

# **Salivary glands**

## intro to teeth

Jan Krivanek

24.3.2021

# Lecture 2

- Overview of the **salivary glands** of the oral cavity and their microscopic structure
- **Large salivary glands** - topography, structure and description.
- **Saliva**
- **Phylogenesis and comparative anatomy of teeth**
- **Tooth and periodontium**
- **Hard tissues of the tooth** - composition and properties
- **Overview of methods** used to study the microscopic structure of teeth (ground sections, sections of decalcified teeth, SEM, confocal microscopy)

# Salivary glands - glandulae salivariae

Exocrine glands with watery, mucous or mixed secretions

Formed by proliferation of the ectoderm of the primitive oral cavity into the ectomezenchyme (composite organ)

## Salivary glands classification

- According to the **type of secretory compartments** and the nature of the secretion:
  - serous** - acini
  - mucinous** - tubules
  - mixed** - acini, tubules + tubules with Gianuzzi lunules (tubuloacinary units)
- According to size:
  - large** – gl. parotis, gl. submandibularis a gl. sublingualis
  - small** – in tela submucosa, the number of 800 - 1000

# General structure of large salivary glands

- Ligament → capsula fibrosa
- Ligament → septa (*+ vessels, nerves, interlobular and larger ducts*)



- Parenchyma → lobes

## Glandular compartments

*(serous acini, mucinous tubules, serous lunules)*

## Ducts

*(intercalated, striated, interlobular, main)*





# Structural components of the salivary glands

## Ligament

gl. parotis and gl. submandibularis ligament forms **capsule**

gl. sublingualis and gl. lingualis anterior capsule incomplete **septa**

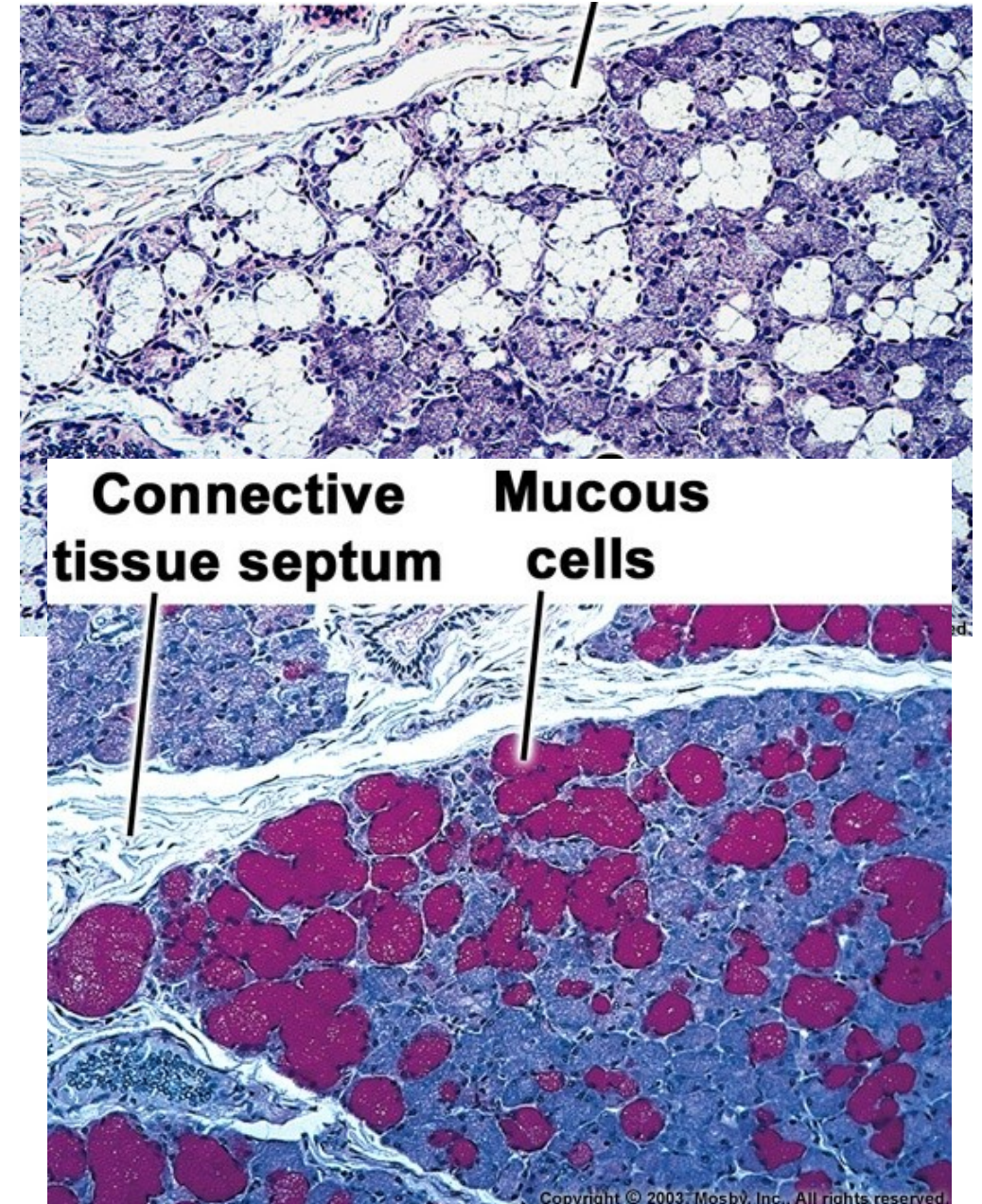
## Glandular tissue (parenchyma)

The **lobules** contain:

**secretory compartments:** serous acins, mucinous tubules or tubules with Gianuzzi lunules +

**2 parts of the duct system - intercalated and striated ducts**

(interlobular and main - in septal ligament)



