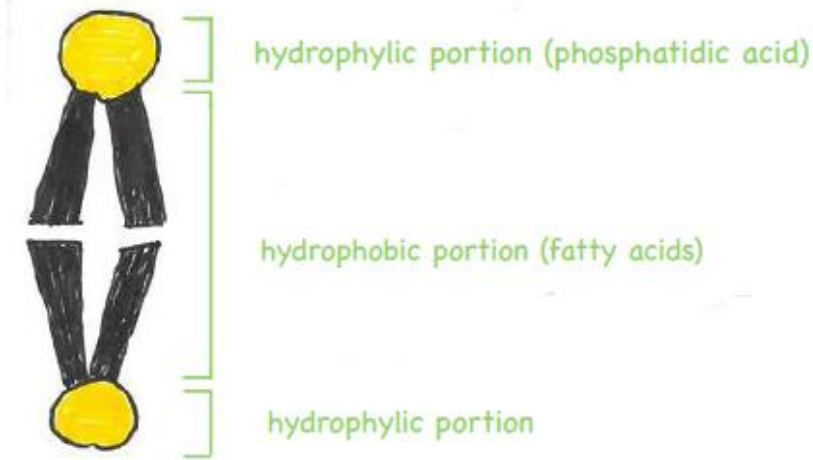
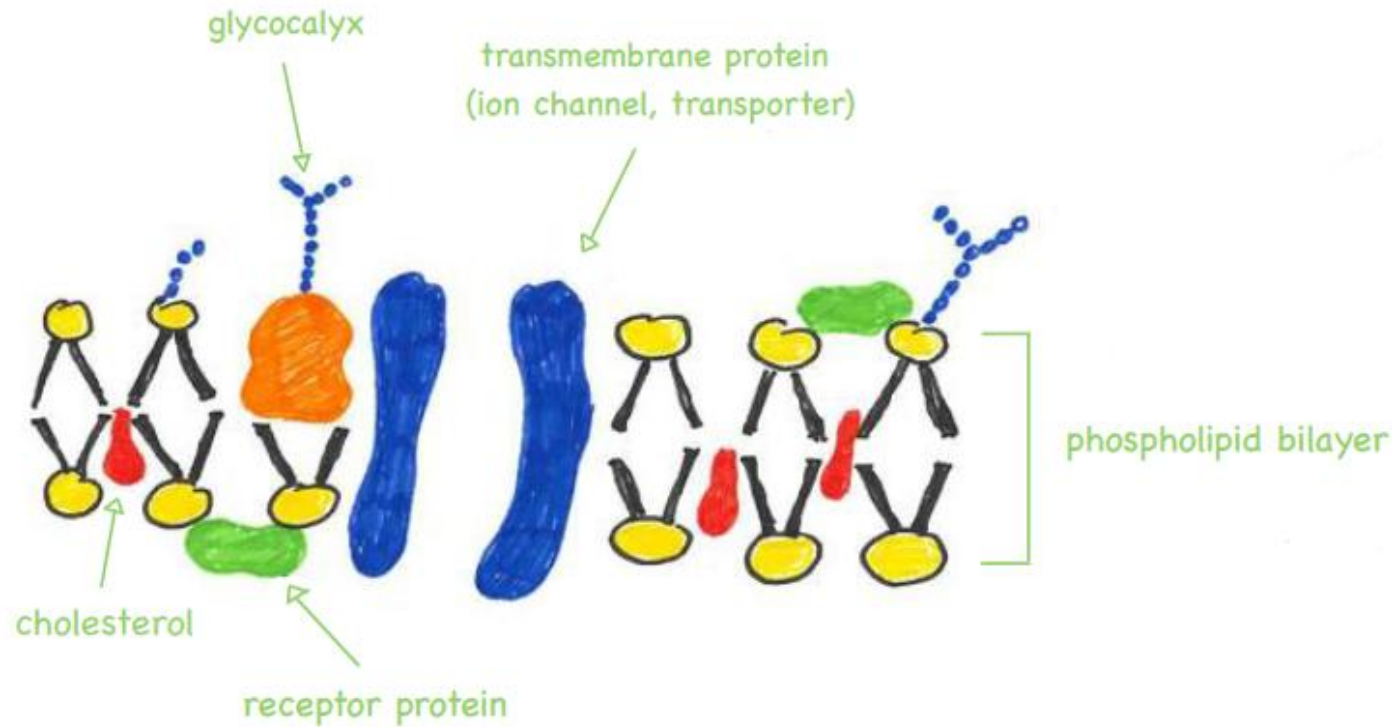
General histology

1. Draw and label cell membrane:

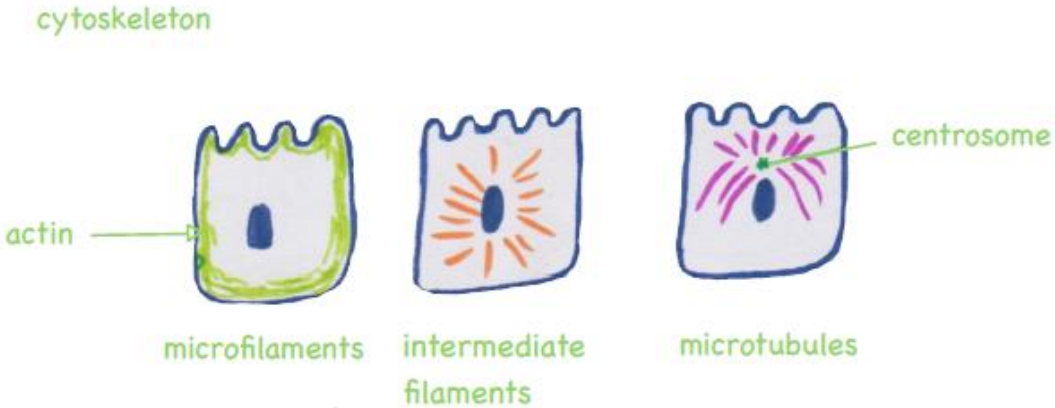
- cross-section of cell membrane: phospholipid bilayer, cholesterol,
- transmembrane protein, ion channel, transporter, and receptor proteins, glycocalyx,
- drawing of phospholipid molecule: highlight hydrophilic (phosphatidic acid) and hydrophobic portion (fatty acids).

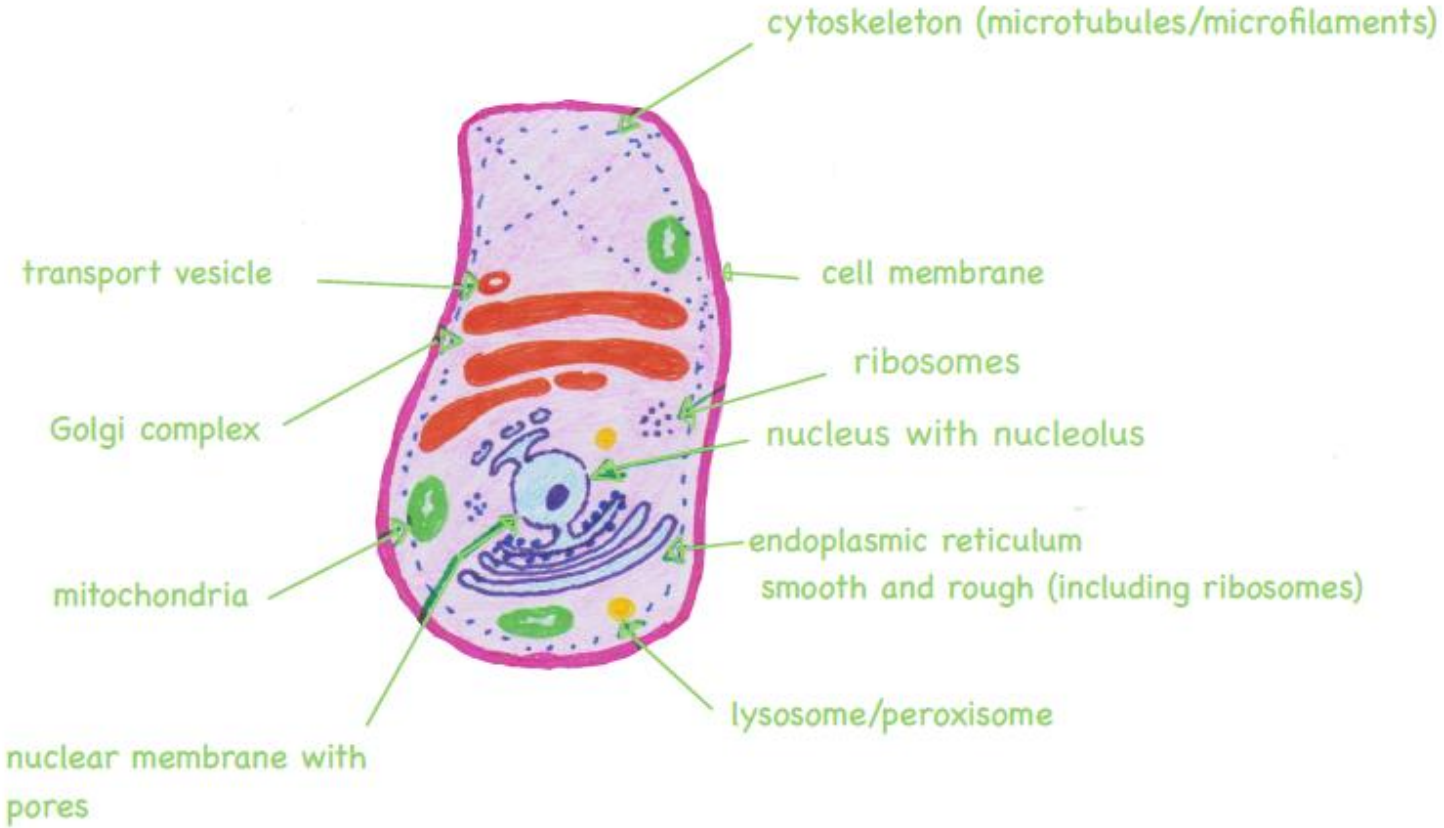




2. Draw and label (animal) cell and its organelles:

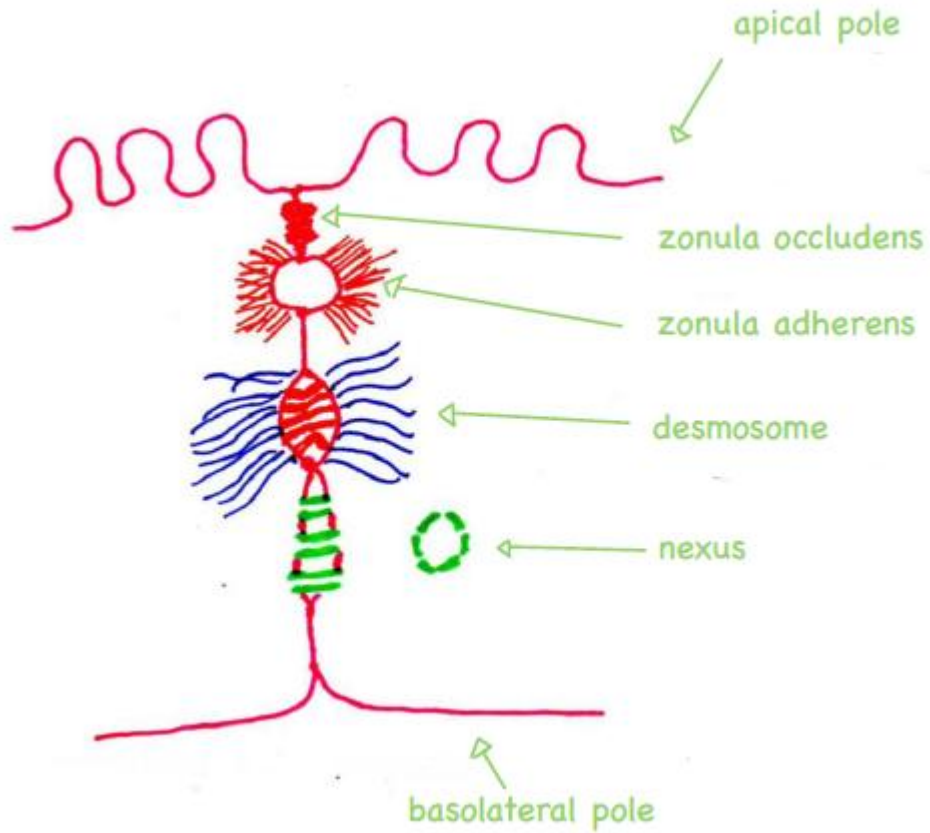
- cell membrane, cytoskeleton (microfilaments, microtubules),
- nucleus in interphase (membrane, pores), nucleolus, cytoskeleton (intermediate filaments),
- endoplasmic reticulum smooth and rough (including ribosomes), Golgi complex, transport vesicle,
- lysosome, mitochondria.





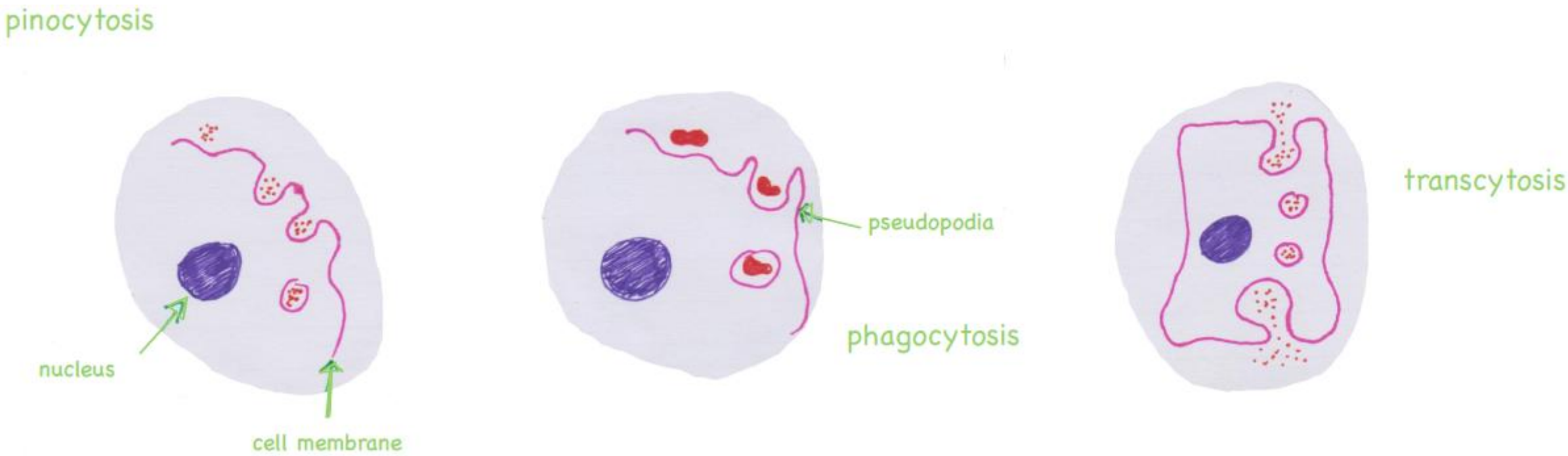
3. Draw and label intercellular junctions in relation to cell polarity:

- draw two adjacent cells and their junctions, highlight apical and basolateral poles of cells,
- zonula occludens,
- zonula adherens,
- desmosome,
- nexus (gap junction).



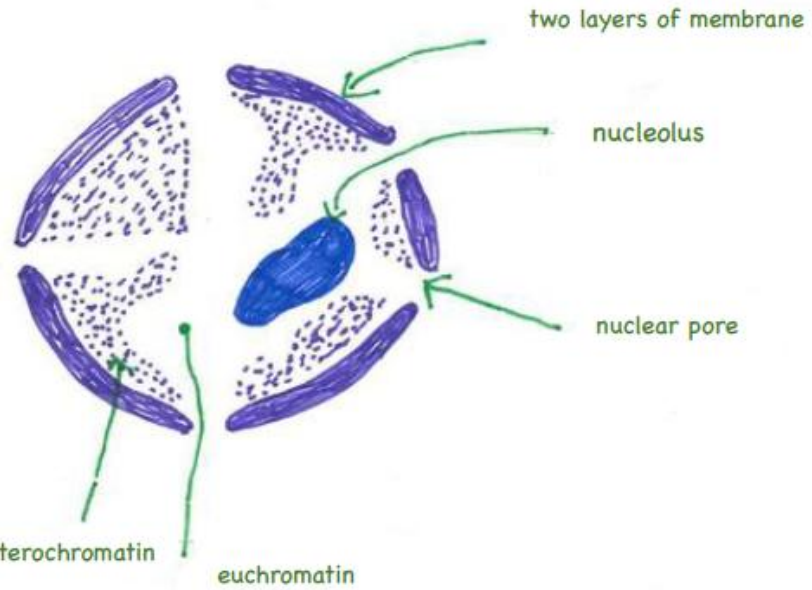
4. Draw and label nutrition uptake by cells:

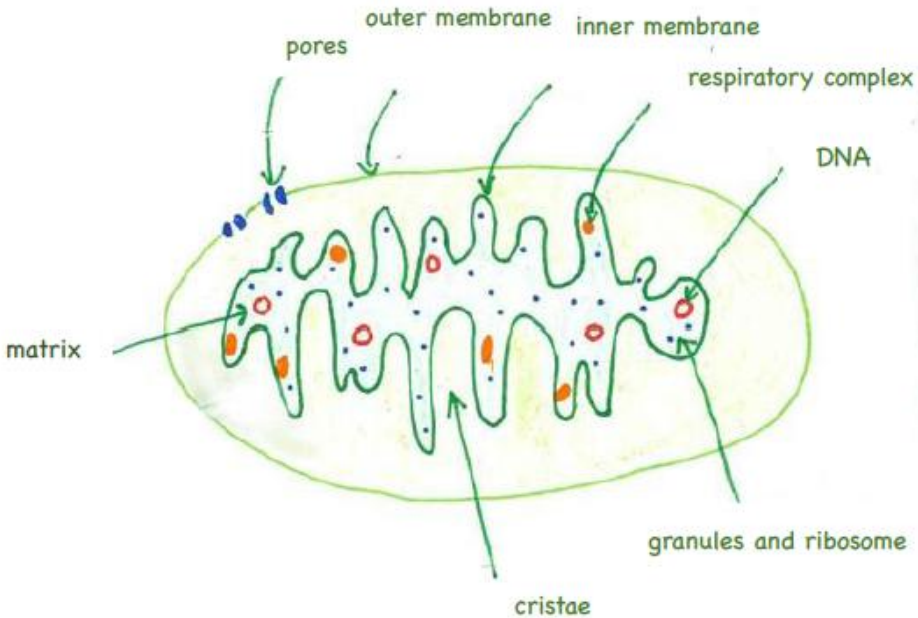
- pinocytosis: small molecules (cell drinking),
- phagocytosis: ingesting larger particles (*e.g.* bacteria), pseudopodia,
- transcytosis: transport of vesicles.

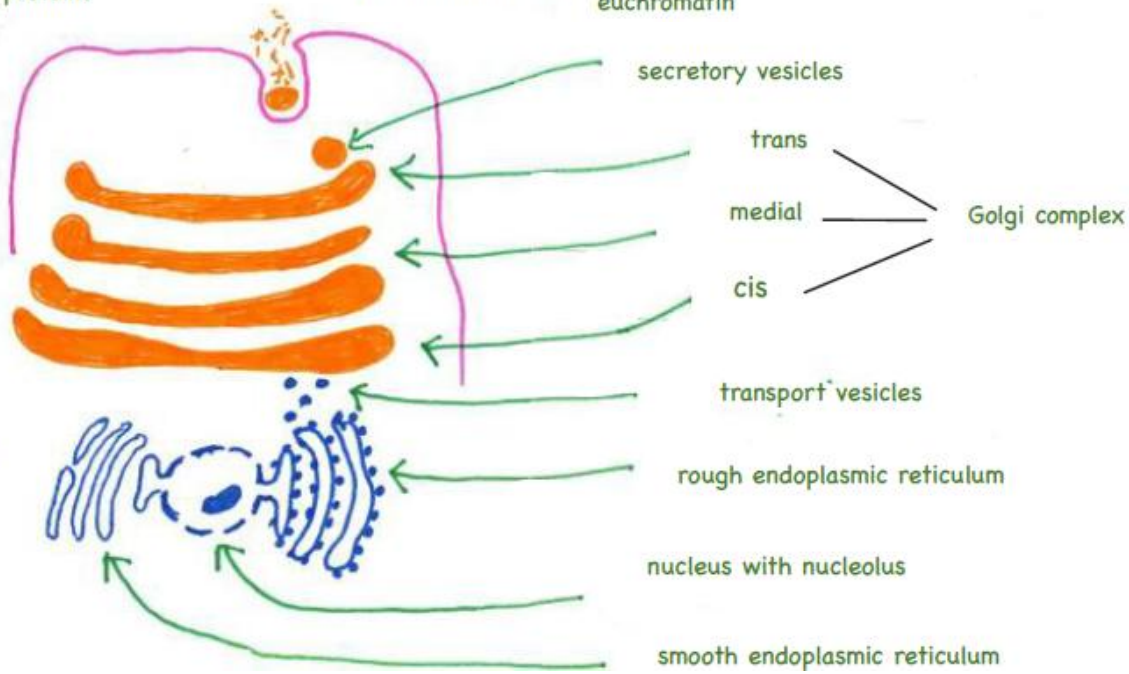


5. Draw and label nucleus of the eukaryotic cell, endoplasmic reticulum, Golgi complex, and mitochondria with its membranes:

- nuclear envelope: two layers of membrane, nuclear pore, heterochromatin, and euchromatin,
- smooth and rough endoplasmic reticulum + Golgi complex,
- outer and inner mitochondrial membrane, cristae, the localisation of respiratory complex proteins in the inner membrane.

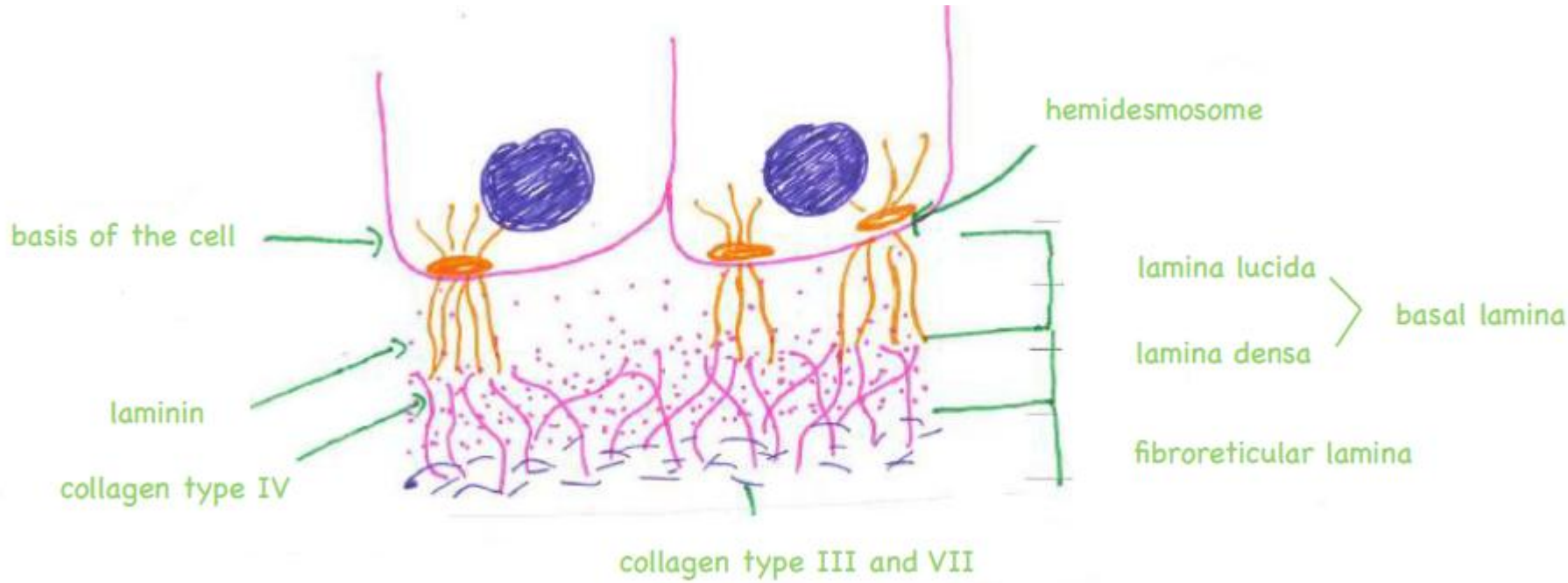






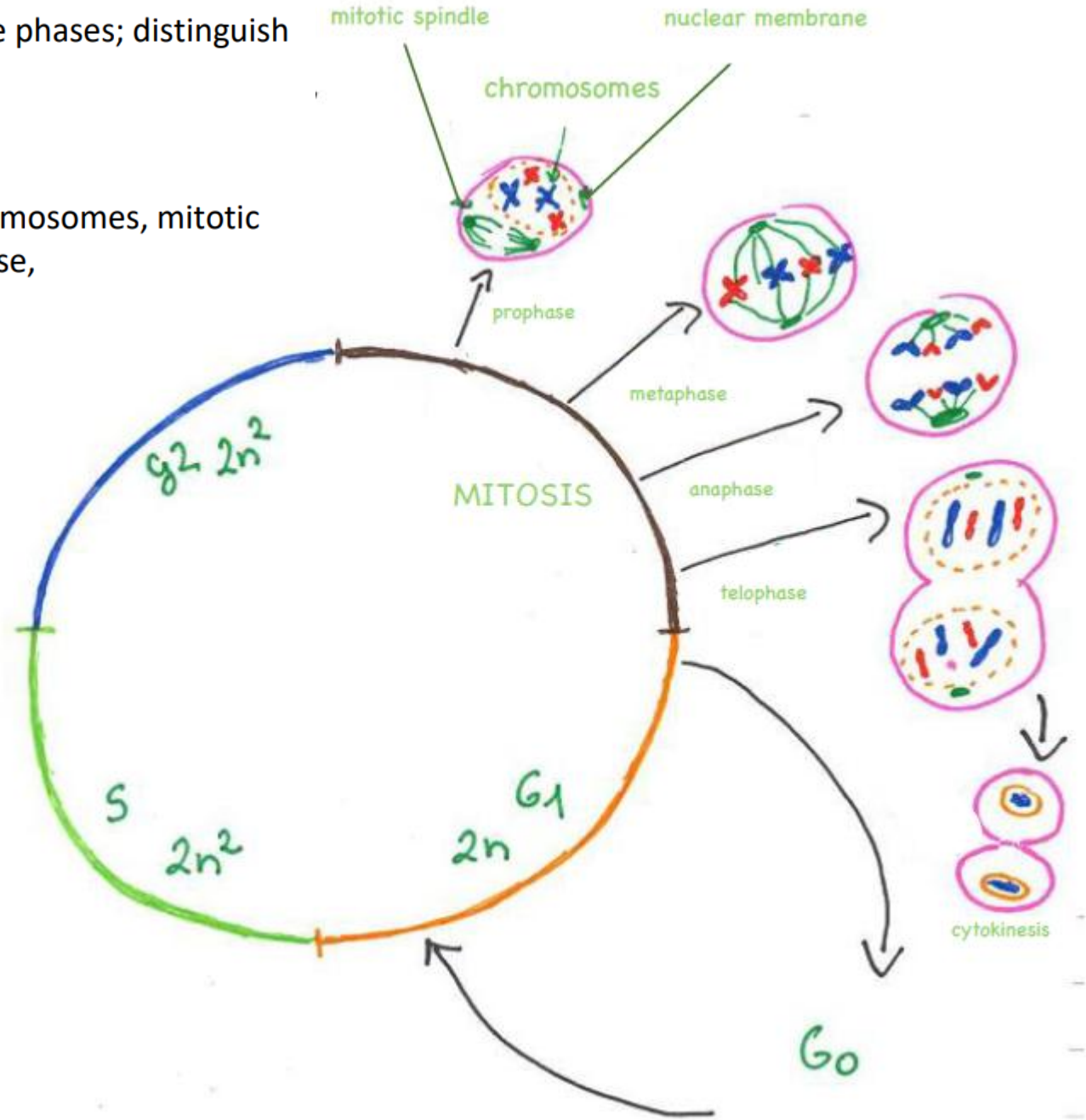
6. Draw and label basement membrane:

- basal lamina consisting of lamina densa (dense layer) et lucida (clear layer): collagen type IV, glycoprotein laminin,
- fibroreticular lamina: collagen type III, collagen type VII,
- basis of the cell attached to lamina lucida by hemidesmosomes.



