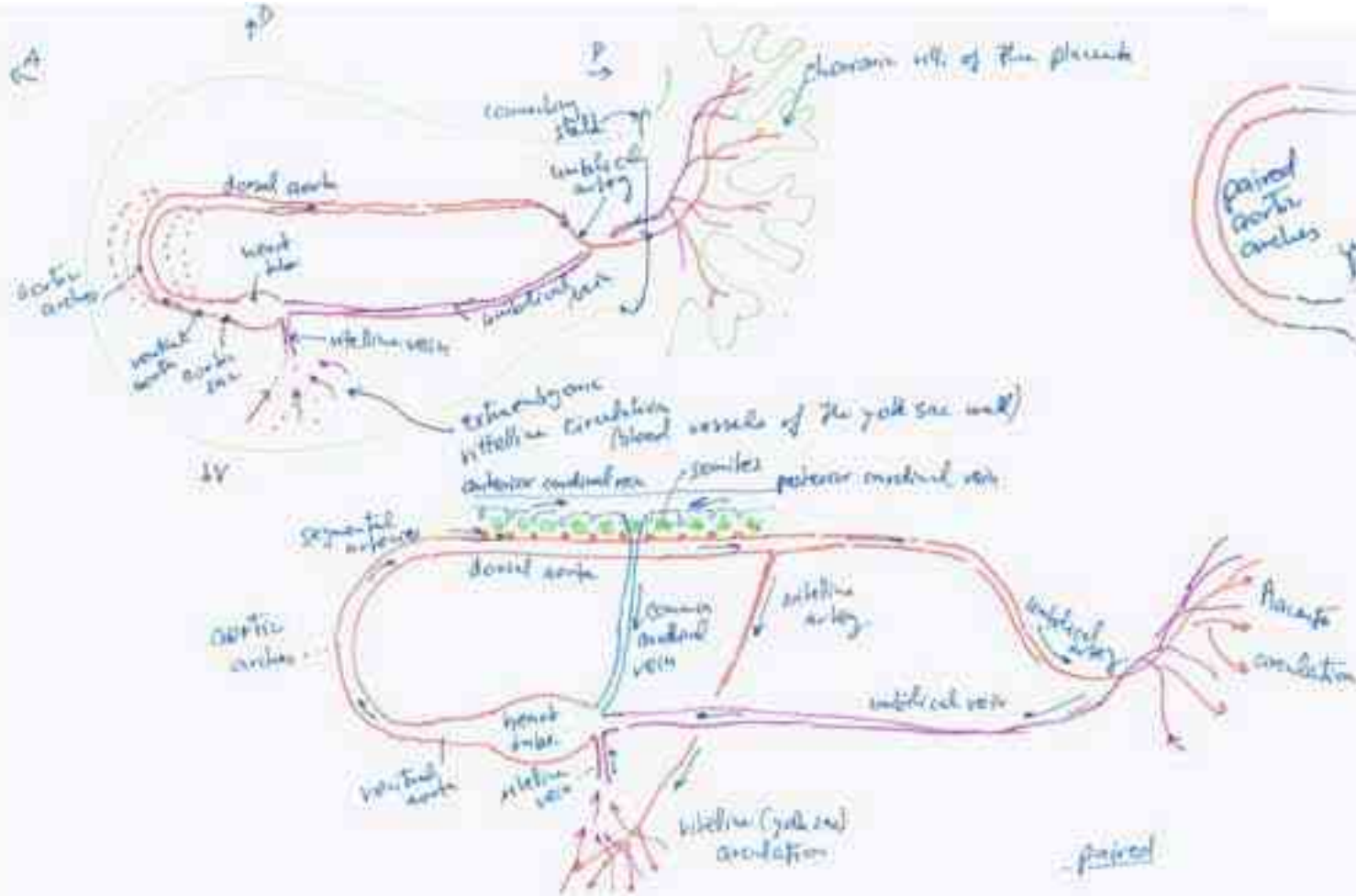
71. Draw and label formation of blood islands and primitive extraembryonic bloodstream:

- blood islands in the extraembryonic mesenchyme of the yolk sac, connecting stalk, and chorionic villi,
- angioblasts, differentiating into erythroblasts, and endothelial cells,
- extraembryonic vitelline vessels.



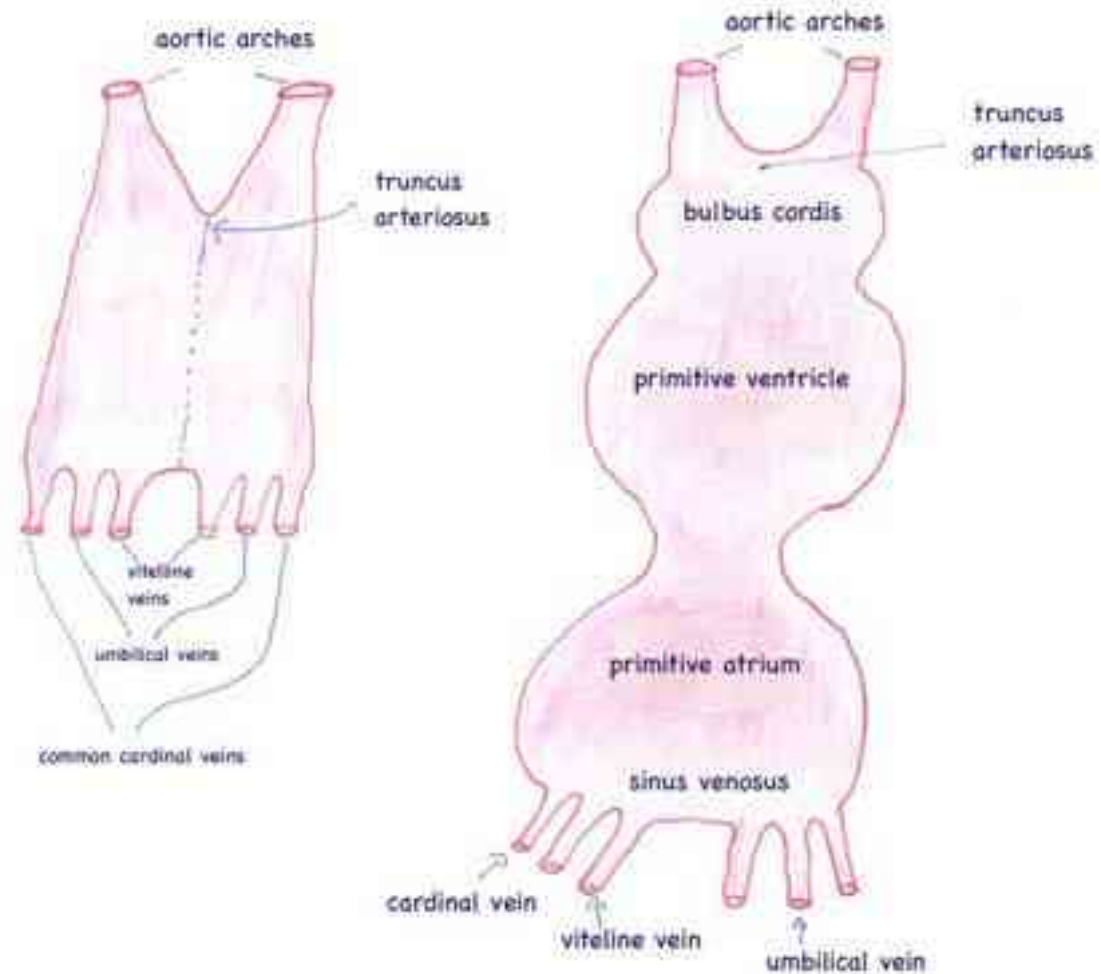
72. Draw and label embryonic circulation from primitive bilateral circulation to unification of paired blood vessels; highlight direction of the blood flow:

- distinguished embryonic and extraembryonic (vitelline) circulation, followed by the unification of them,
- umbilical vein (draining the chorionic villi), common cardinal vein (tributaries: pre- and postcardinal vein, draining somite areas), vitelline vein (from the extraembryonic circulation),
- heart, internal carotid artery, aorta, vitelline artery, umbilical artery.



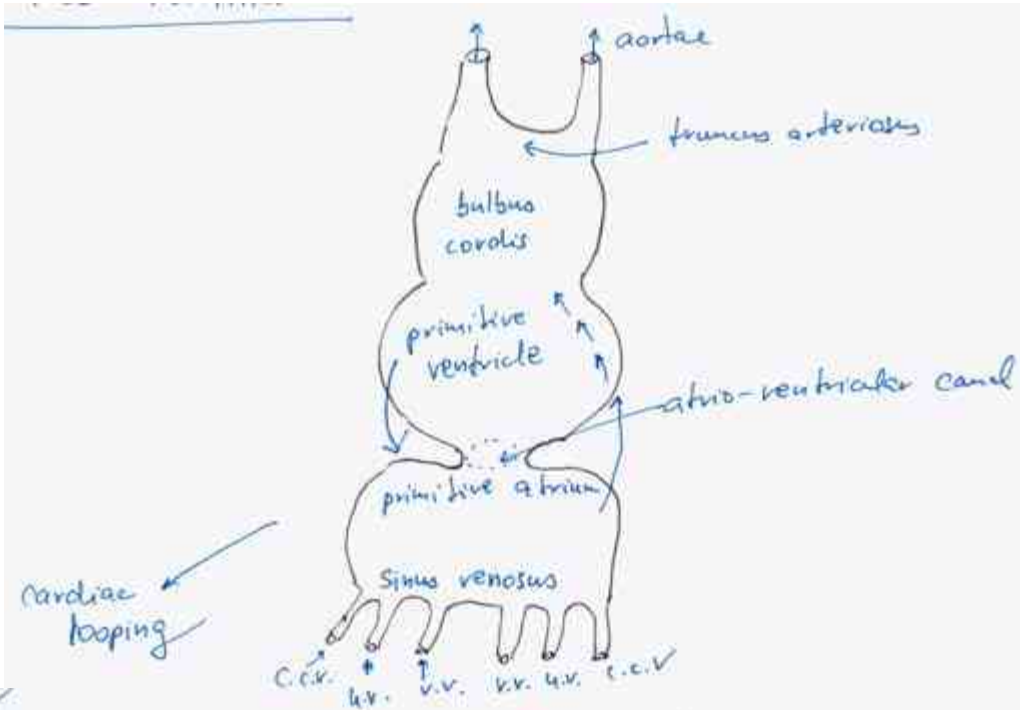
73. Draw and label the formation of heart tube:

- fusion of paired heart tube,
- six venous tributaries: paired common cardinal veins, umbilical veins, vitelline veins,
- sinus venosus and atria, sino-atrial aperture, atrio-ventricular canal,
- ventricular space, heart bulbus, truncus, and aortic arches.

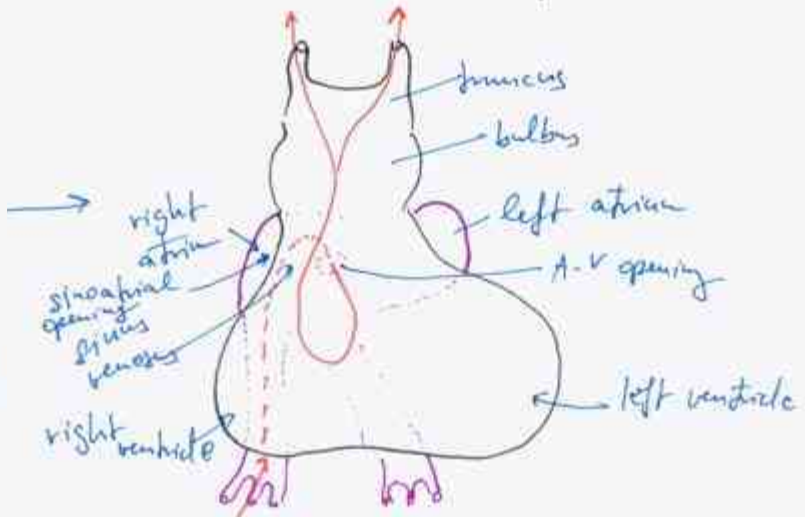
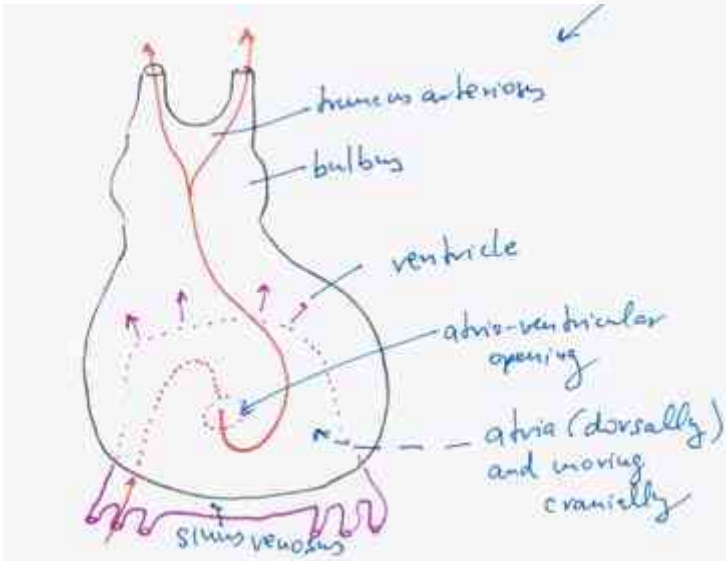


74. Draw and label the formation of the heart loop:

- sinus venosus, sino-atrial opening, atrioventricular canal, ventricles,
- heart bulbus, truncus, and aortic arches,
- heart loop formation and separation of future right and left atrium and ventricle.

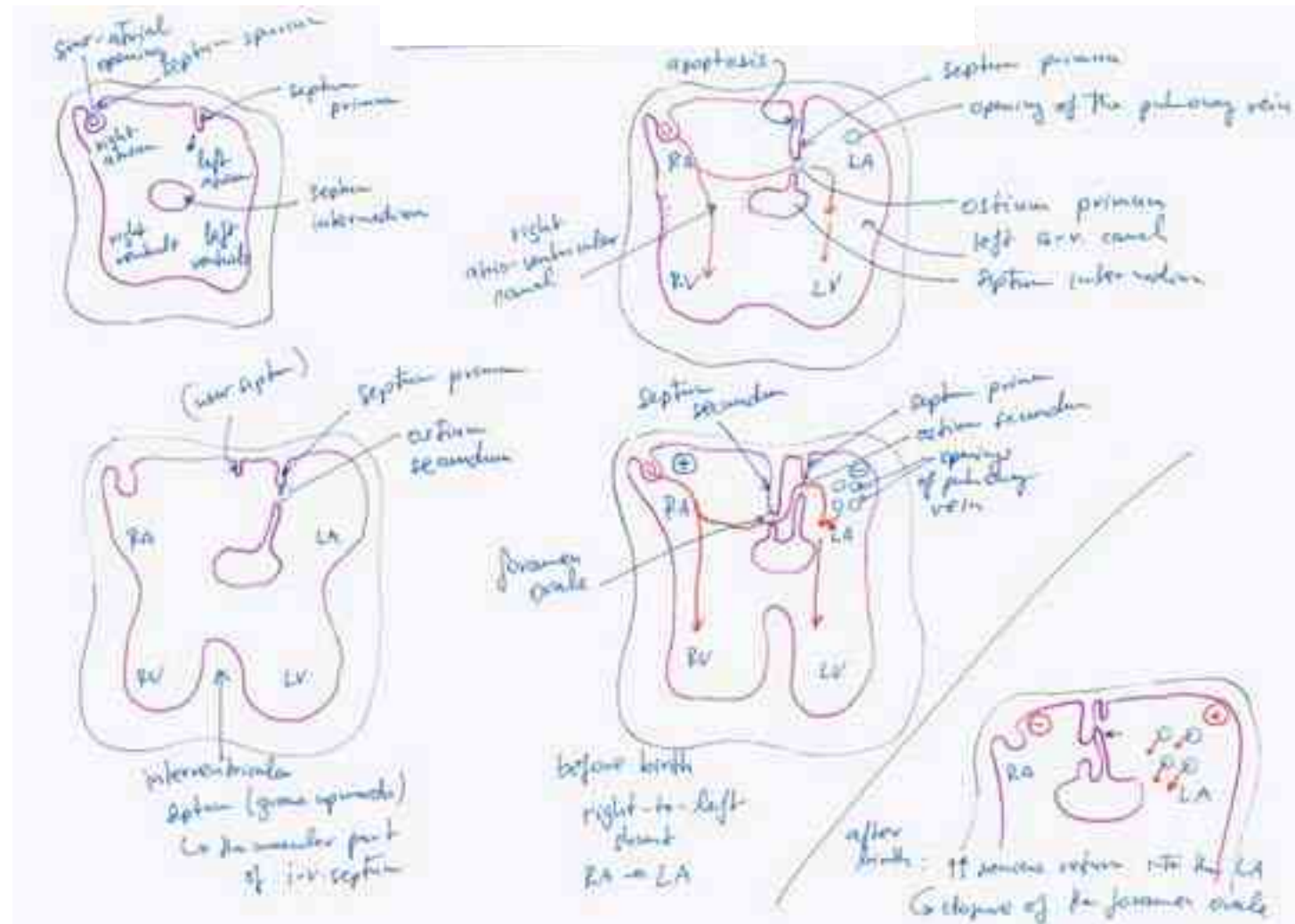


cardiac looping



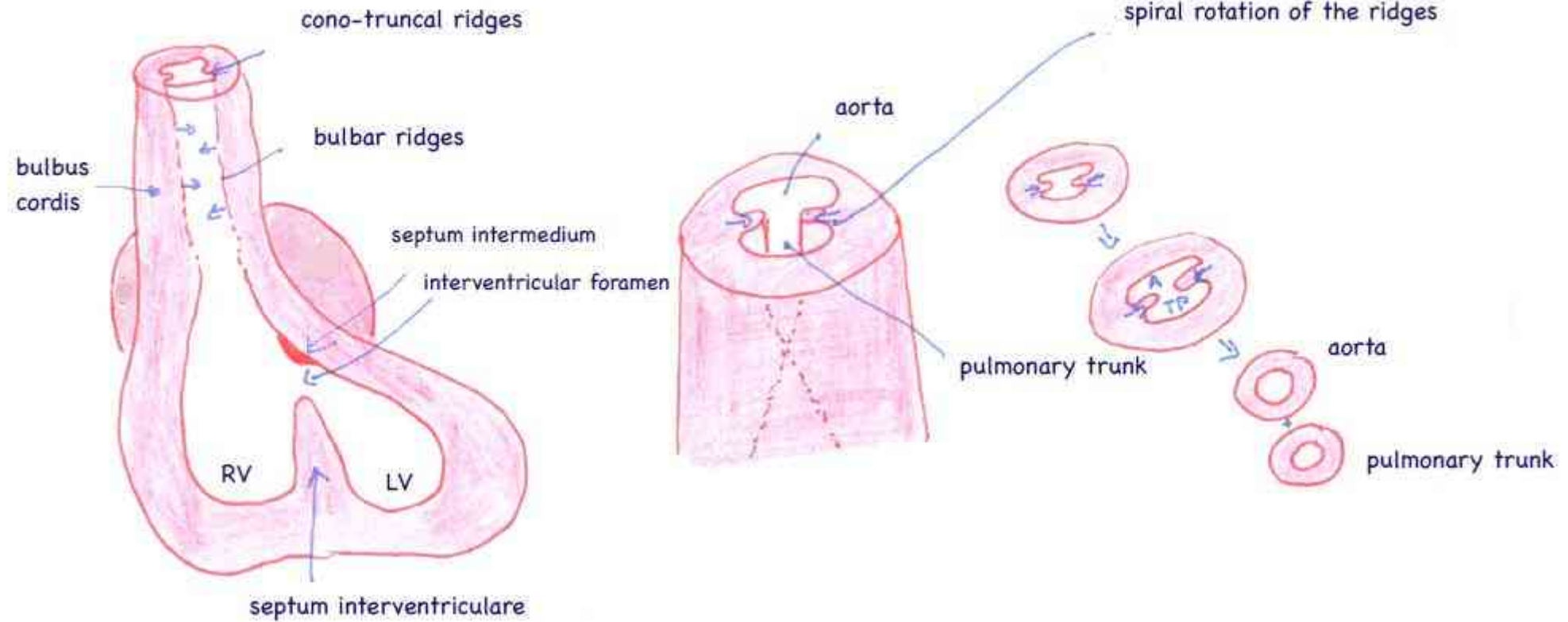
75. Draw and label atrial septation. Highlight the establishment of atrial septum before and after the birth:

- sinu-atrial orifice and septum spurium,
- septum intermedium,
- septum primum and foramen (ostium) primum,
- fusion of septum primum and septum intermedium; origin of foramen (ostium) secundum,
- septum secundum and foramen ovale, separation of right ventricle from left one,
- after the birth – closing the foramen ovale, septum primum is pressed against septum secundum.

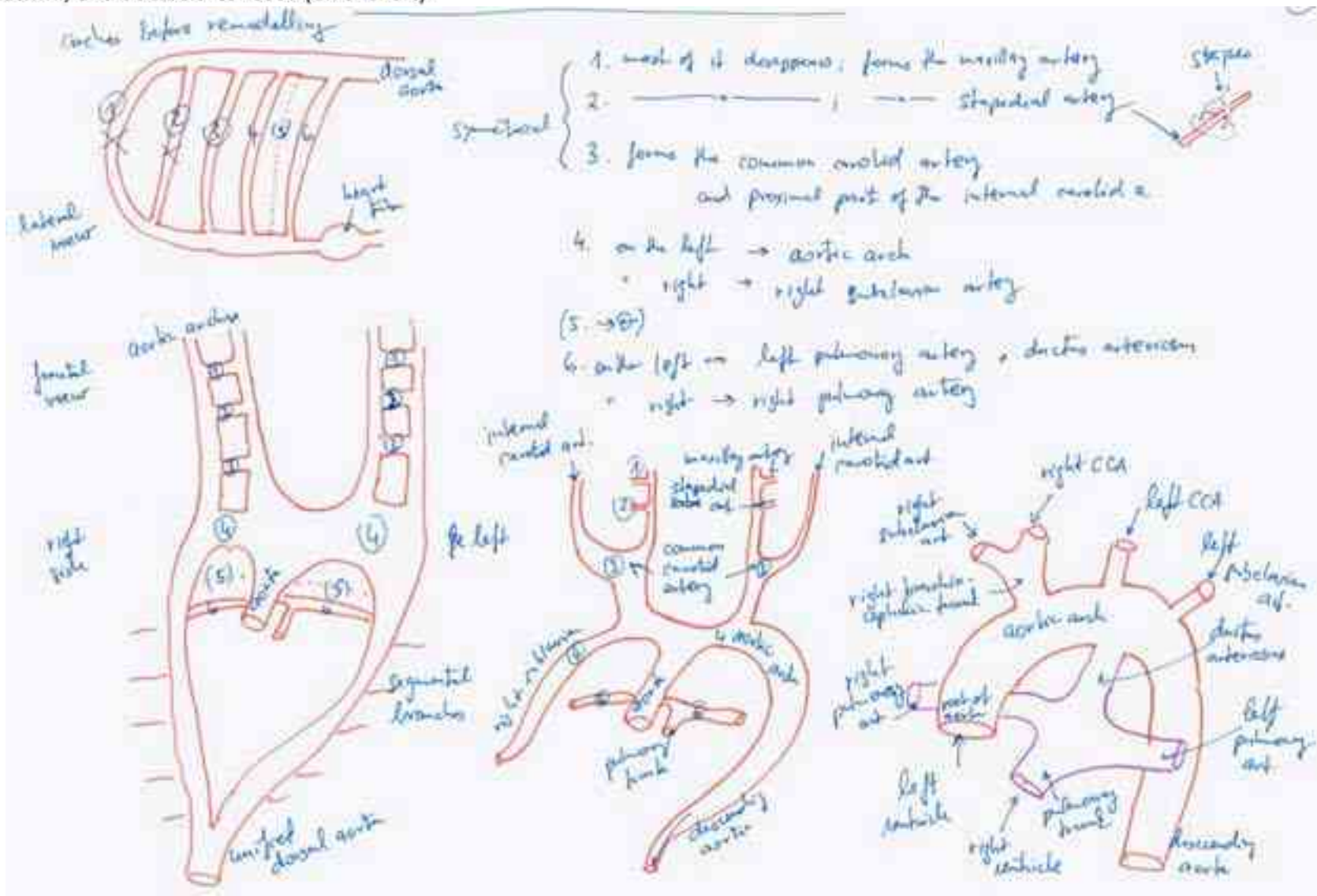


76. Draw and label septation of heart ventricles and the separation of large arteries:

- septum intermedium and septum interventriculare with foramen interventriculare,
- membranous and muscular parts, closing of interventricular foramen,
- bulbar ridges, aortico-pulmonary septum,
- separated aorta and pulmonary trunk.

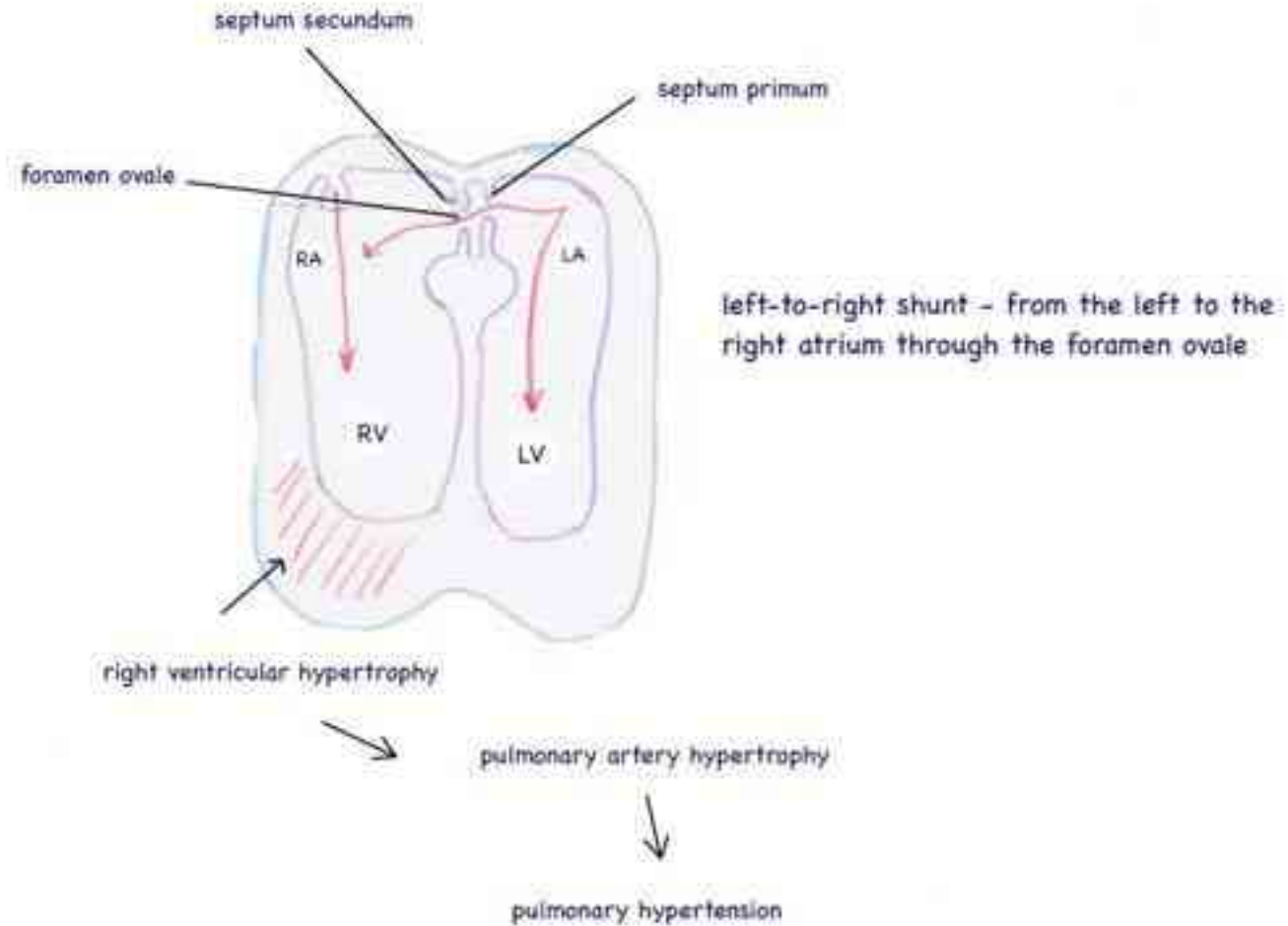


- remnants of the 1st arch artery – maxillary artery,
- remnants of the 2nd arch artery – stapedial artery,
- 3rd arch – common and internal carotid artery,
- 4th arch – aortic arch (on the left) and right subclavian artery (on the right),
- 5th arch – no developed,
- 6th arch – pulmonary trunk, a. pulmonalis dx. et sin., and ductus arteriosus (on the left).

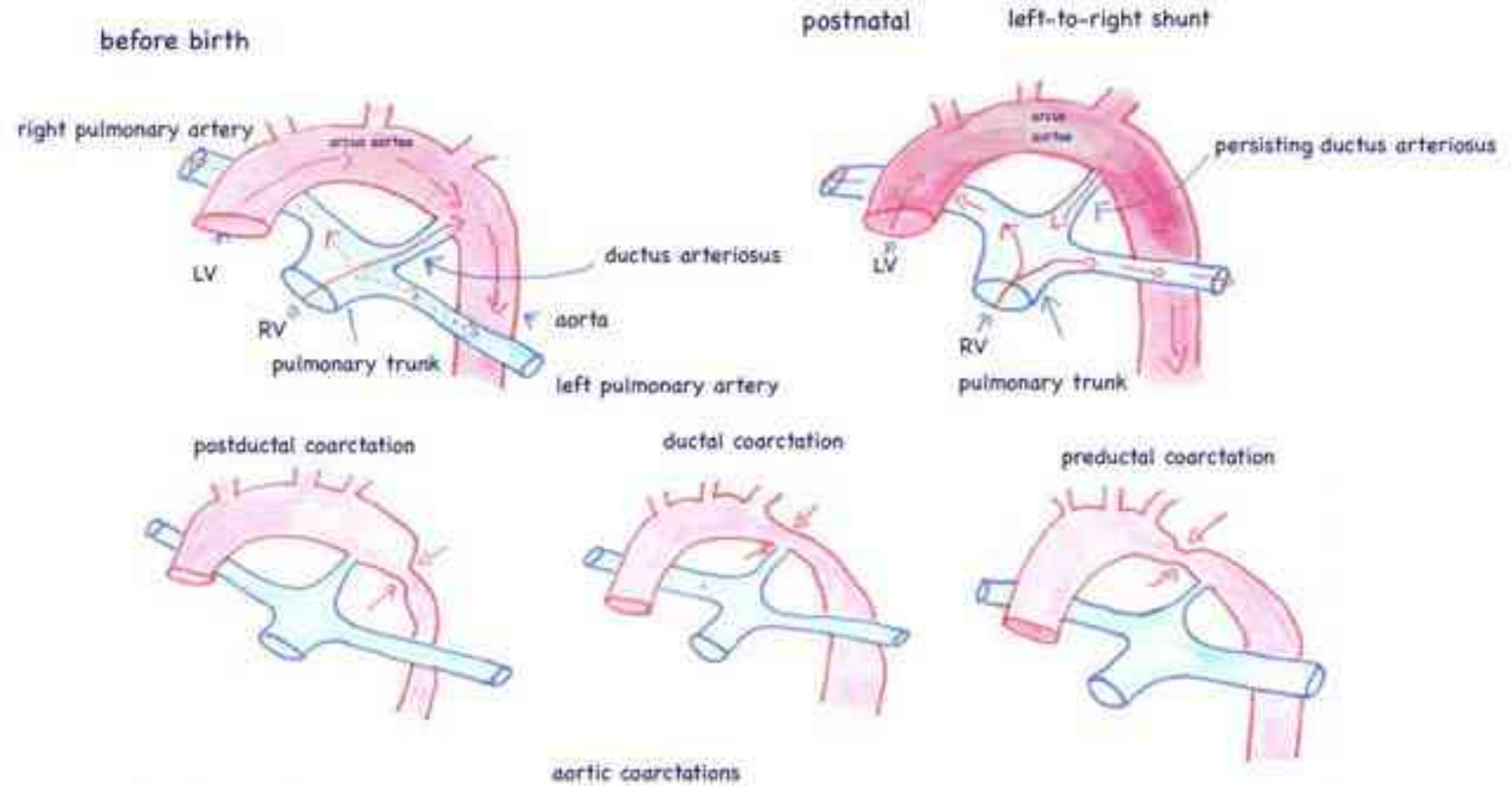


78. Draw and label patens foramen ovale (foramen ovale apertum) after birth:

- septum primum, septum secundum,
- blood flowing to the left atrium via pulmonary veins, left-to-right shunt from the left to the right atrium through the foramen ovale, overload of the right atrium and right ventricle,
- right ventricular hypertrophy, pulmonary artery hypertrophy,
- reduced hypotrophic aorta.

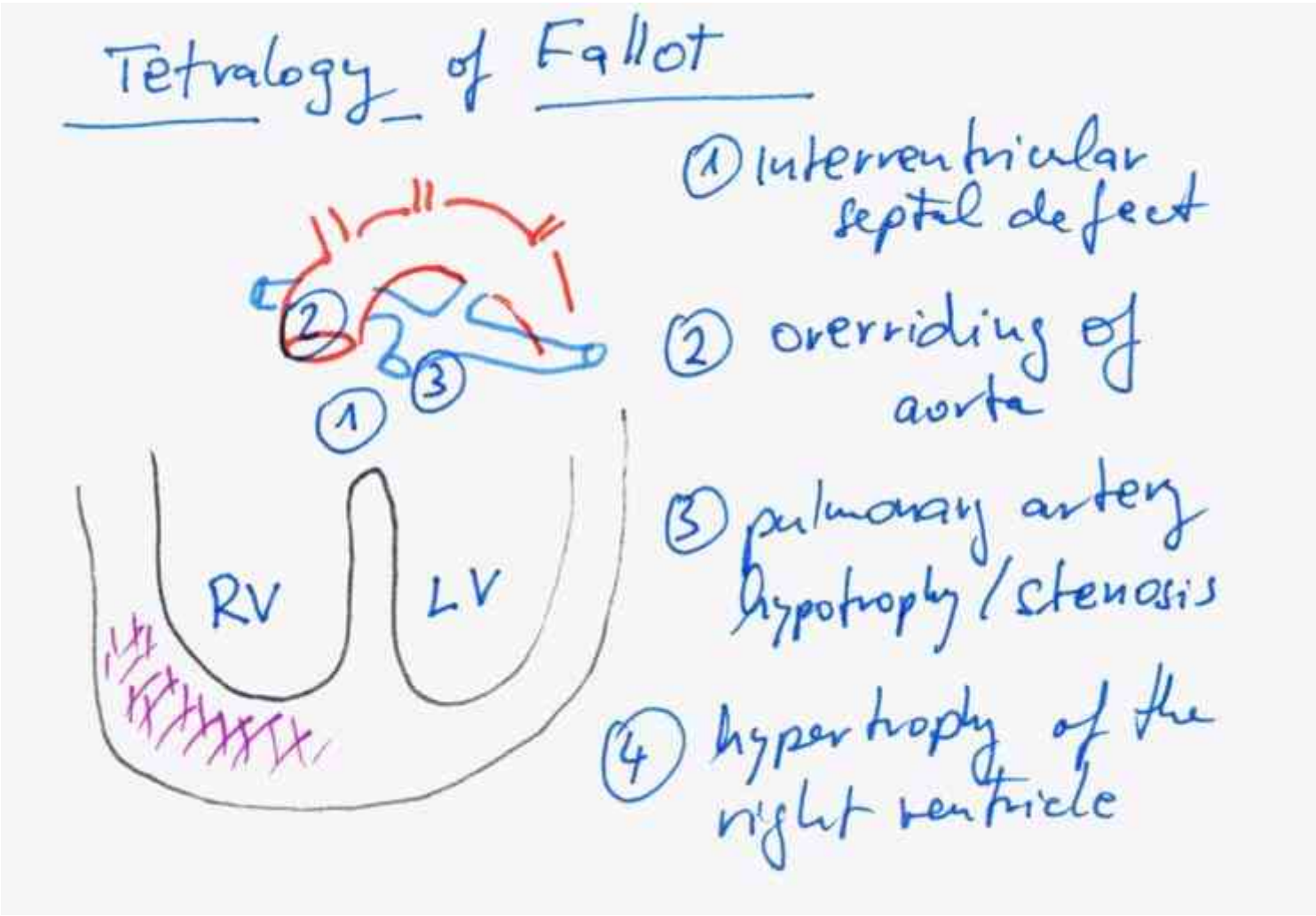


79. Draw and label patens (persistent) ductus arteriosus including postnatal flow of blood;
draw and label types of aortic coarctation:
- arcus aortae, pulmonary trunk, ductus arteriosus,
 - direction of blood flow to pulmonary trunk via persistent duct,
 - preductal, ductal, and postductal coarctation,
 - mechanism of the coarctation.