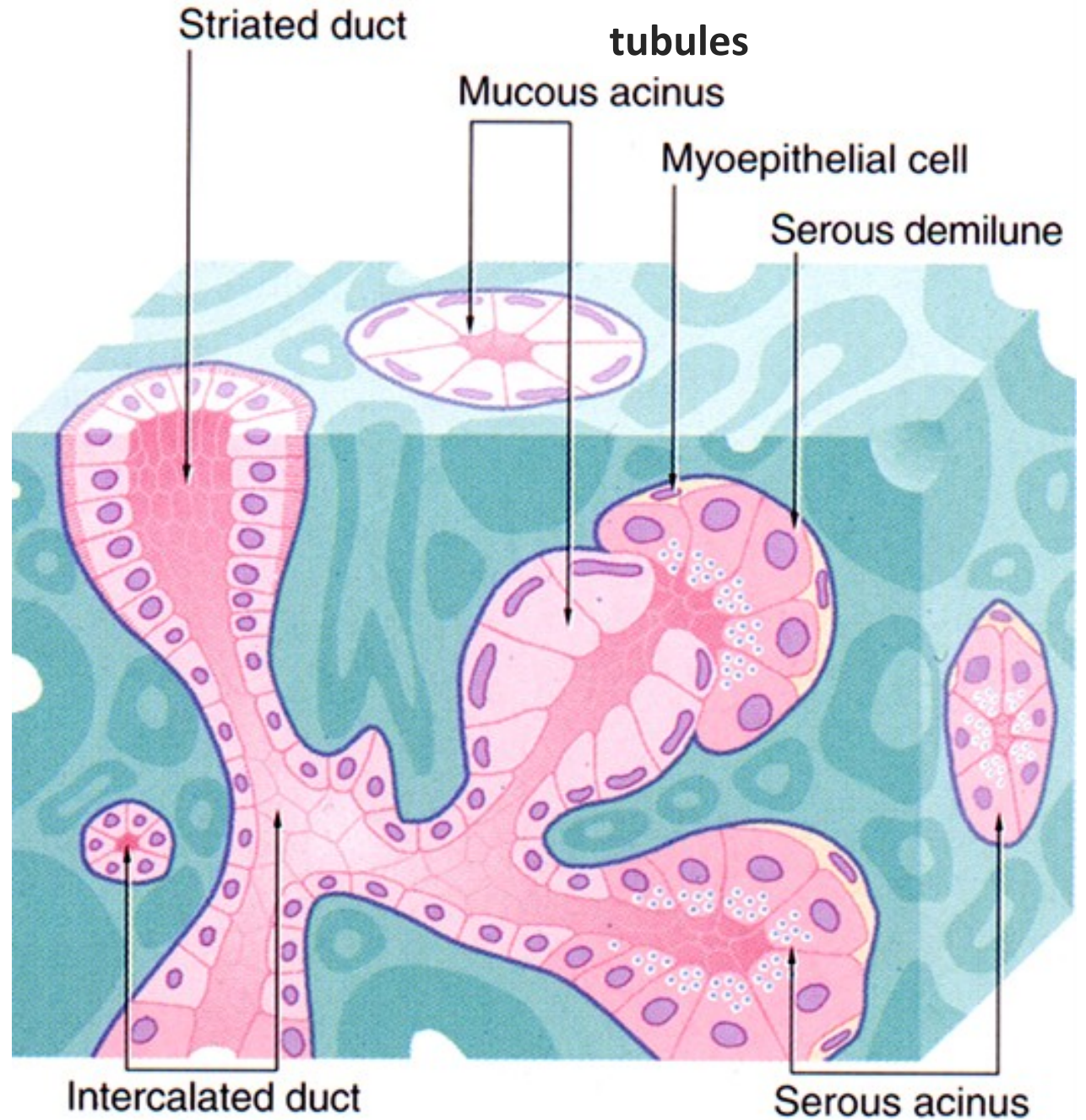


## Wall of secretory compartments:

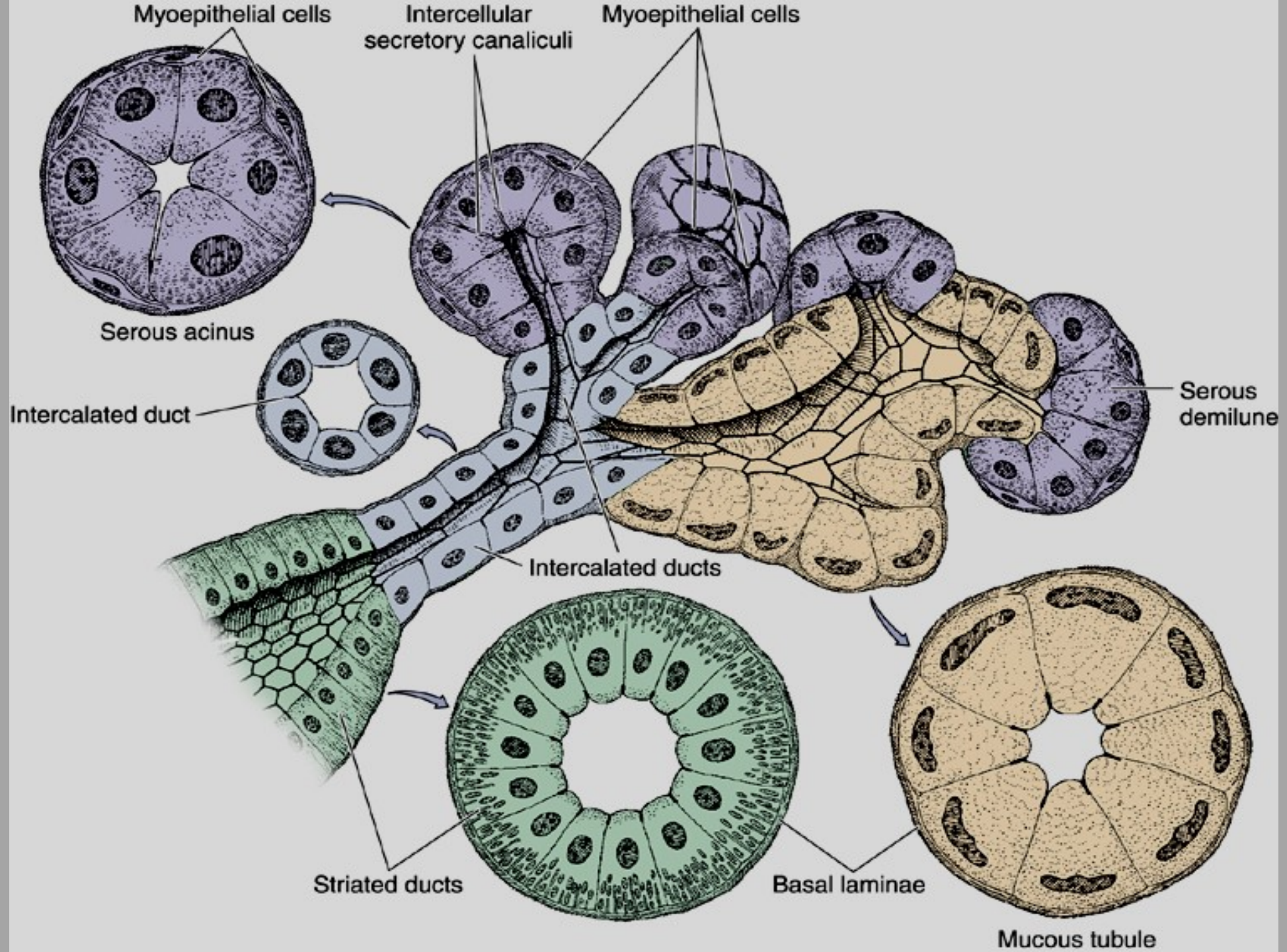
- basement membrane
- myoepithelial cells
- glandular cells

## Wall of intercalated and striated ducts

- basement membrane
- myoepithelial cells (intercalated ducts only)
- Epithelial cells