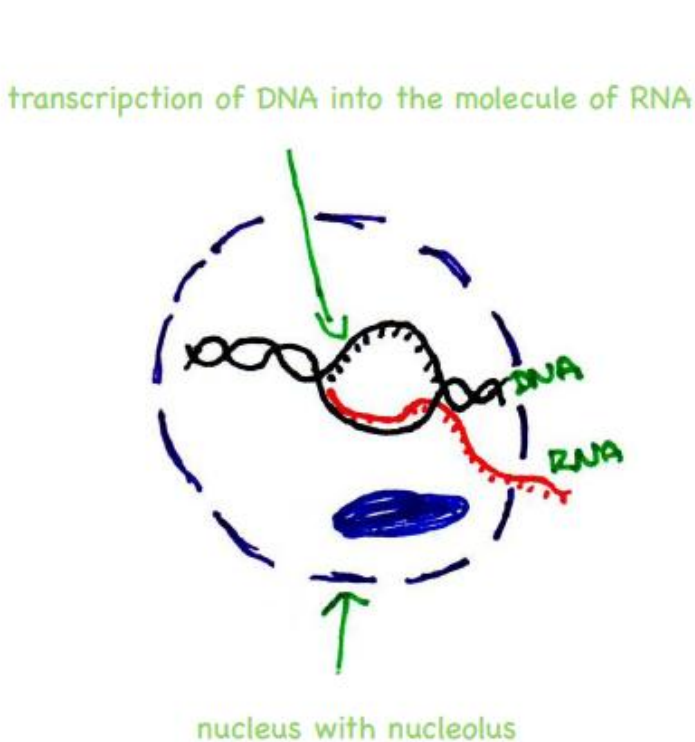
7. Draw and label the cell cycle; what is the regular sequence of the phases; distinguish the phases of mitosis:

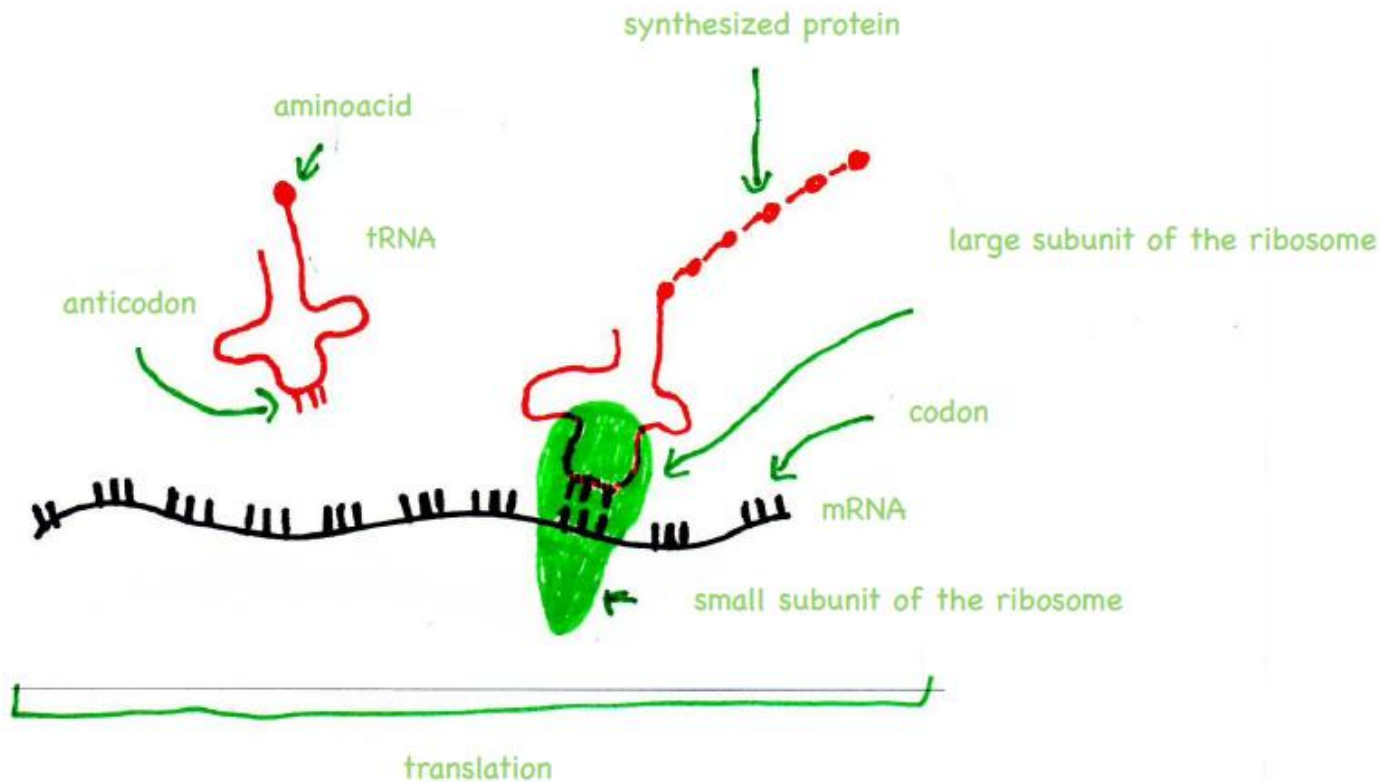
- G1 (G0) – S – G2 – M,
- interphase nucleus in G1 – S – G2 phases,
- draw schemes of individual mitotic (M) phases (position of chromosomes, mitotic spindle, cell division): prophase, metaphase, anaphase, telophase,
- cytokinesis.



8. Draw and label protein synthesis starting with DNA and RNA:

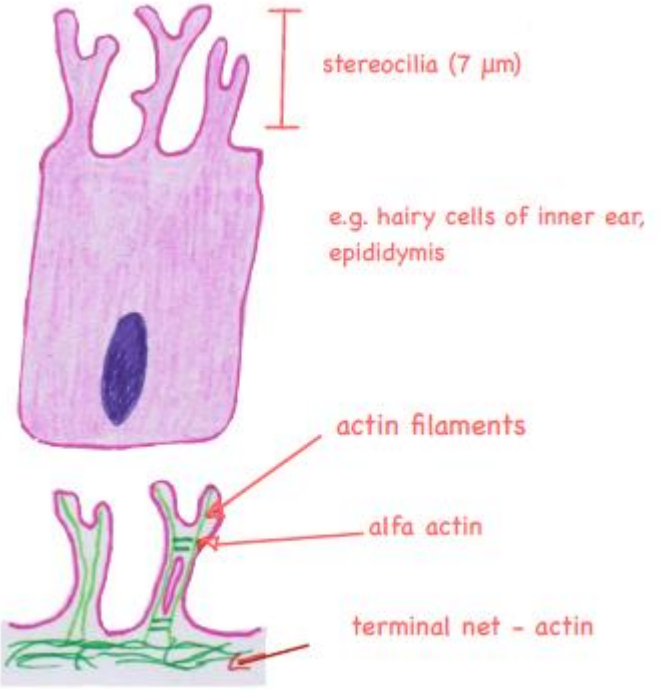
- transcription of DNA into the molecule of RNA,
- mRNA translation into protein sequence, ribosome, the relation between codon-mRNA, and anti-codon-tRNA, synthesized protein,
- small and large subunit of the ribosome.

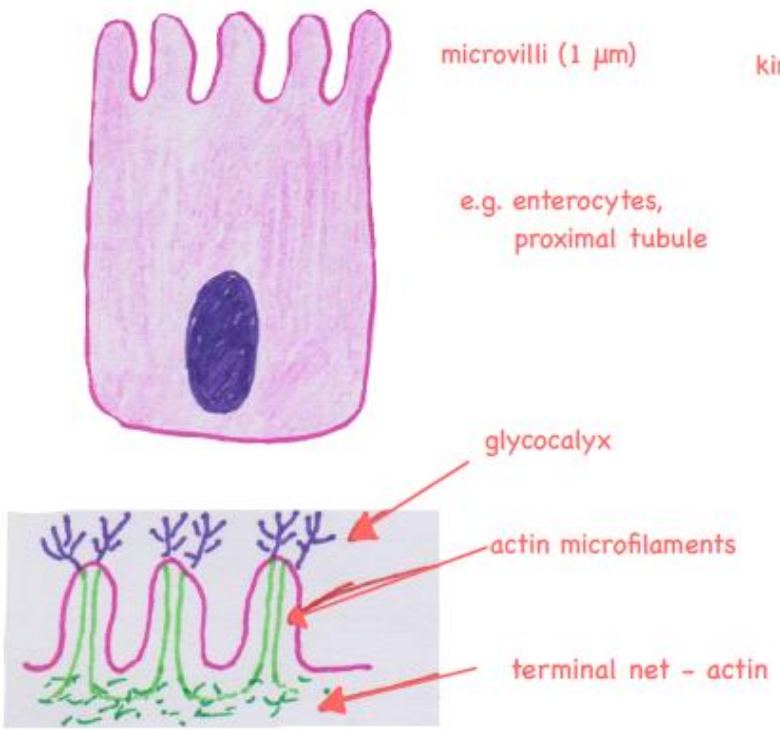


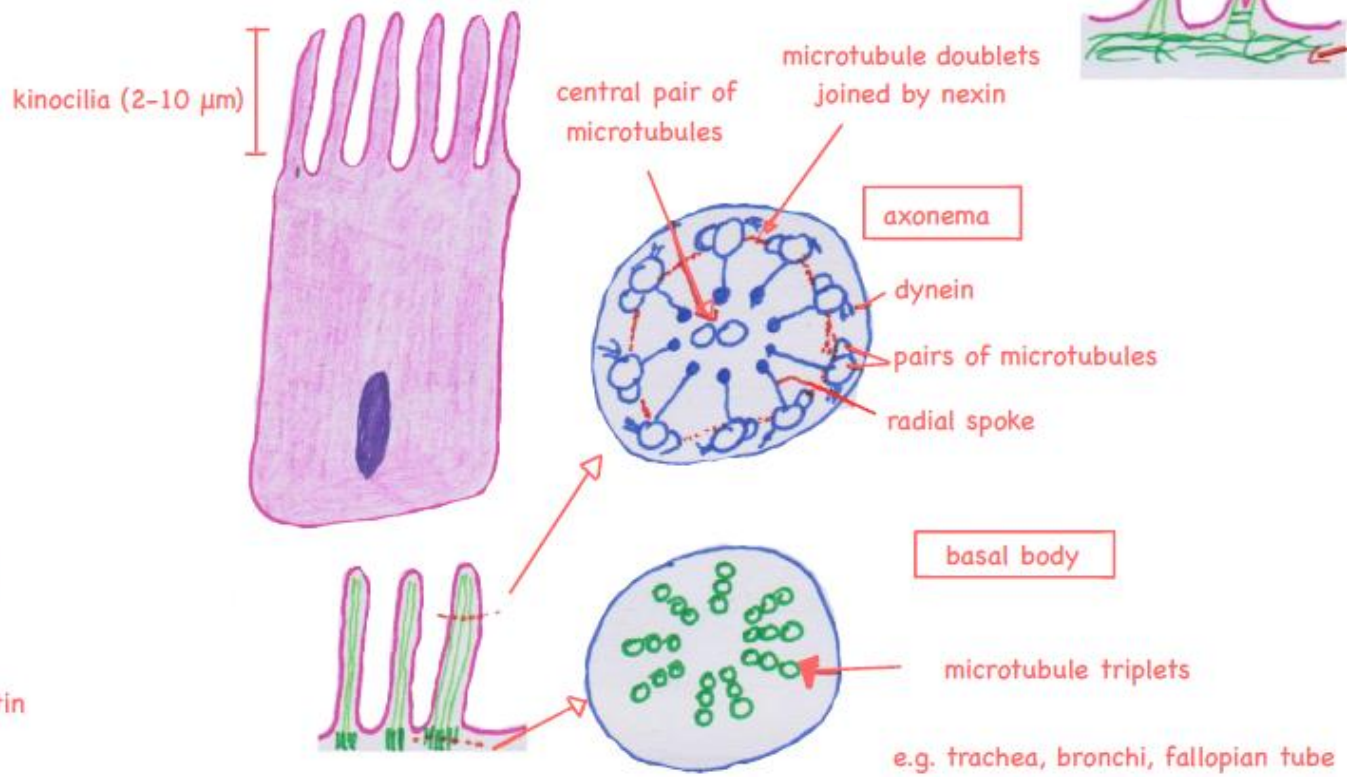


9. Draw and label specializations of the cell apical pole including their size, and details of their structure; give an example for each modification:

- microvilli: cytoplasm processes about 1 µm long, a base formed by actin microfilaments, top of microvilli covered by glycocalyx; complex of microvilli and glycocalyx = brush (microvillous) border, *e.g.* duodenum, gallbladder, proximal tubule of kidney,
- stereocilia: branched variety of microvilli, also formed by actin microfilaments, 7 µm long, *e.g.* epididymis, hair cells of inner ear,
- kinocilia: motile processes of the cells, 2-10 µm long, microtubules in arrangement 9+2 = axonema, dynein (molecular motor), pairs of microtubules (microtubule doublets) joined by nexin, anchored in the basal bodies, *e.g.* trachea, bronchi, fallopian tube.

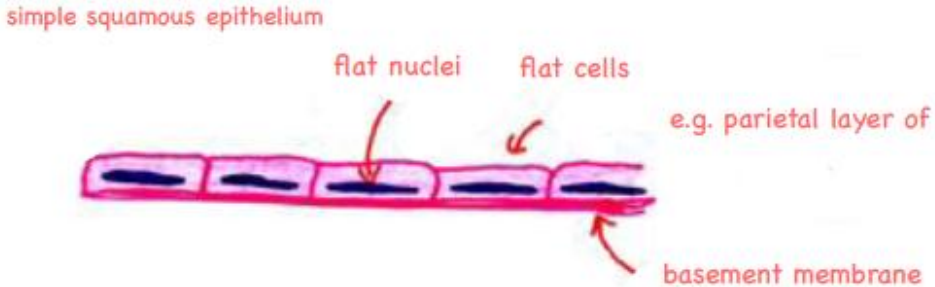


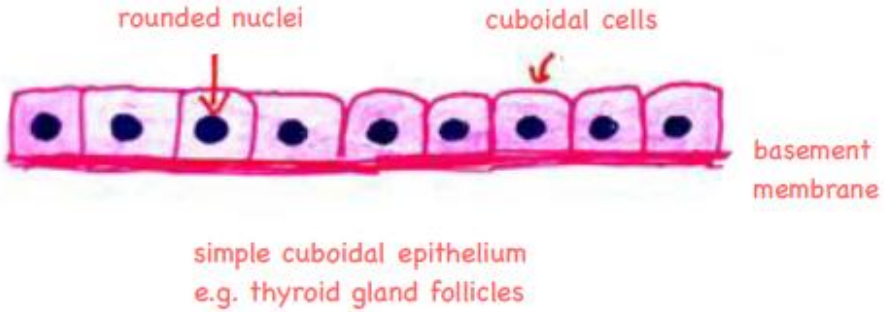


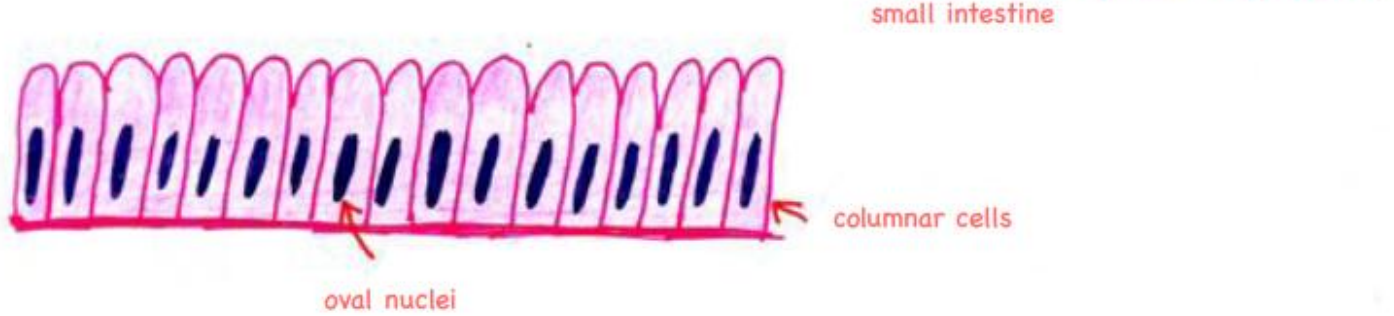


10. Draw and label simple epithelia; give examples:

- simple squamous epithelium: single layer of uniform flat cells, flat nuclei, *e.g.* pulmonary alveoli, parietal layer of the Bowman capsule,
- simple cuboidal epithelium: single layer of uniform cuboidal cells, rounded nuclei, *e.g.* thyroid gland follicles,
- simple columnar epithelium: single layer of uniform columnar cells, oval nuclei, *e.g.* stomach, small and large intestine, gallbladder, and uterine mucosa (endometrium),
- pseudostratified columnar ciliated epithelium: basal parts of all cells rest on the basement membrane, nuclei in different distances from the basement membrane, *e.g.* trachea and bronchi.



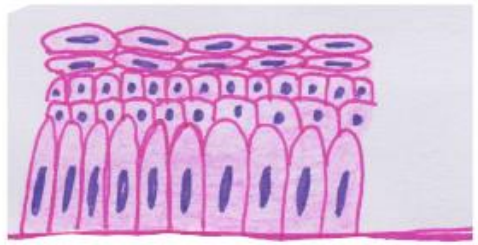




11. Draw and label stratified squamous epithelia; give examples:

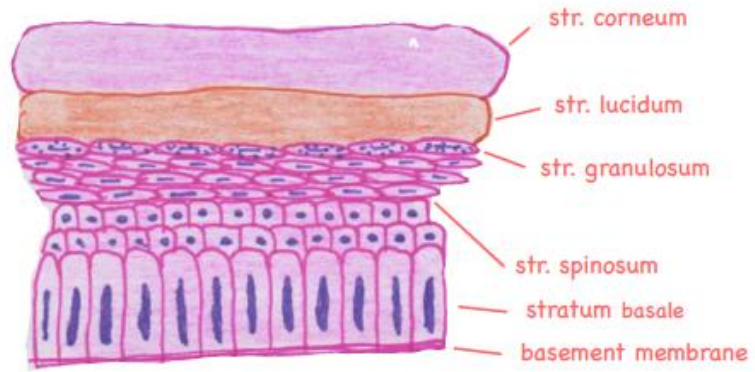
- stratified squamous epithelia non-keratinized: nuclei present in superficial cells, *e.g.* oral cavity, oesophagus,
- stratified squamous epithelia keratinized, thin type of the skin: stratum basale, str. spinosum, str. granulosum, (str. lucidum – only in thick type of the skin), str. corneum, str. disjunctum, *e.g.* axilla,
- stratified squamous epithelia keratinized, thick type of the skin – in addition str. lucidum, *e.g.* planta, palma.

stratified squamous epithelia non-keratinized e.g. oral cavity, oesophagus



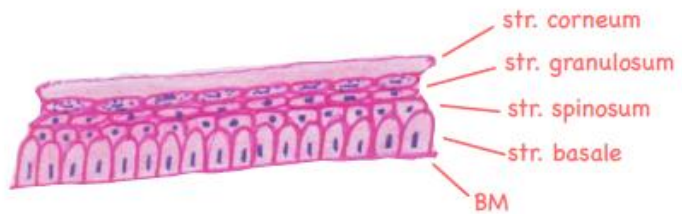
stratified squamous epithelia keratinized

thick type of the skin



e.g. planta, palma

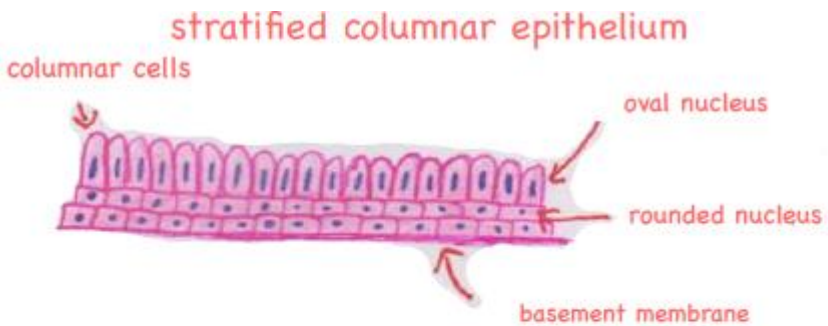
thin type of the skin



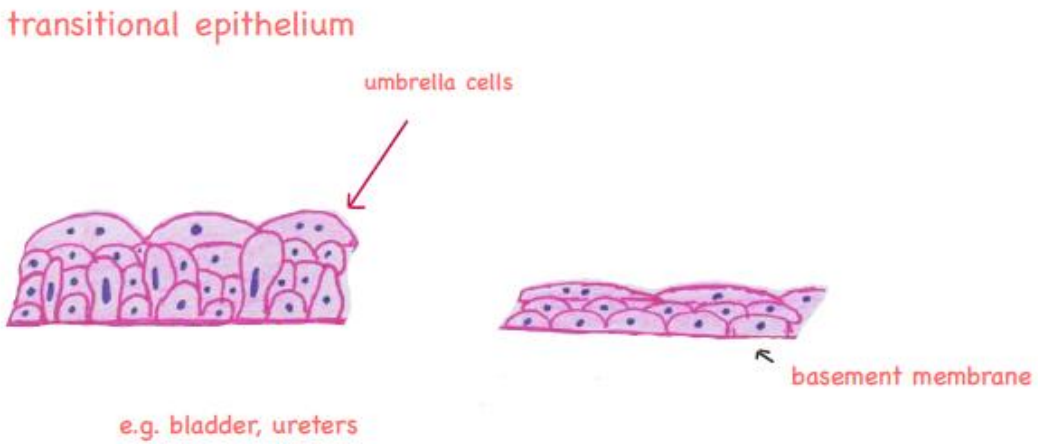
e.g. axilla

12. Draw and label stratified columnar epithelium, stratified cuboidal epithelium, and transitional epithelium; give examples:

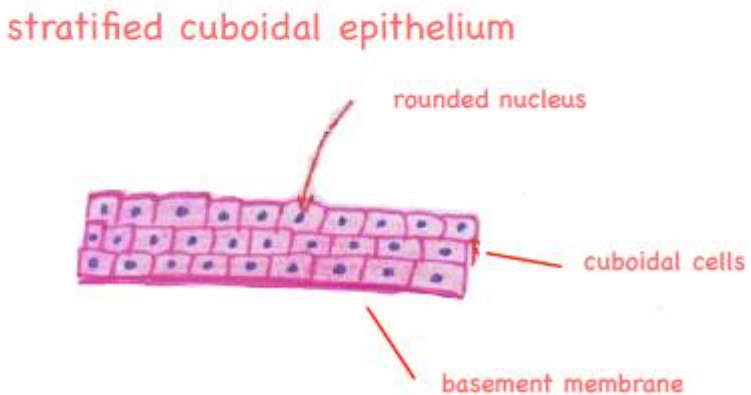
- stratified cuboidal epithelium: several layers of cuboidal cells, *e.g.* large ducts of glands,
- stratified columnar epithelium: basal cuboidal layer, above few layers of columnar, cells, *e.g.* conjunctiva,
- transitional epithelium: 2 schemes according to the functional state of the organ (depending on the state of its filling); flattened and high epithelium, changing shapes of cells, umbrella cells, *e.g.* bladder, ureters.



e.g. conjunctiva



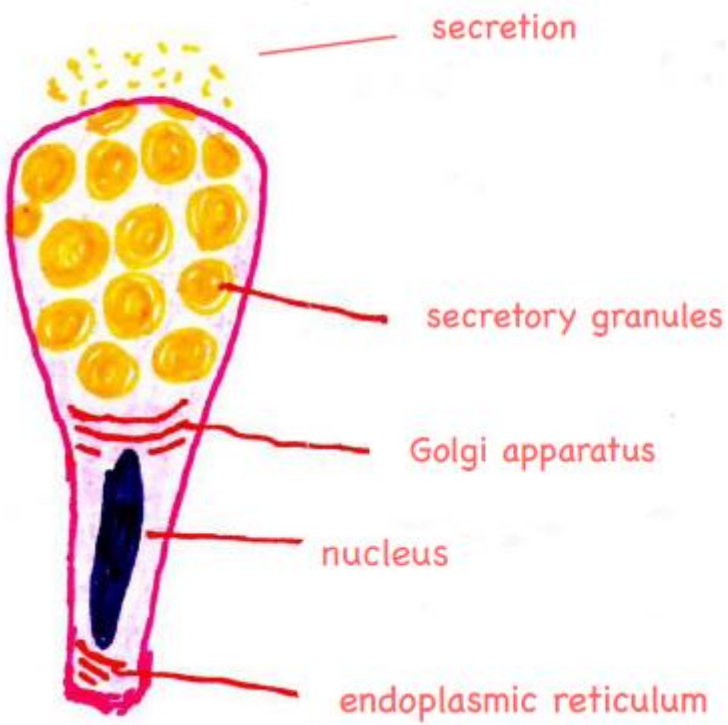
e.g. bladder, ureters



e.g. large ducts of glands

13. Draw and label Goblet cell in the context of two epithelia in which is present; give examples:

- unicellular intraepithelial mucous gland,
- nucleus located in the basal part, surrounded by rough endoplasmic reticulum, large Golgi apparatus, secretory granules in the apical segment of the cell,
- within a simple columnar and pseudostratified columnar ciliated epithelium, *e.g.* trachea, intestine.