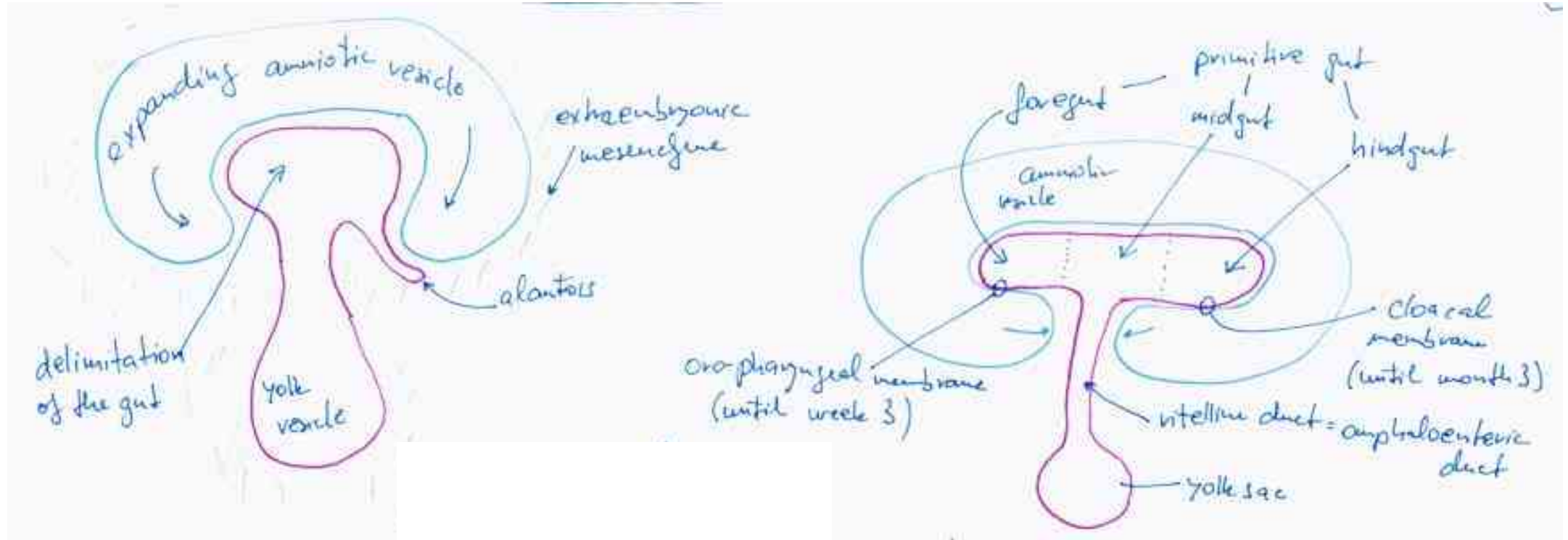
80. Draw and label tetralogy of Fallot:

- ventricular septal defect with irregular division of the bulbus,
- aorta connected to both the right and the left ventricle,
- pulmonary stenosis,
- right ventricular hypertrophy.



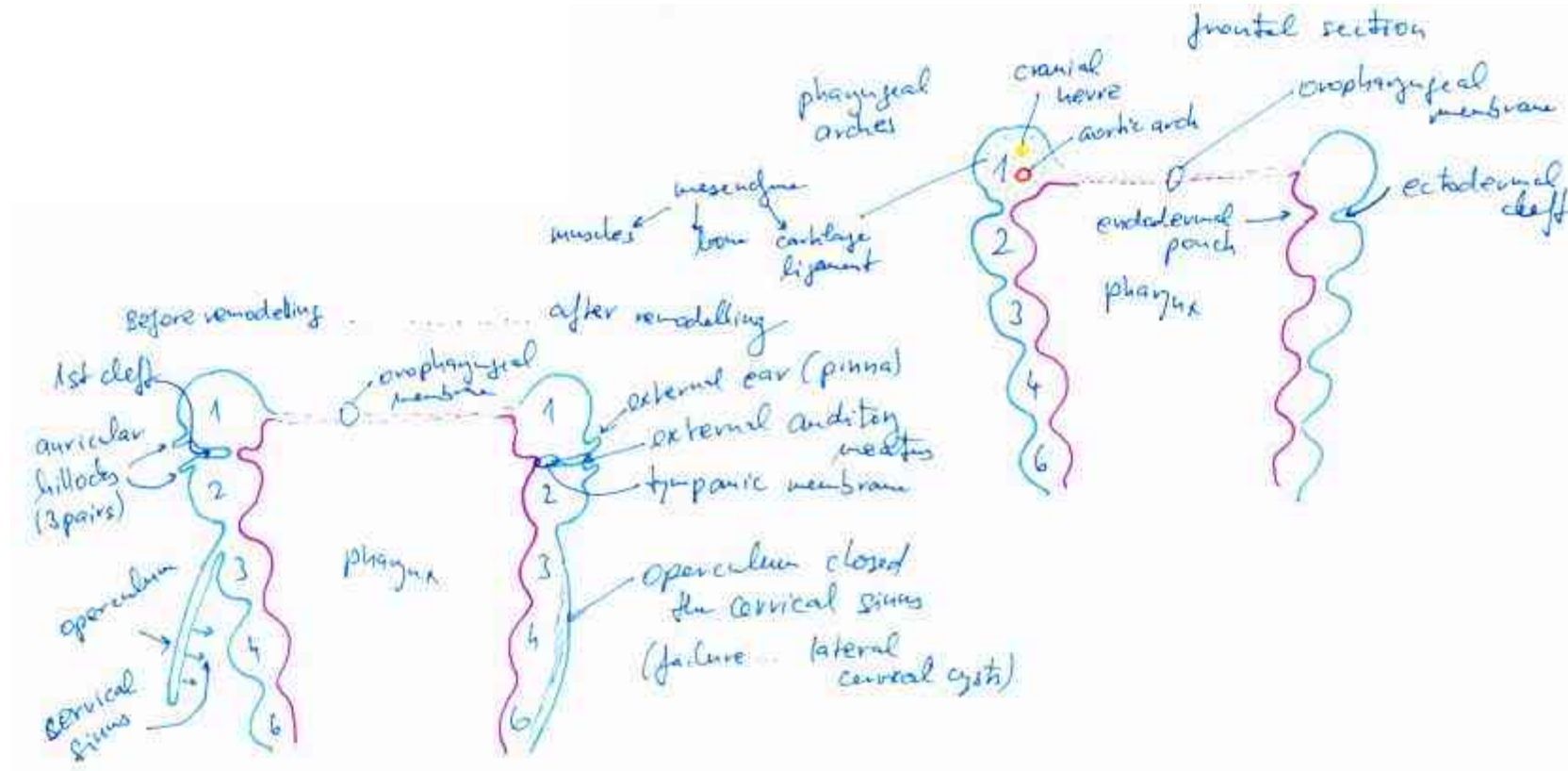
81. Draw and label the origin of the primitive gut:

- relation of the amniotic sac and the yolk sac,
- delimitation of the primitive gut due to expansion of the amniotic sac over the yolk sac,
- oral (oropharyngeal) and cloacal membrane,
- yolk vesicle connected to the gut via the vitelline (omphaloenteric) duct.



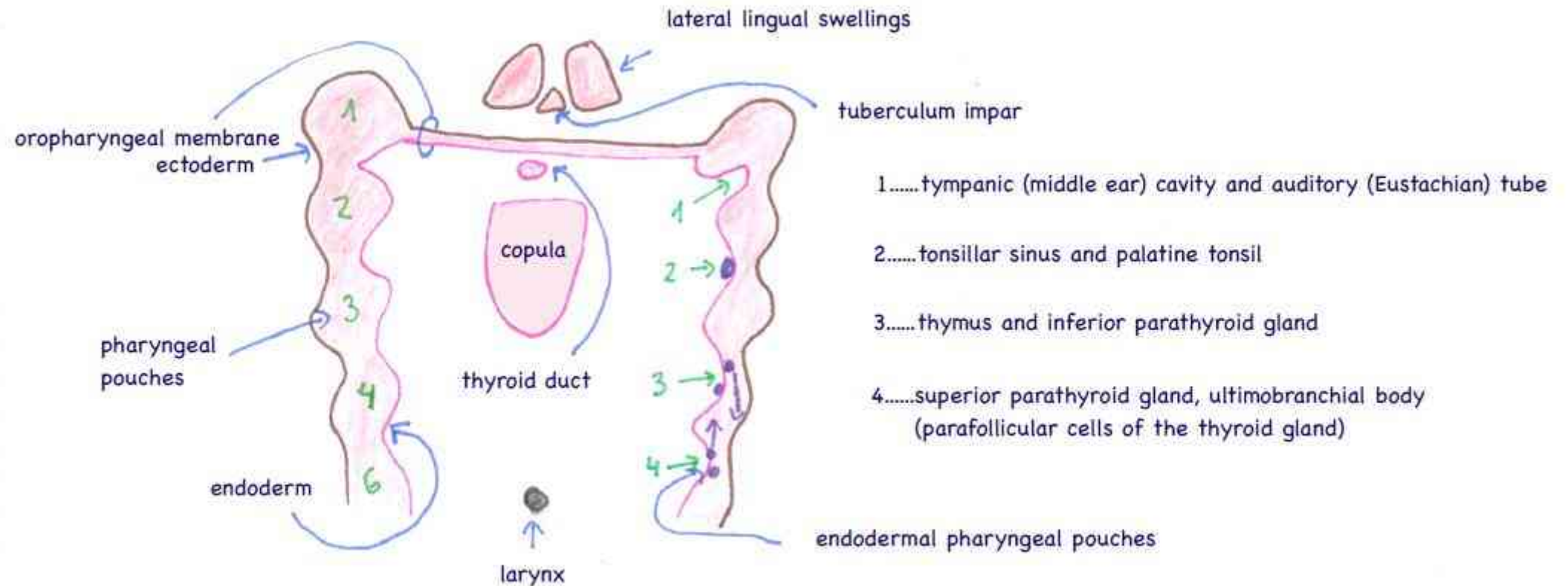
82. Draw and label development and the fate of ectodermal pharyngeal clefts – frontal view:

- oropharyngeal membrane,
- mandibular arch, hyoid arch, three pairs of tubercles (pinnae) as a primordium of external ear, first pharyngeal cleft developing into the meatus acusticus externus, tympanic membrane,
- operculum closing the space of sinus cervicalis.



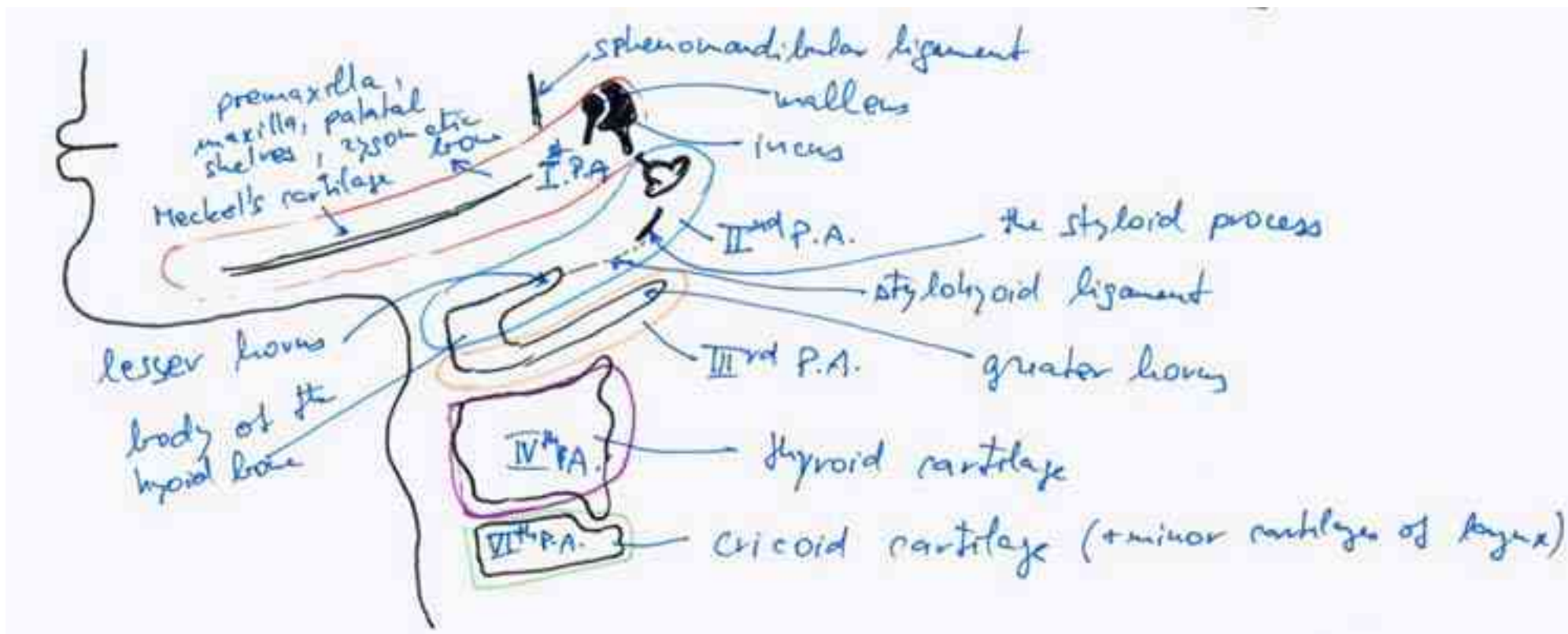
83. Draw and label development and derivatives of entodermal pharyngeal pouches, including primordium of the tongue:

- position of tuberculum impar and copula, thyroid gland, and larynx,
- 1st pouch – tympanic (middle ear) cavity and auditory (Eustachian) tube,
- 2nd pouch – tonsillar sinus and palatine tonsil,
- 3rd pouch – thymus and inferior parathyroid gland,
- 4th pouch – superior parathyroid gland, ultimobranchial body (parafollicular cells of the thyroid gland).



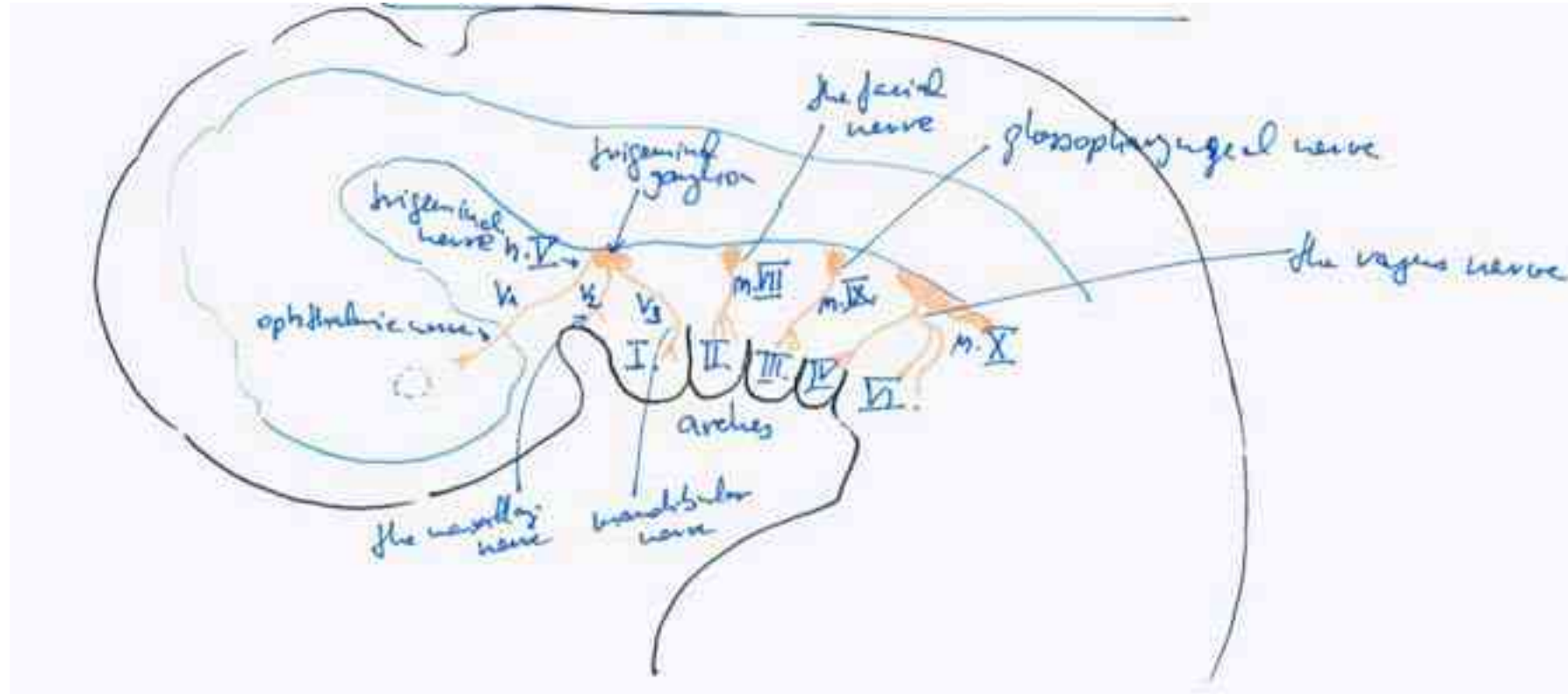
84. Draw and label skeleton of the pharyngeal arches, note the examples of muscles:

- 1st arch – Meckel's cartilage, malleus, incus, sphenomandibular ligament; masticatory muscles, *e.g.* mylohyoid muscle, anterior belly of the digastric muscle, tensor tympani muscle,
- 2nd arch – upper part of hyoid bone body, lesser cornua, stylohyoid ligament, styloid process, stapes; mimic muscles, platysma, further *e.g.* posterior belly of the digastric muscle, stylohyoid, and stapedius muscle,
- 3rd arch – lower part of the body of the hyoid bone, greater cornua; *e.g.* stylopharyngeus muscle,
- 4th arch – thyroid cartilage, cuneiform cartilages; pharyngeal and laryngeal muscles,
- 6th arch – cricoid, corniculate cartilages; pharyngeal and laryngeal muscles.