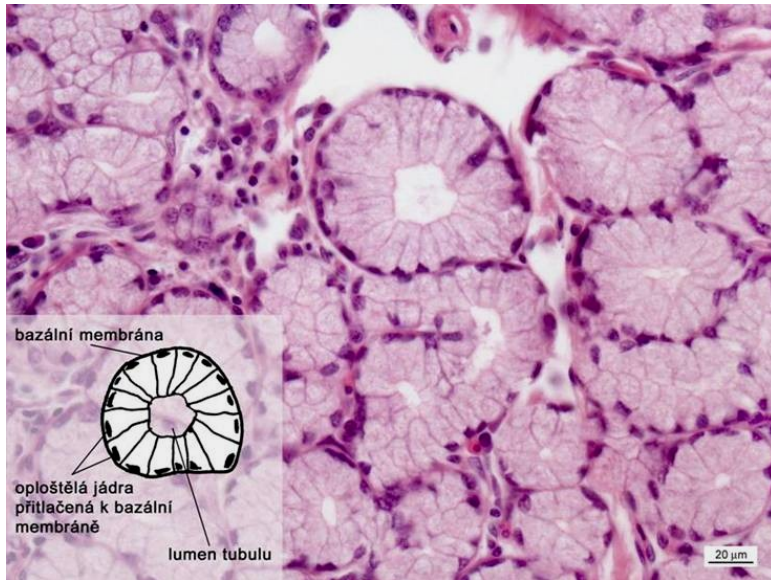




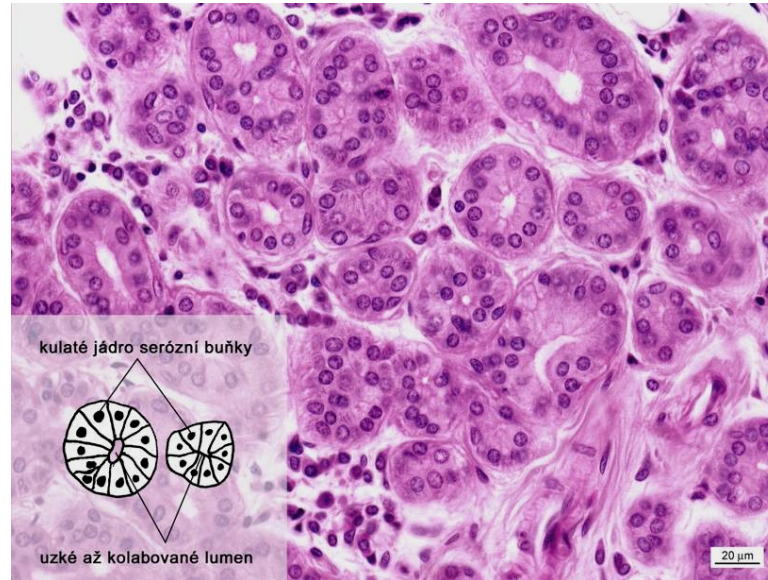


# Secretory compartments

## Mucinous tubules



## Serous acini



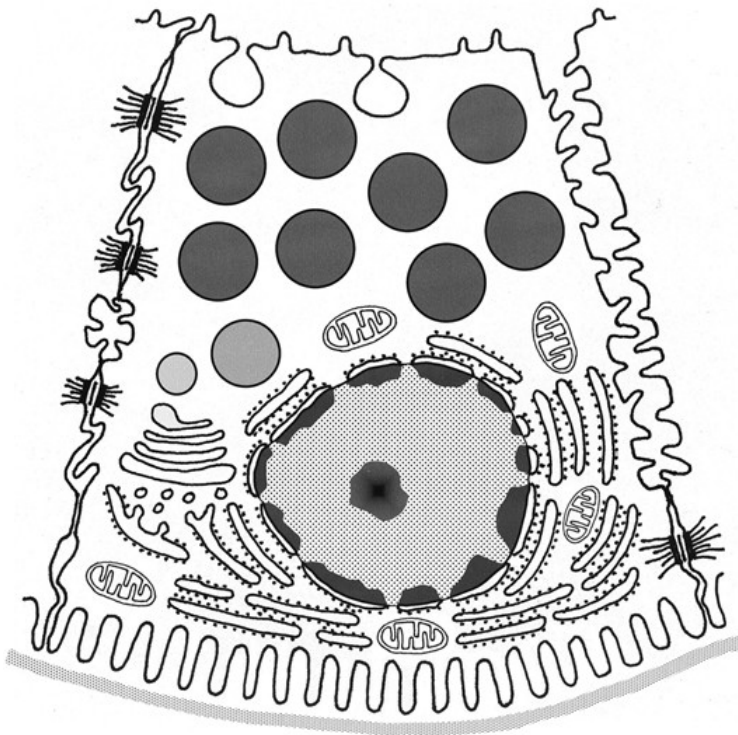
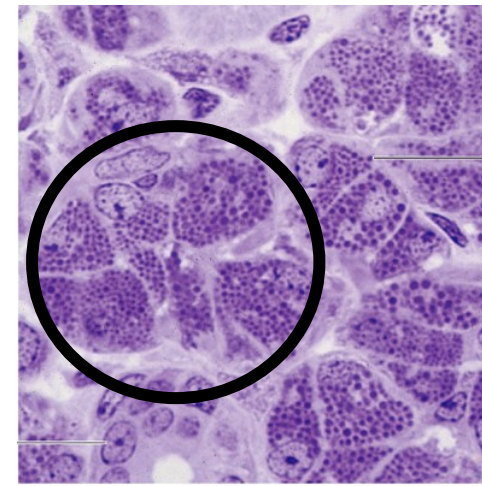
## Tubules with lunules





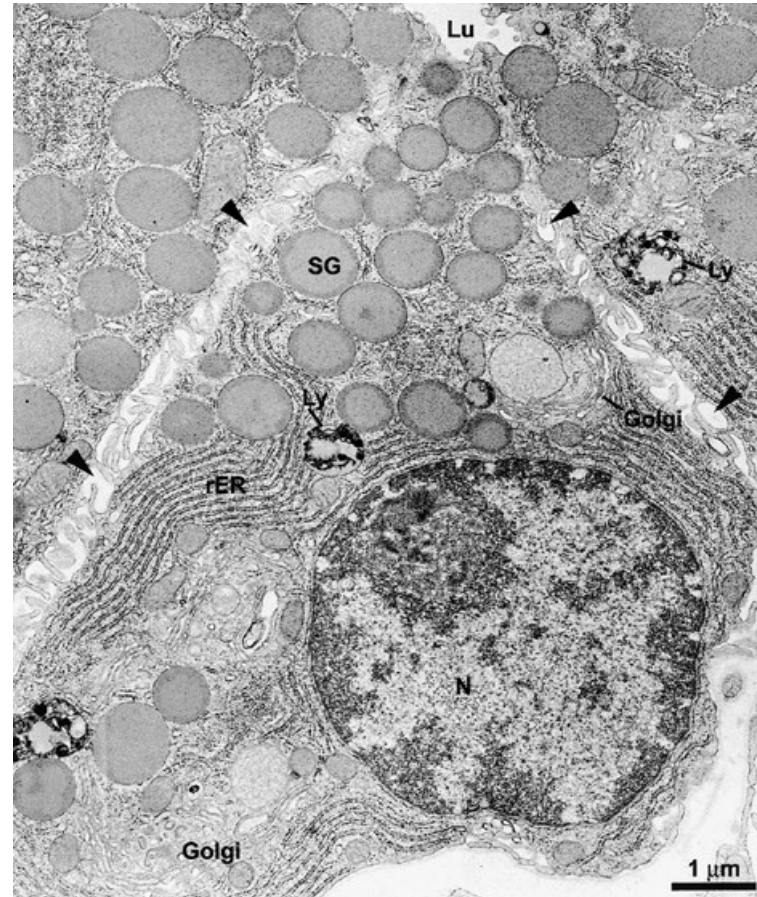
## Serous acini

spherical to ovoid sacs (60 - 150  $\mu\text{m}$ ) with a narrow lumen  
wall: serous cells, myoepithelial cells, basement membrane



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Serózní buňky

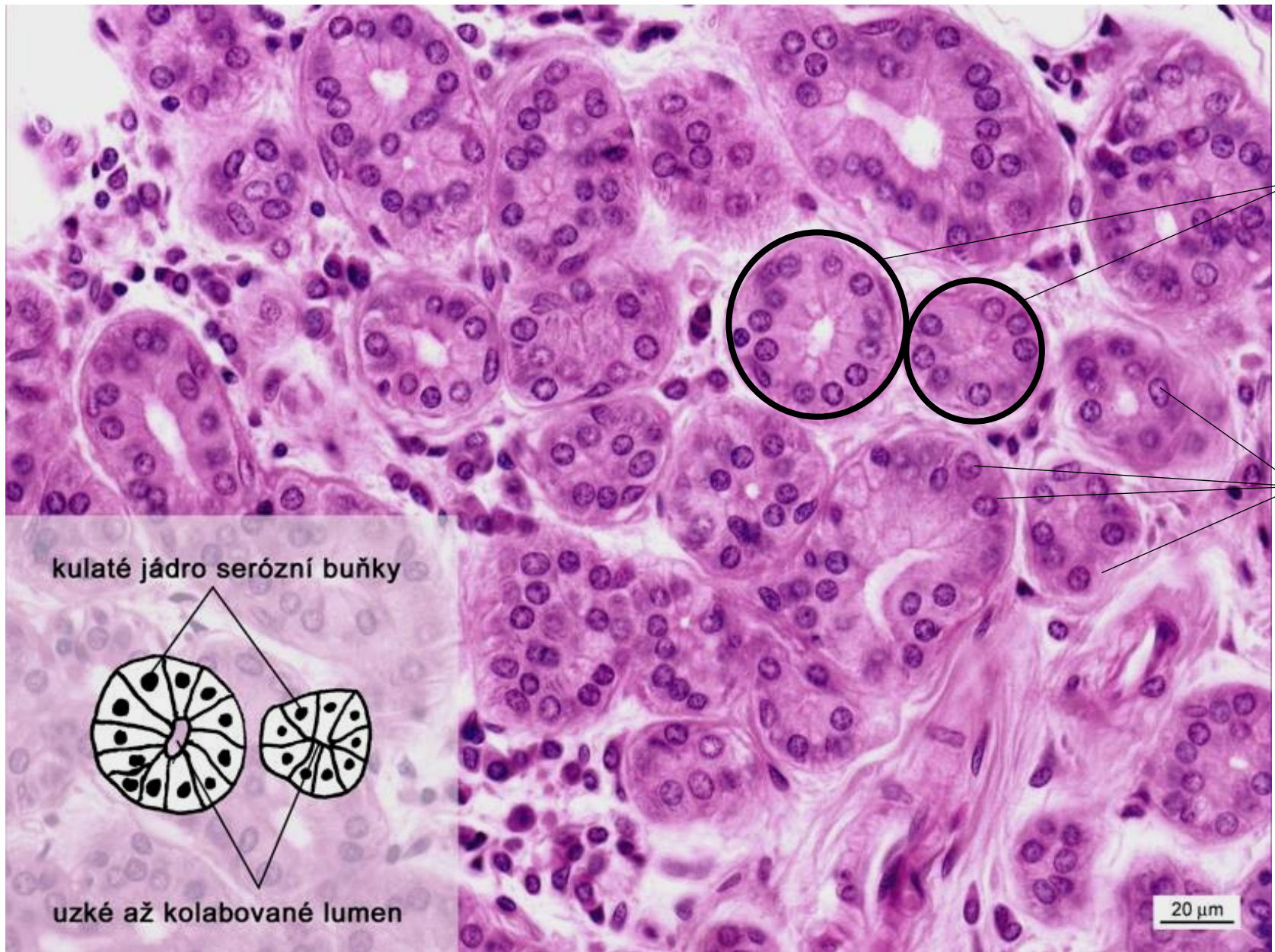


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### Cells

- pyramidal shape and spherical nucleus at the base
- below the nucleus is a basophilic cytoplasm (rER, mitochondria and ribosomes)
- supranuclear - eosinophilic secretory grains / zymogenic = proenzyme  
(zymogen = inactive enzyme precursor)