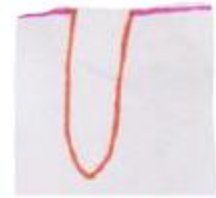
Goblet cell

pseudostratified columnar ciliated epithelium e.g. trachea

simple columnar epithelium e.g. intestine

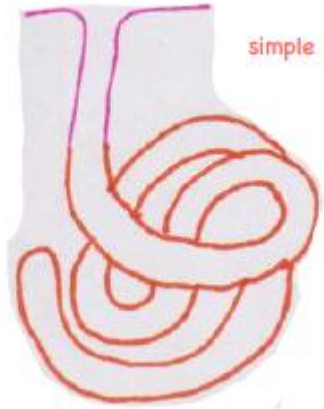
14. Draw and label classification of multicellular exocrine glands according to the structure of the ducts and the secretory compartments; give examples:

- simple tubular glands: *e.g.* intestinal crypts, endometrial glands; simple tubular coiled glands: *e.g*. sweat glands; simple tubular branched glands: *e.g.* gastric glands,
- compound tubular glands: *e.g*. duodenal Brunner´s glands,
- simple alveolar glands: *e.g*. sebaceous glands; compound alveolar glands: *e.g*. lactating mammary gland,
- compound acinar glands: *e.g*. pancreas, parotid gland,
- compound tubuloalveolar glands: *e.g*. sublingual or submandibular glands.



simple tubular gland

e.g. endometrial glands



simple tubular coiled gland

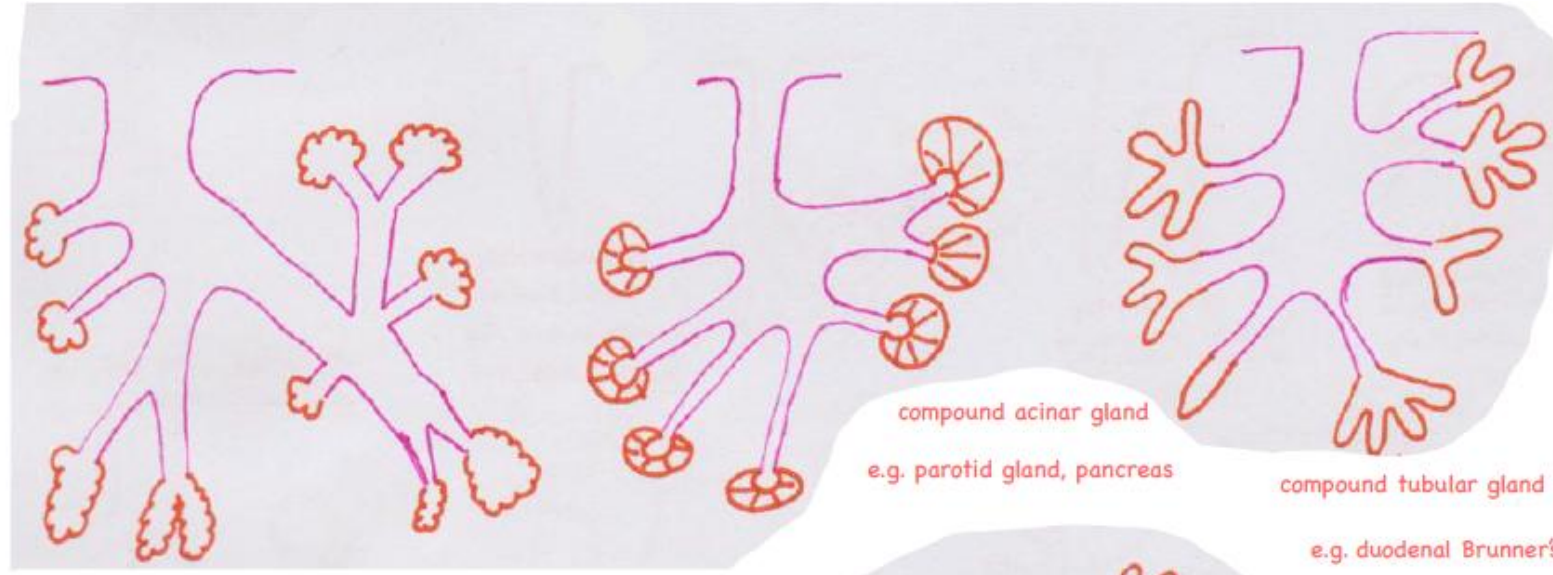
e.g. sweat gland

simple tubular branched gland

e.g. gastric gland

simple alveolar branched gland

e.g. sebaceous gland



compound alveolar gland

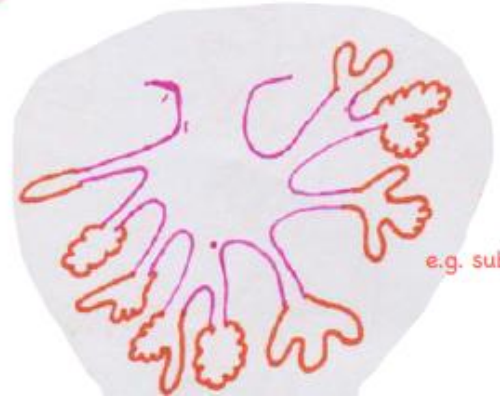
e.g. lactating mammary gland

compound acinar gland

e.g. parotid gland, pancreas

compound tubular gland

e.g. duodenal Brunner's gland



compound tubuloalveolar gland

e.g. sublingual, submandibular gland

15. Draw and label skin glands according to the classification based on the mechanism of secretion; give examples:

- merocrine/eccrine gland: *e.g.* sweat gland,
- apocrine gland: *e.g.* aromatic (sweat) gland,
- holocrine gland: *e.g.* sebaceous gland.

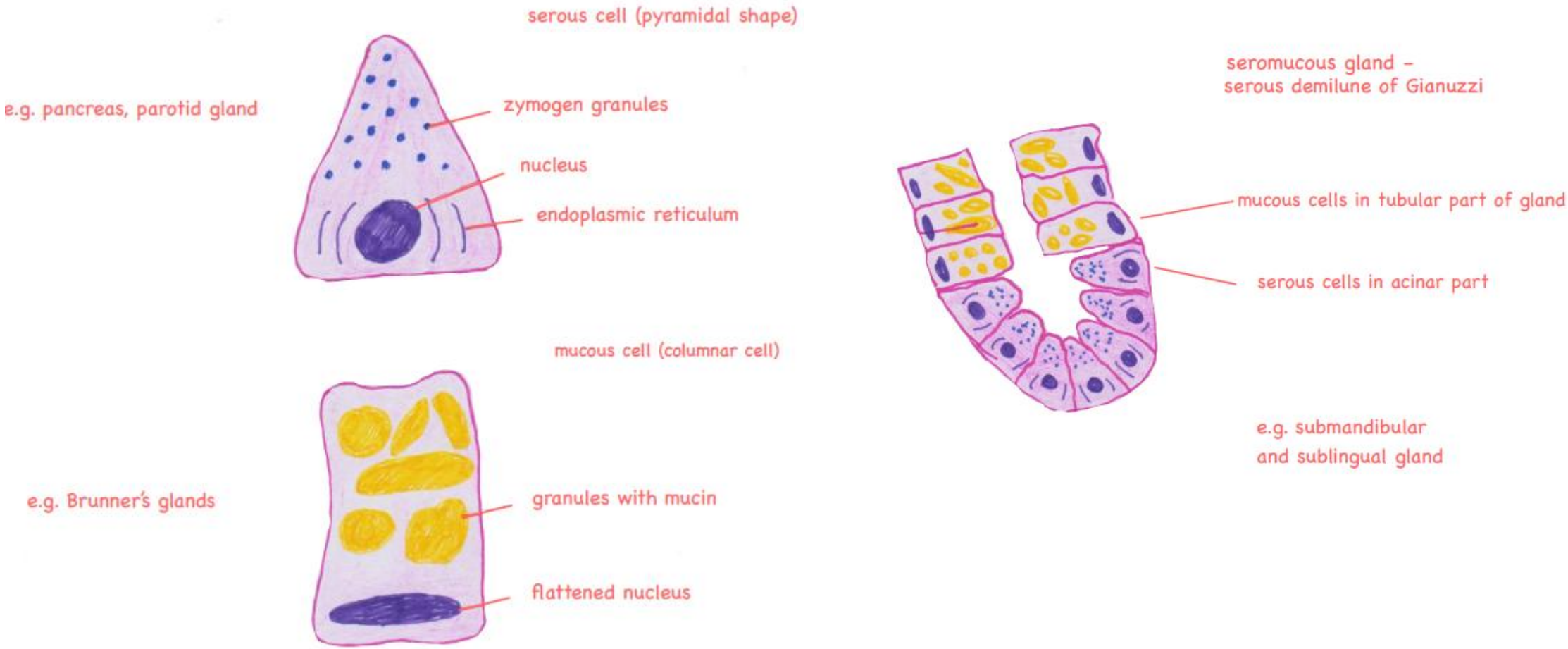
merocrine/eccrine gland
e.g. sweat gland

apocrine gland e.g. aromatic (sweat) gland

holocrine gland
e.g. sebaceous gland

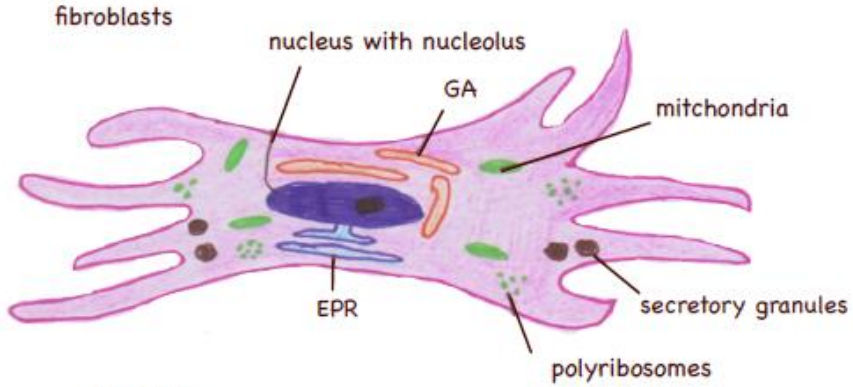
16. Draw and label differences between serous, mucous, and seromucous glands; give examples:

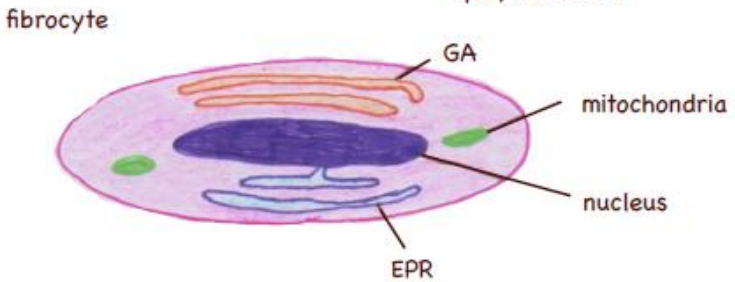
- serous cells: pyramidal shape of the cell with zymogen granules, round nuclei, basophilic cytoplasm, abundant rough endoplasmic reticulum, *e.g.* pancreas, parotid gland,
- mucous cells: columnar cell with flattened nucleus on the cell base, granules with mucin, *e.g.* Brunner´s glands,
- seromucous (mixed) gland: two types of secretion units, mucous cells in tubular part of gland, serous cells in acinar part, serous demilune of Gianuzzi, *e.g.* submandibular and sublingual gland.

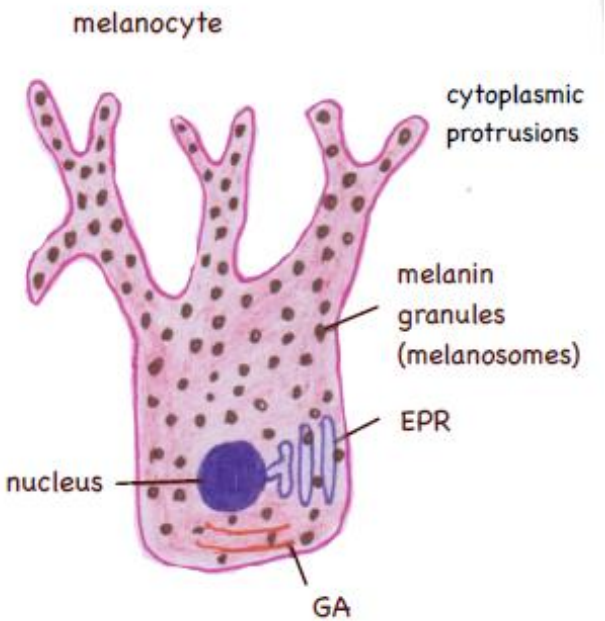


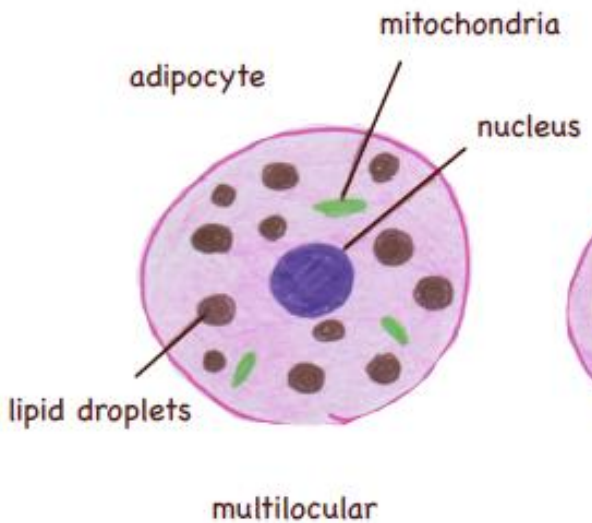
17. Draw and label resident cells of the connective tissue proper:

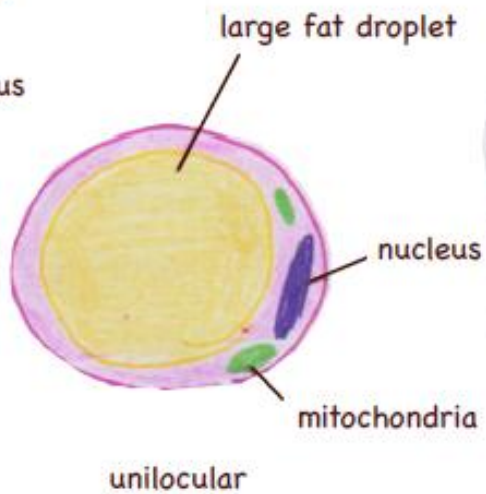
- fibroblast: oval nucleus with nucleoli, rough endoplasmic reticulum, Golgi apparatus, mitochondria, secretory vesicles, production of extracellular matrix,
- fibrocyte: less cytoplasm and cell processes compared to a fibroblast,
- reticular cell: star-shaped cell, oval nucleus, production of reticular fibres,
- adipocyte (fat cell): multilocular (nucleus in the centre, a number of mitochondria, lipid droplets) and unilocular (spherical shape with one large fat droplet, eccentric nucleus, and thin layer of cytoplasm),
- pigment cell (melanocyte): cytoplasmic protrusions, nucleus, melanin granules (melanosomes).

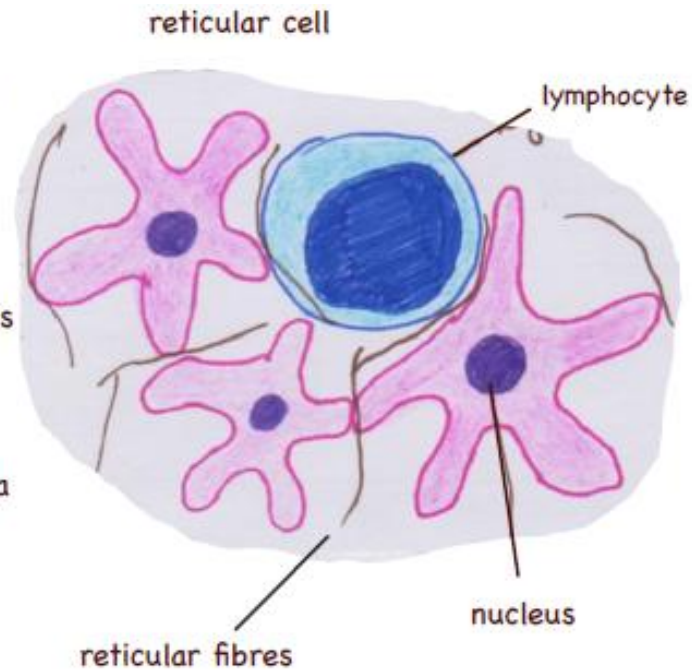






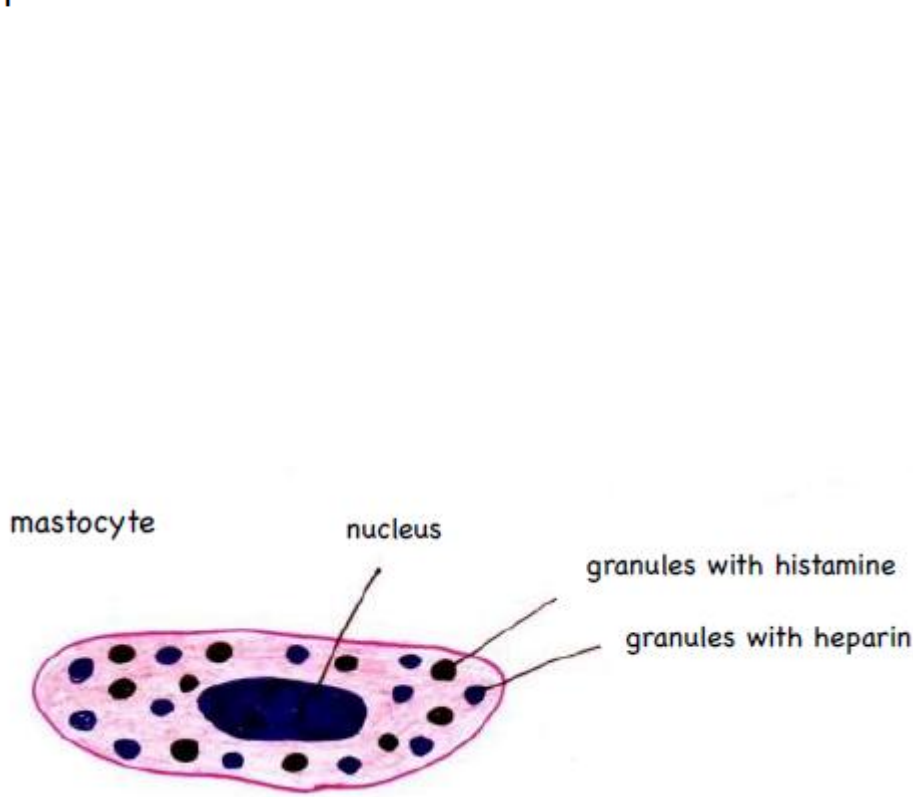


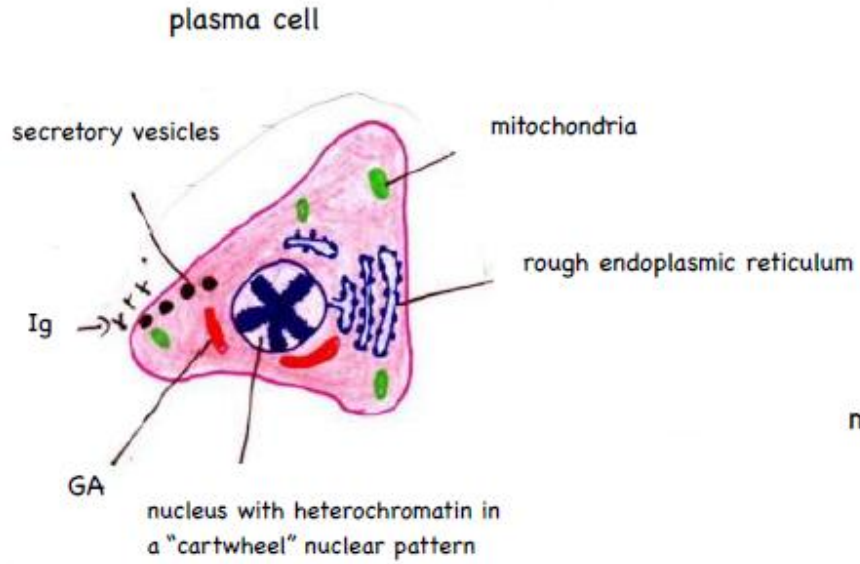


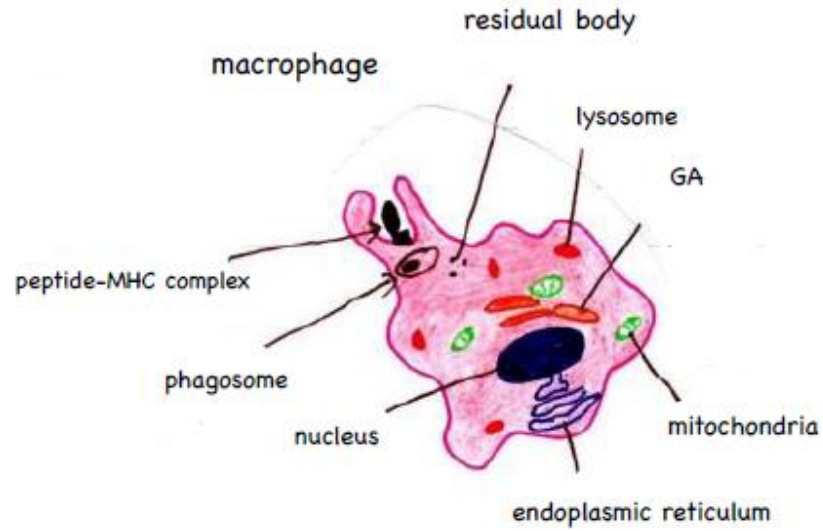


18. Draw and label wandering cells of the connective tissue proper:

- macrophage (histiocyte): round to oval shape, irregular eccentrically placed dark nucleus, Golgi apparatus, and endoplasmic reticulum, phagocytic vesicles, lysosome, phagosome, peptide-MHC complex on the surface,
- plasma cell (plasmocyte): round or spherical shape, nucleus with heterochromatin in a “cartwheel” nuclear pattern, rough endoplasmic reticulum, Golgi apparatus, secretory vesicles, immunoglobulin’s synthesis,
- mast cell (mastocyte, heparinocyte): oval shape, small nucleus, secretory granules with heparin and histamine.

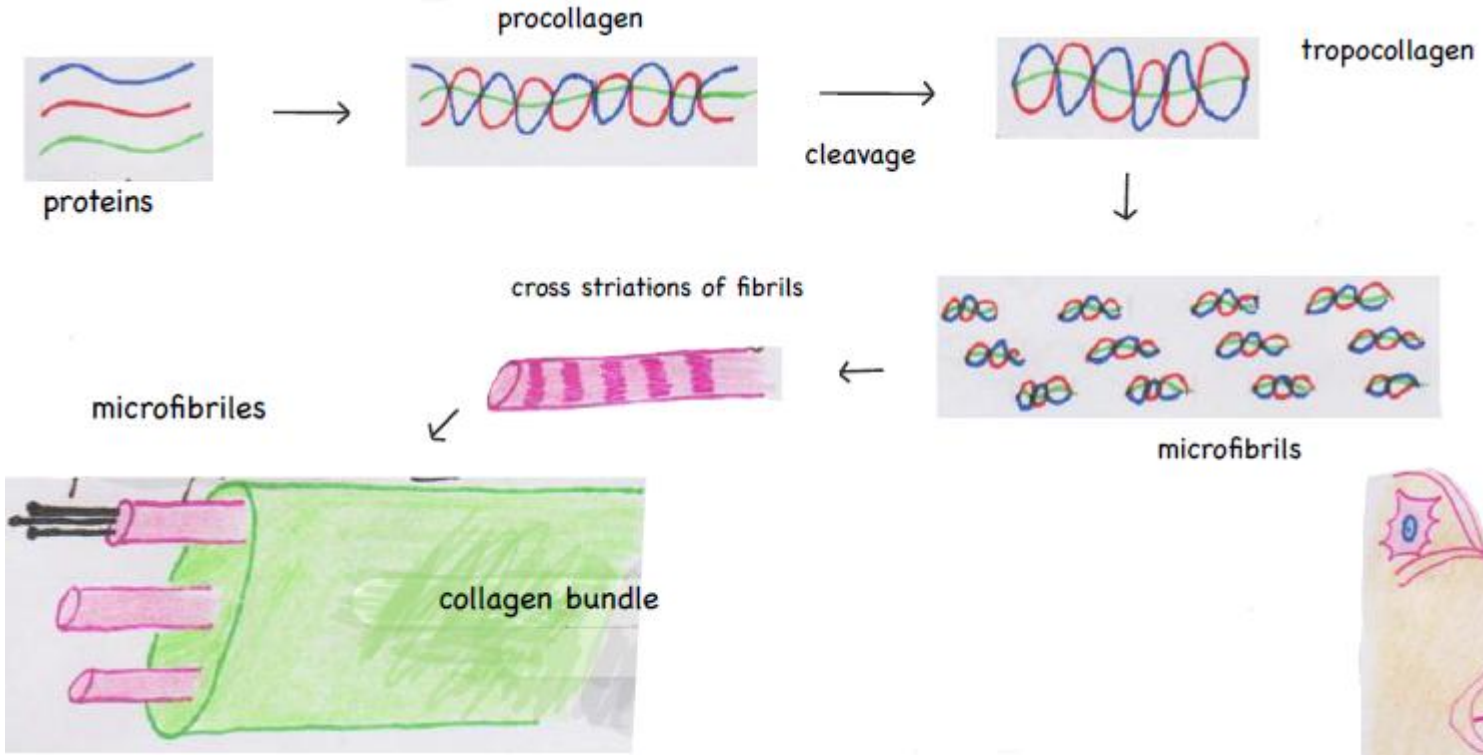


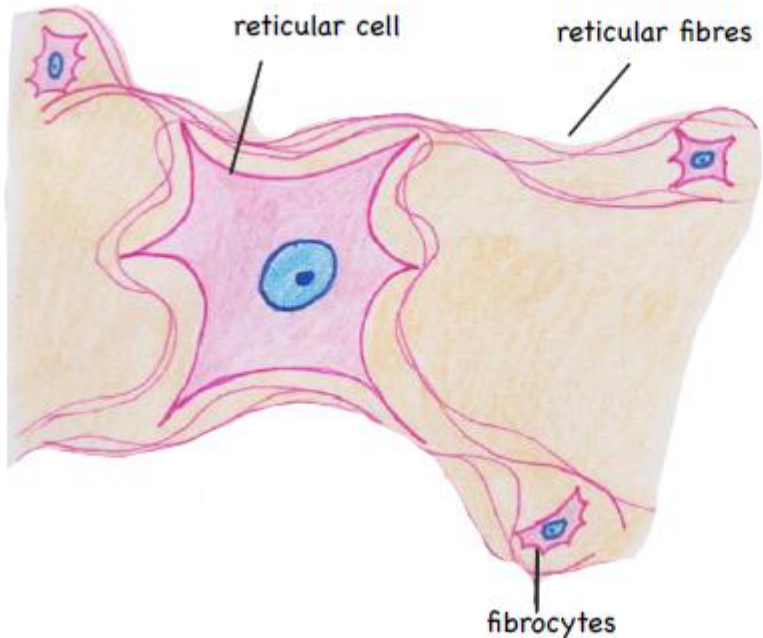


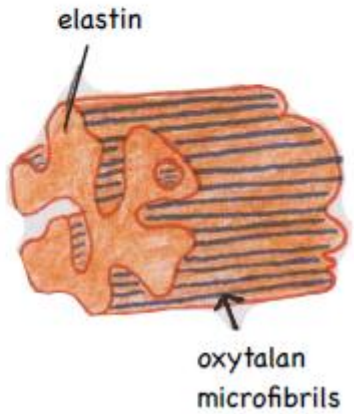


19. Draw and label biosynthesis of collagen; draw and label reticular and elastic fibres:

- collagen fibre: procollagen, triple helix of tropocollagen, and their overlapping within microfibrils, cross striations of fibrils, collagen bundle,
- shape of reticular fibres, their arrangement among fibrocytes or reticular cells,
- elastic fibres: oxytalan microfibrils surrounding the elastin core.