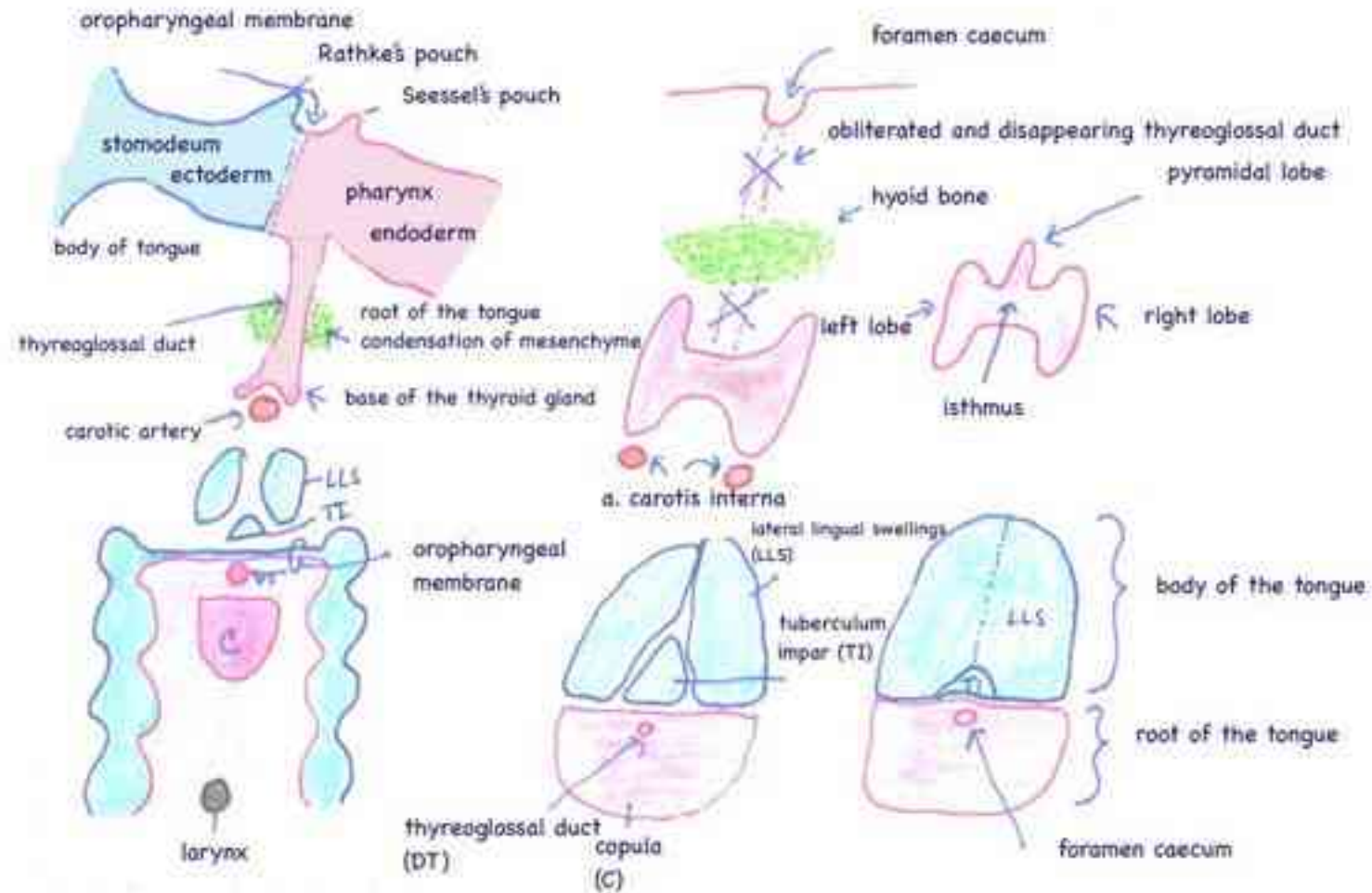
85. Draw and label nerves of the pharyngeal arches:

- 1st arch – trigeminal nerve,
- 2nd arch – facial nerve,
- 3rd arch – glossopharyngeal nerve,
- 4th arch – vagus nerve,
- 6th arch – recurrent laryngeal nerve (vagus nerve).



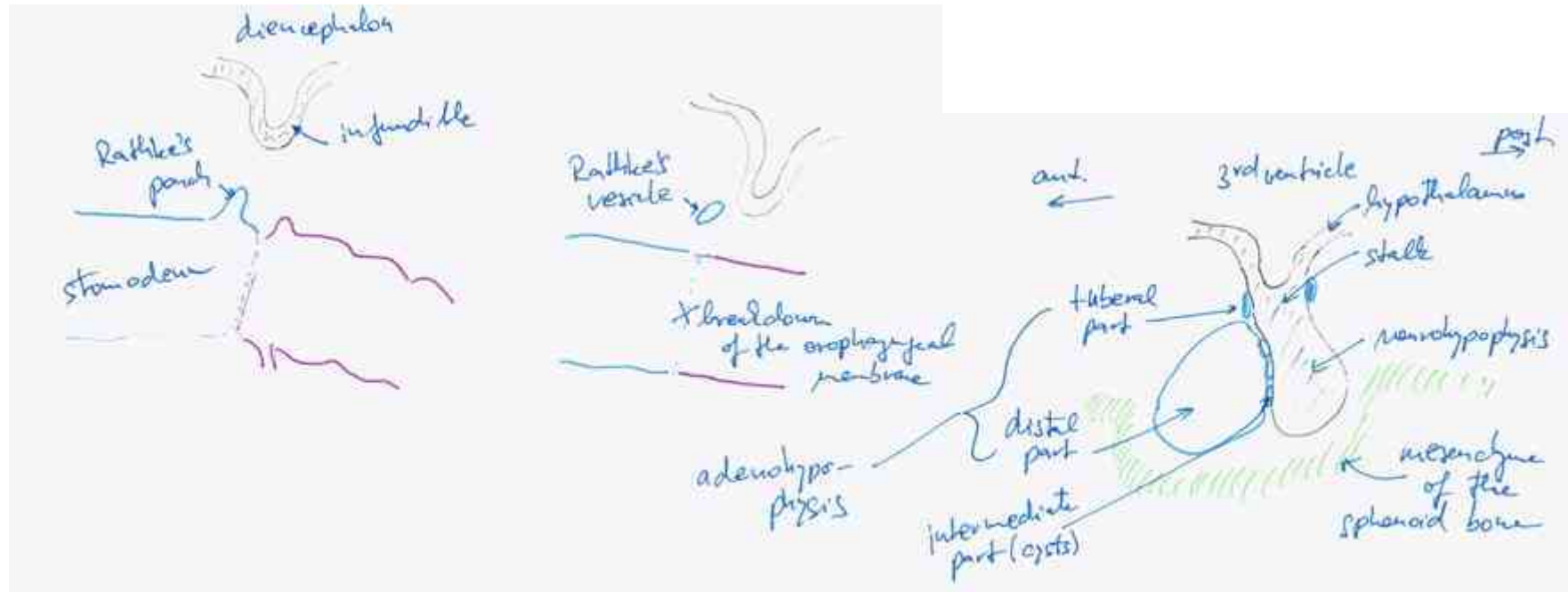
86. Draw and label development of the tongue and thyroid gland:

- the borderline between the ectoderm and endoderm – oropharyngeal membrane,
- ectodermal origin of tuberculum impar and lateral lingual swellings of the mandibular arch – the body of the tongue,
- endodermal origin of copula the root of the tongue,
- thyreoglossal duct, right/left/pyramidal lobe of the thyroid, foramen caecum.



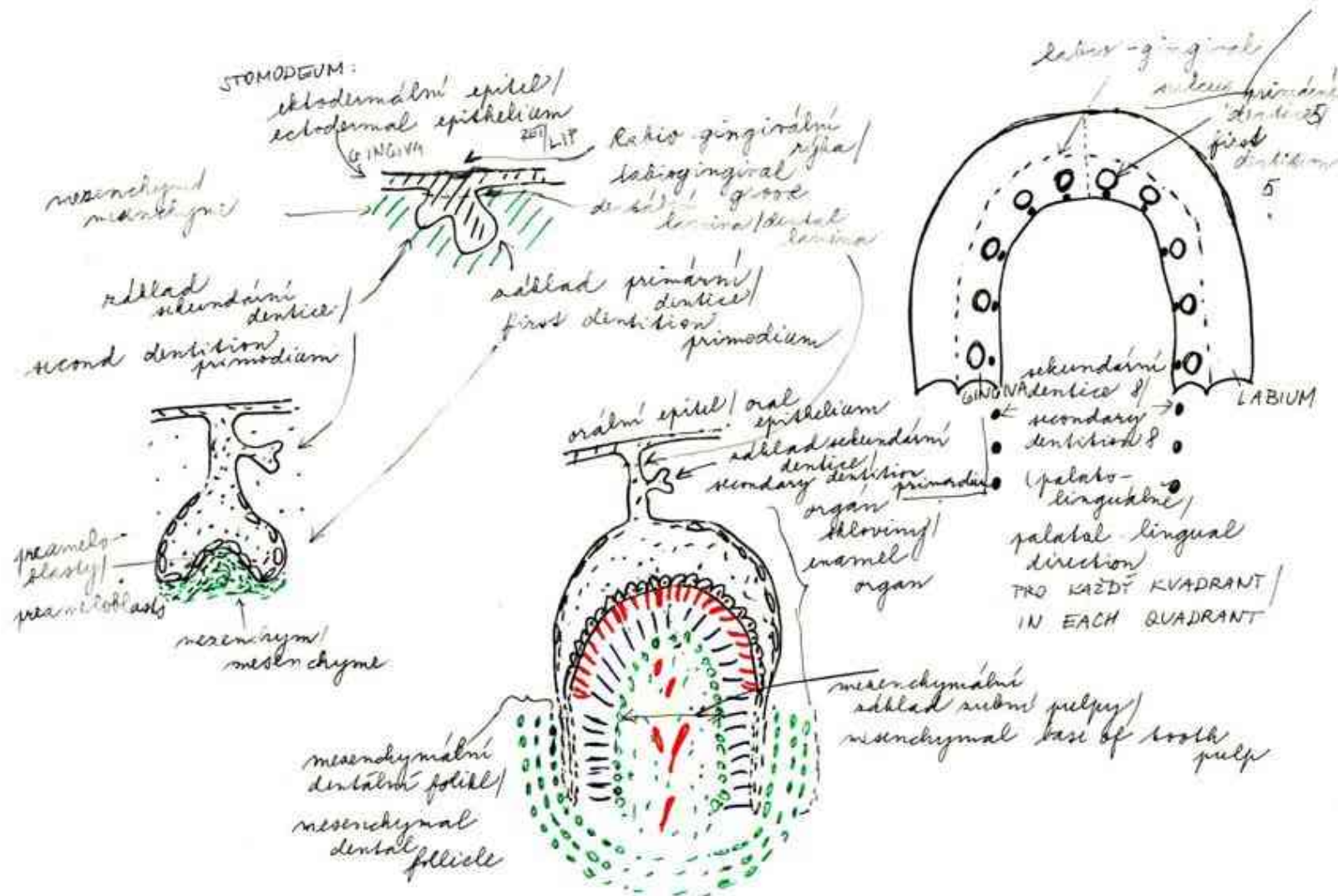
87. Draw and label development of the hypophysis:

- stomodeum (ectoderm), oropharyngeal membrane, pharynx (entoderm),
- Rathke's pouch in the roof of the stomodeum; infundibulum of the 3rd ventricle from the diencephalon,
- adenohypophysis originating from the Rathke's pouch; neurohypophysis growing from the infundibulum.



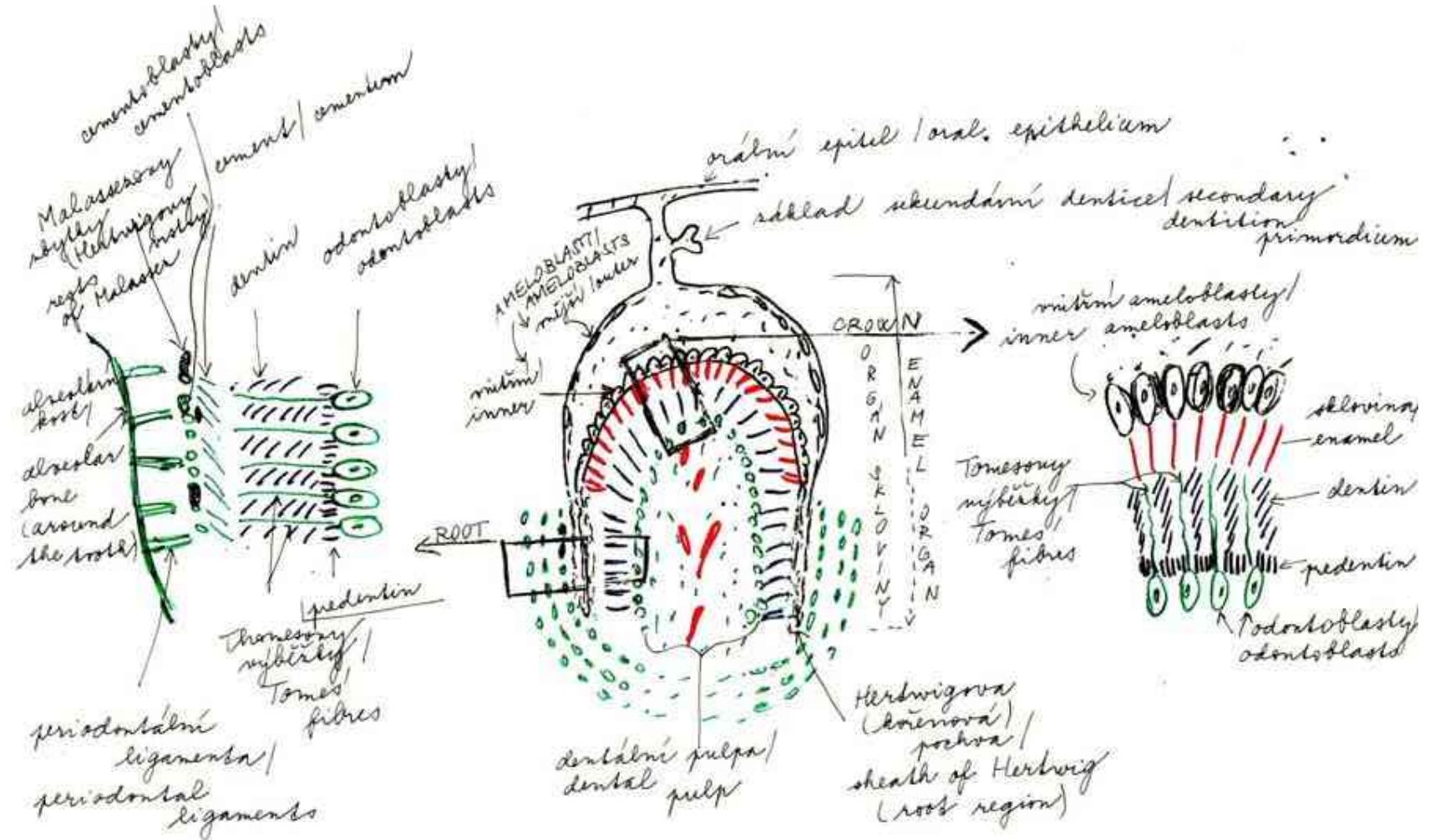
88. Draw and label development of dental lamina, teeth primordia, and tooth development:

- labiogingival groove separating the lip from the gingiva,
- dental lamina (at the gingiva) and the segmentation to five buds forming the primordia of the primary teeth; 8 primordia of the secondary teeth growing in the palatal/lingual direction in each quadrant,
- enamel organ in the bud stage, cap stage, and bell stage,
- mesenchymal dental follicle as a base of tooth pulp, primordium of a secondary (permanent) tooth.