Serous acini

Serous cells

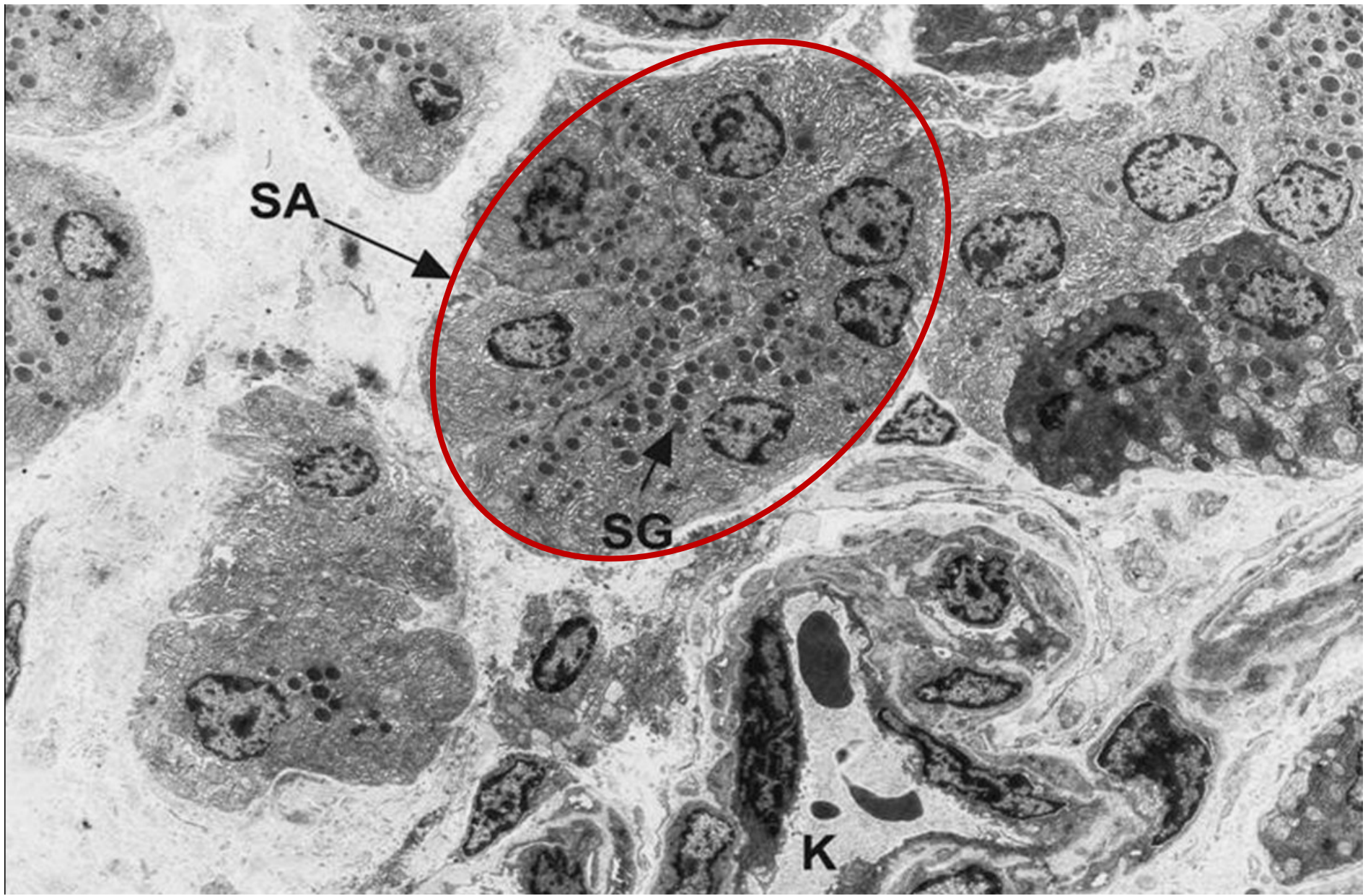
kulaté jádro serózní buňky

uzké až kolabované lumen

20 μm

Aqueous secretion, rich in proteins and enzymes





**Rat salivary gland parenchyma:** SA – serous acinus, SG – secretory granule, K – capillary. TEM, primary magnification 1,500x



# Mucinous tubules

Usually larger diameter than serous acins (about 200  $\mu\text{m}$ ), distinct lumen

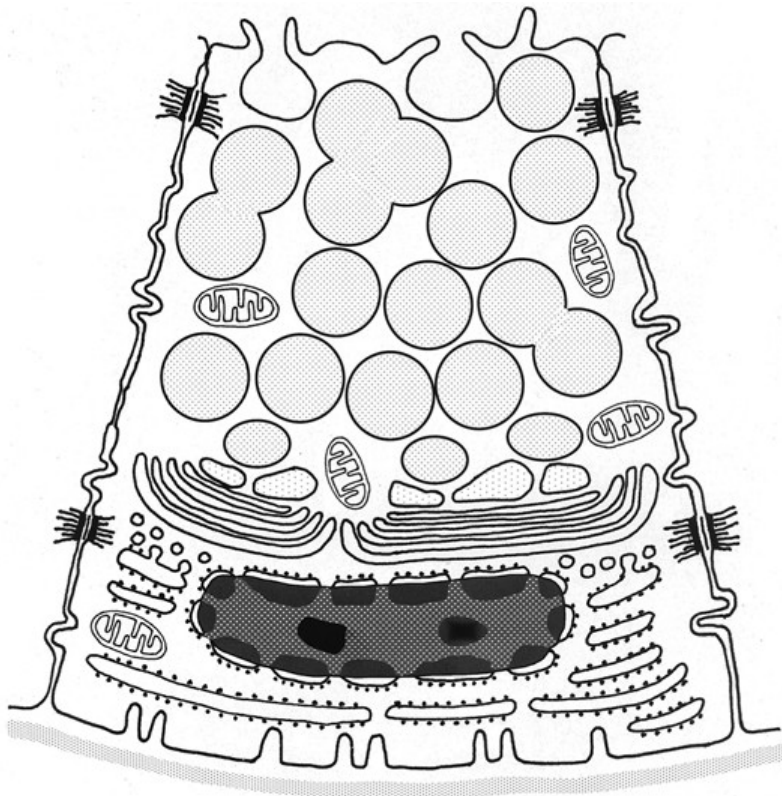
On sections: transversely or longitudinally sectioned