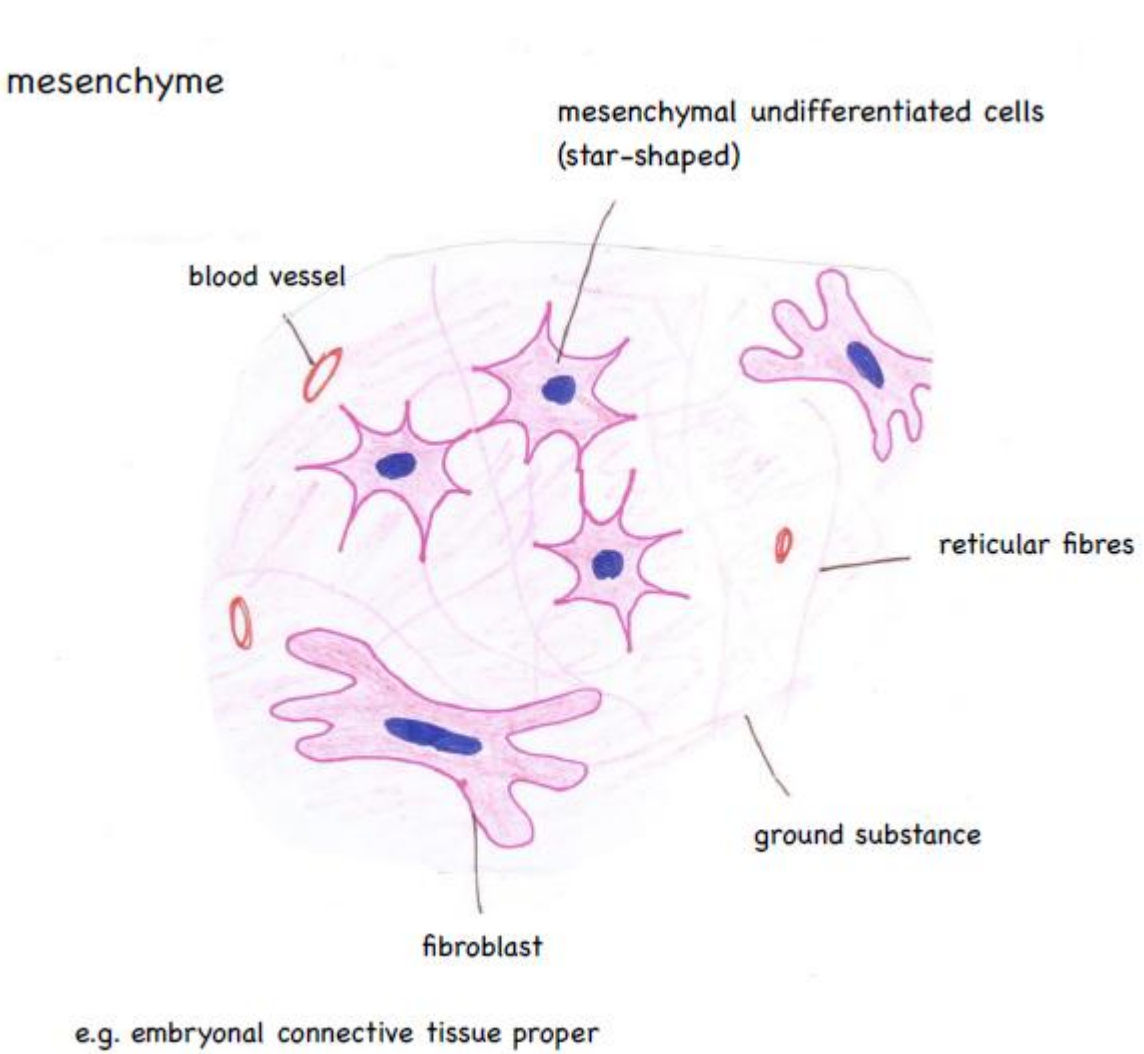


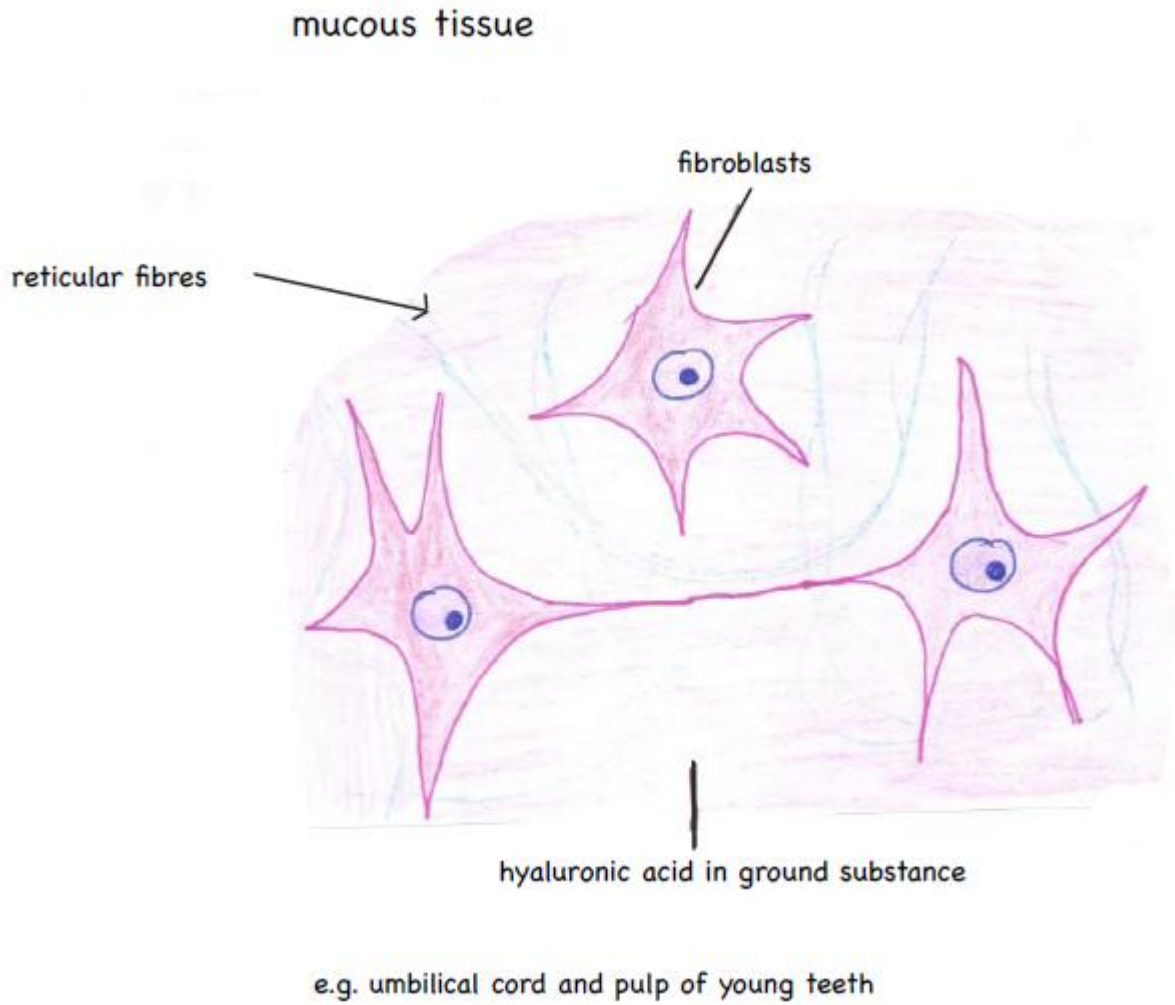




20. Draw and label mesenchyme and mucous tissue; give an example:

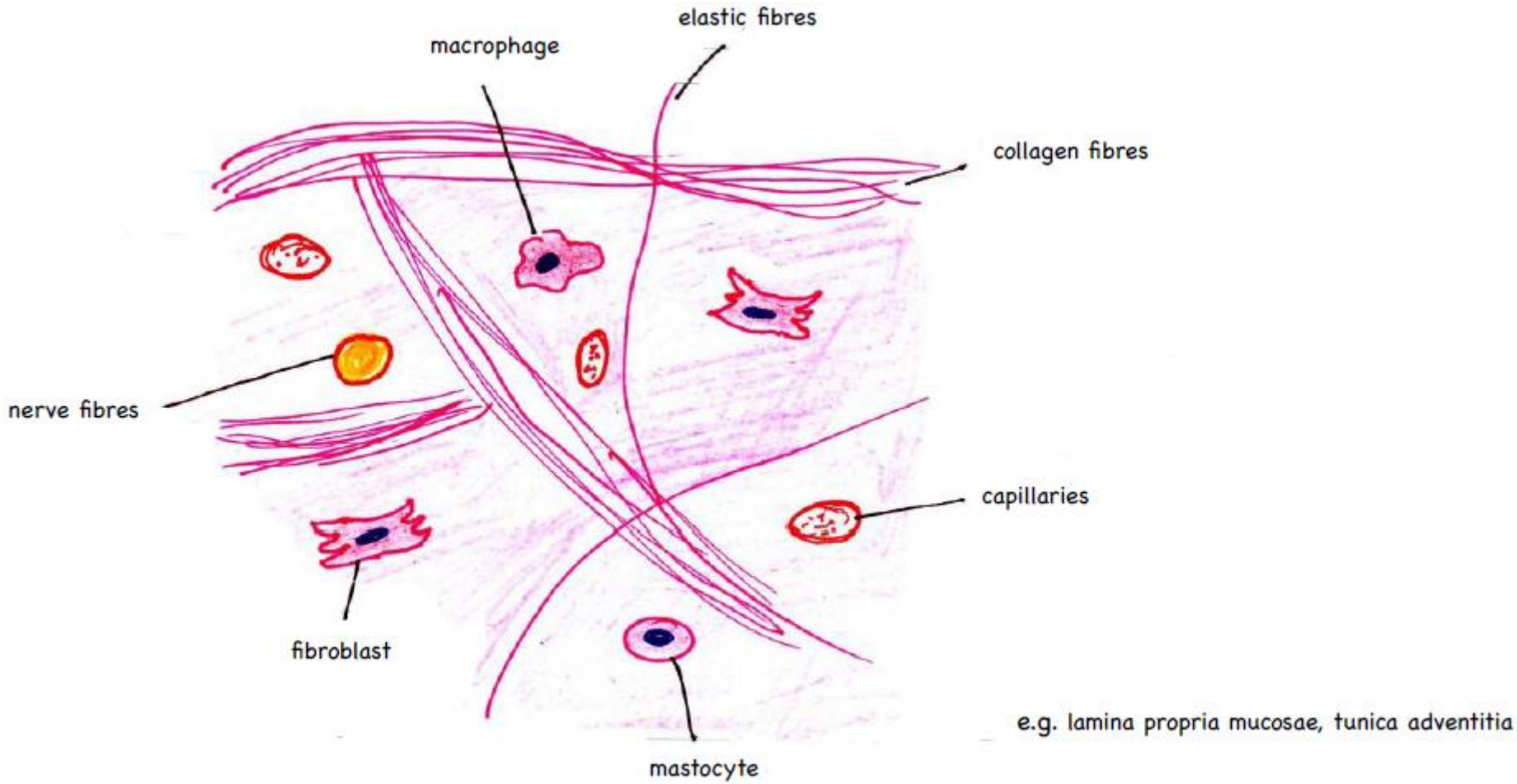
- mesenchyme: mesenchymal undifferentiated cells (star-shaped), fibroblasts, reticular fibres, ground substance,
- *e.g.* embryonal connective tissue proper (mesenchyme),
- mucous tissue: fibroblasts, reticular fibres, hyaluronic acid in ground substance,
- *e.g.* umbilical cord and pulp of young teeth





21. Draw and label loose (collagen) connective tissue; give an example:

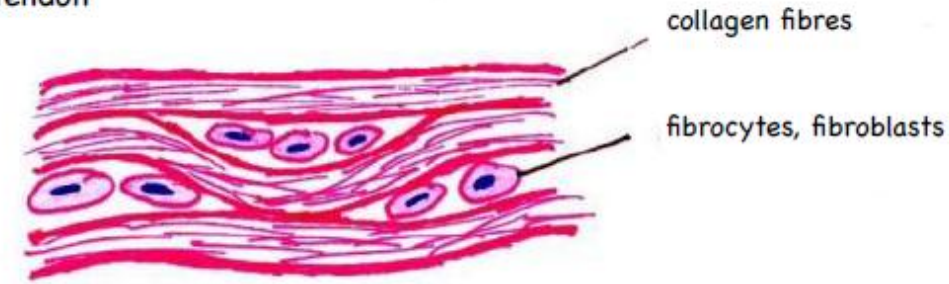
- collagen and elastic fibres,
- fibroblast, macrophage, mastocyte,
- capillaries, nerve fibres,
- *e.g.* connective tissue layer of the mucosa (lamina propria mucosae), tunica adventitia.



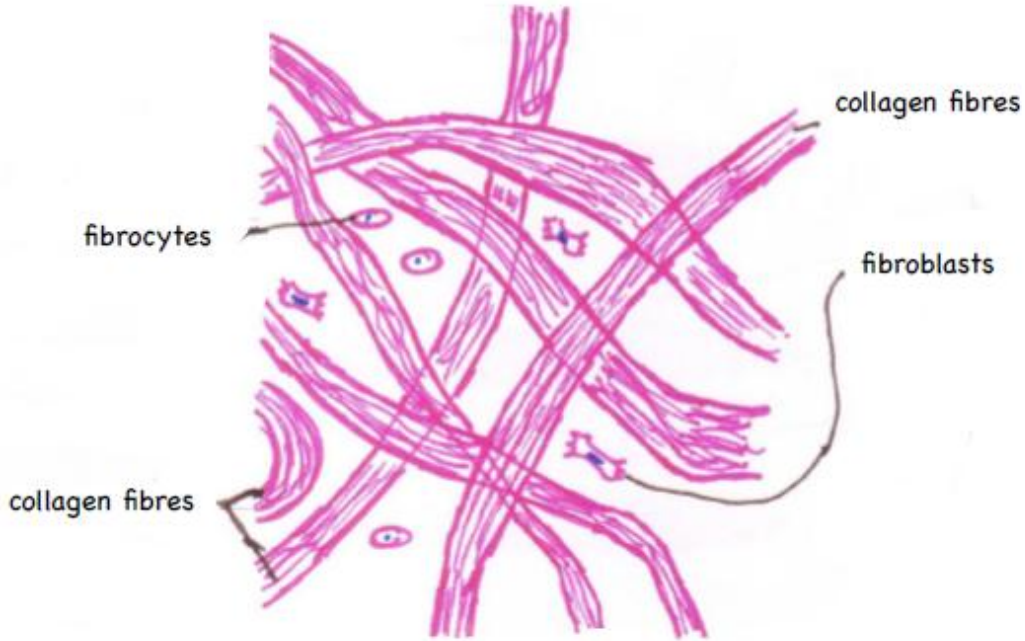
22. Draw and label regular and irregular dense connective tissue; give an example:

- irregular dense connective tissue: collagen fibres running in various directions, fibroblasts, fibrocytes,
- *e.g.* reticular layer of the corium, fibrous capsules of organs,
- regular dense connective tissue: collagen fibres running in parallel bundles, fibroblasts, fibrocytes,
- *e.g.* tendon.

regular dense connective tissue
e.g. tendon

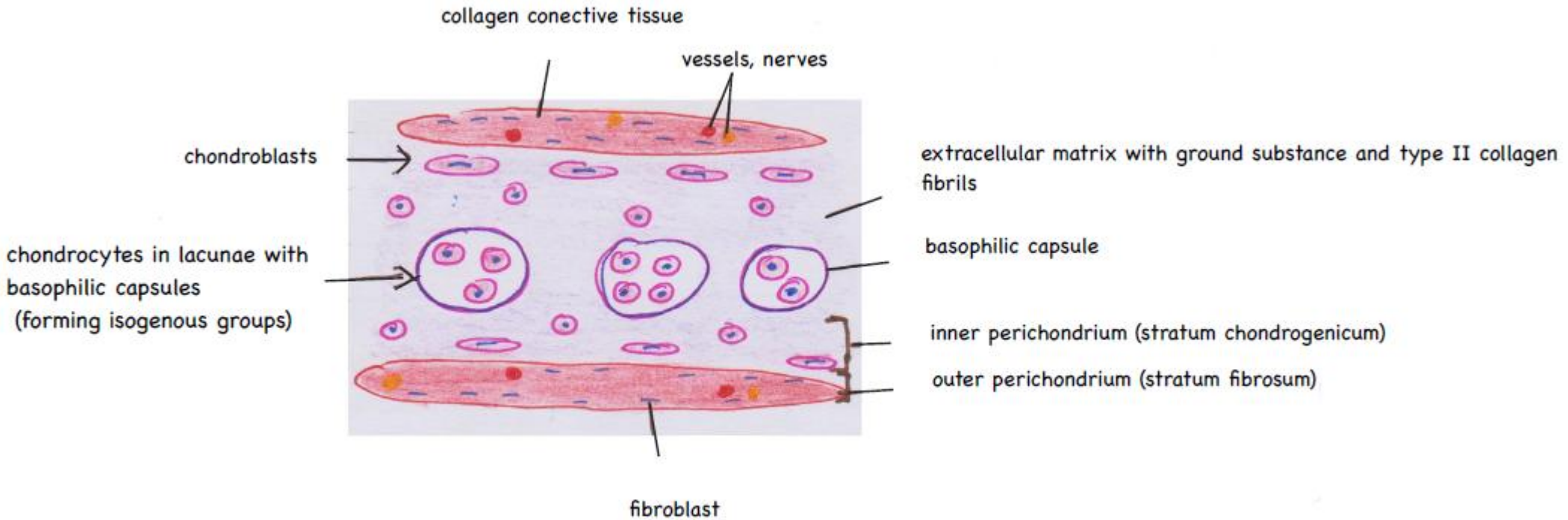


irregular dense connective tissue
e.g. dermis



23. Draw and label hyaline cartilage; give an example:

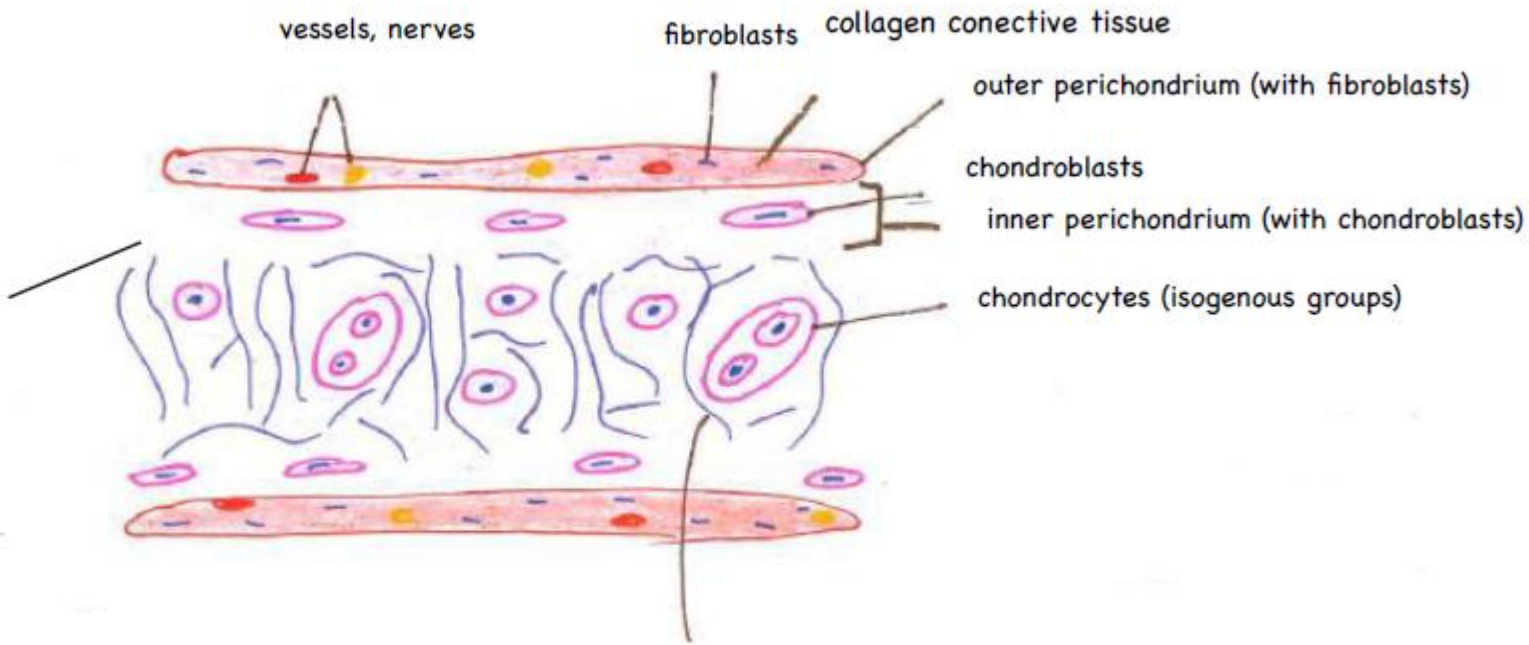
- chondrocytes in lacunae with basophilic capsules, forming isogenous groups,
- extracellular matrix with ground substance and type II collagen fibrils,
- perichondrium: outer layer (stratum fibrosum) – fibroblasts, collagen connective tissue, blood and lymphatic vessels, nerves; inner) layer (stratum chondrogenicum) – chondroblasts,
- *e.g.* trachea.



e.g. trachea

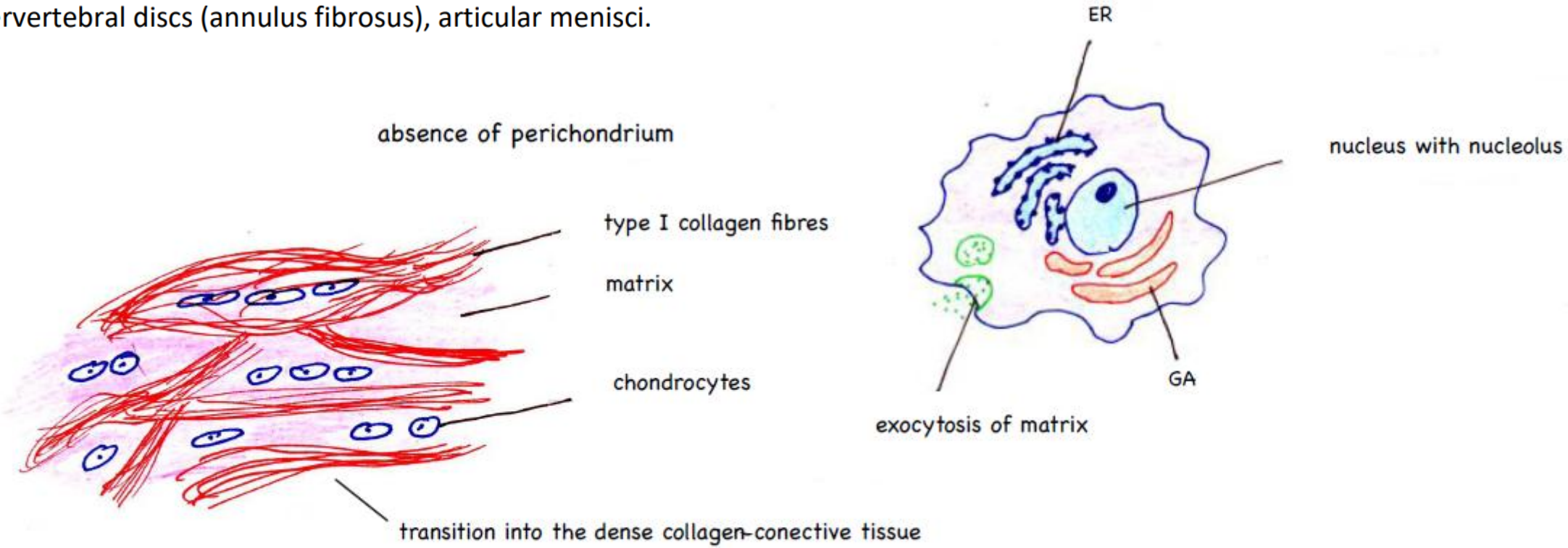
24. Draw and label elastic cartilage; give an example:

- individual chondrocytes or small isogenous groups,
- extracellular matrix with ground substance, elastic fibres, and type II collagen fibres,
- perichondrium: outer layer with fibroblasts, collagen connective tissue, vessels, and nerves; inner layer with chondroblasts,
- *e.g.* auricle, epiglottis.



25. Draw and label fibrous cartilage; give an example; draw and label ultrastructure of chondrocyte:

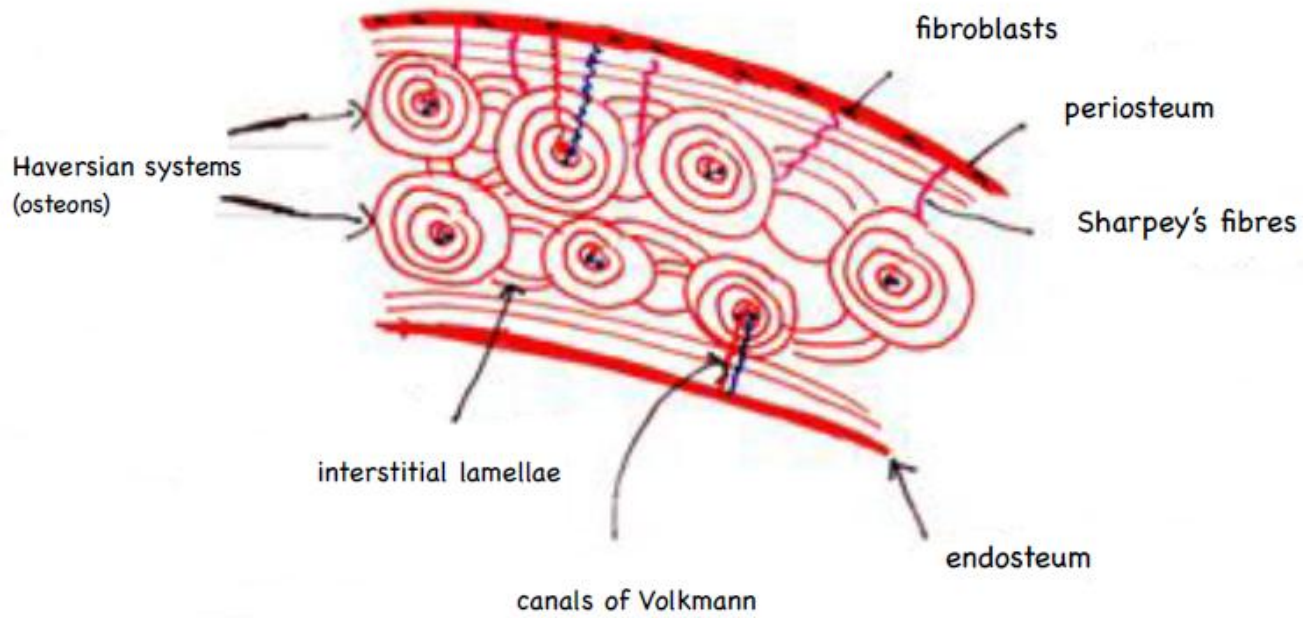
- transition of cartilage into the dense collagen connective tissue at the periphery,
- separated chondrocytes or chondrocytes in linear groups,
- eosinophilic extracellular matrix with type I collagen fibres in form of irregular bundles or parallel bundles,
- chondrocyte ultrastructure: nucleus, rough endoplasmic reticulum, Golgi apparatus, exocytosis of matrix,
- *e.g.* intervertebral discs (annulus fibrosus), articular menisci.