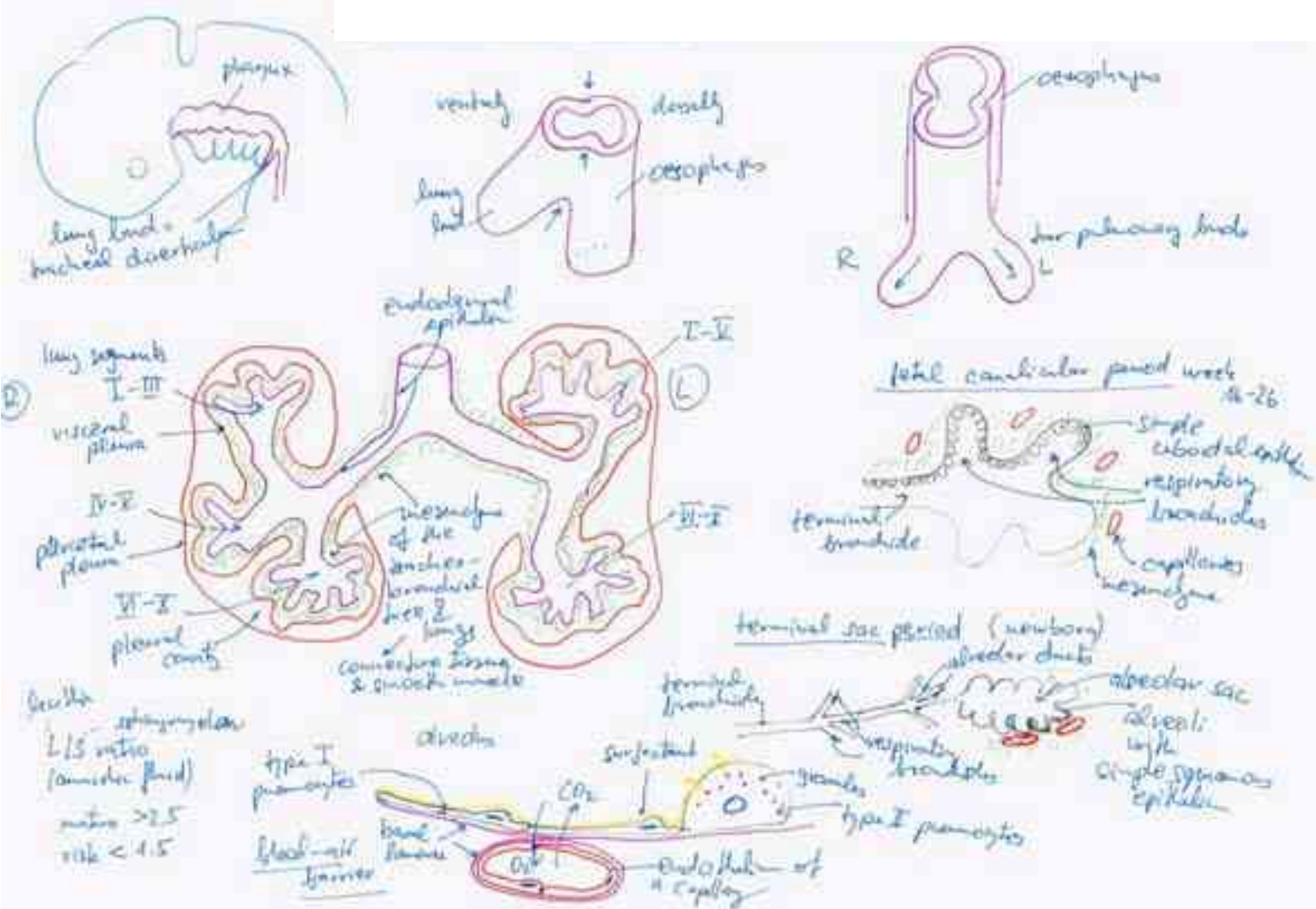


89. Draw and label histogenesis of the crown and root of a tooth:

- enamel organ, enamel-producing ameloblasts, sheath of Hertwig,
- dental pulp, odontoblasts, Tomes' fibres, predentine, dentine,
- cementoblasts, periodontal ligaments, and alveolar bone around the root.

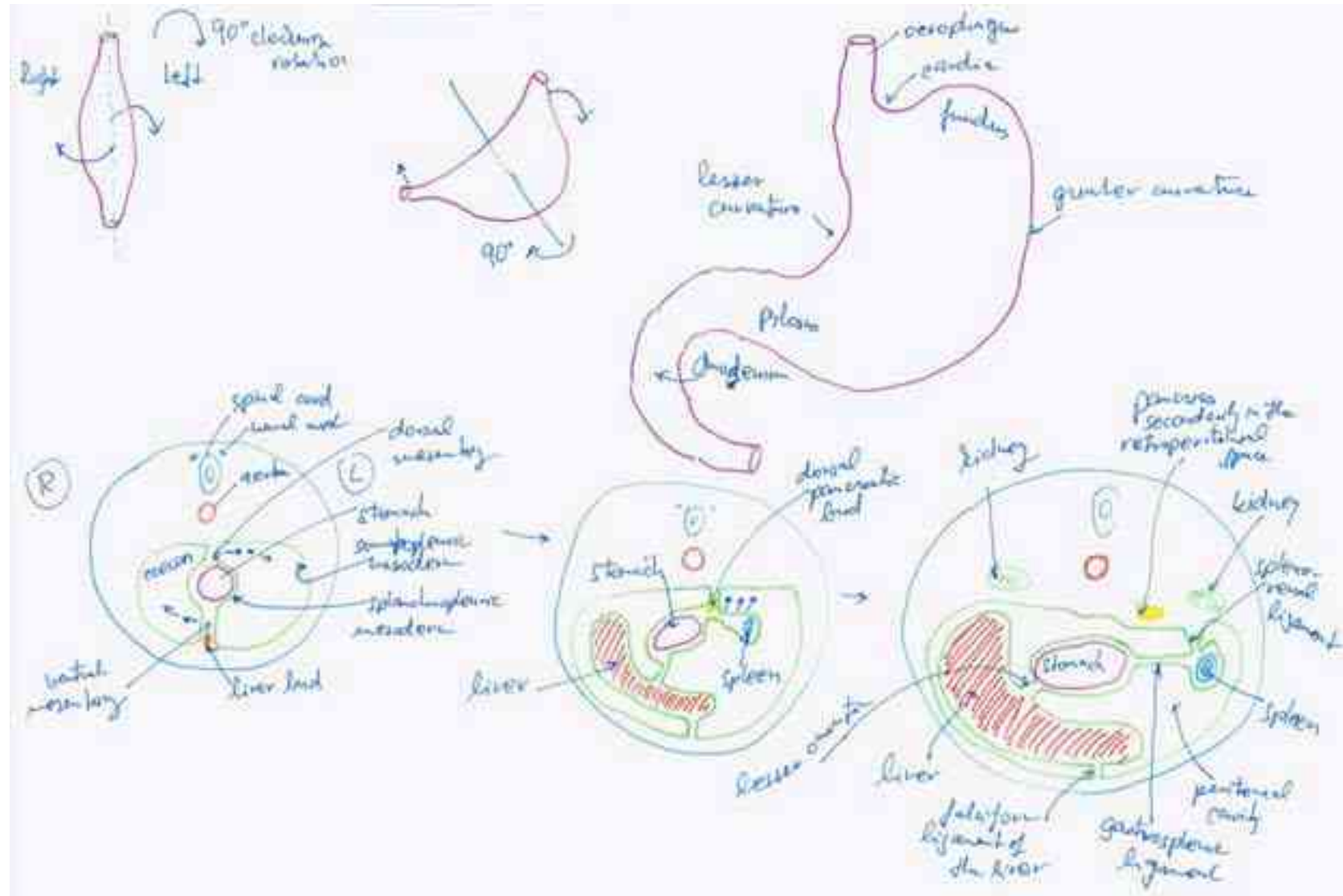


90. Draw and label development of trachea and lungs, tracheo-oesophageal fistula;
distinguish fetal canicular stage and terminal sac stage of developing lungs:
- larynx separated by laryngotracheal groove from the ventral part of the oesophagus,
 - fistula – communication between oesophagus and trachea (or another organ),
 - fetal canicular stage (week 16-26): terminal and respiratory bronchiole lined by simple cuboidal epithelium; vessels separated by mesenchyme from bronchiole,
 - terminal sac stage (week 26 onwards): ductus alveolares, saccus alveolaris, alveoli with simple squamous epithelium and tightly adjacent to capillaries.



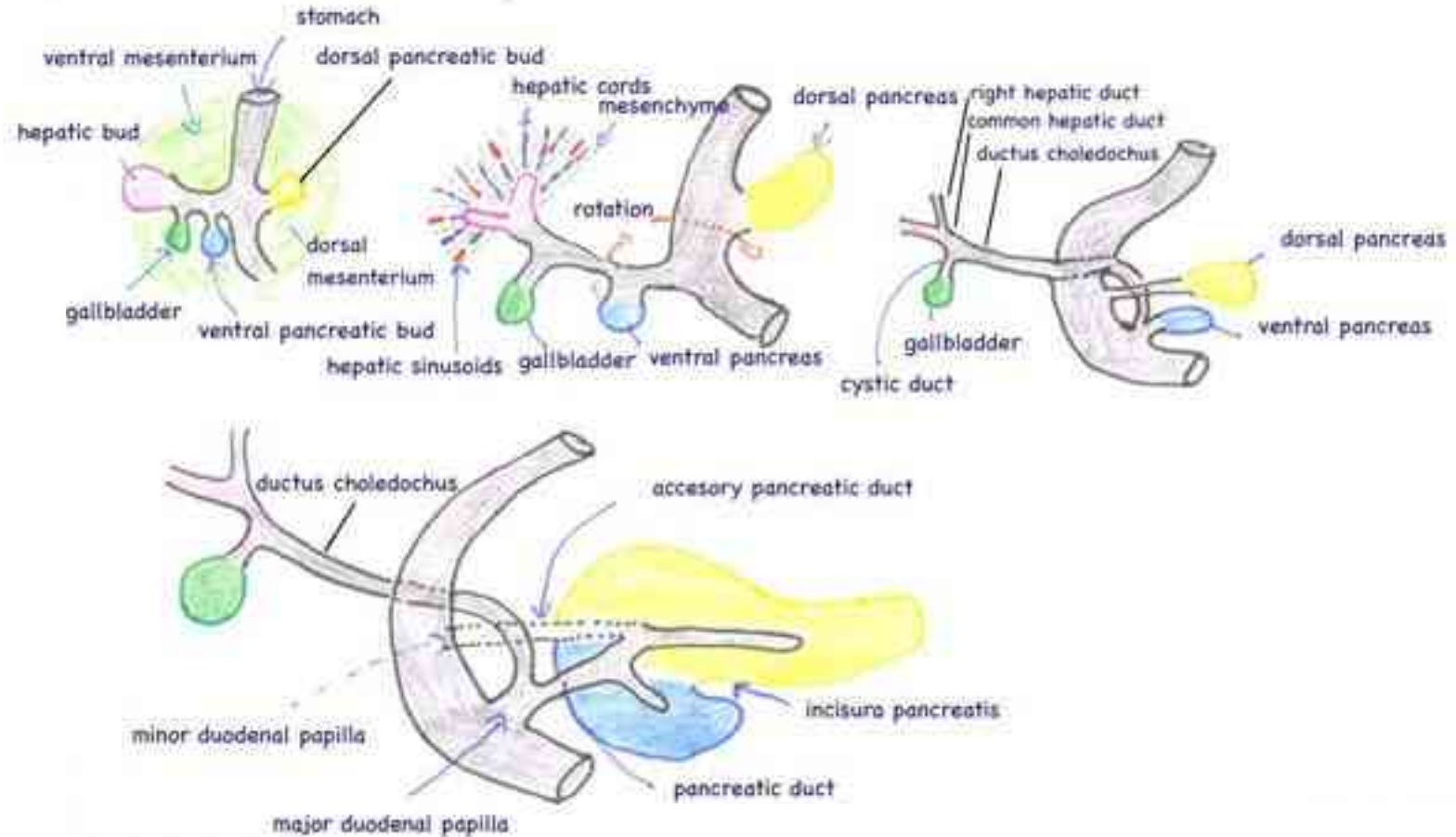
91. Draw and label the rotation of the oesophagus and stomach, migration of the liver primordium and the relationship to the coelomic cavity – transversal views:

- relations of stomach, coelomic cavity, dorsal and ventral mesentery,
- rotation of the stomach – right side towards the dorsal wall of coelom, left side towards the ventral wall of coelom; greater curvature shifted to the left side, lesser curvature shifted to the right,
- liver primordium shifted to the right within the ventral mesentery.



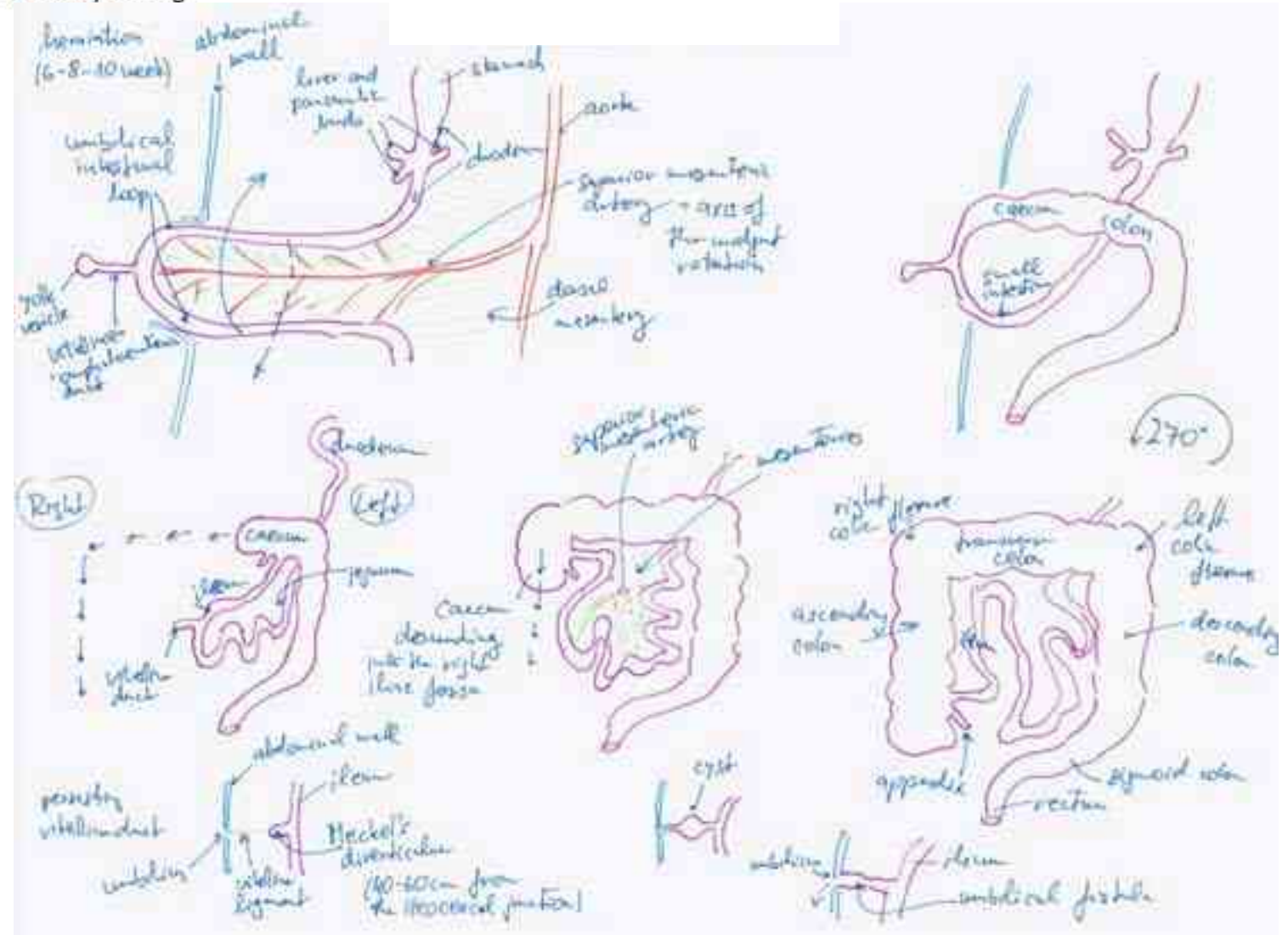
92. Draw and label the development of liver and pancreas:

- hepatic diverticulum growing out of the gut, branching to the bile duct system, and hepatic cords,
- dorsal and ventral pancreatic primordium,
- rotation of the ventral pancreas and ductus choledochus to the dorsal direction, fusion of ventral and dorsal pancreas,
- major pancreatic duct and part of the head of pancreas originating from the ventral primordium; accessory pancreatic duct, the body and the tail originate from the dorsal primordium.