Wall: cylindrical mucinous cells, myoepithelial cells and basement membrane

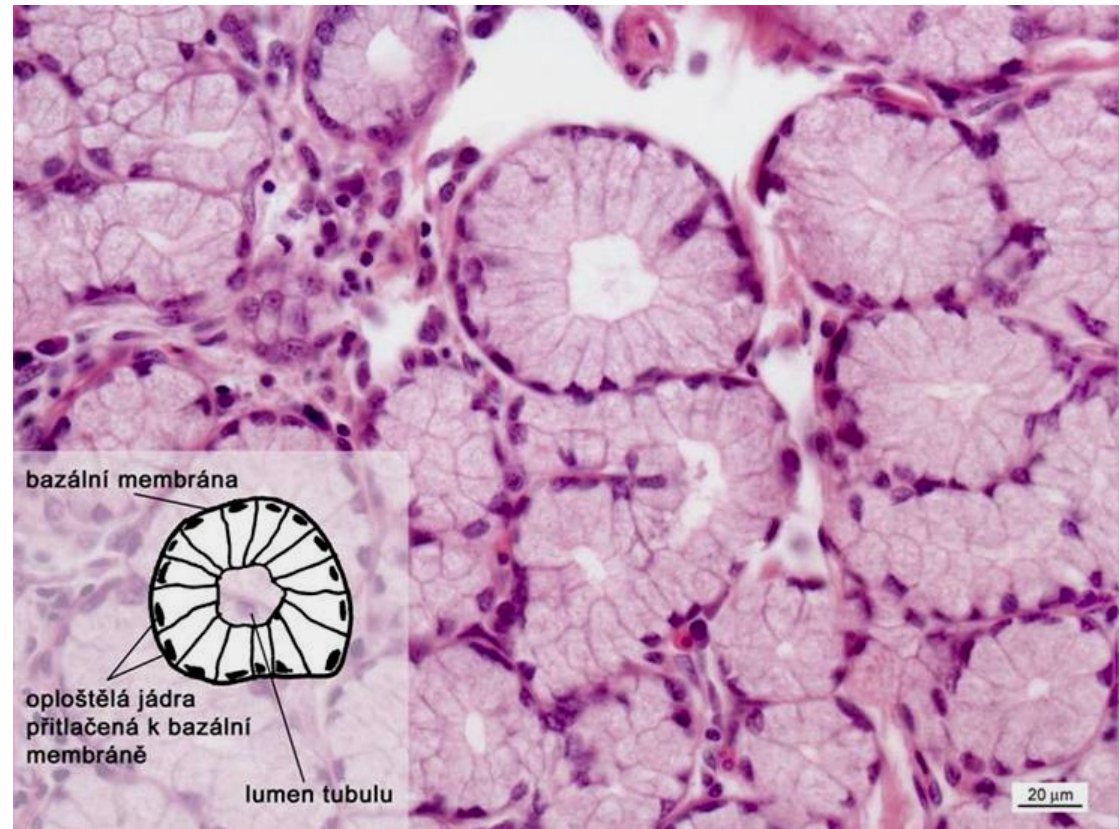
Flattened nuclei

**Apexes - numerous grains of mucinogen**

**Viscous mucus secretion**



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## Tubules with lunules (Gianuzzi) - tubuloacinary units

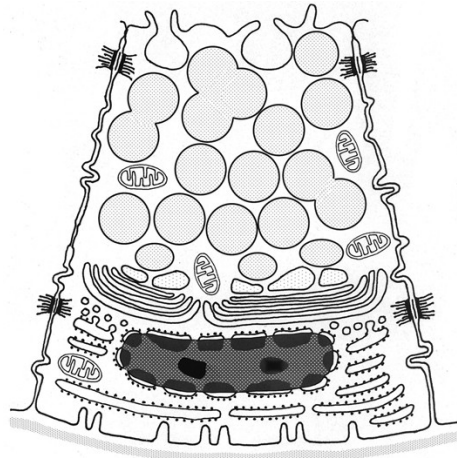
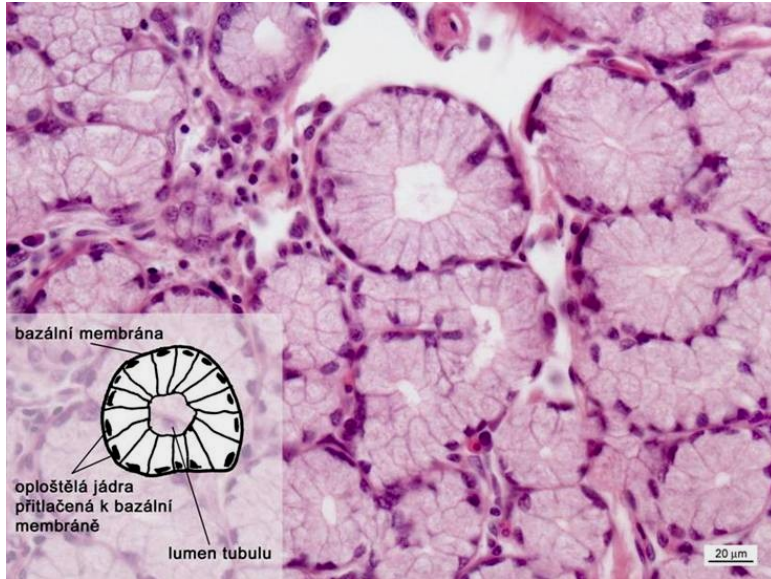
Lunule (demilune) = aggregation of serous cells at one or both ends of a mucinous tube, similar to a demilunes





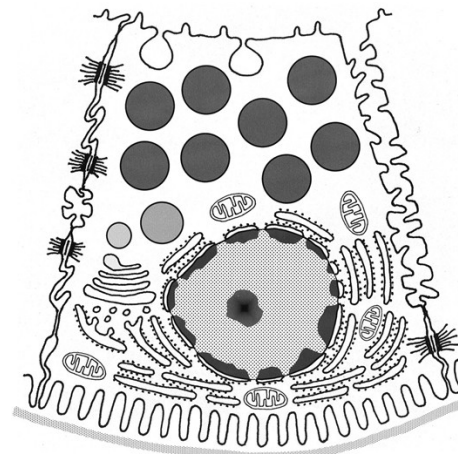
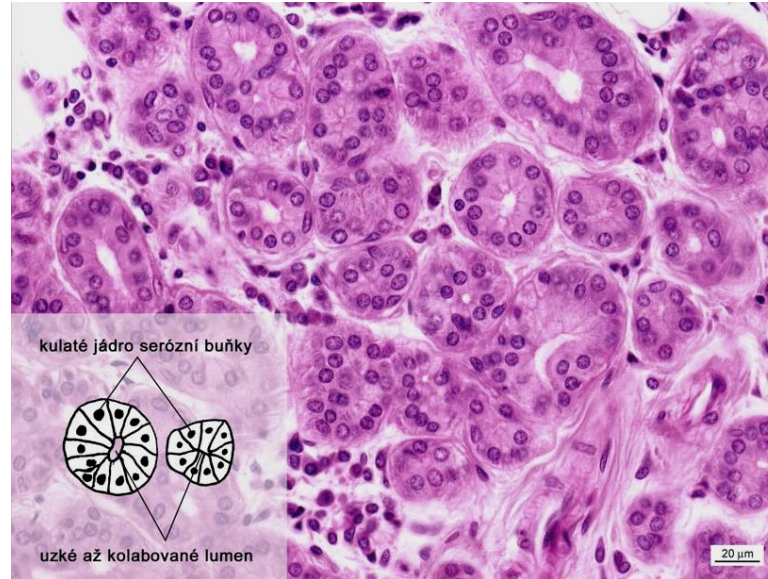
# Secretory compartments