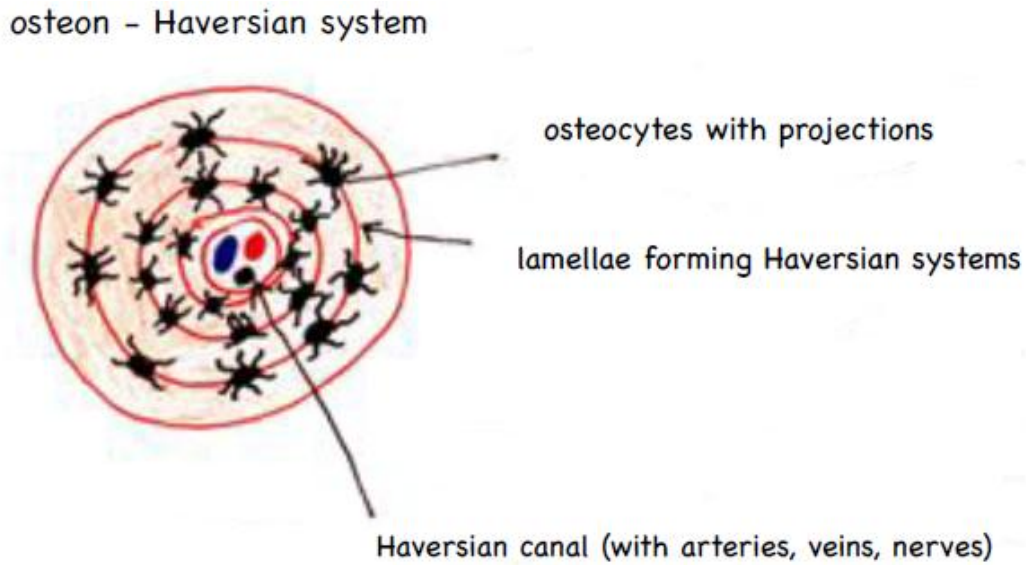


e.g. intervertebral discs (annulus fibrosus),
articular menisci

26. Draw and label histology of compact bone:

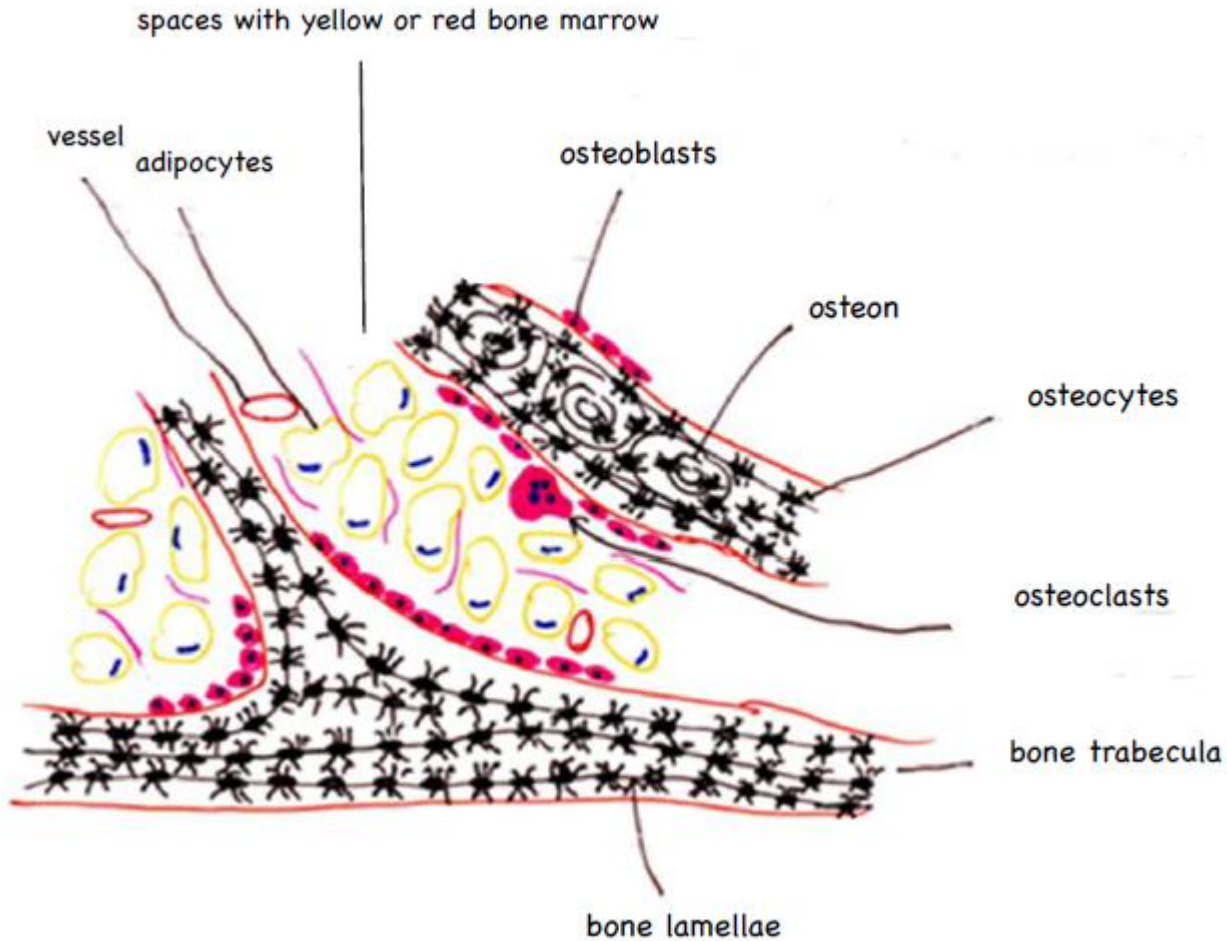
- lamellae forming Haversian systems (osteons), interstitial lamellae, Haversian canal inside osteon,
- osteocytes with projections running through bone canaliculi, transverse and oblique canals of Volkmann,
- periosteum with collagen connective tissue, Sharpey's fibres, and fibroblasts,
- endosteum on the inner bone surface.





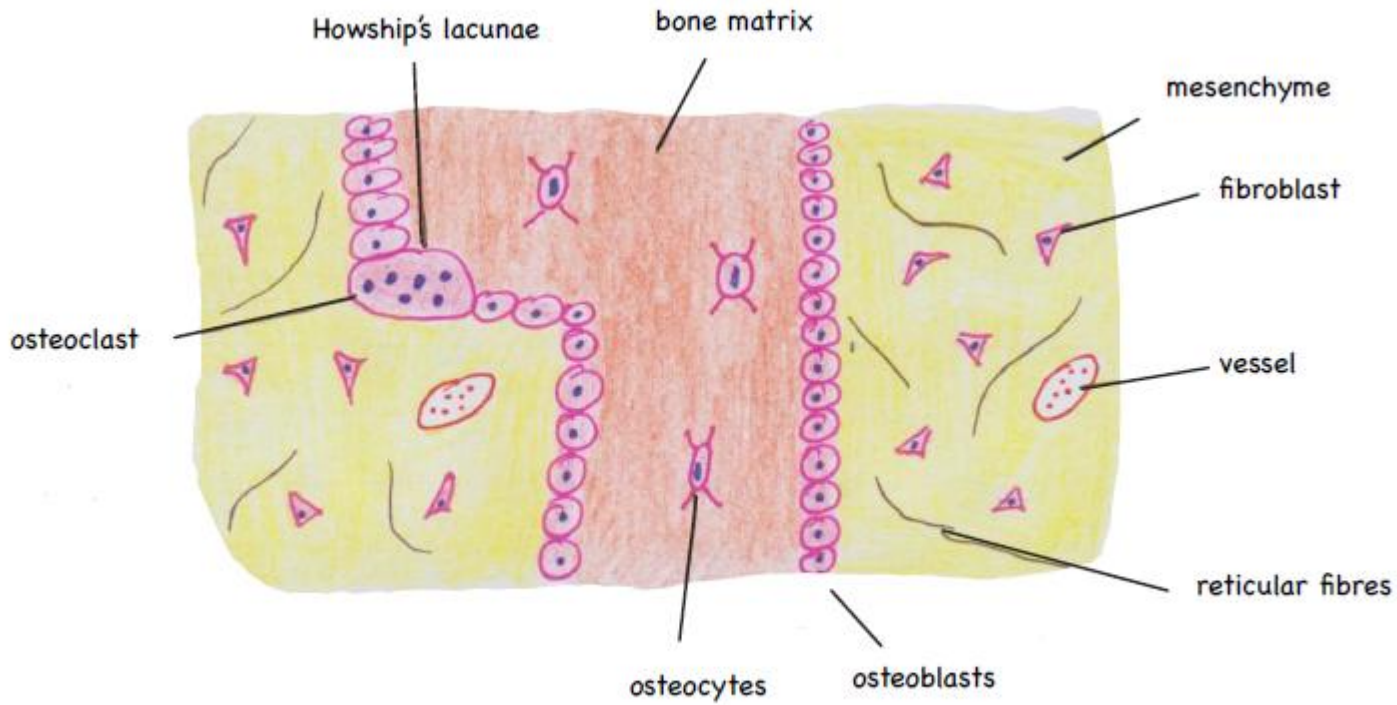
27. Draw and label histology of trabecular (spongy, cancellous) bone:

- branched bony trabeculae composed of lamellar bone,
- osteons in thick trabeculae,
- osteocytes, osteoblasts, osteoclasts,
- spaces among the trabeculae contain either red or yellow bone marrow (adipocytes).



28. Draw and label intramembraneous (desmogenous) ossification; give an example of bone formed via the desmogenous ossification:

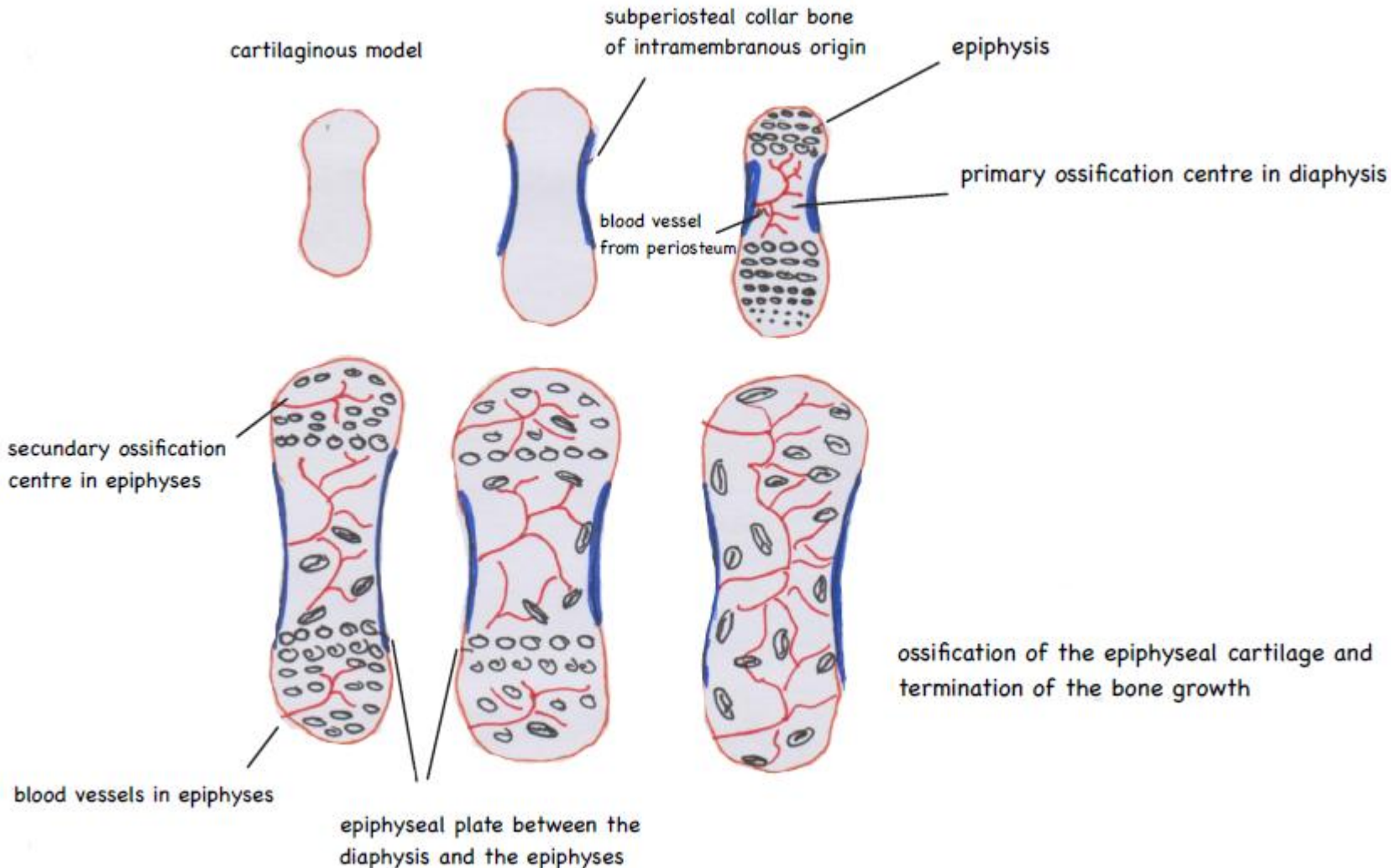
- ossification centres with reticular fibres and fibroblasts gradually differentiate into osteoblasts on the surface of newly formed bone trabeculae, production of unmineralized bone matrix (osteoid), osteocytes surrounded by the bone matrix,
- connective tissue proper among the bone trabeculae, blood vessels,
- osteoclasts in erosion (Howship´s) lacunae on the surface,
- *e.g.* flat cranial bones, upper and lower jaw.



e.g. flat cranial bones, upper and lower jaw

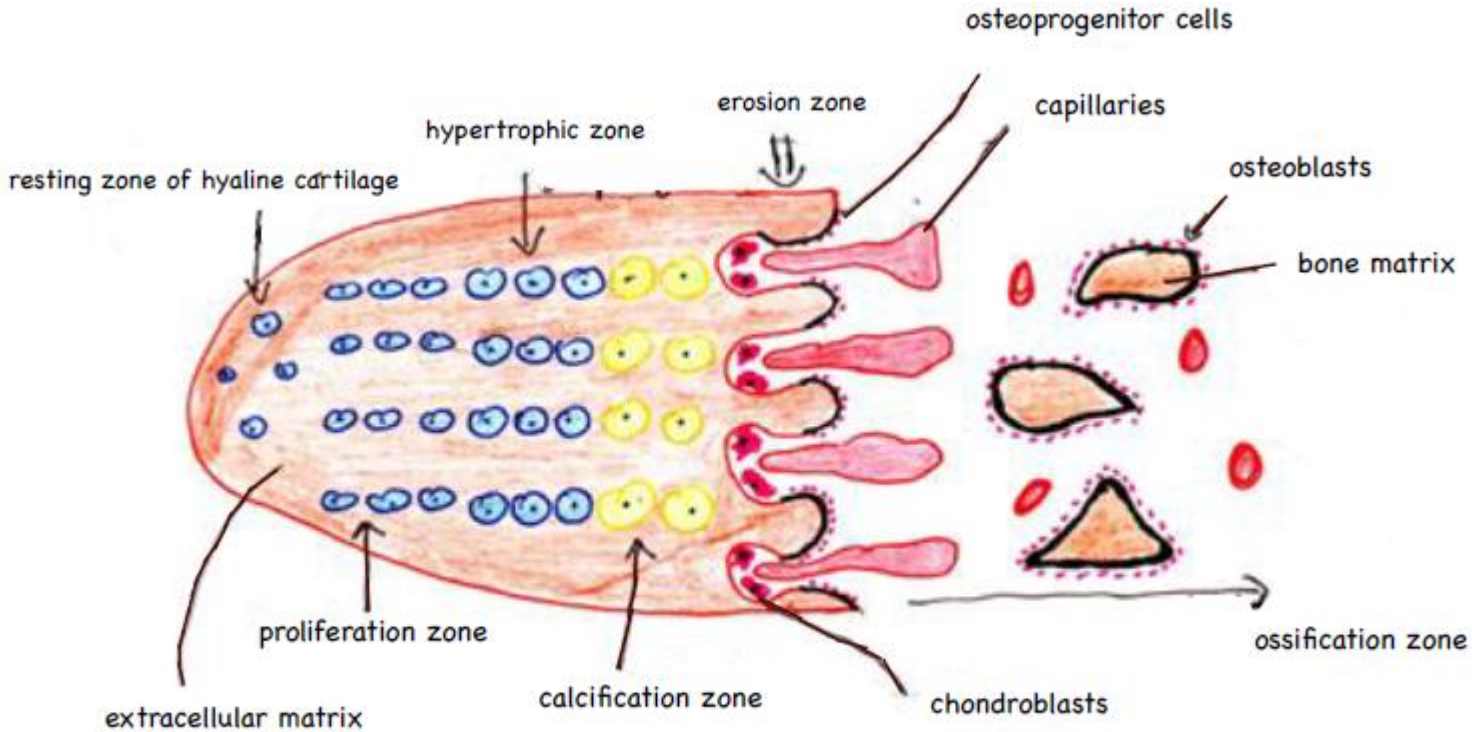
29. Draw and label ossification of a long bone as a whole – stages of long bone formation:

- cartilaginous model, subperiosteal collar bone of intramembranous origin in the extent of the diaphysis,
- primary ossification centre in diaphysis, blood vessels in diaphysis,
- secondary ossification centres in epiphyses, blood vessels in diaphysis,
- epiphyseal plates between the diaphysis and the epiphyses,
- ossification of the epiphyseal cartilage and termination of the bone growth.



30. Draw and label zones of epiphyseal growth cartilage; give an example of bone formed via chondrogenous ossification:

- resting zone of hyaline cartilage,
- proliferation zone with rapidly divided chondroblasts forming columns,
- hypertrophic zone with huge chondrocytes,
- calcification zone,
- erosion zone/line with blood capillaries, chondroclasts, and osteoprogenitor cells,
- ossification zone with newly formed bone trabeculae, osteoblasts producing bone matrix,
- *e.g.* bones of upper and lower limbs, vertebrae, ribs, pelvic bones.



e.g. bones of upper and lower limbs, vertebrae, ribs, pelvic bone

31. Draw (including their appropriate staining) and label erythrocytes – morphology (including their size) and number in men and women in peripheral blood:

- size: 7.5 µm x 2.5 µm, morphology: biconcave disc without a nucleus,
- 4.0-5.8 millions/mm^3 in men; 3.8-5,2 millions/mm^3 in women,
- eosinophilic cytoplasm.

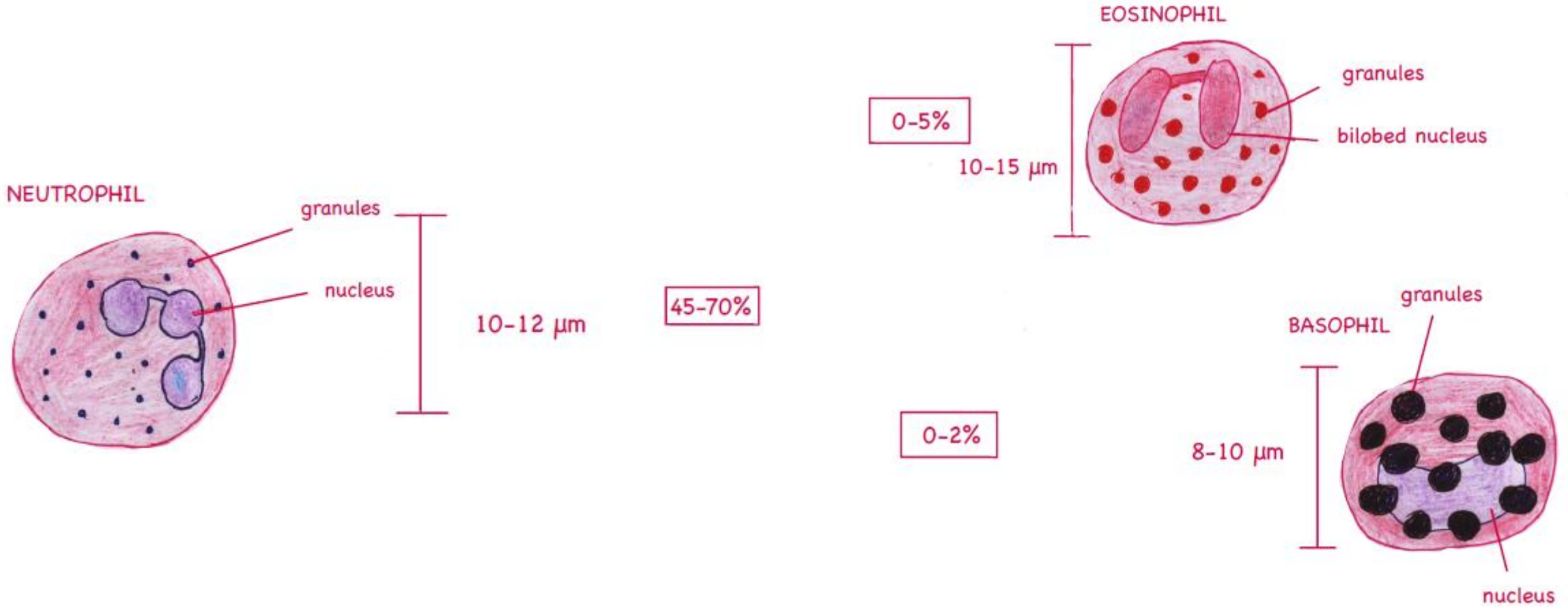
2.5 µm

Men – 4 – 5.8 x $10^6/mm^3$
Women – 3.8 – 5.2 x $10^6/mm^3$

7.2–7.5 µm

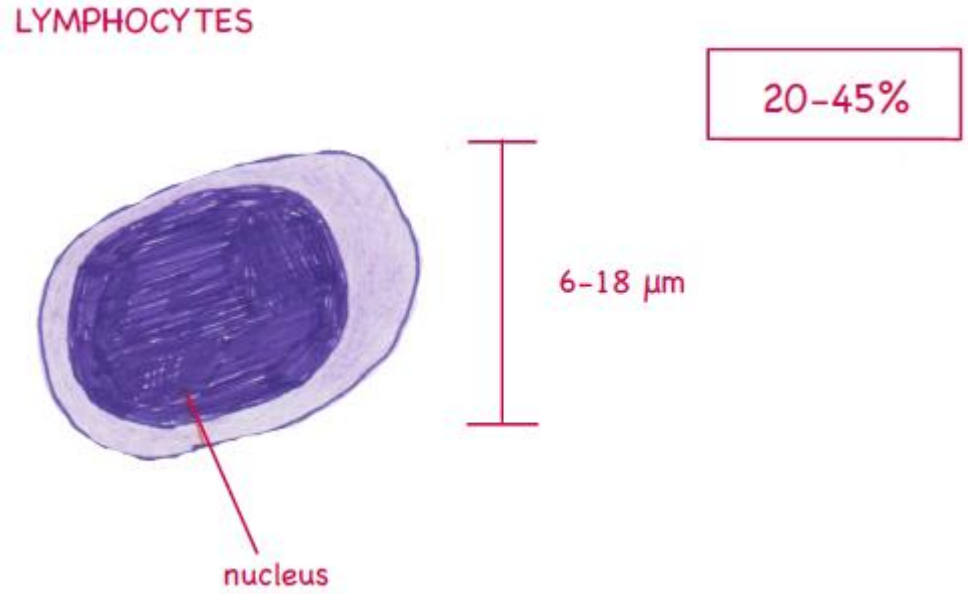
32. Draw (including their appropriate staining) and label granulocytes – morphology (including their size) and differential count (the percentage ranges given for each type of leukocyte):

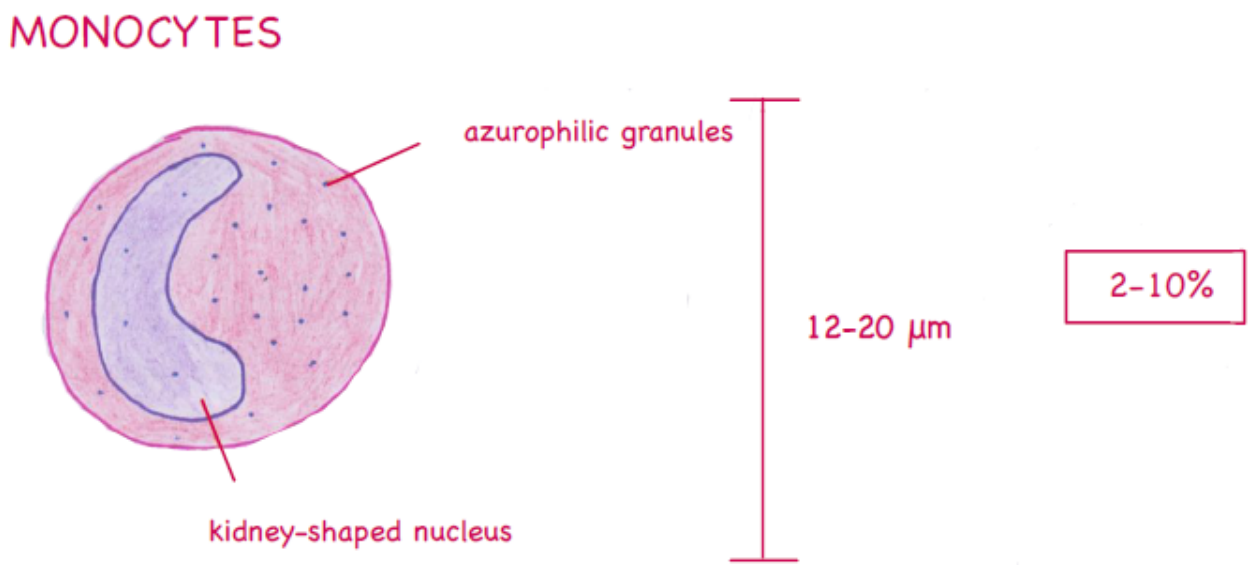
- neutrophils (45-70%), size: 10-12 µm, morphology: granules smaller then in basophils and eosinophils with limited affinity to stain, segmented nucleus,
- eosinophils (0-5%), size: 10-15 µm, morphology: bilobed nucleus, large red granules (take up reddish/orange colour),
- basophils (0-2%), size: 8-10 µm, irregular shape of nucleus, large basophilic granules.

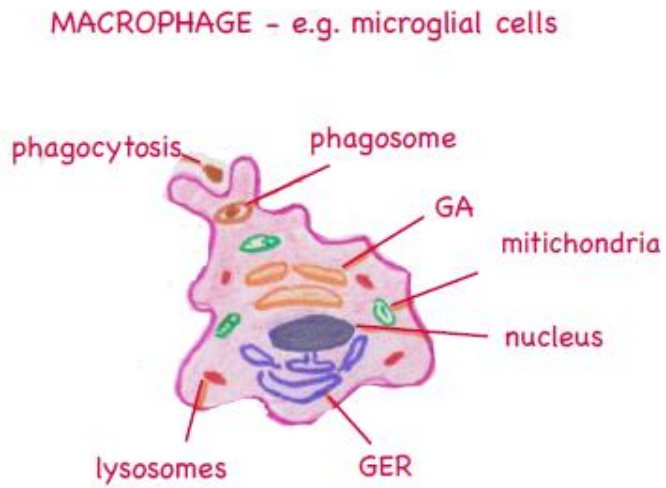


33. Draw (including their appropriate staining) and label agranulocytes – morphology (including their size) and differential count (the percentage ranges given for each type of leukocyte); draw and name 1 type of macrophage:

- lymphocytes (20-45%), size: 6-18 µm, morphology: large nucleus almost fills the cell, thin rim of cytoplasm,
- monocytes (2-10%), size: 12-20 µm, morphology: kidney-shaped nucleus, azurophilic granules (lysosomes),
- macrophage: osteoclasts, microglial cells, or wandering cell of connective tissue proper.