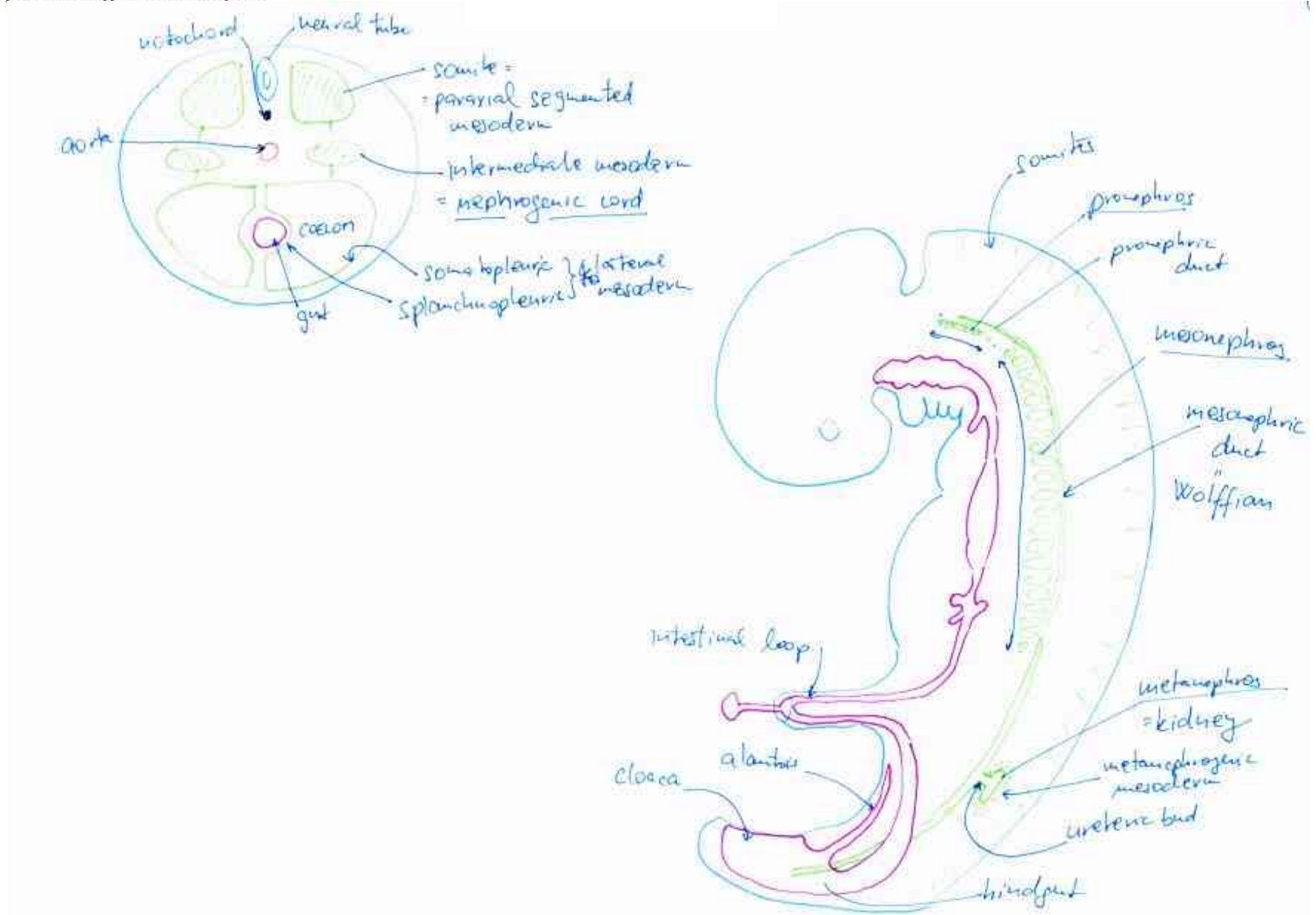


93. Draw and label the rotation of the midgut and hindgut; explain the origin of Meckel's diverticulum and faecal fistula formation:

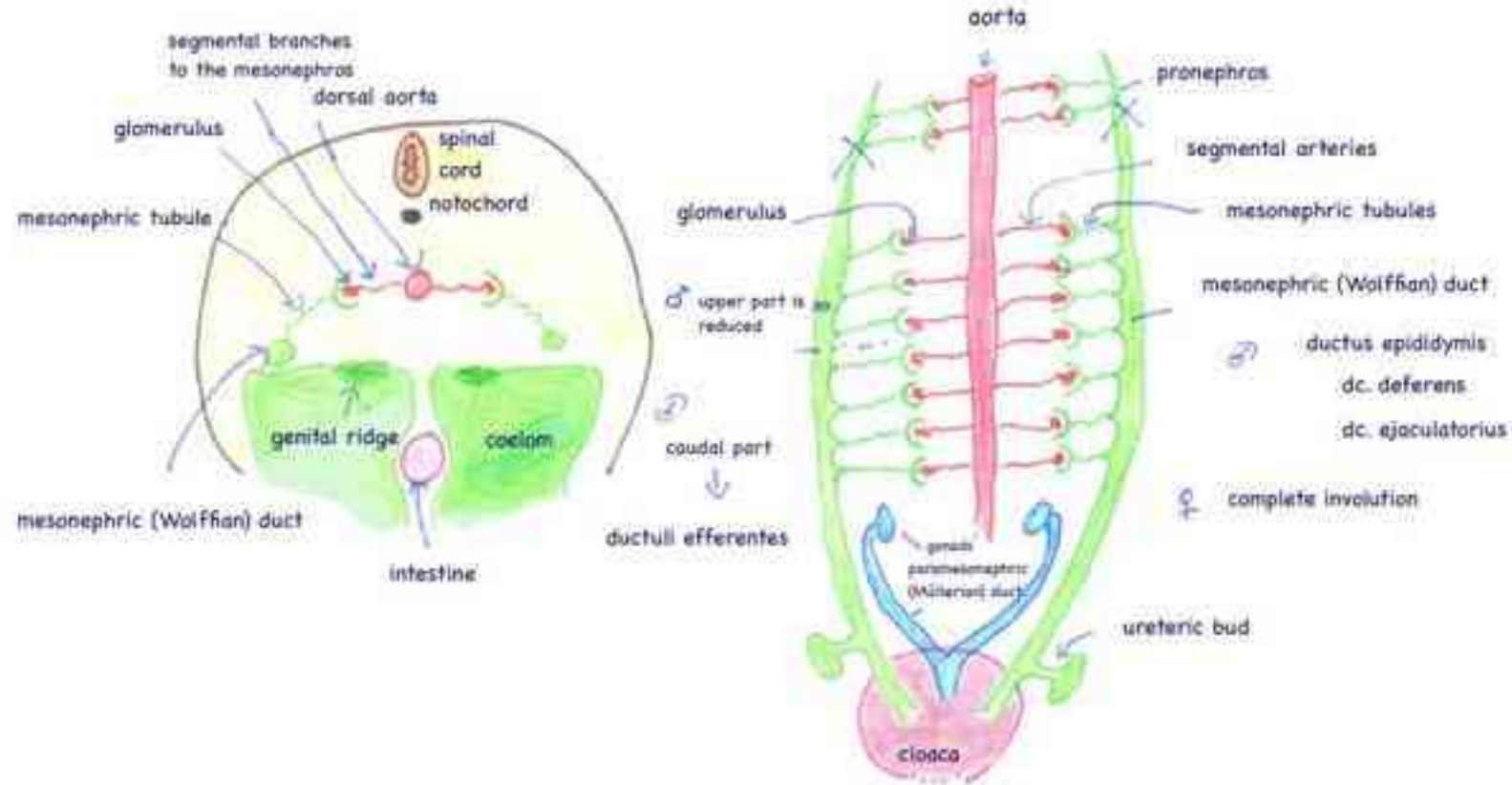
- Midgut rotation around superior mesenteric artery,
- extraembryonic jejuno-ileal knot (physiological umbilical hernia) being pulled back to the abdominal cavity, closing of the umbilicus and yolk stalk (omphaloenteric duct),
- hindgut rotation: cranial shift of the caecum, pulling left of colon descendens, splenic flexure, colon transversum, hepatic flexure, colon ascendens,
- remnants of the yolk stalk open at the umbilicus as faecal fistula or blindly ending Meckel's diverticulum (two schemes).



94. Draw and label segmentation of the nephrogenic cord using transverse and sagittal sections; draw the relation to mesoderm, mesenchyme, and coelomic cavity:
- pronephros in the cervical region,
 - mesonephros in the thoracic region, originated from intermediate mesoderm,
 - metanephrogenic blastema in the lumbar region, developed through mesenchyme condensation.

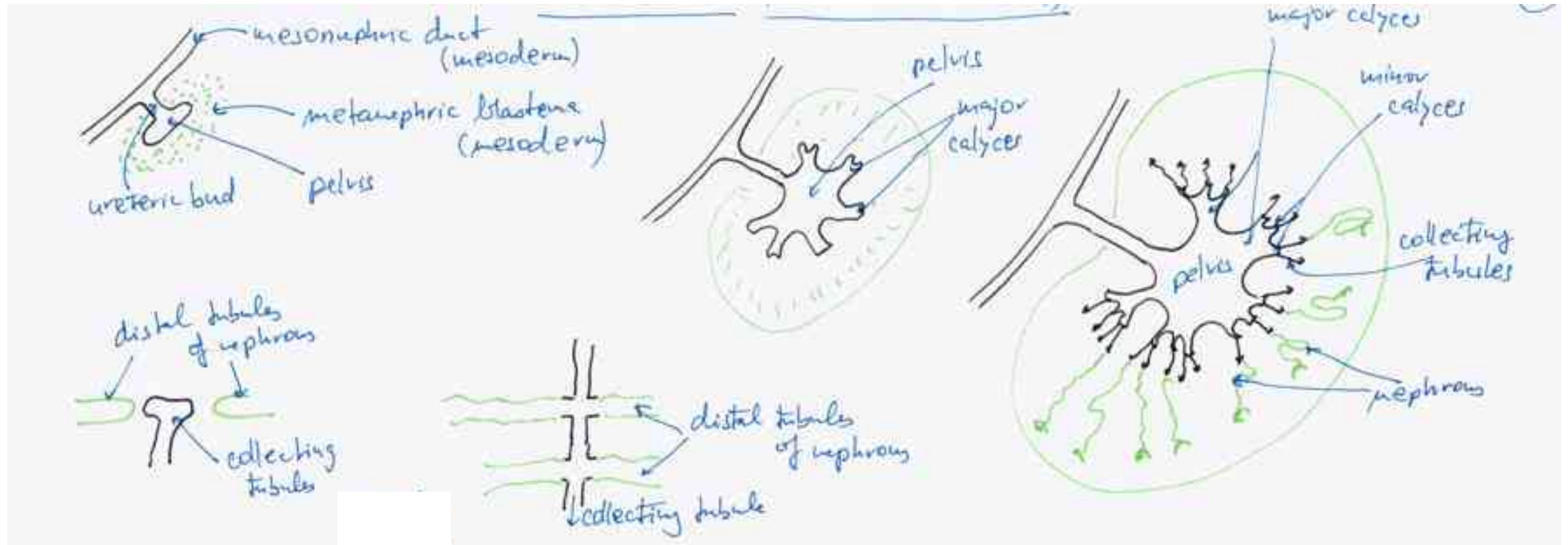


95. Draw and label development of pronephros and mesonephros, and their ducts; note the further destiny of mesonephros and their duct in male and female fetus:
- pronephros: mesodermal tubule at the cranial part of nephrogenic ridge,
 - mesonephros: glomeruli of segmental aortic branches; mesonephric (Wolffian) duct and paramesonephric (Müllerian) duct opening in the cloaca, in relation to nephrogenic ridge,
 - female: disappearance of mesonephros and its canal,
 - male: ductuli efferentes testis from mesonephros; ductus epididymis, d. deferens, and d. ejaculatorius from mesonephric duct.



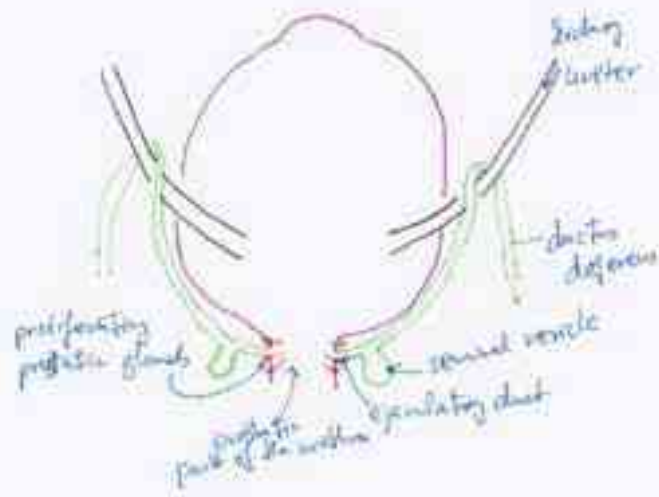
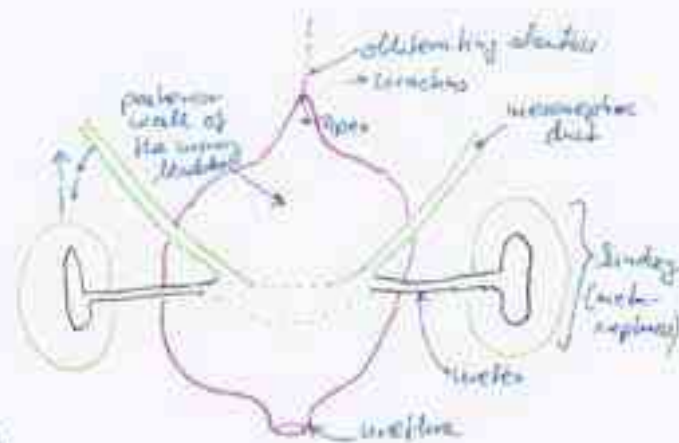
96. Draw and label development of metanephros:

- metanephric (ureteral) bud growing from the mesonephric (Wolffian) duct towards the metanephrogenic blastema,
- branching ureteric bud giving rise to the ureter, renal pelvis, major and minor calyces, and collecting tubules,
- connection of renal collecting tubules to distal tubules of nephron.

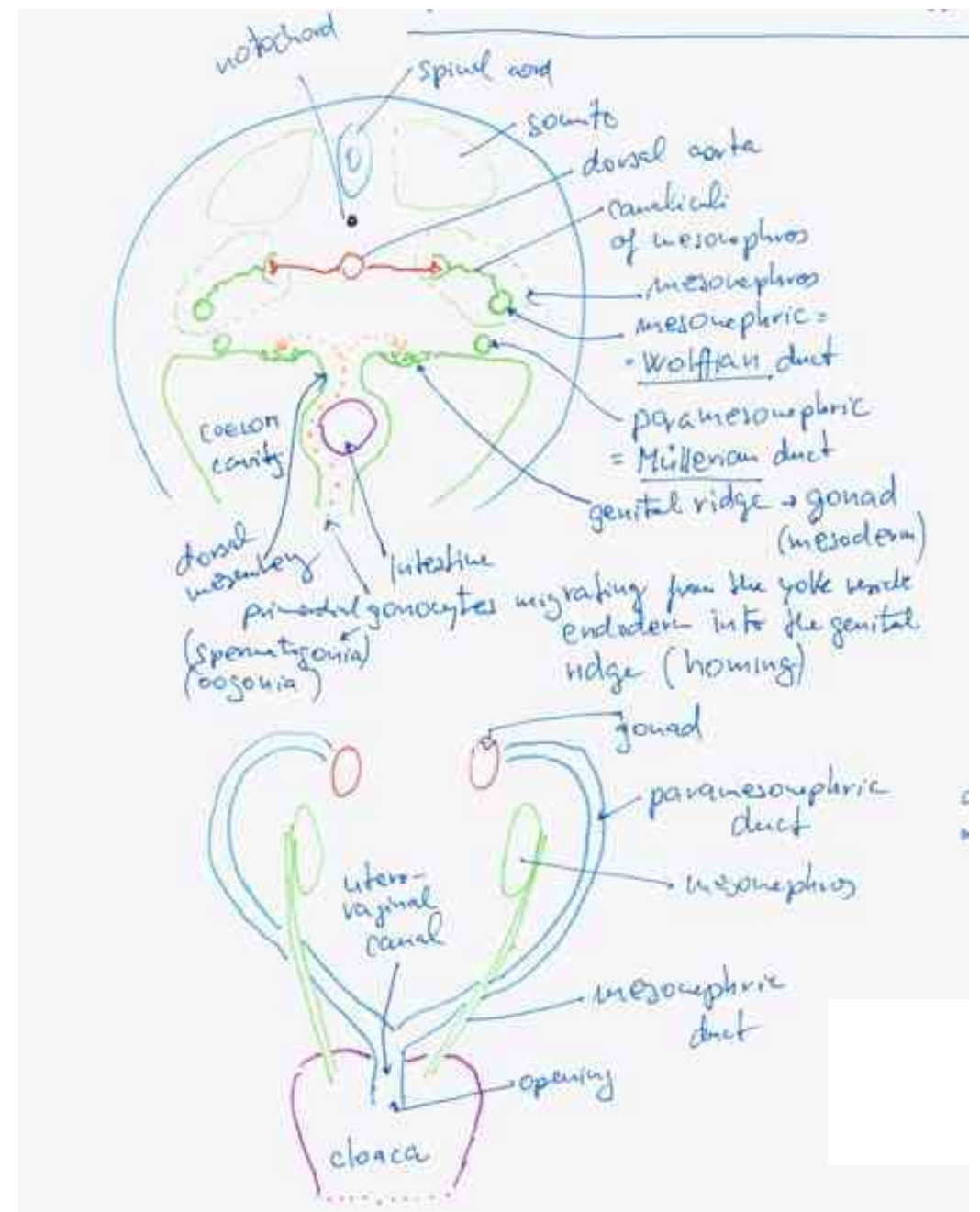
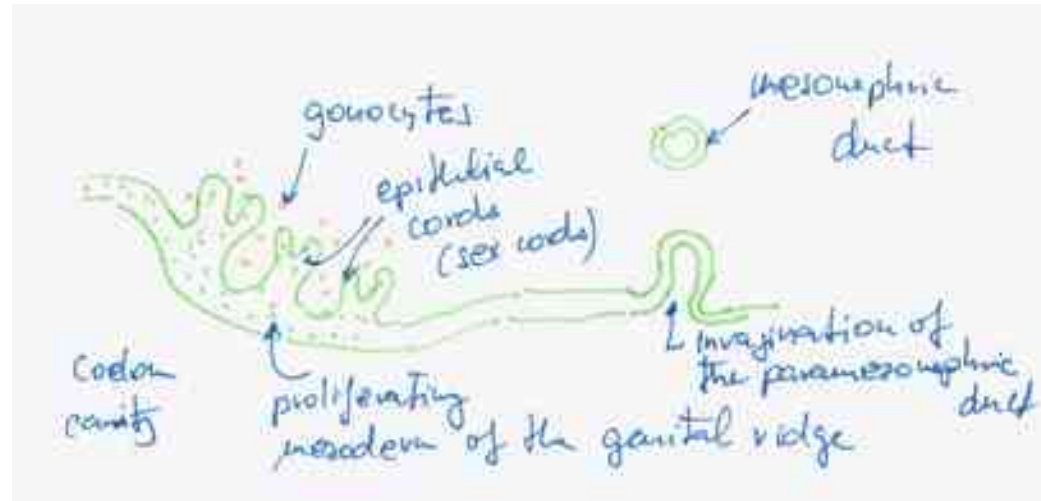