## Mucinous tubules



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## Serous acini



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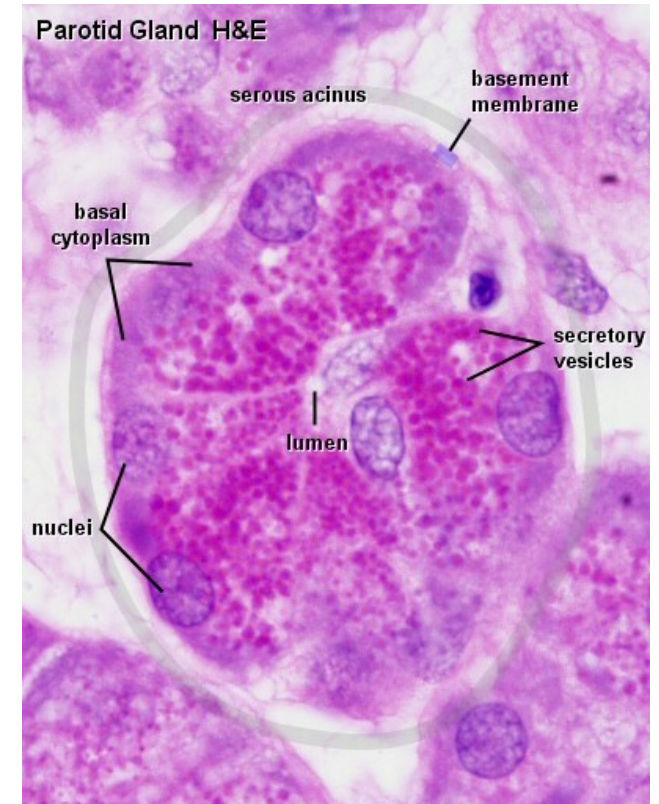
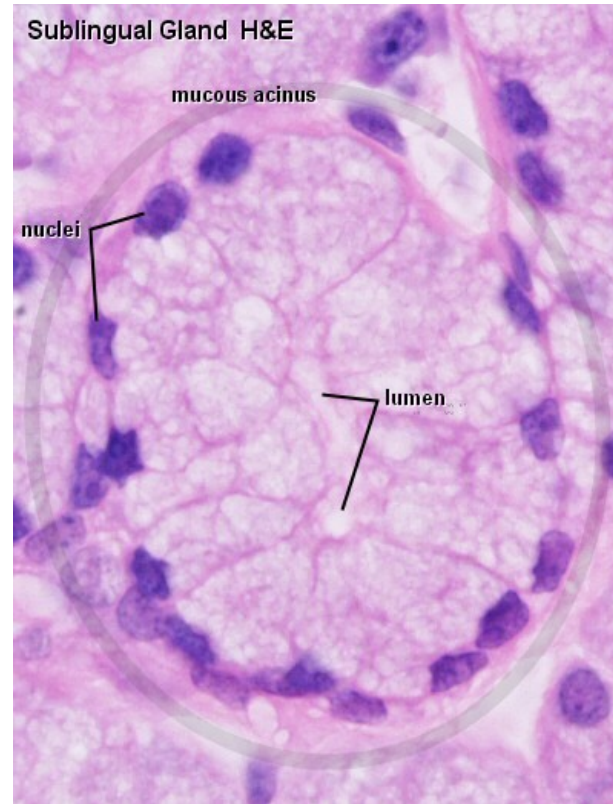
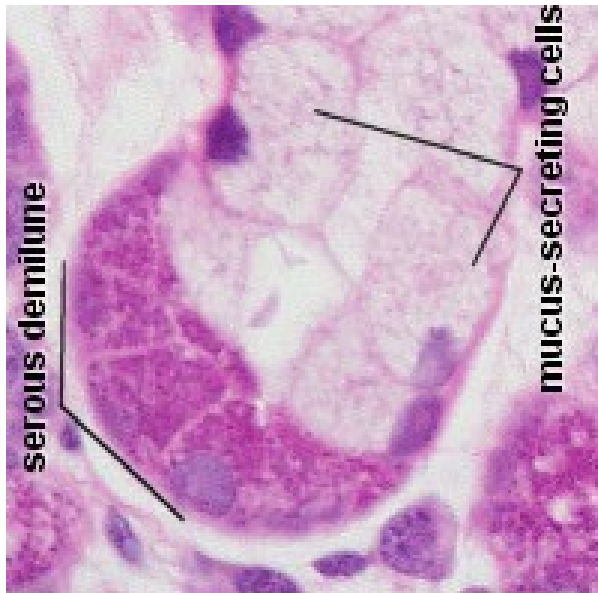
## Tubules with lunules





# Secretory compartments

- Serous acini
- Mucinous tubules
- Lunules (demilunes)



# Myoepithelial cells

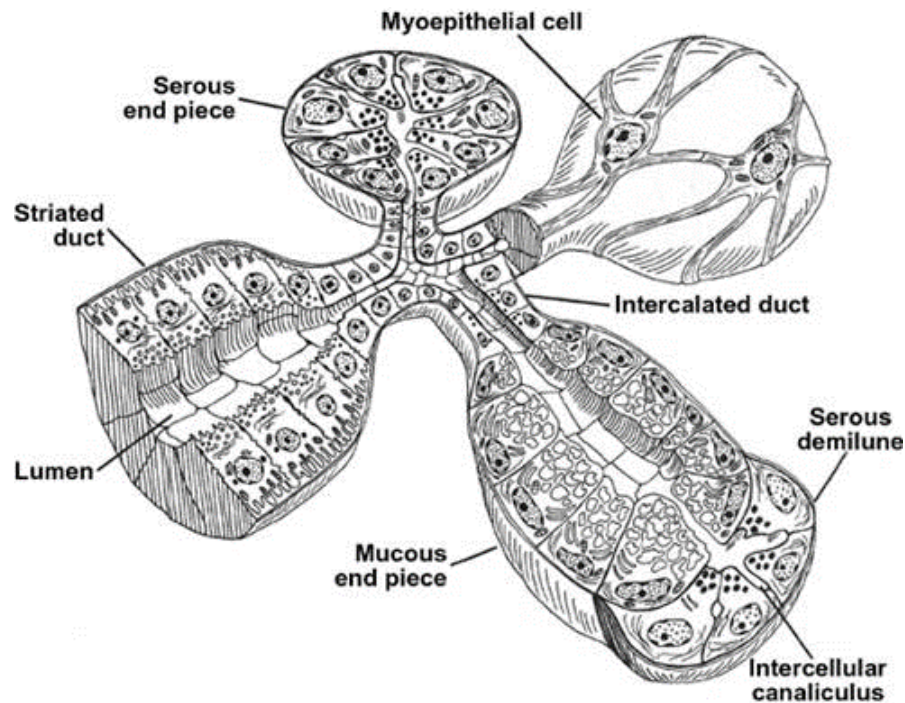
Capable **contractions**, **Vegetative** control

They **regulate secretion**, control nutrient supply and control electrolytes

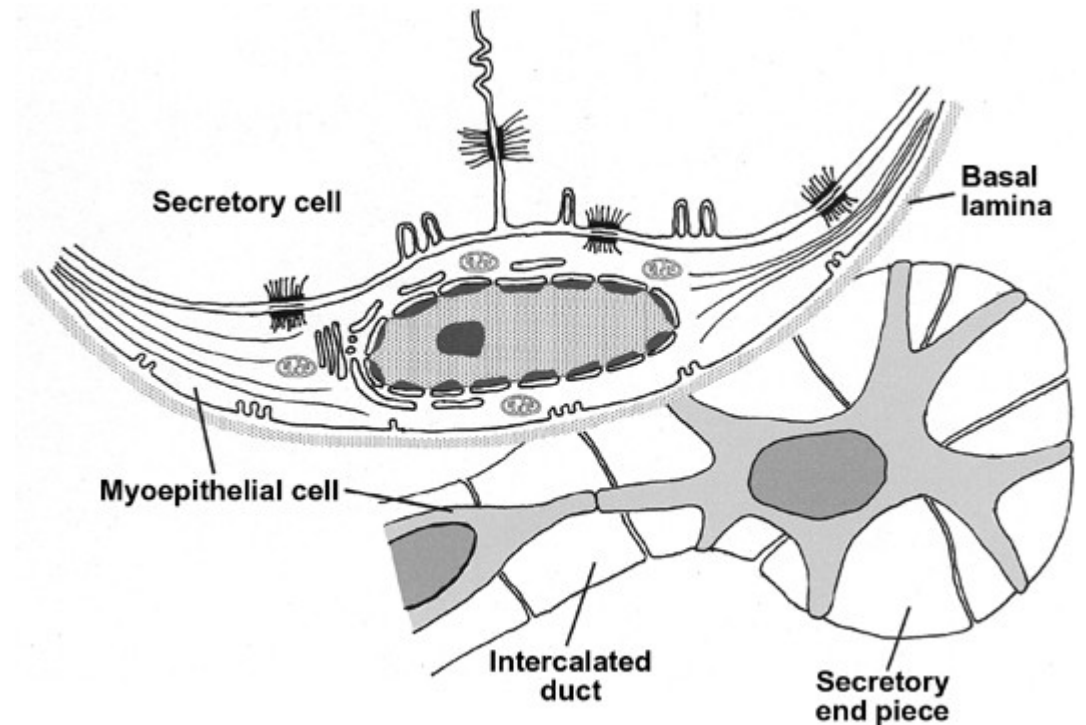
Inserted **between the bases of secretory cells** (acins and tubules) **and the basement membrane**