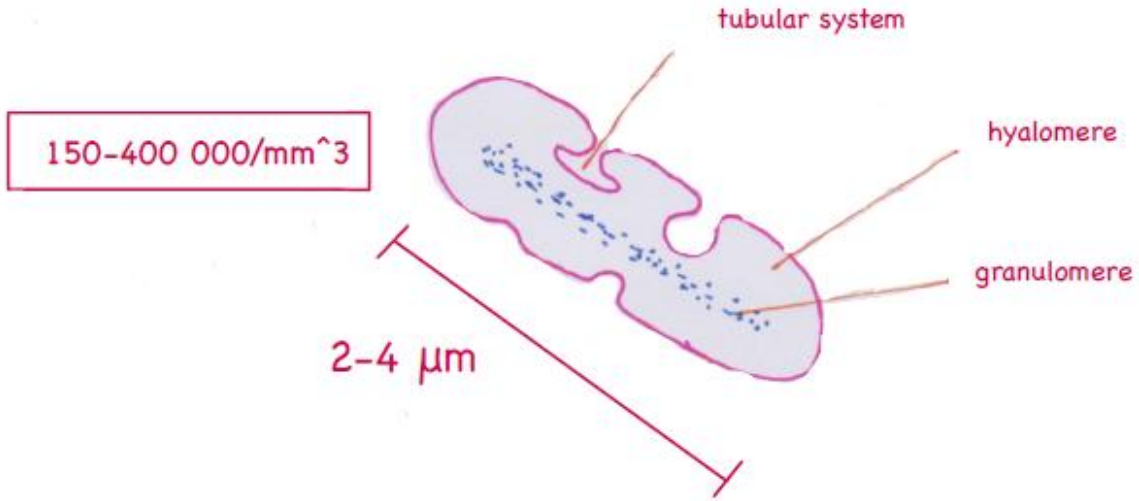


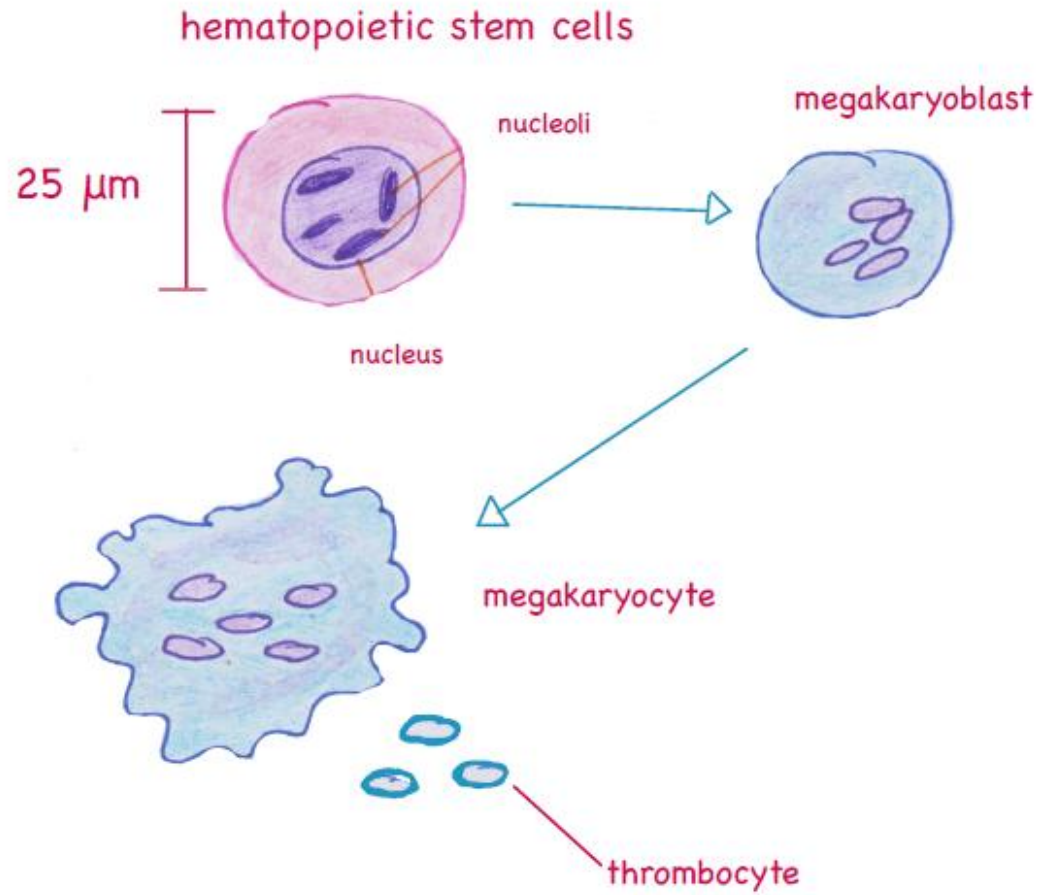




34. Draw and label thrombopoiesis and blood platelets – morphology (including their size) and number in peripheral blood:

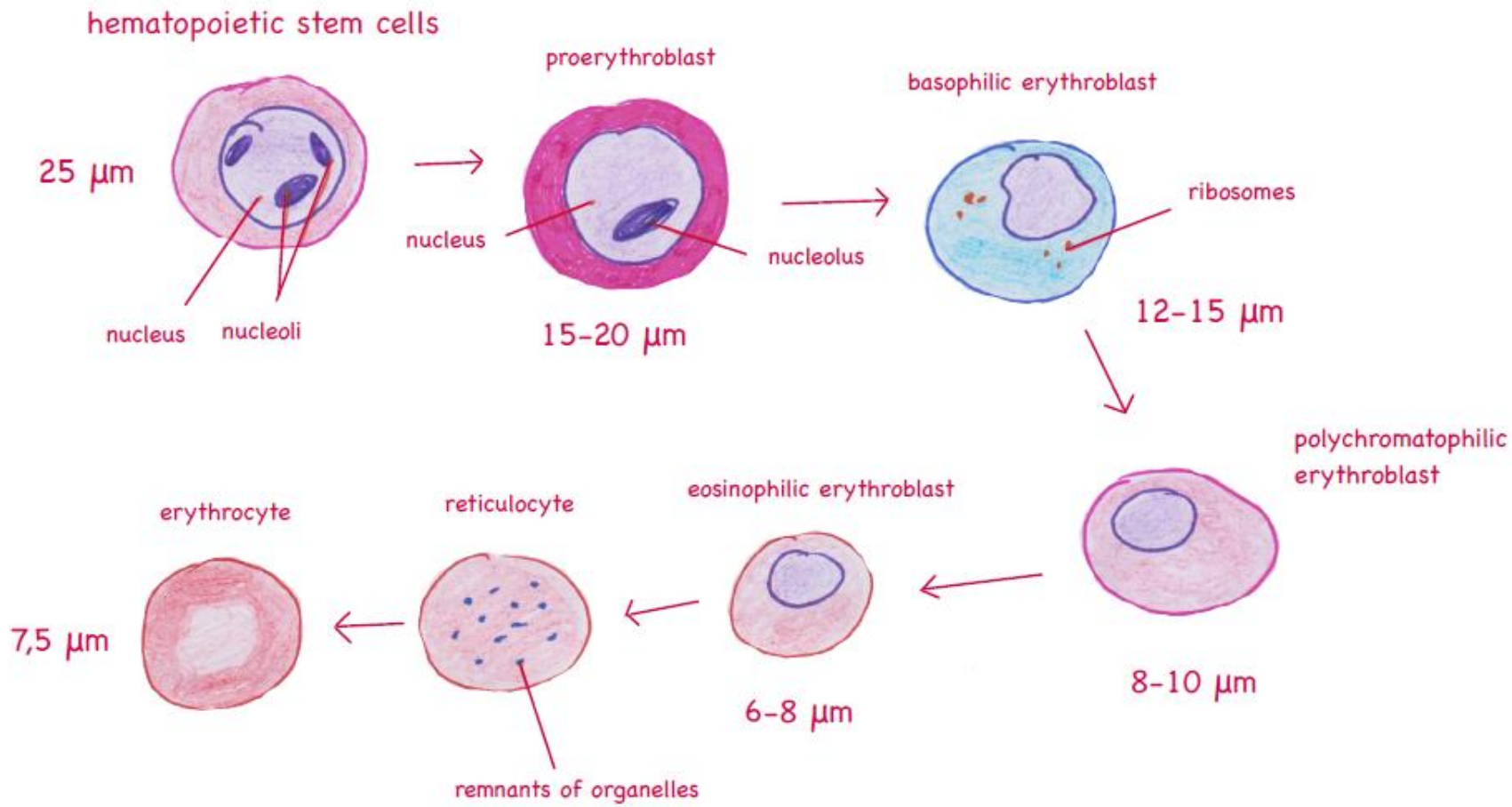
- oval-shaped thrombocyte without nucleus, size: 2-4 µm, morphology: hyalomere and granulomere, tubular system,
- thrombopoiesis: hematopoietic stem cells/hemocytoblast (25 µm, rounded nucleus, nucleoli), megakaryoblast, megakaryocyte, thrombocyte,
- 150 000-400 000/mm^3 of peripheral blood.





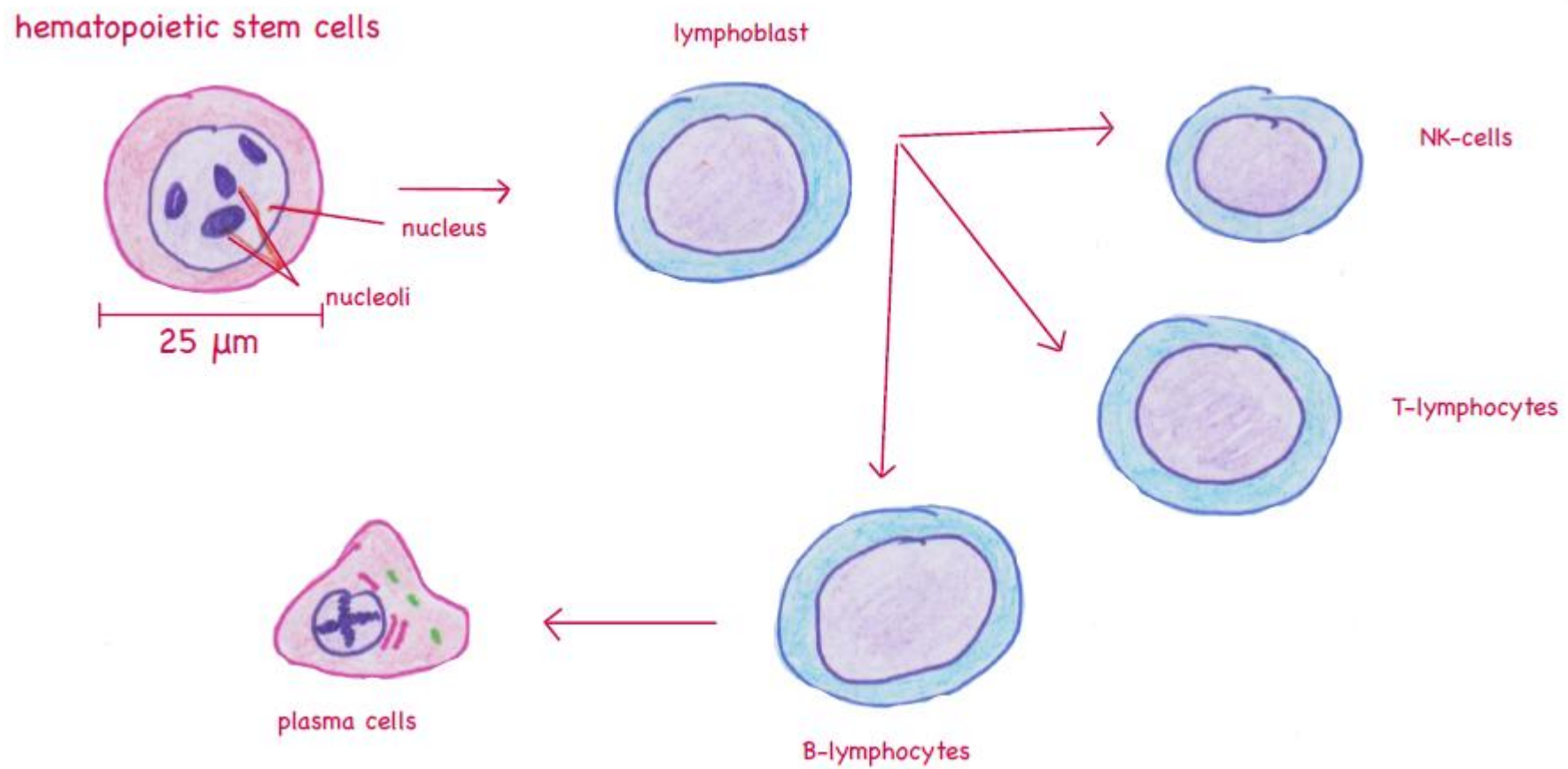
35. Draw (including appropriate staining and size) and label erythropoiesis:

- hematopoietic stem cells (HSC)/hemocytoblast: 25 µm, rounded nucleus, nucleoli,
- proerythroblast: 15-20 µm, purple cytoplasm, nucleus, nucleolus,
- basophilic erythroblast: 12-15 µm, blue cytoplasm, ribosomes,
- polychromatophilic erythroblast: 8-10 µm, purple to pink cytoplasm,
- orthochromatophilic (eosinophilic) erythroblast: 6-8 µm, pinkish to reddish cytoplasm,
- reticulocyte: remnants of organelles (ribosomes, endoplasmic reticulum), no nucleus,
- erythrocyte: 7,5 µm, eosinophilic.



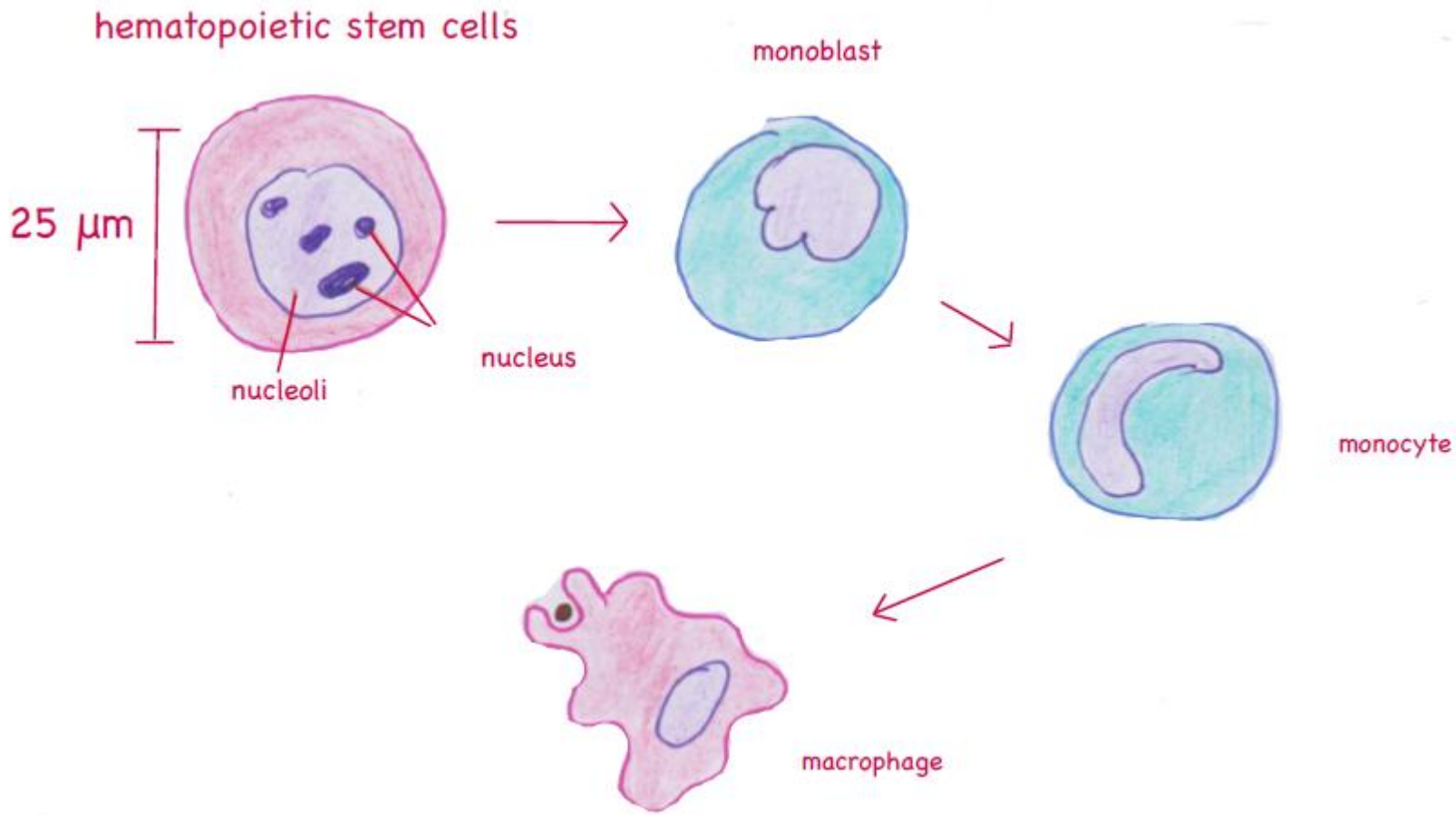
36. Draw and label lymphopoiesis:

- hematopoietic stem cells (HSC)/hemocytoblast: 25 µm, rounded nucleus, nucleoli,
- lymphoblast,
- T- and B-lymphocytes (plasma cells differentiating from B-lymphocytes), NK cells.



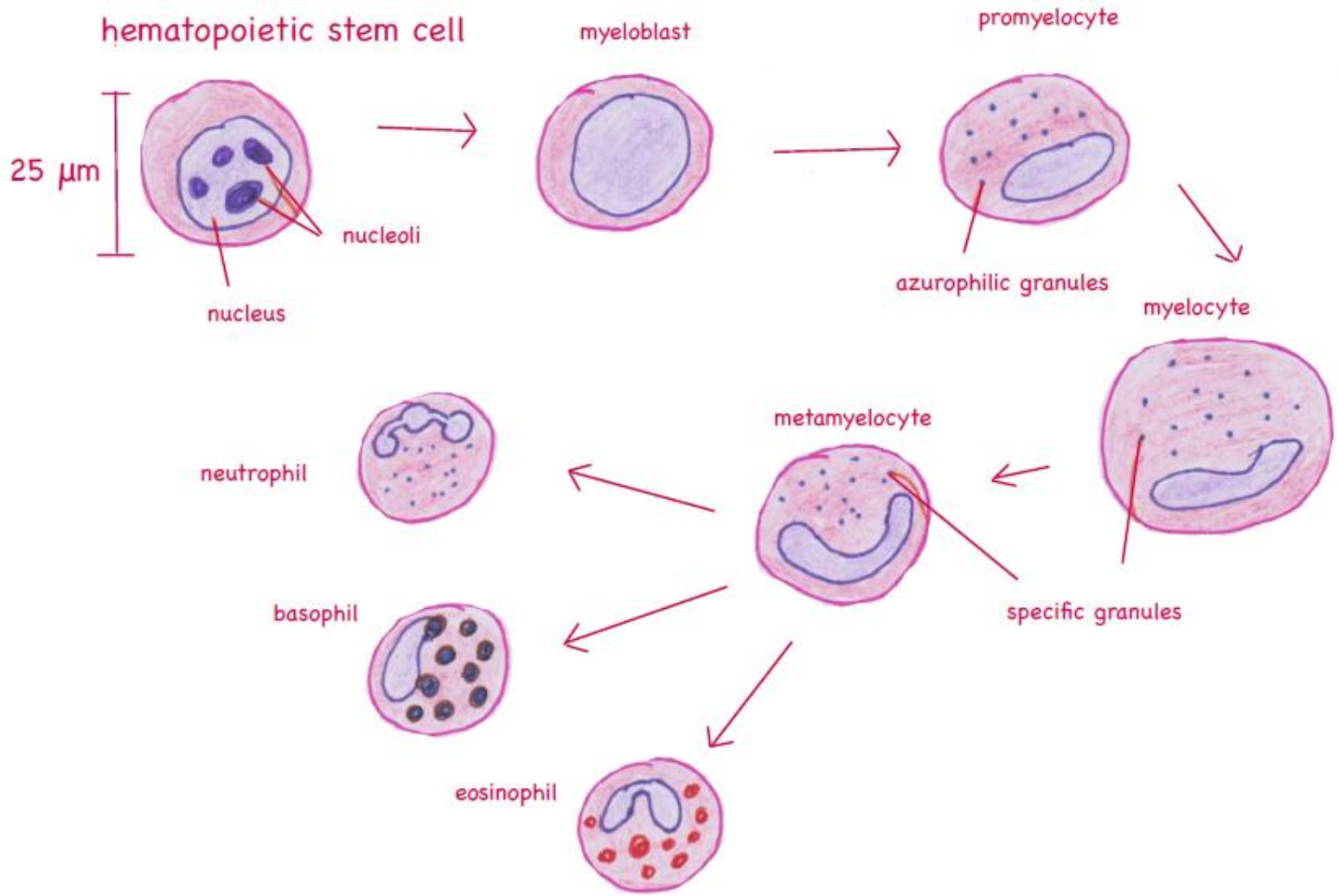
37. Draw and label monopoiesis (monocytopoiesis):

- hematopoietic stem cells (HSC)/hemocytoblast: 25 µm, rounded nucleus, nucleoli,
- monoblast,
- monocyte,
- macrophage in tissue.



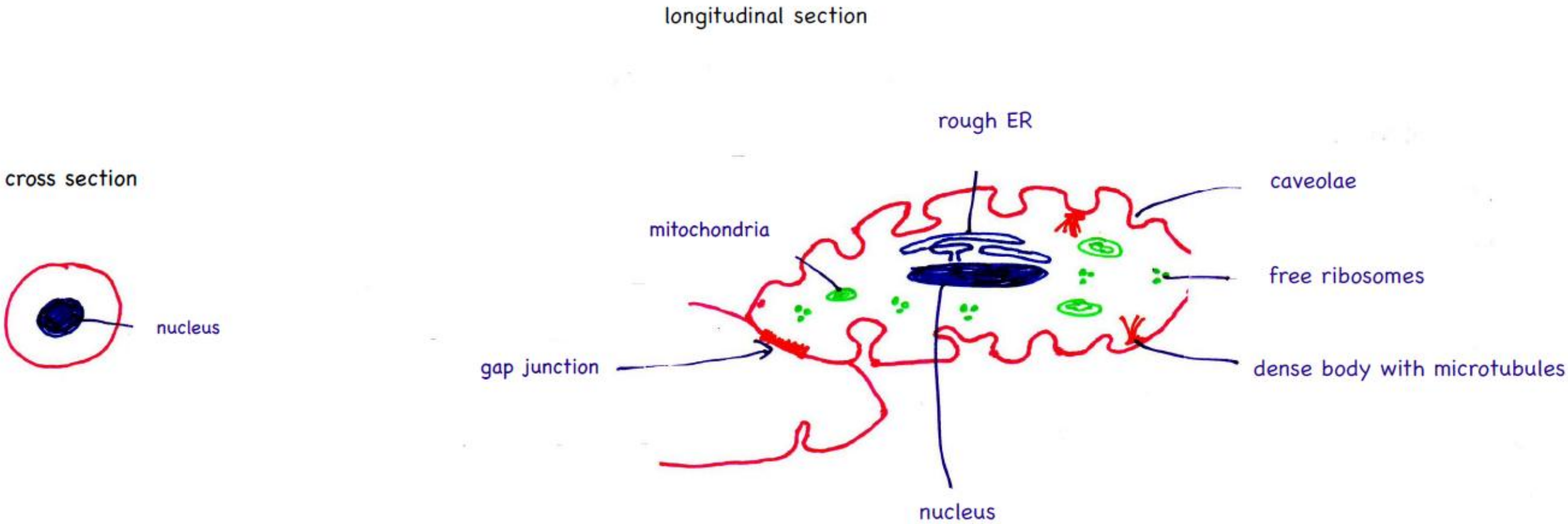
38. Draw and label granulopoiesis (granulocytopoiesis):

- hematopoietic stem cells (HSC)/hemocytoblast: 25 µm, rounded nucleus, nucleoli,
- myeloblasts,
- promyelocytes with azurophilic granules,
- myelocytes with specific granules,
- metamyelocytes,
- neutrophils, eosinophils, basophils.



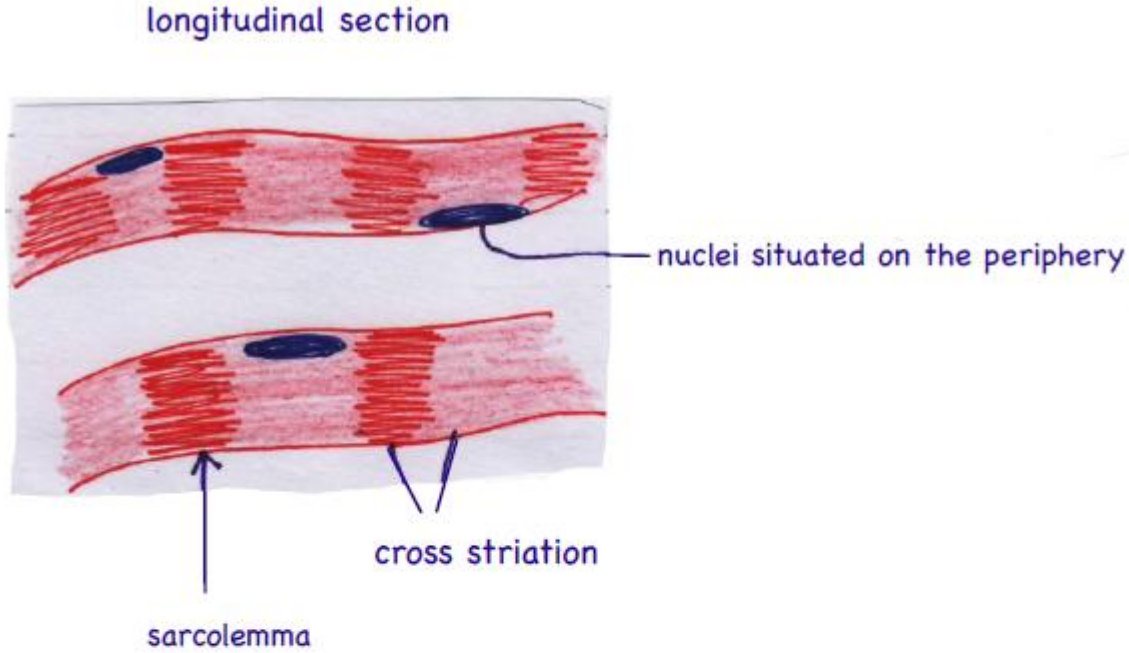
39. Draw and label smooth muscle cell, 2 schemes with a longitudinal and a cross-section:

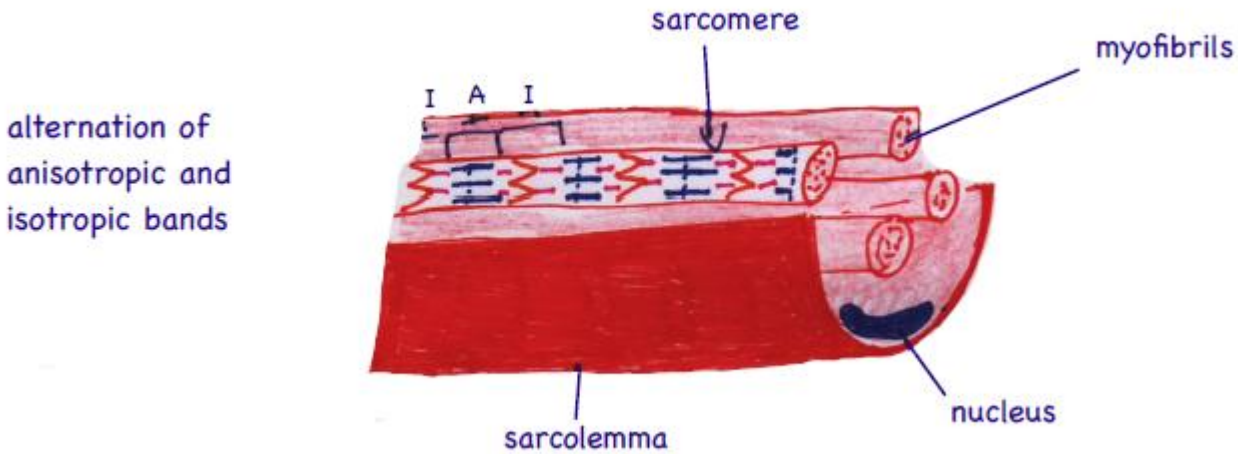
- longitudinal section: long, spindle-shaped cell and nucleus, nucleus in central position, caveolae, microtubules,
- free ribosomes, rough endoplasmic reticulum, mitochondria, gap junctions,
- cross section: smooth muscle cell with 1 central nucleus.