97. Draw and label partitioning of the cloaca and its further development:

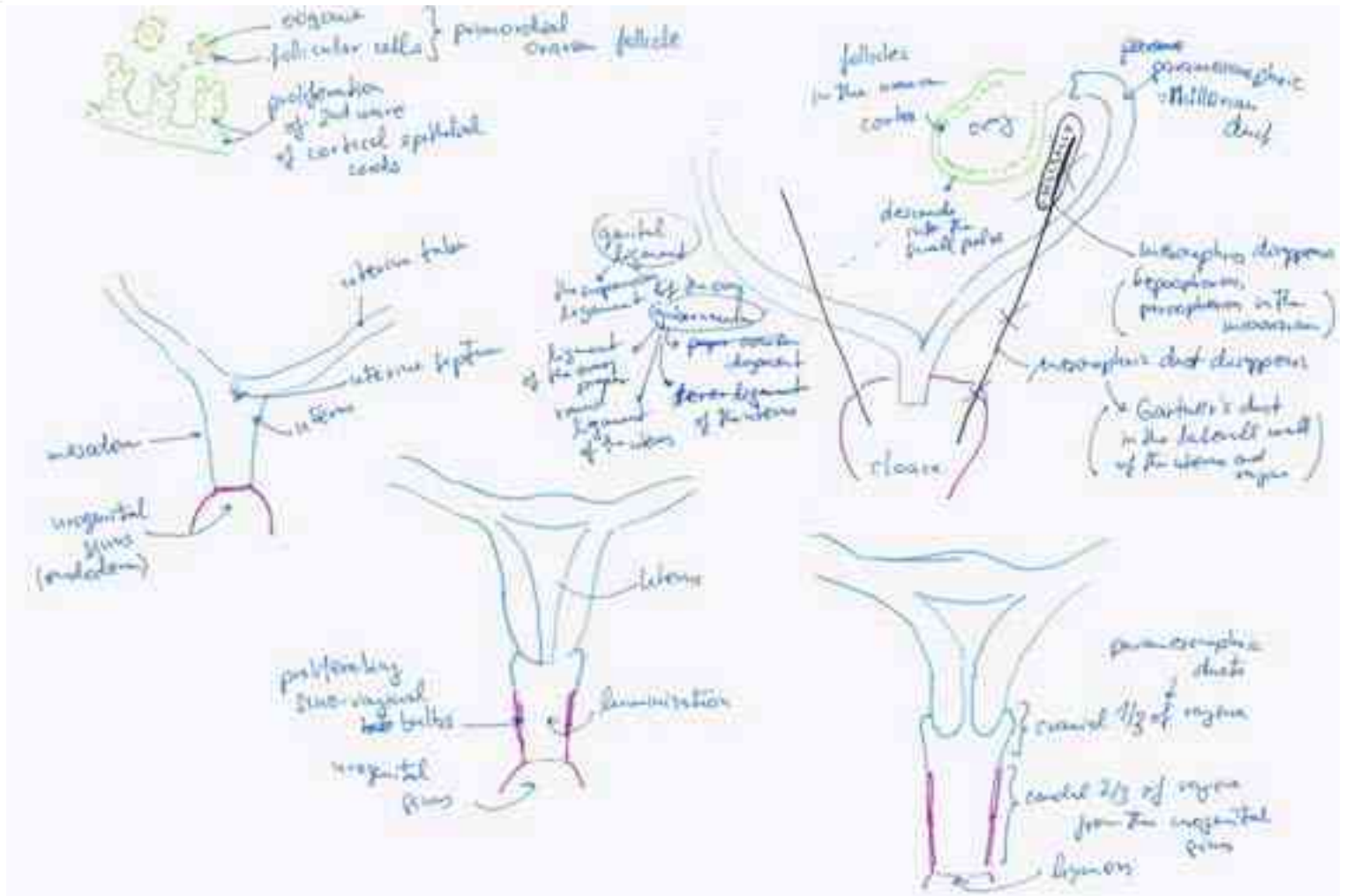
- terminal part of the colon and mesonephric (Wolffian) duct ending in the cloaca,
- cloacal septum dividing the cloaca to the ventral urogenital sinus and dorsal rectum,
- origin of urine bladder, fate of allantois (*i.e.*, urachus).



98. Draw and label indifferent stage of gonads, their relation to coelom, mesonephros, mesonephric (Wolffian) and paramesonephric (Müllerian) duct, and to the cloaca:
- indifferent gonads proliferated from the coelomic epithelium, medial to the mesonephros; paramesonephric (Müllerian) ducts running towards the cloaca and fusing in the middle line,
 - migration of primordial gonocytes through the dorsal mesentery to the base of gonads,
 - sex cords in gonads,
 - mesonephric duct being medial to the paramesonephric ducts, then running laterally,
 - mesonephros lateral to the gonad, mesonephrotic duct entering cloaca paramesonephric (Müllerian) duct run laterally at first but enter the cloaca medially.

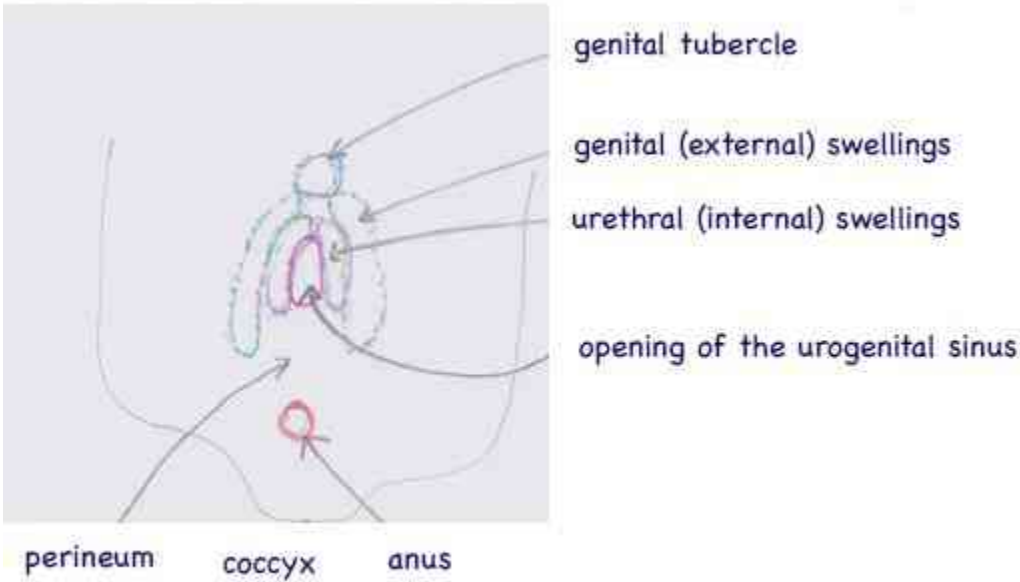


- ovary situated in dorsal part of the coelom, gonocytes, and primordial follicle,
- paramesonephric (Müllerian) duct lateral to ovary, running to cloaca, differentiation of fallopian tube, origin of uterus due to fusion of right and left paramesonephric (Müllerian) ducts,
- vagina developing from the paramesonephric (Müllerian) ducts and luminisation of vaginal bud from endoderm flows into sinus urogenitalis,
- regression of mesonephros, mesonephric (Wolffian) duct remnants.



100. Draw and label indifferent stage of external genital organs; describe what these organs differentiate in male and female fetus:

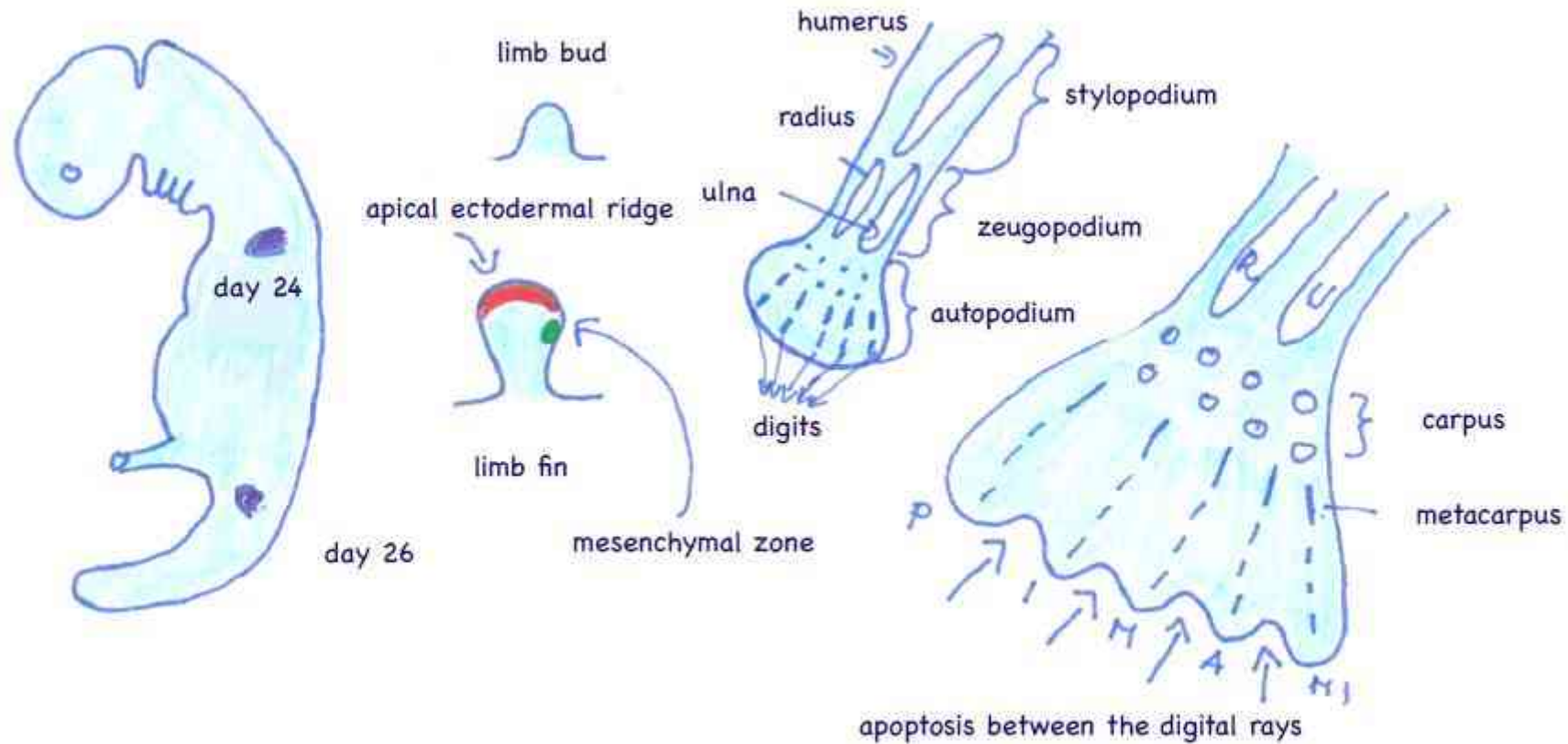
- genital tubercle (phallus): penis in male, clitoris in female,
- urethral (internal) swellings: corpus spongiosum penis in male, labia minora in female,
- genital (external) swellings: fusion onto the scrotum in male, labia majora in female,
- perineum and anus in both males and females.



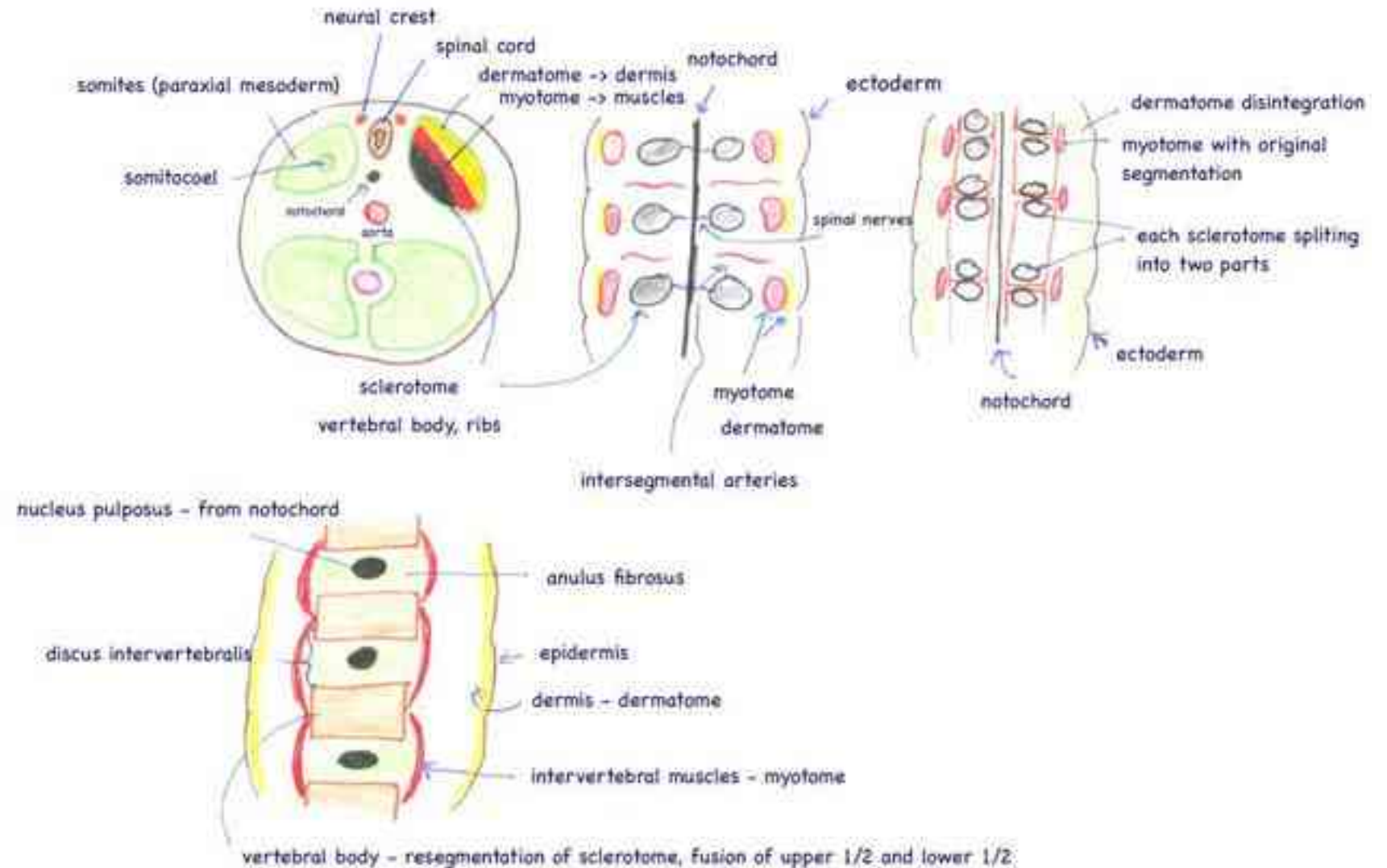
	genital tubercle	urethral swellings	genital swellings
MEN	penis	corpus spongiosum penis, penile urethra	scrotum
WOMEN	clitoris	labia minora	labia majora

101. Draw and label development of extremities:

- limb bud (day 24 in the thoracic limb; day 26 in the pelvic limb), limb fin, ectodermal ridge, and mesenchyme,
- stylopodium with one bone element, zeugopodium with two bone elements, autopodium (carpus and metacarpus or tarsus and metatarsus, digits),
- digital rays within the autopodium, apoptosis between the digital rays.