**Flattened body**, several protrusions, between secretory and myoepithelial cells numerous desmosomes or hemidesmosomes

In the **cytoplasm actin microfilaments** (bundles) + cytokeratin filaments

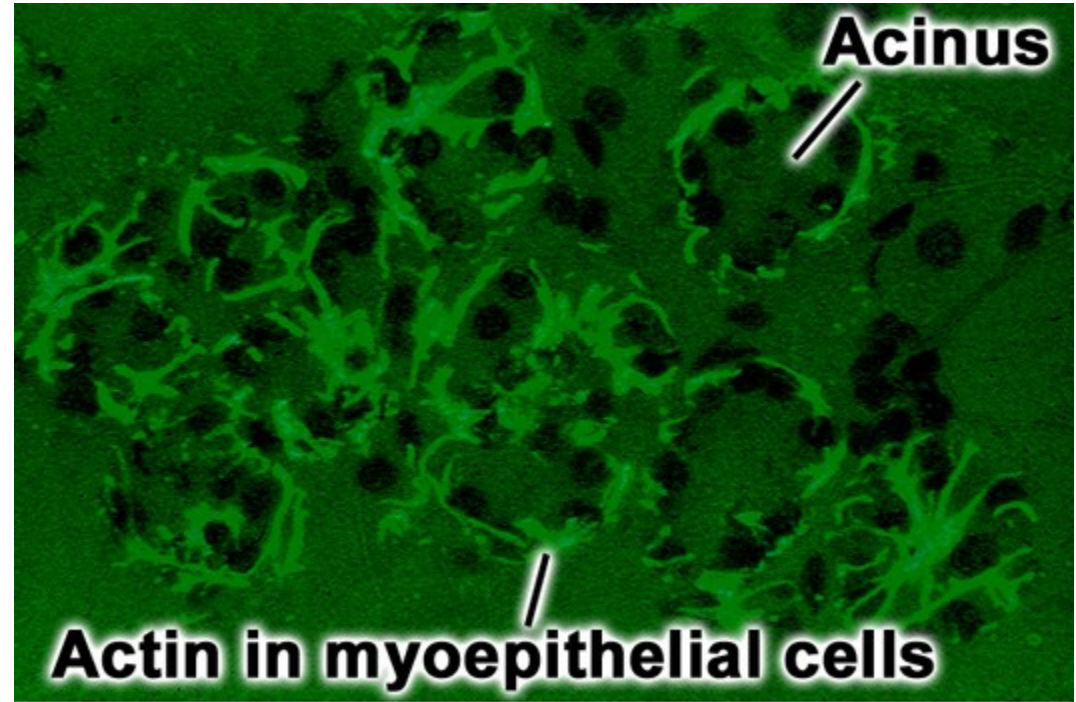
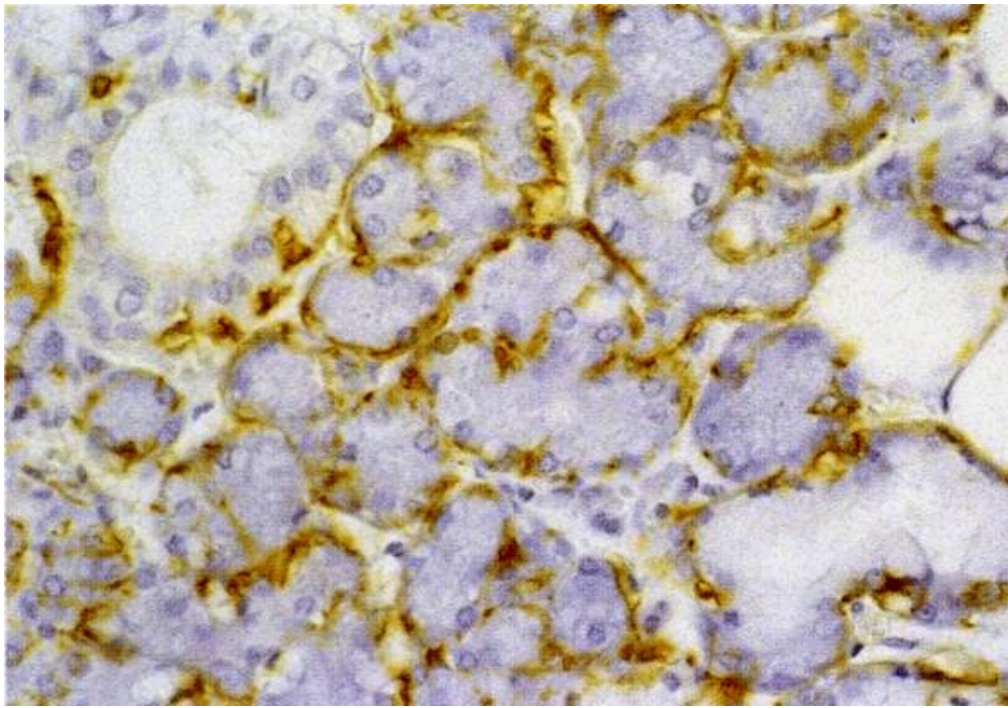


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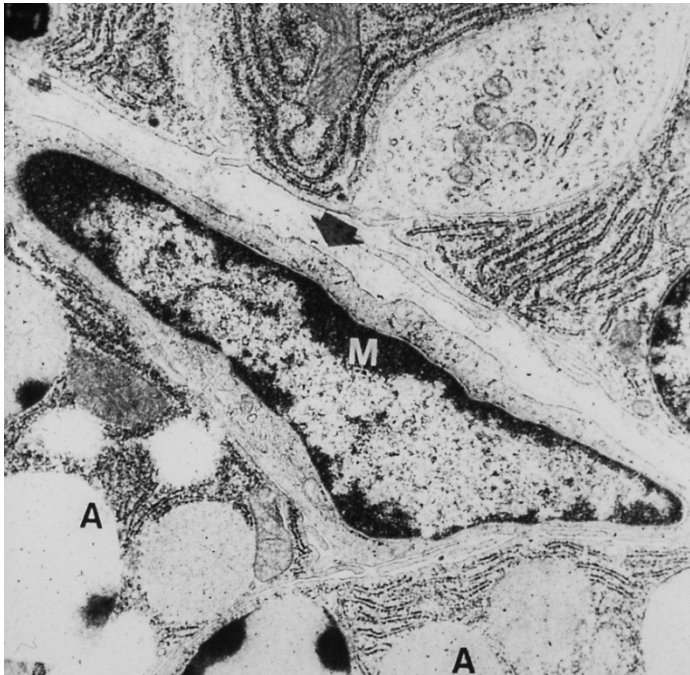


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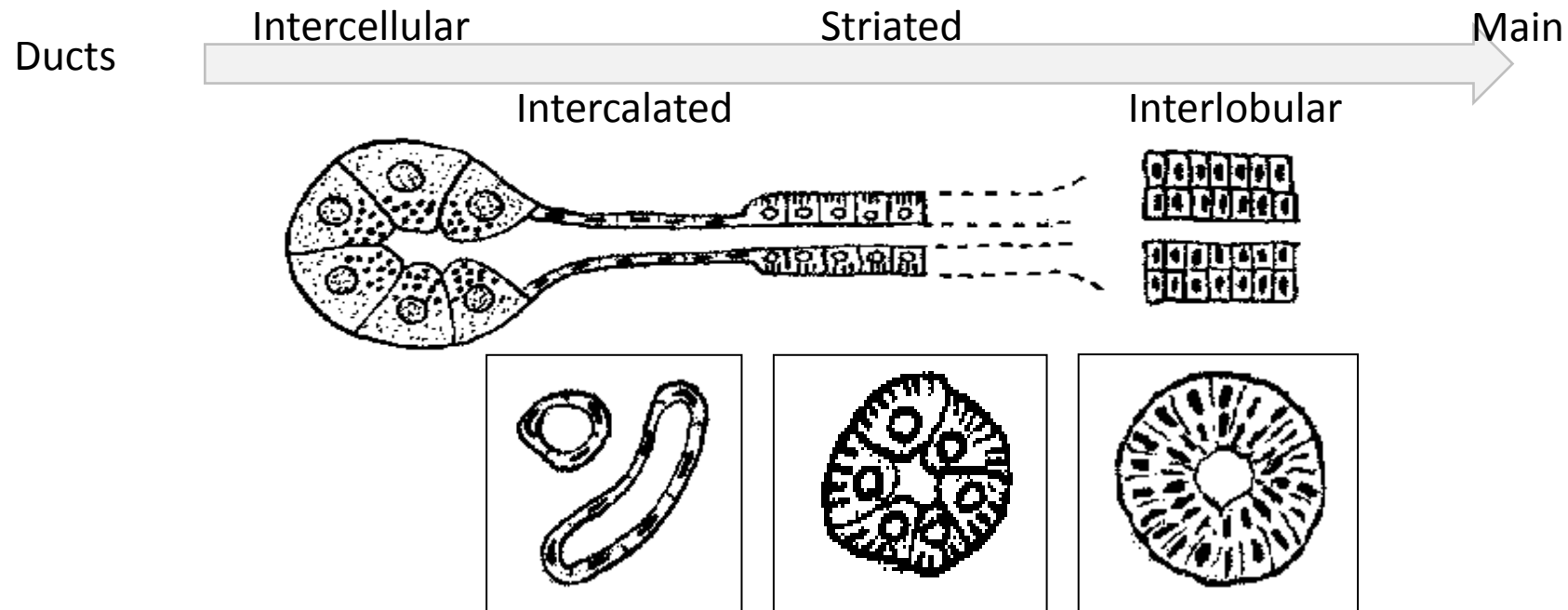