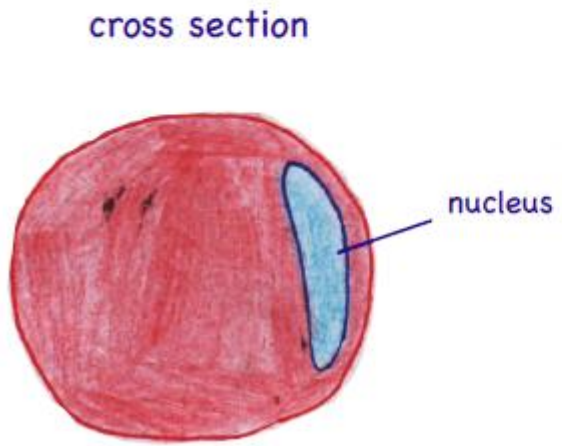


40. Draw and label skeletal muscle fibre, 2 schemes with a longitudinal and cross-section:

- longitudinal section: sarcolemma, myofibrils, sarcomere, nuclei situated on the periphery,
- cross striation, alternation of anisotropic and isotropic bands,
- cross section: skeletal muscle fibre with nuclei on periphery.

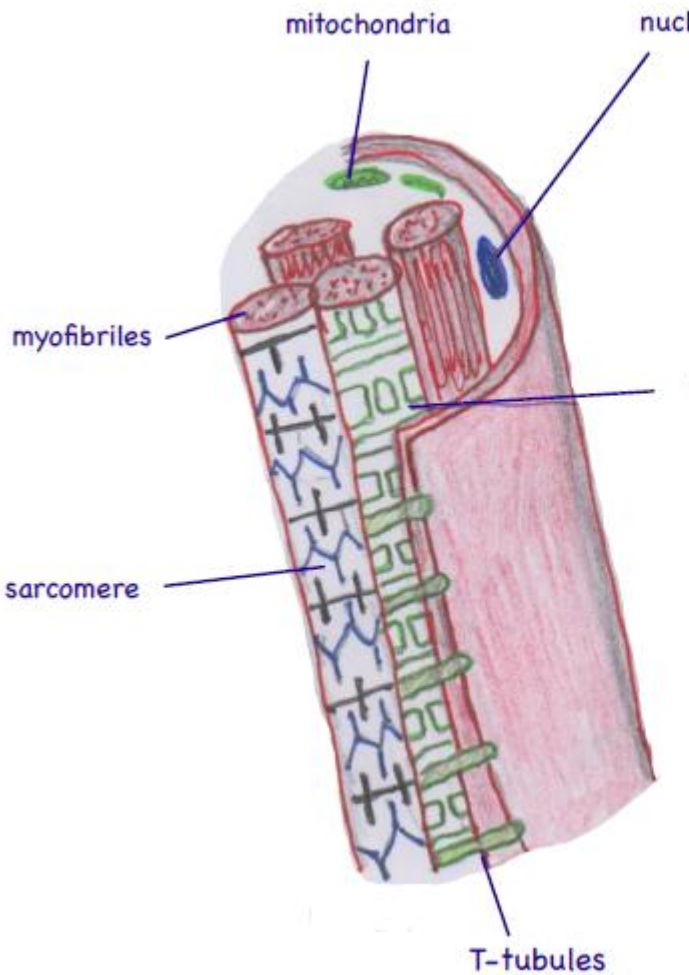


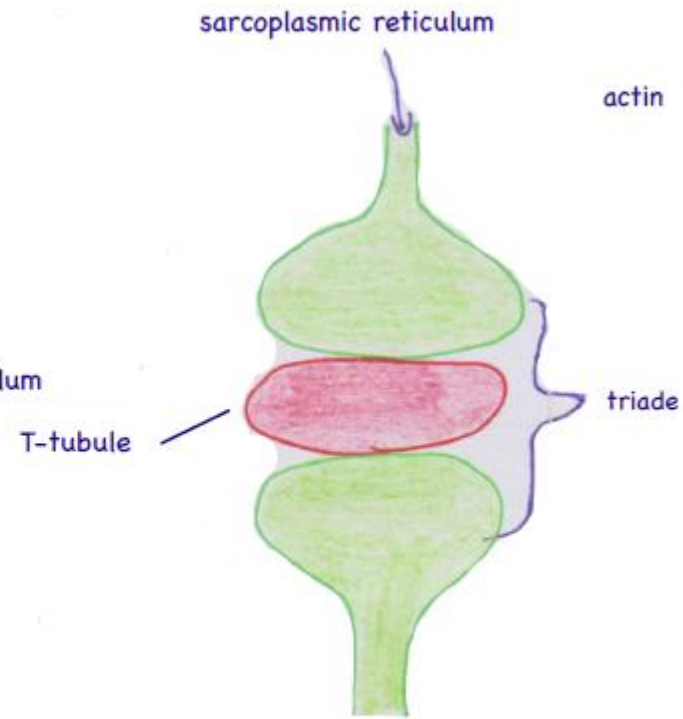


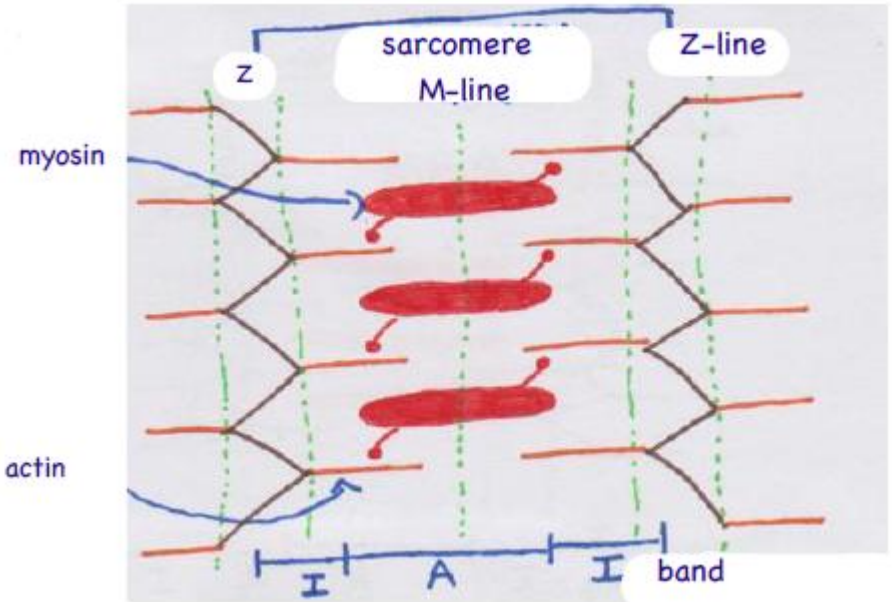


41. Draw and label ultrastructure of skeletal muscle fibre including scheme of a sarcomere and a triade:

- Z lines bordering the sarcomere, actin anchored to Z-lines, myosin,
- A-band, I-band, M-line,
- a triade consisting of T-tubule invaginating towards the terminal cisterns of sarcoplasmic reticulum,
- nuclei on the periphery, mitochondria in sarcoplasm.

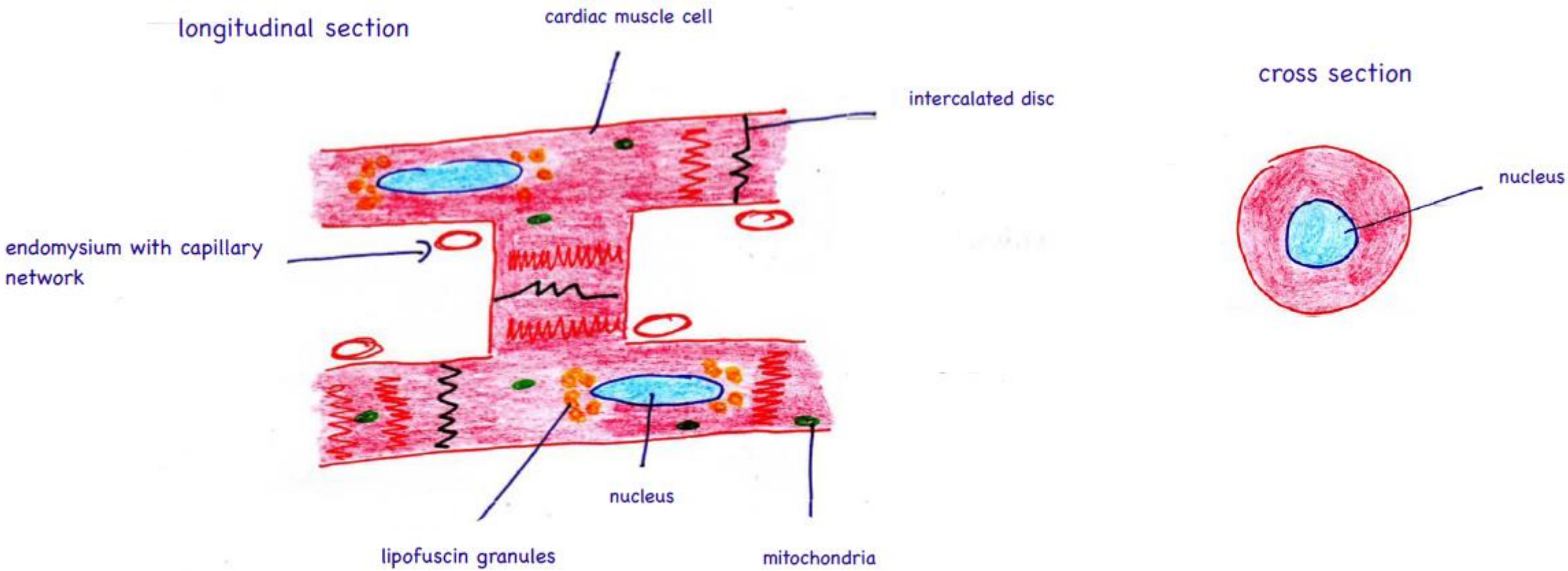






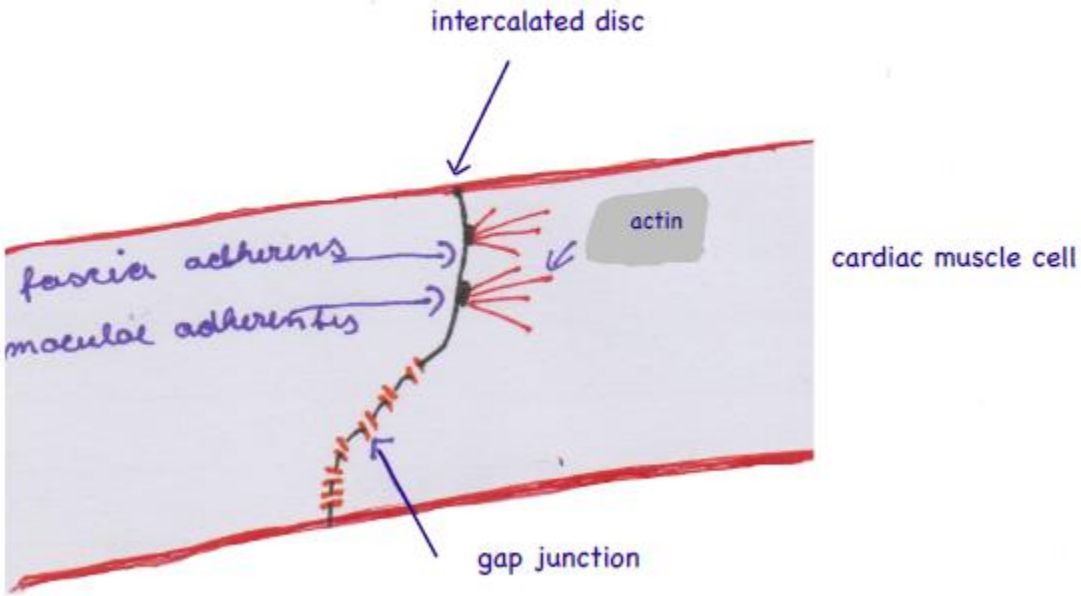
42. Draw and label cardiac muscle, 2 schemes with a longitudinal and cross section:

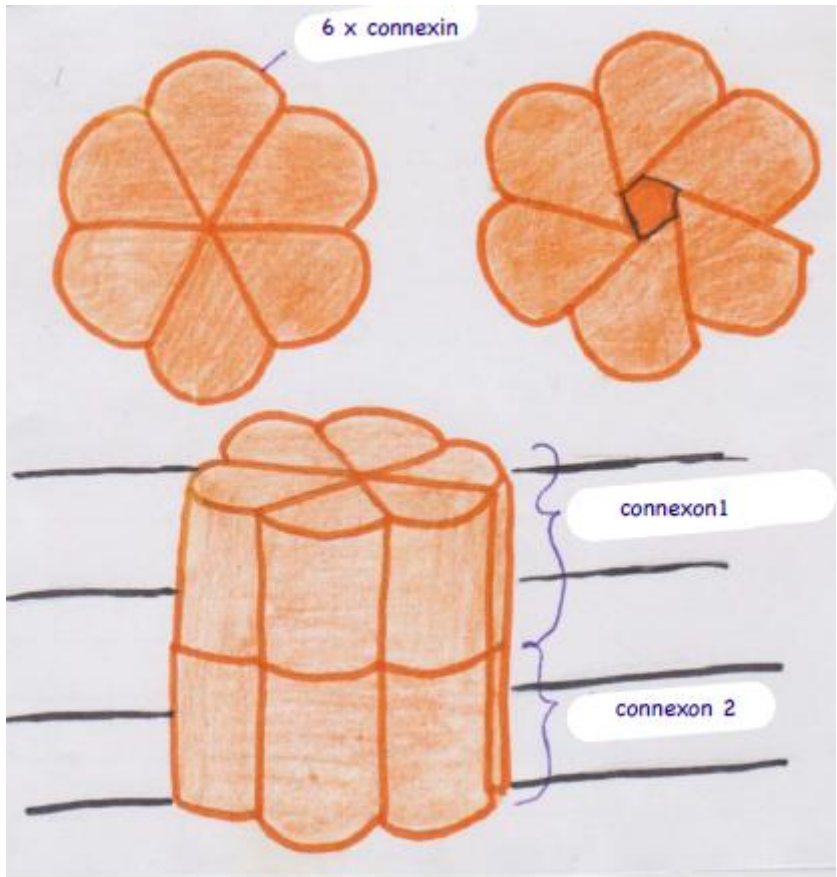
- longitudinal section: cardiac muscle cells, intercalated discs, central position of nucleus, lipofuscin granules near the poles of nuclei, mitochondria,
- endomysium with very dense capillary network,
- cross section: cardiac muscle cell with central nucleus.



43. Draw and label ultrastructure of the intercalated disc:

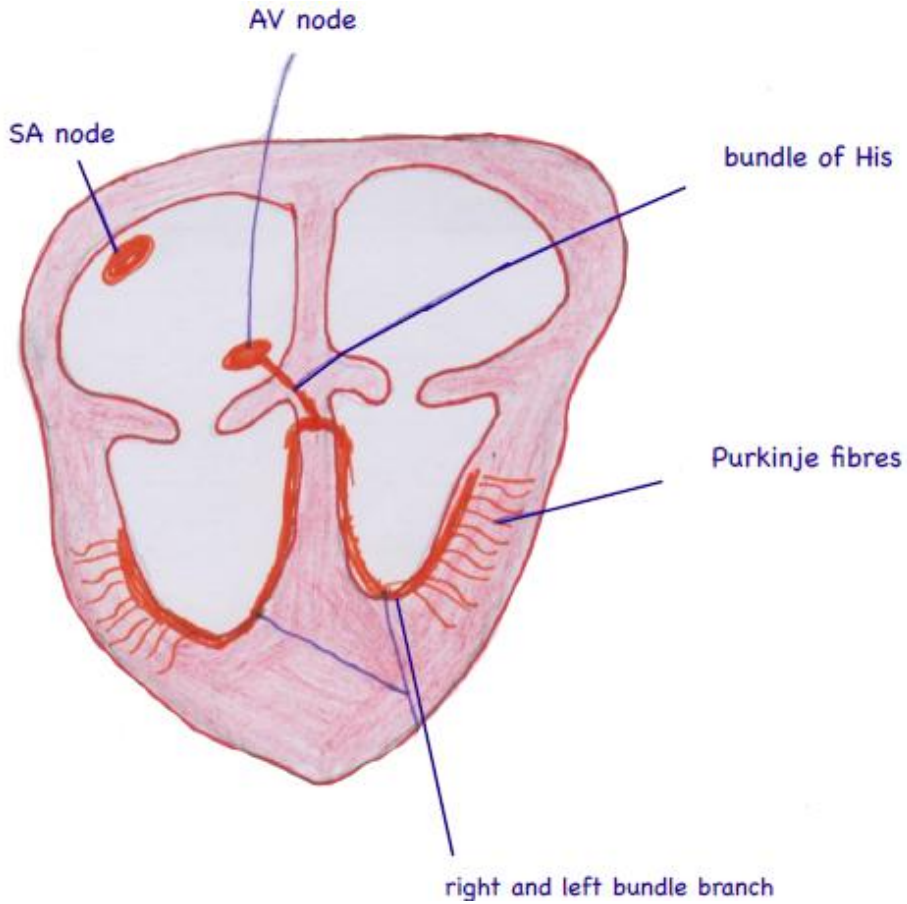
- maculae adherentes (desmosomes): make tissue coherent,
- zonula adherens (adhesive belt): connected to actin filaments,
- gap junction (nexus): two connexons of adjacent cells with a channel inside; each connexon consisting of six molecules of connexin protein.

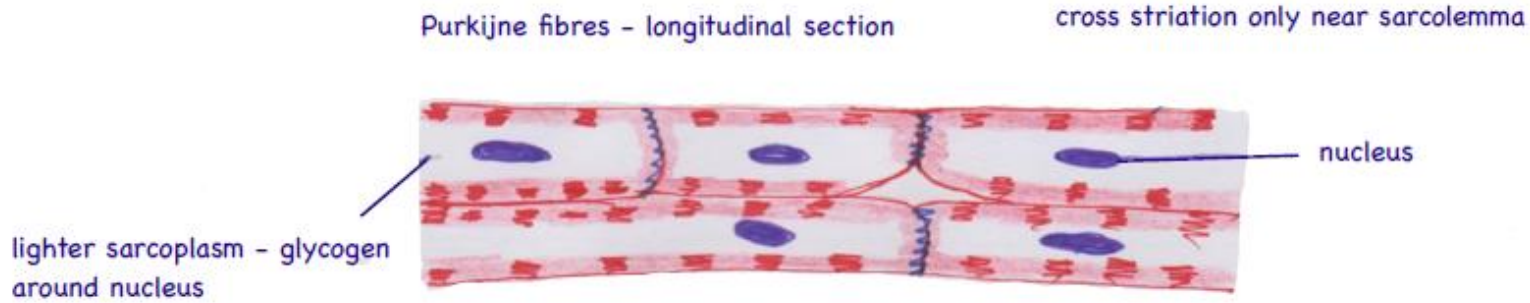




44. Draw and label cardiac conducting system including histology of the terminal part of this system:

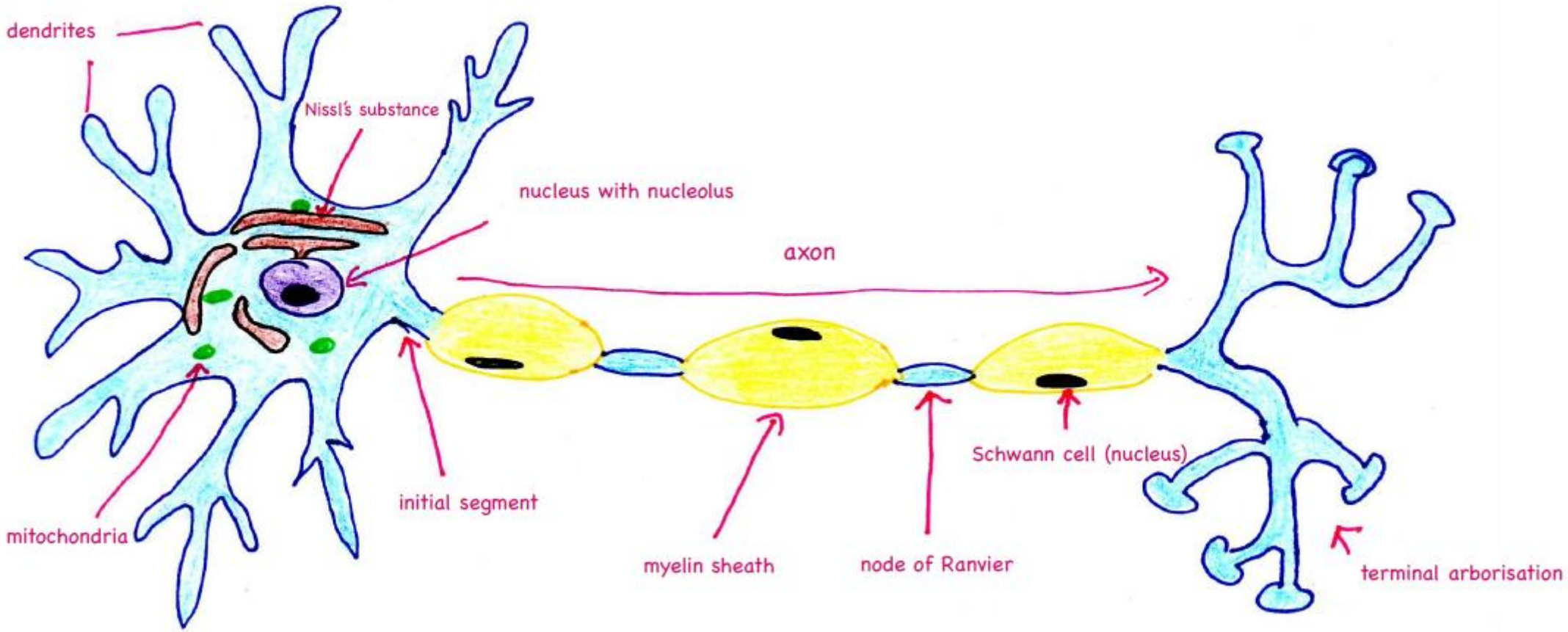
- sinoatrial and atrioventricular node,
- bundle of His, right and left bundle branch,
- Purkinje fibres: histology: less myofibrils, lighter sarcoplasm – glycogen around the nucleus, larger diameter then normal cardiomyocytes.





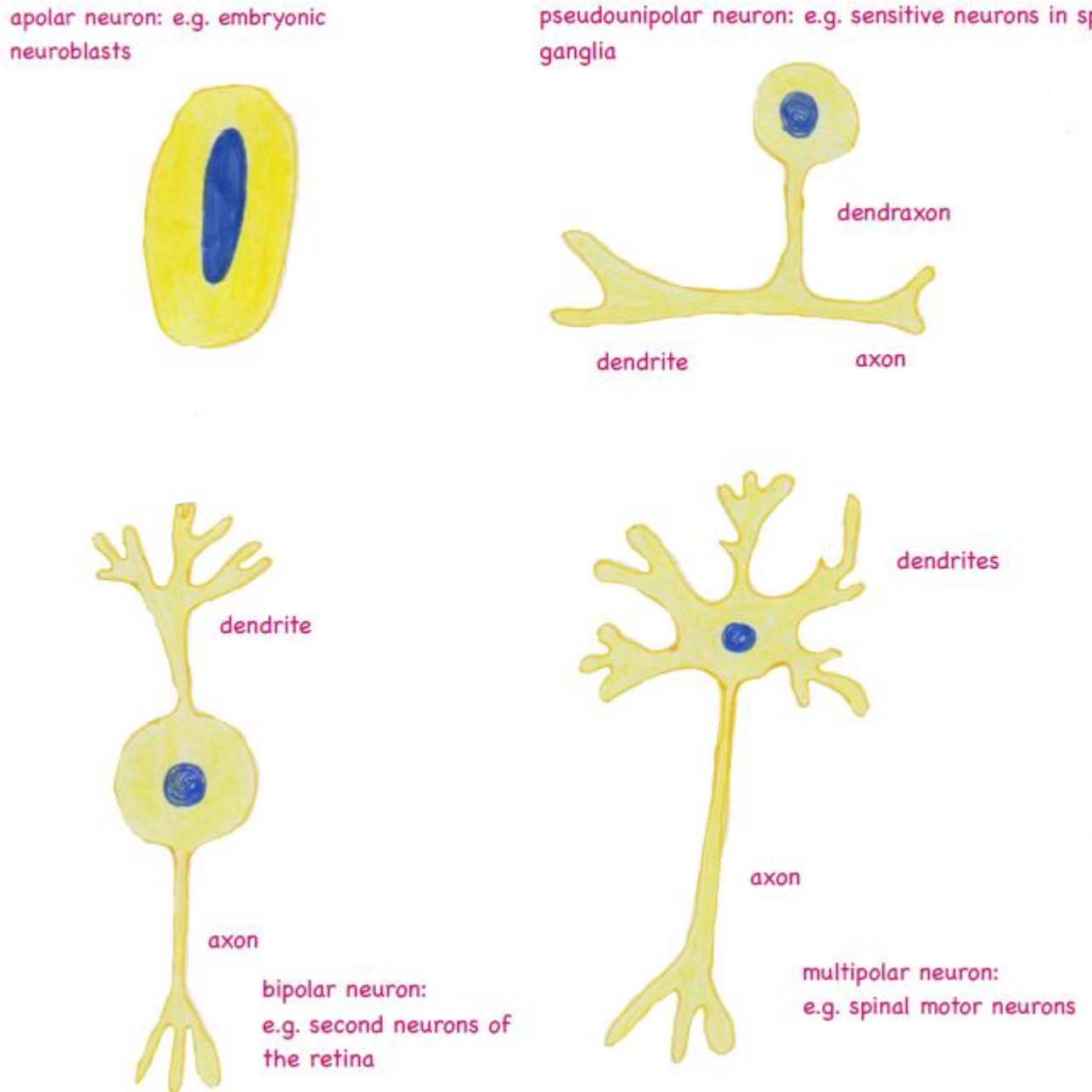
45. Draw and label a neuron:

- nerve cell body (perikaryon), nucleus, nucleolus, Nissl's substance (rough endoplasmic reticulum), mitochondria,
- dendrites, axon, initial segment,
- myelin sheath, node of Ranvier, Schwann cells, terminal arborisation – branching of the axon on the effector.