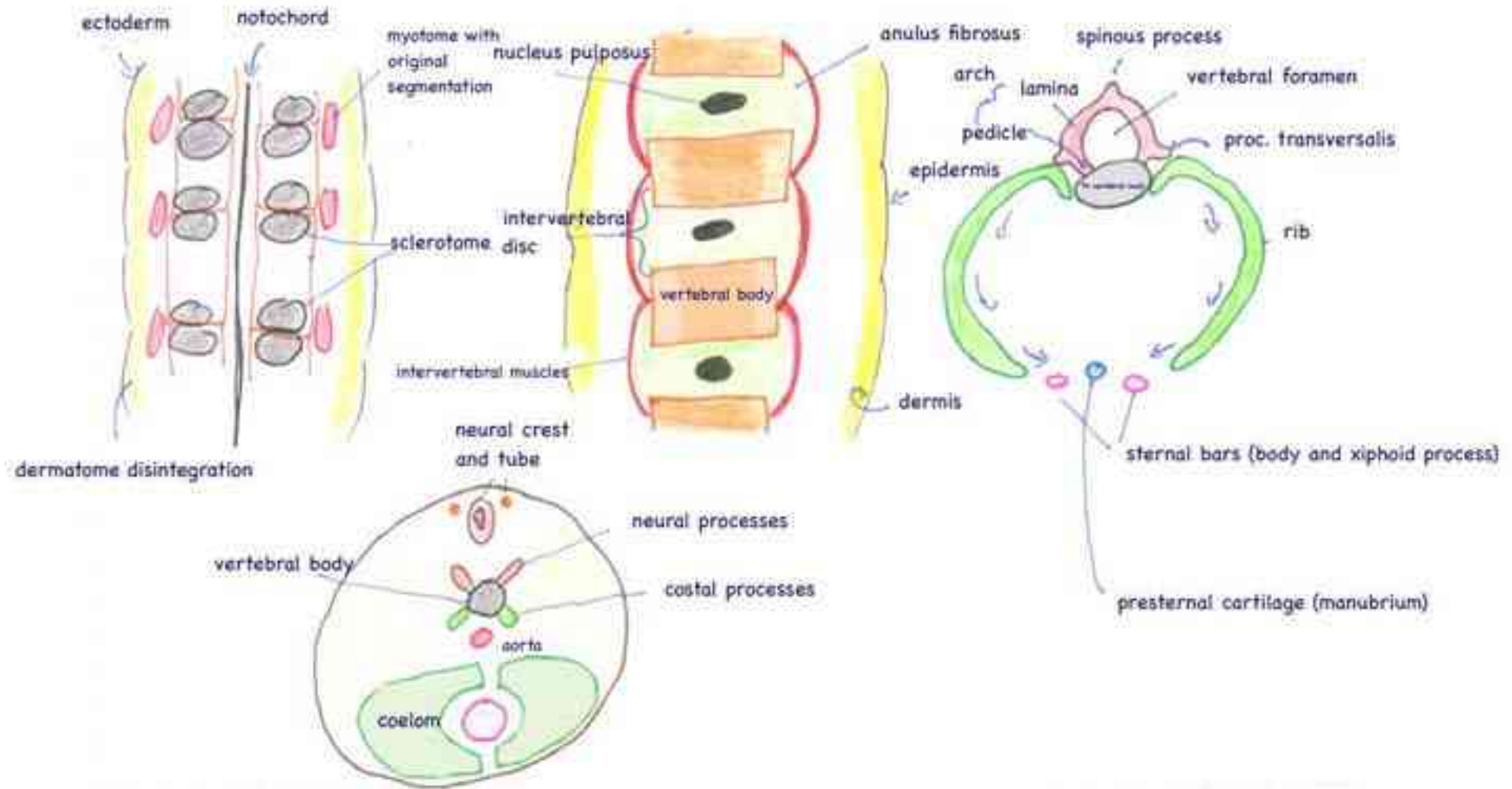


102. Draw and label division of body somites into three mesenchyme populations; name the structures developing from these three parts of somites; explain how the bodies of vertebrae originate:
- somite divided into dermatome (lateral), sclerotome (medial), and myotome,
 - cranial and caudal part of sclerotomes, origin of vertebral body by fusion of the adjacent parts of sclerotomes,
 - fate of chorda dorsalis,
 - dermis originating from the dermatome.



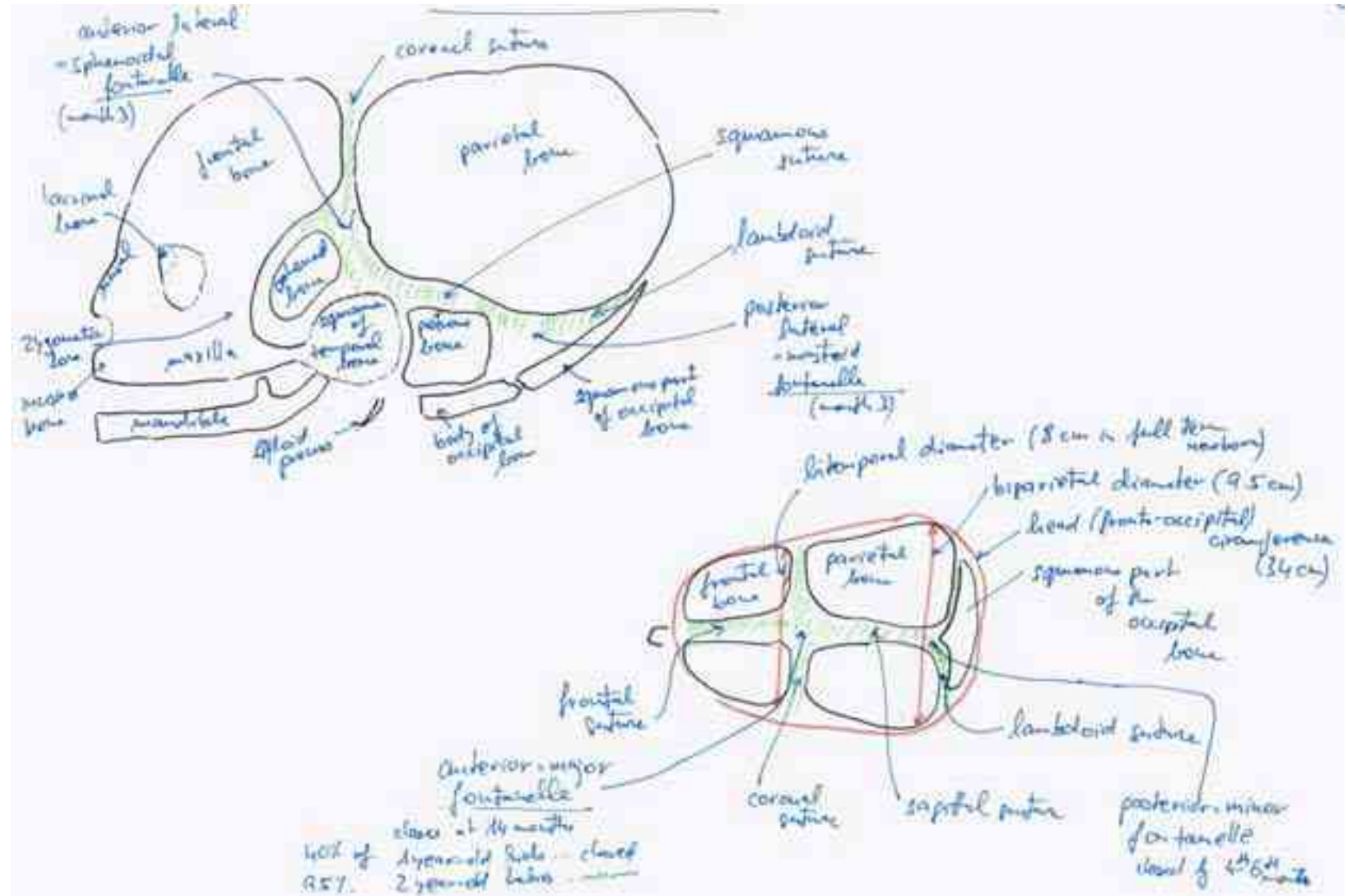
103. Draw and label development of vertebral body and processes:

- resegmentation of sclerotomes, intervertebral muscles from myotomes,
- body of vertebra originating from the inferior half of the upper sclerotome fusing with the superior half of the lower sclerotome,
- neural processes surrounding the spinal cord and closing the vertebral canal,
- costal processes growing in the ventral direction.



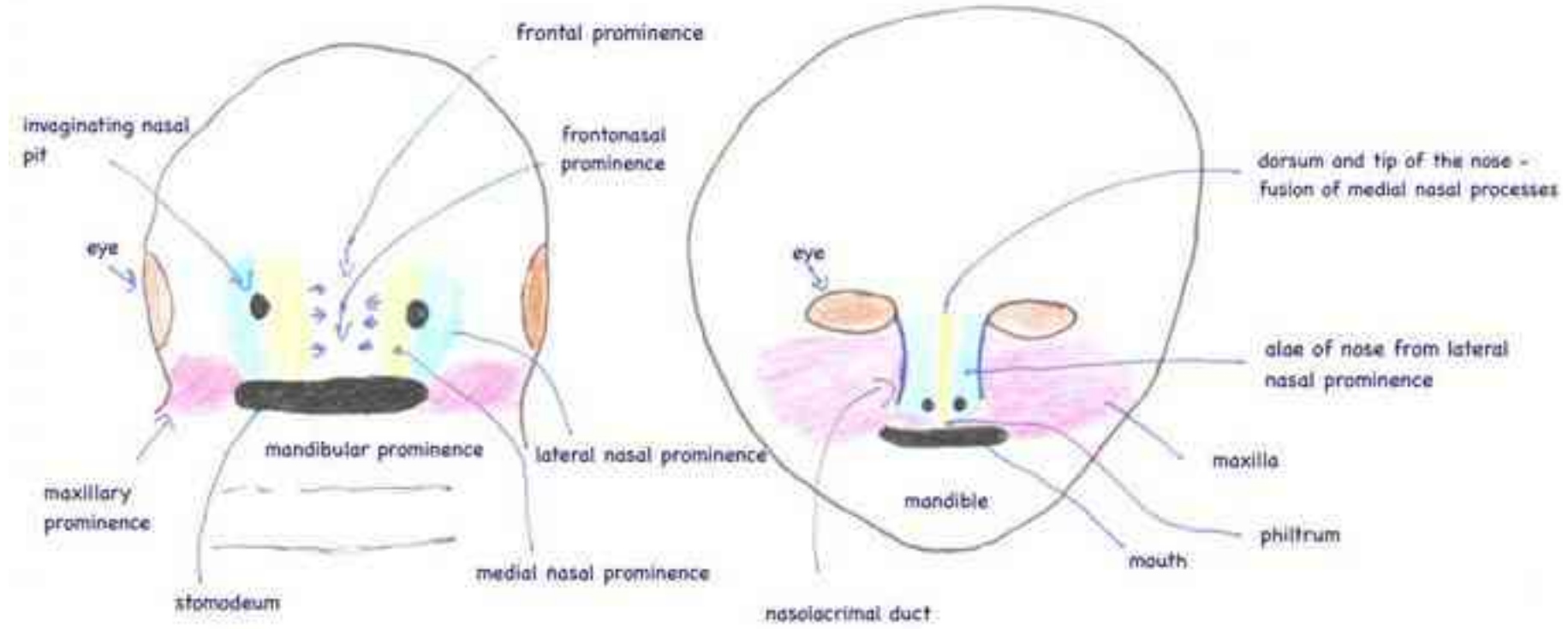
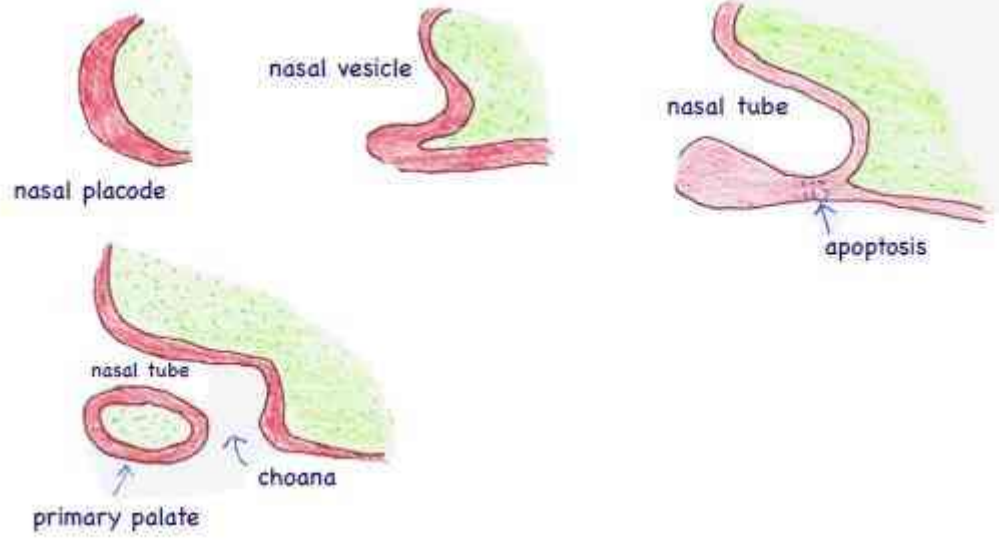
104. Draw and label skull of a newborn (including its circumference) – lateral and cranial view, age of obliteration of at least two of the fontanelles:

- frontal bone, parietal bone, temporal bone, occipital bone,
- frontal suture, coronal suture, sagittal suture, lambdoid suture,
- anterior fontanelle (fonticulus), posterior f., sphenoidal f., mastoid f.,
- 34 cm in circumference; closing due 1.5 year (anterior f.), 6th month (posterior f.), 3rd month (sphenoidal and mastoid fontanelles).

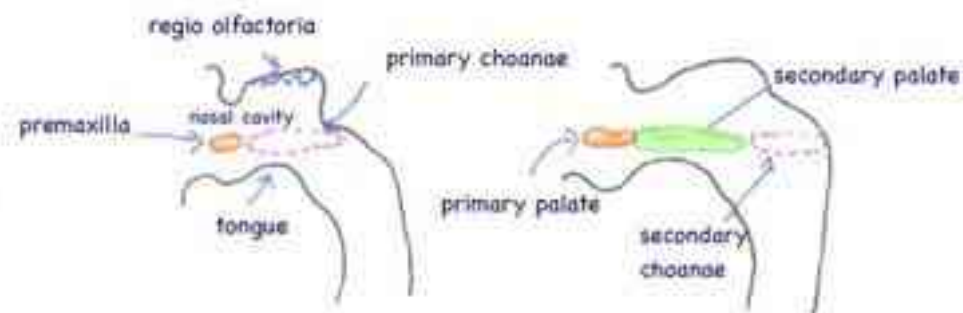
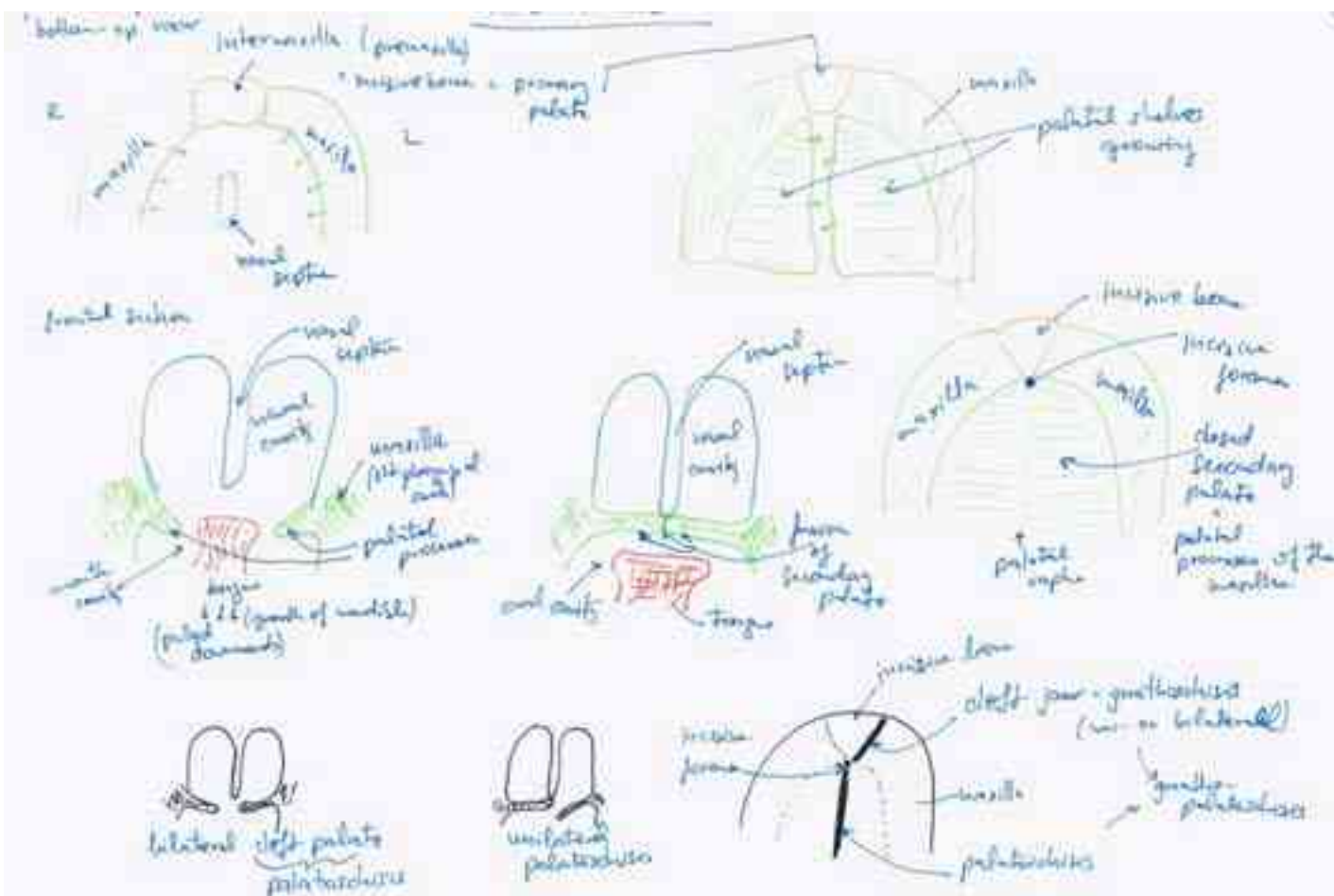


105. Draw and label development of the face including the nose:

- frontal processes, eye, maxillar and mandibular processes, stomodeum,
- olfactory (nasal) placodes, invaginating nasal vesicles,
- medial and lateral circumnasal ridges around the nostrils; nasolacrimal duct – maxillary prominence,
- fusion of medial circumnasal ridges results to nasal field and philtrum.



- premaxilla and primitive choanae, secondary (definitive) choanae as the entrance to the nasopharynx,
- relation of maxilla and premaxilla,
- horizontalization of palatal processes of the maxilla, fusion of palatal processes with the nasal septum,
- Difference of cleft lip (cheiloschisis), cleft jaw (gnathoschisis in front of foramen incisivum), palatoschisis.



107. Draw and label histological sections of the umbilical cord. Draw and label placenta and its parts. Describe differences in the placental barrier of mature and immature placenta:
- umbilical cord – two umbilical arteries, single umbilical vein, Wharton's jelly, ductus omphalonentericus, allantois, the amniotic epithelium on the surface,
 - placenta – fetal part: chorion and villi; maternal part: decidual part and blood supply, intervillous space,
 - immature placenta – intervillous space, syncytiotrophoblast, cytotrophoblast, extraembryonic mesenchyme, blood vessels in the centre of the villus,
 - mature placenta – reduction of cytotrophoblast, blood vessels on the periphery of the villus.