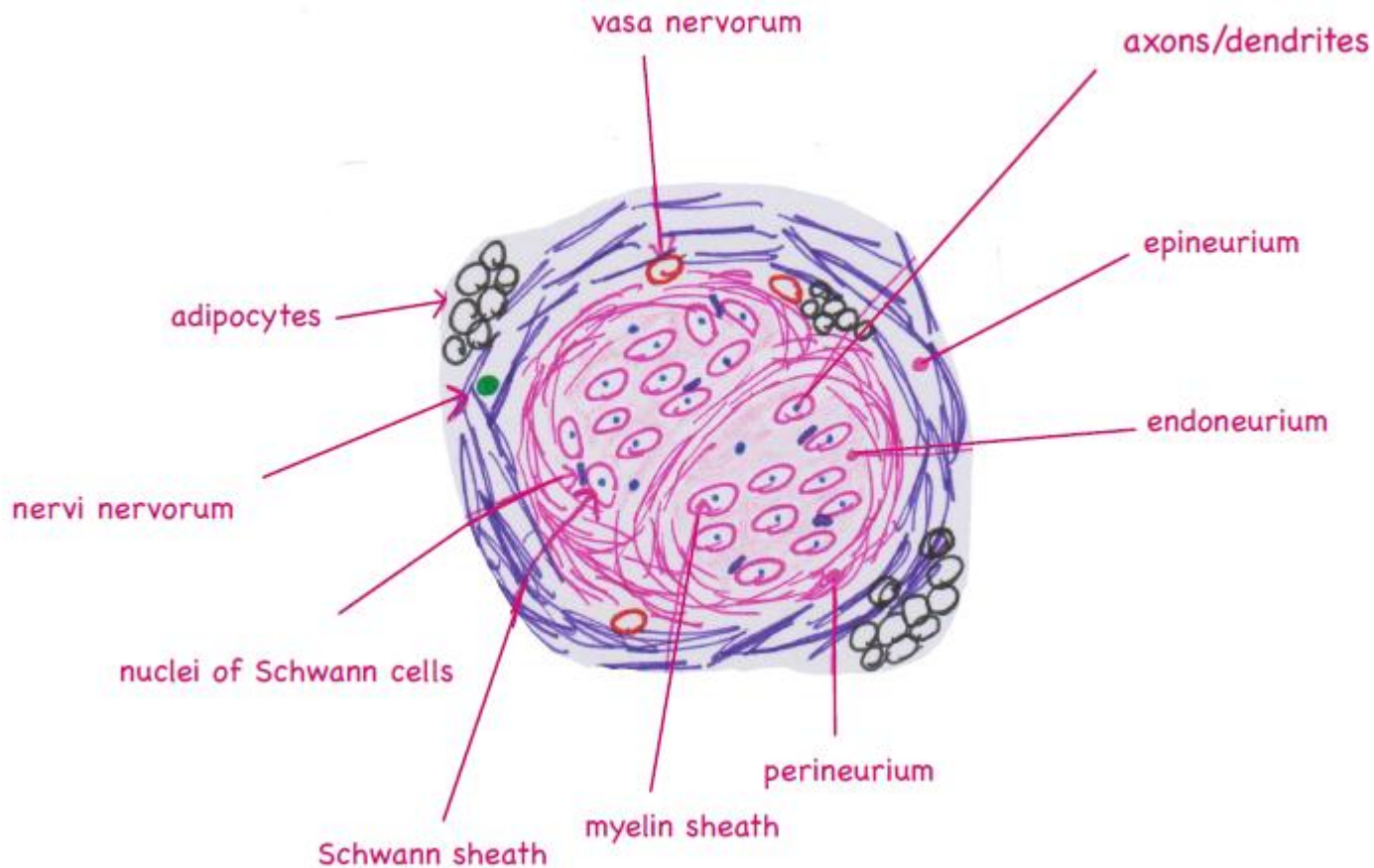
46. Draw and label types of neurons according to the number of processes. Label neuron processes in all schemes. Give examples:

- apolar: embryonic neuroblasts,
- bipolar: second neurons of the retina,
- pseudounipolar: sensitive neurons in spinal ganglia,
- multipolar: spinal motor neurons in ventral horns.



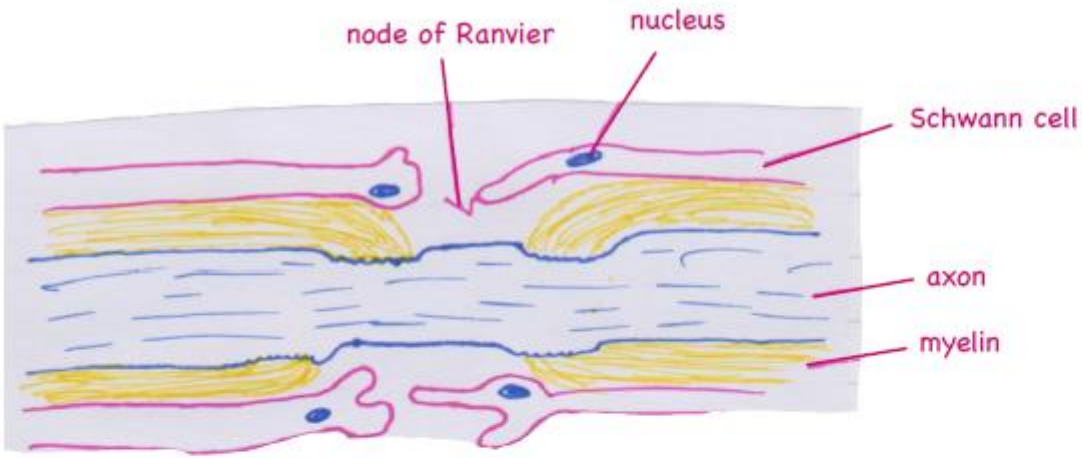
47. Draw and label histological structure of peripheral nerve:

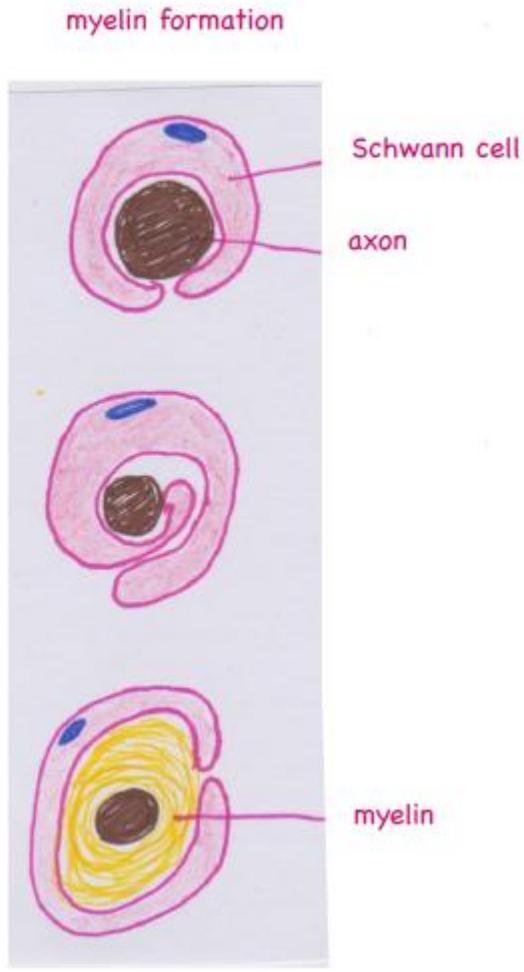
- epineurium, perineurium, endoneurium,
- axons and dendrites, myelin sheath, Schwann cells, nuclei of Schwann cells,
- vasa nervorum, nervi nervorum.

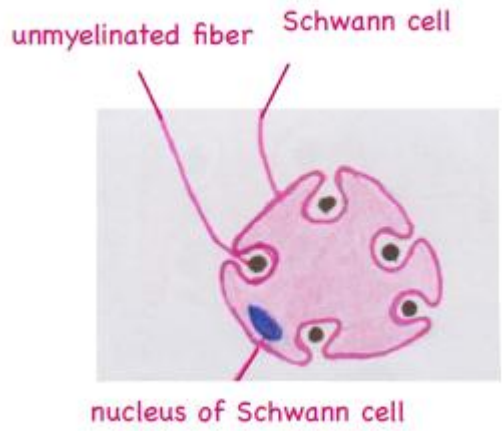


48. Draw and label myelinated and unmyelinated axons in peripheral nerve system, development of myelin sheath (3 schemes) and longitudinal section of myelinated axon:

- development: axon, Schwann cell, and its membrane wrapped around the axon, myelin formation,
- longitudinal section: axon, Schwann cells, layers of myelin, node of Ranvier,
- multiple axons enfolded by Schwann cell.

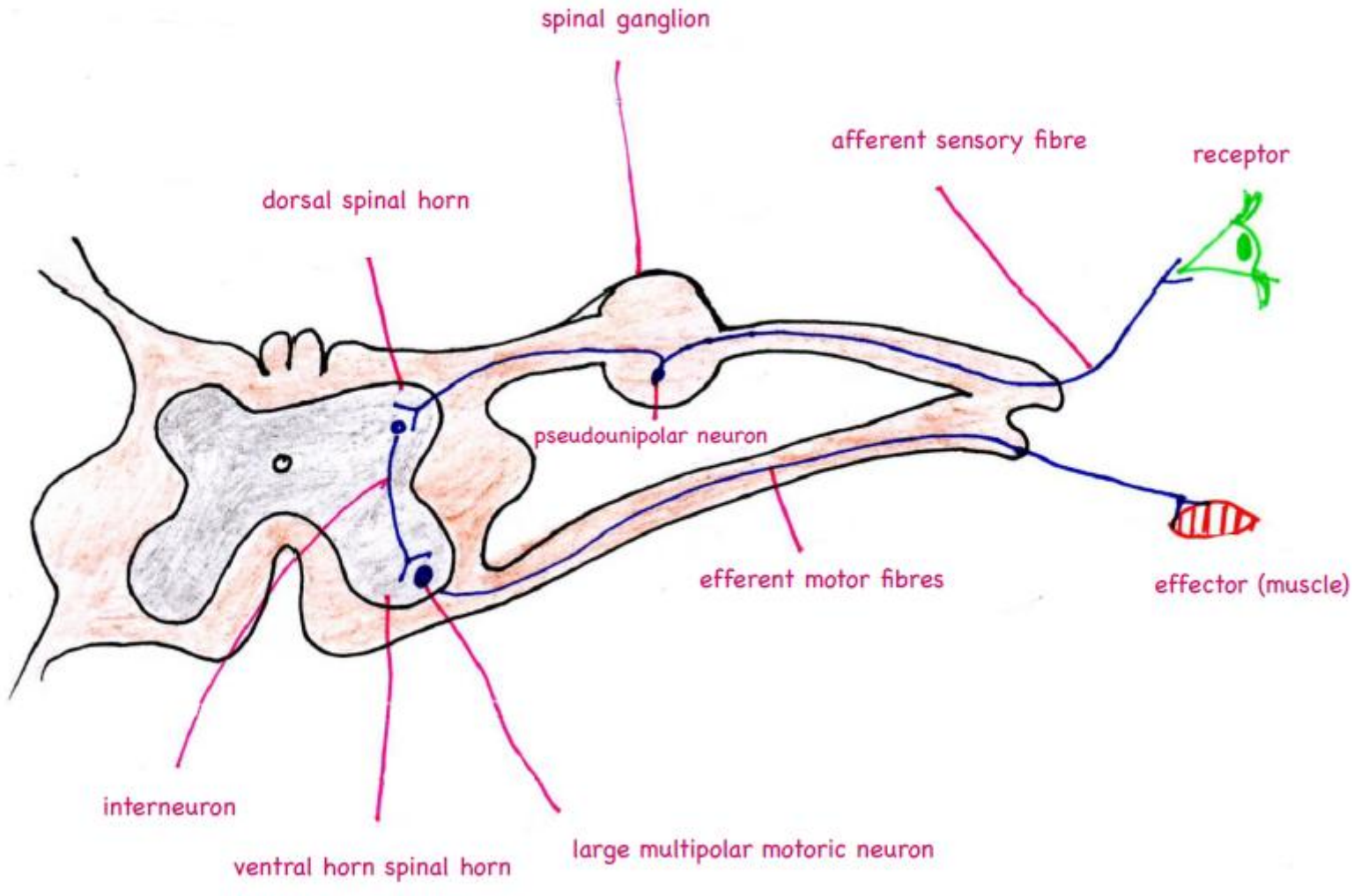






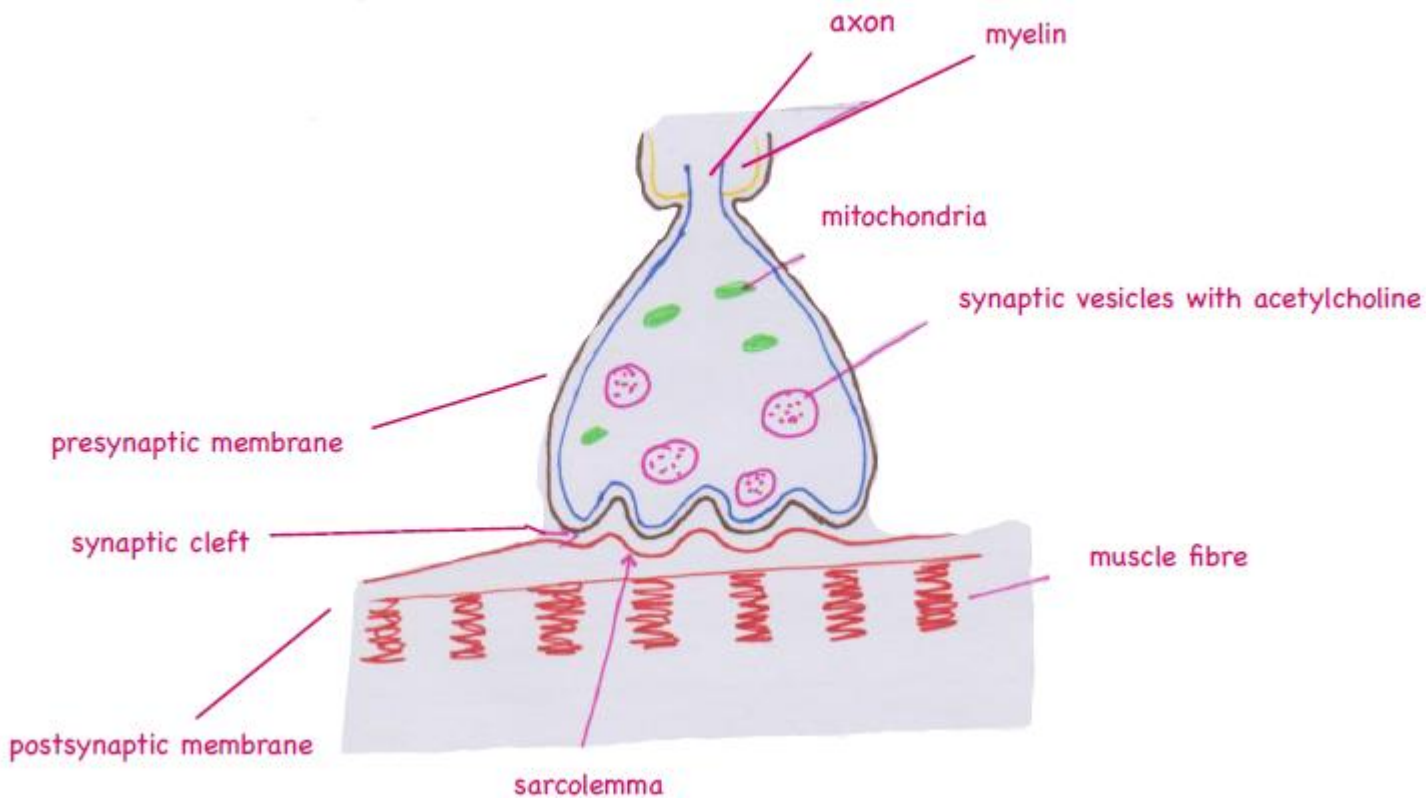
49. Draw and label histological structure of monosynaptic reflex arc:

- receptor, afferent sensory fibre, spinal ganglion with pseudounipolar neuron, dorsal spinal horn,
- interneuron of the spinal cord, large multipolar motoric neuron in the ventral horn,
- efferent motor fibres, effector (muscle).



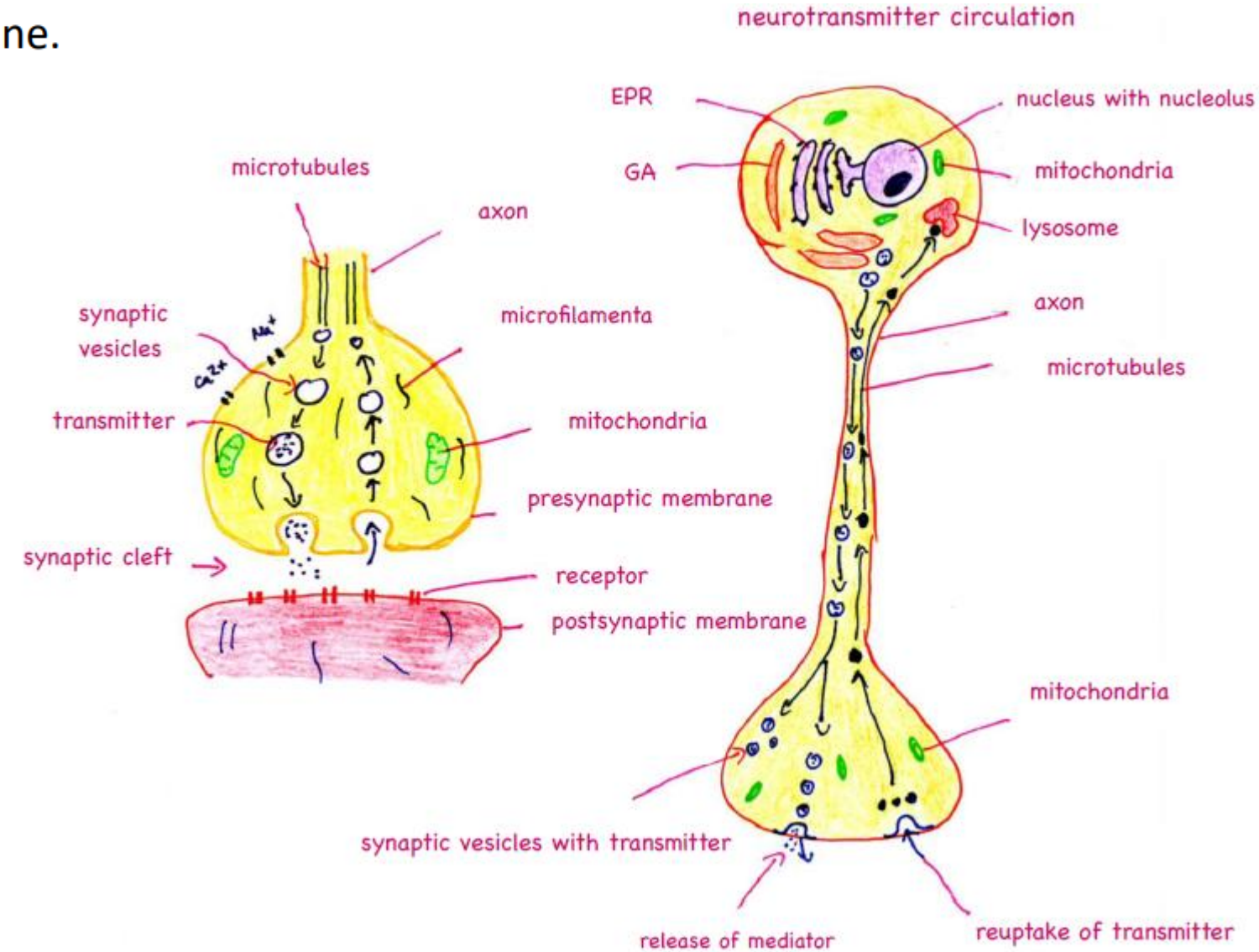
50. Draw and label motor end plate (neuromuscular junction):

- axon, myelin,
- axon terminal of motoneuron, synaptic vesicles with neurotransmitter acetylcholine,
- presynaptic and postsynaptic membrane, synaptic cleft, sarcolemma of skeletal muscle.



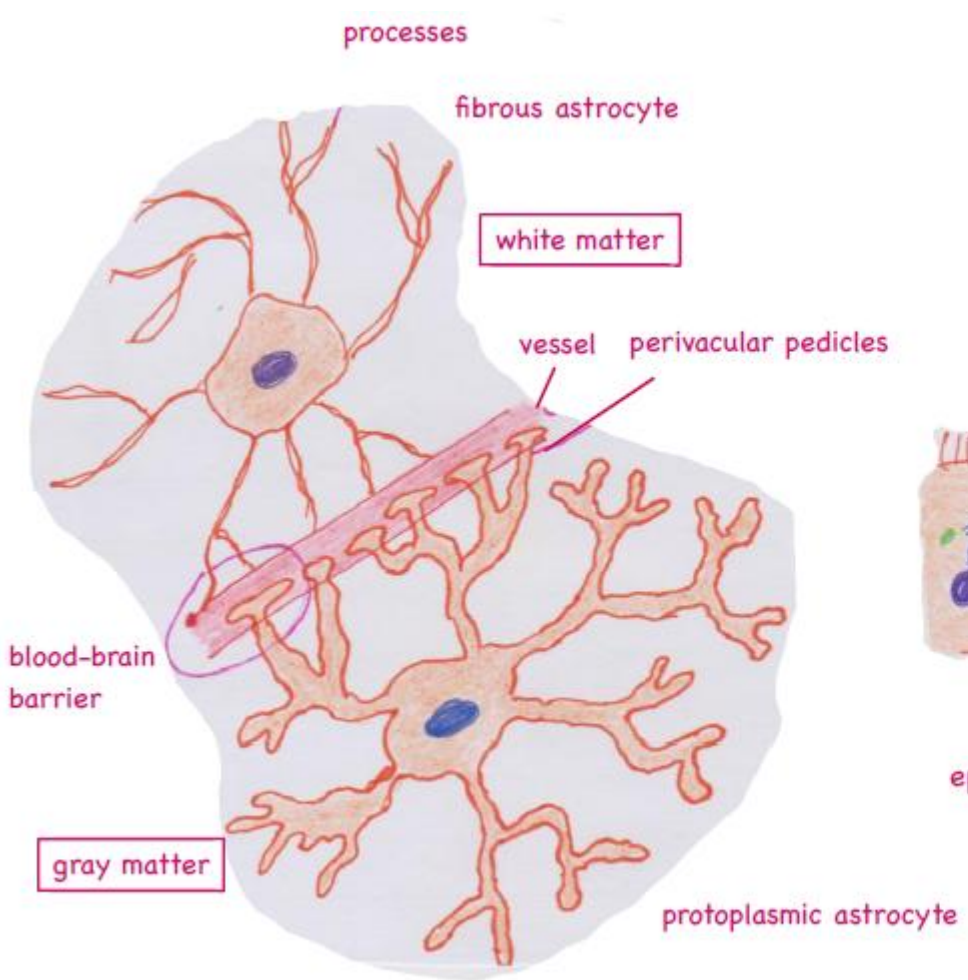
51. Draw and label synapse and neurotransmitter circulation:

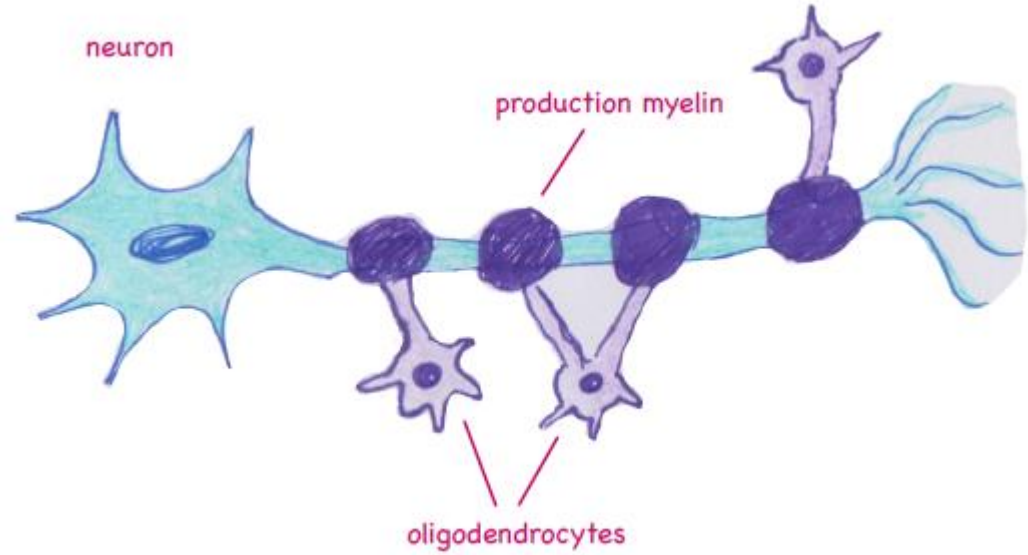
- axon, microtubules, microfilaments, mitochondria,
- synaptic vesicles with transmitter, synaptic cleft,
- presynaptic and postsynaptic membrane.

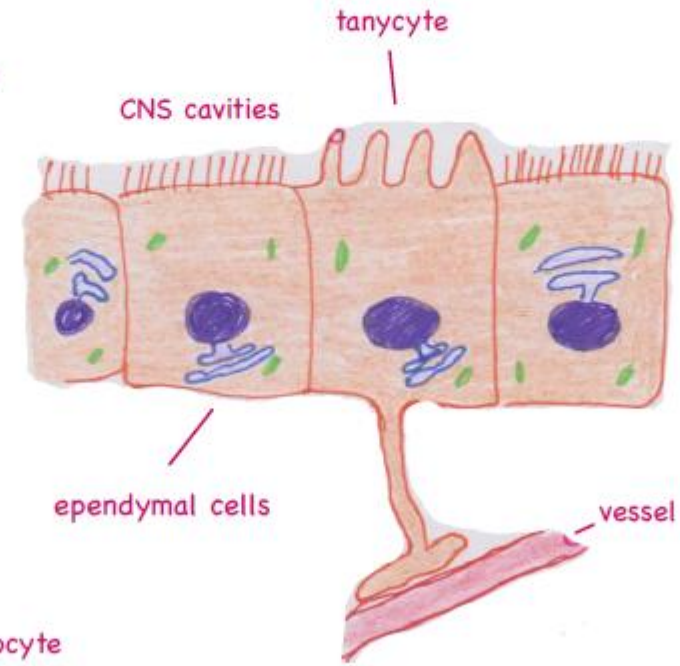


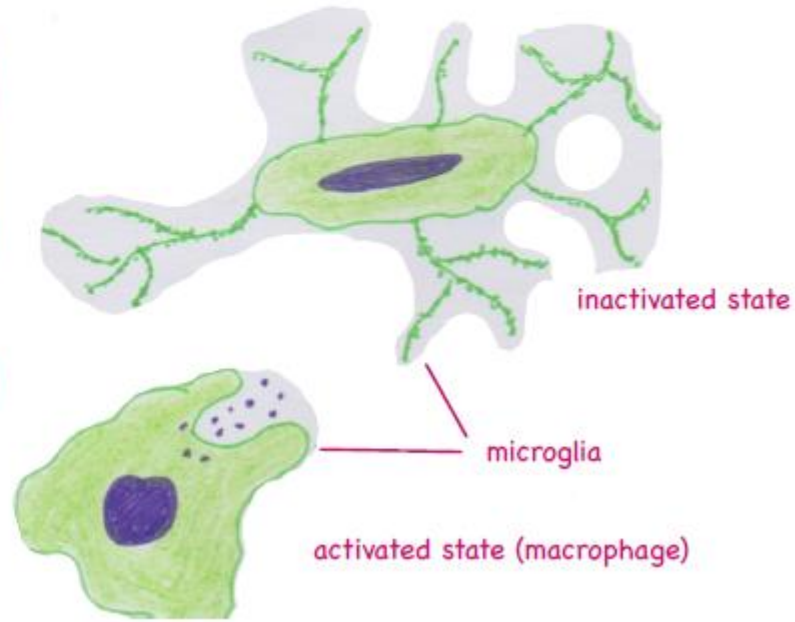
52. Draw and label neuroglia of central nervous system (CNS) and their function:

- fibrous (in white matter) and protoplasmic (in gray matter) astrocytes; processes, perivascular pedicles, blood-brain barrier,
- oligodendrocytes: produces myelin in CNS,
- ependymal cells lining CNS cavities, tanycyte
- microglial cells: inactivated microglia and activated glia (*i.e.* macrophage).









53. Draw and label tissues of meninges:

- periosteum, dura mater: dense collagen tissue,
- arachnoid: loose trabecular connective tissue, arachnoid villi (granulations) protruding to the venous sinuses,
- pia mater: loose collagen connective tissue with blood vessels, its inner side covers the surface of the CNS.