The cells help to release the secretion into the lumen of the secretory compartments and its further passaged through the inserted ducts (in the wall of which they are also present)

Origin: Neural crest, active from the 25th week of development

# Salivary ducts types

- **Intercellular** (*they do not have their own wall, intercellular space*)
- **Intercalated** (*simple squamous ep., only serous and mixed glands*)
- **Striated** (*simple cuboidal/low columnar ep.; basal labyrinth → striation*)
- **Interlobular** (*simple – stratified columnar ep., in septs*)
- **Main** (*stratified columnar ep.*)





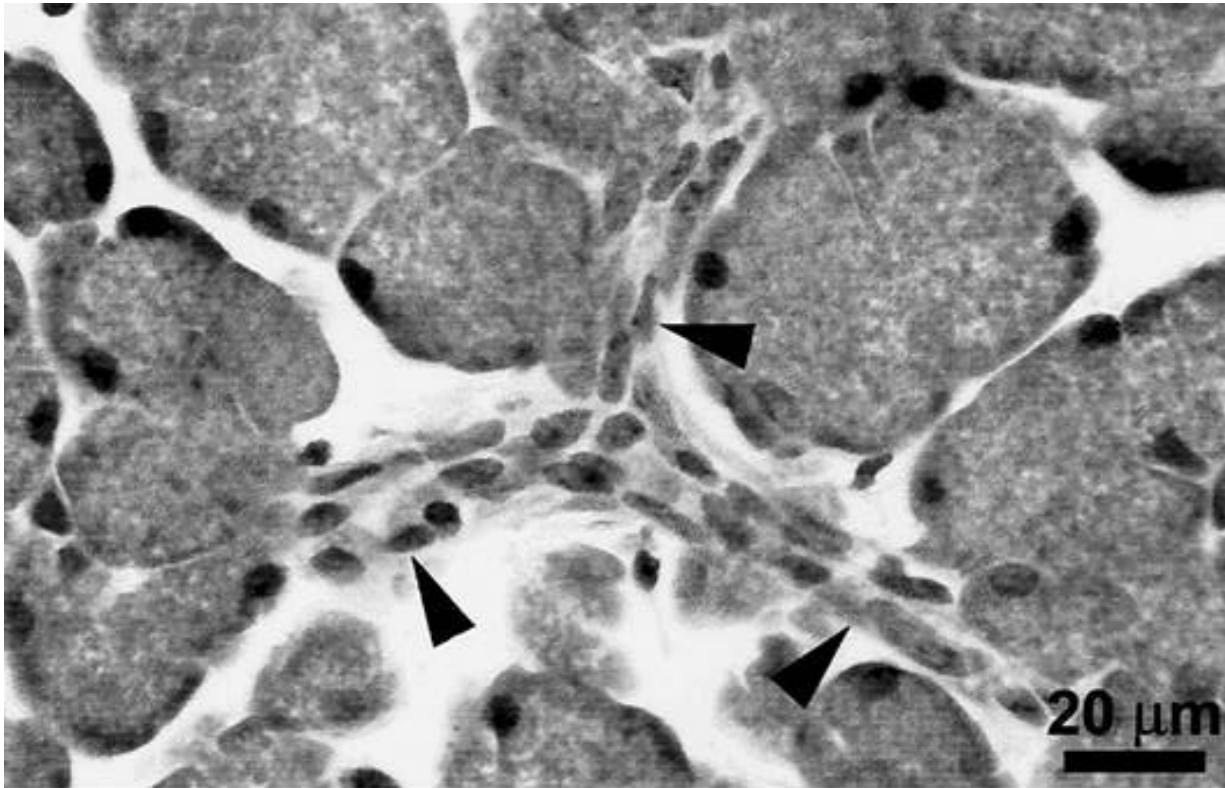
## Intercalated ducts

Narrow and thin-walled channel, collapsed on slides

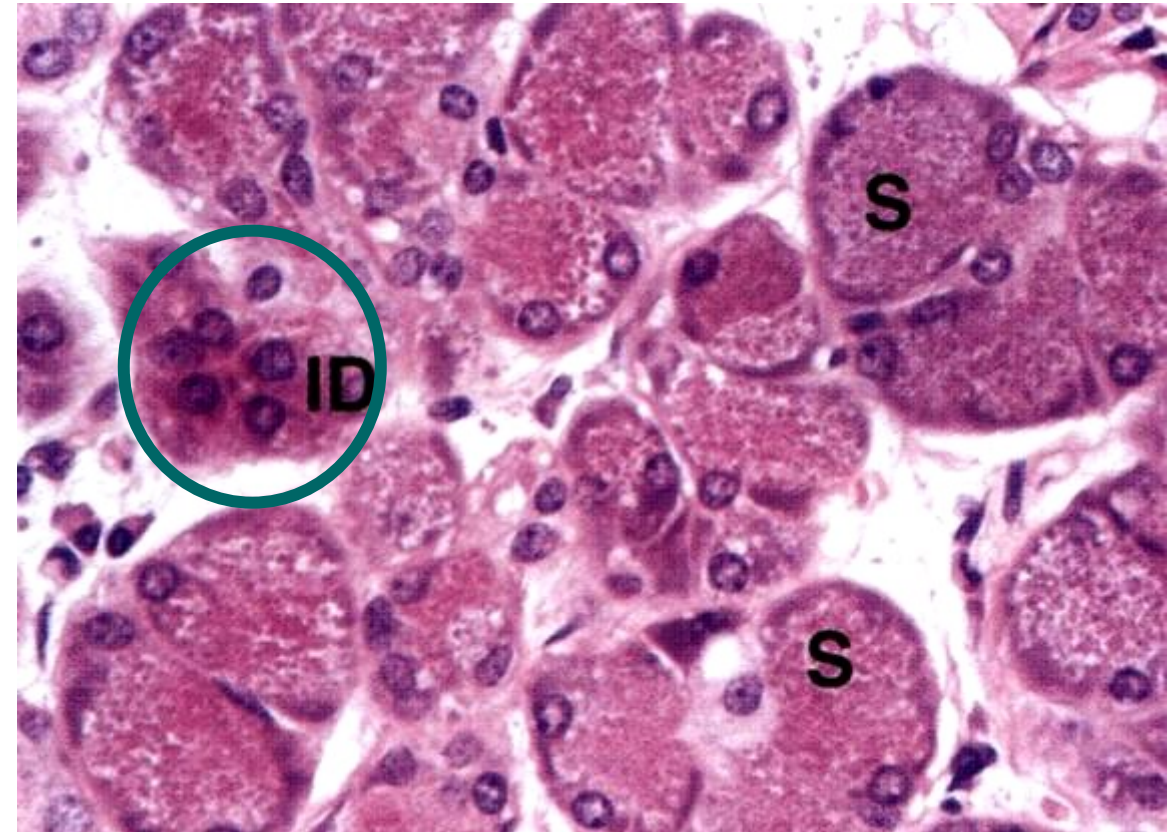
Wall: basal membrane, myoepithelial cells and simple squamous to low cubic ep.

Numerous in serous type of glands

**(cells of intercalated ducts secrete to saliva macromolecular substances: lysozym + lactoferin)**



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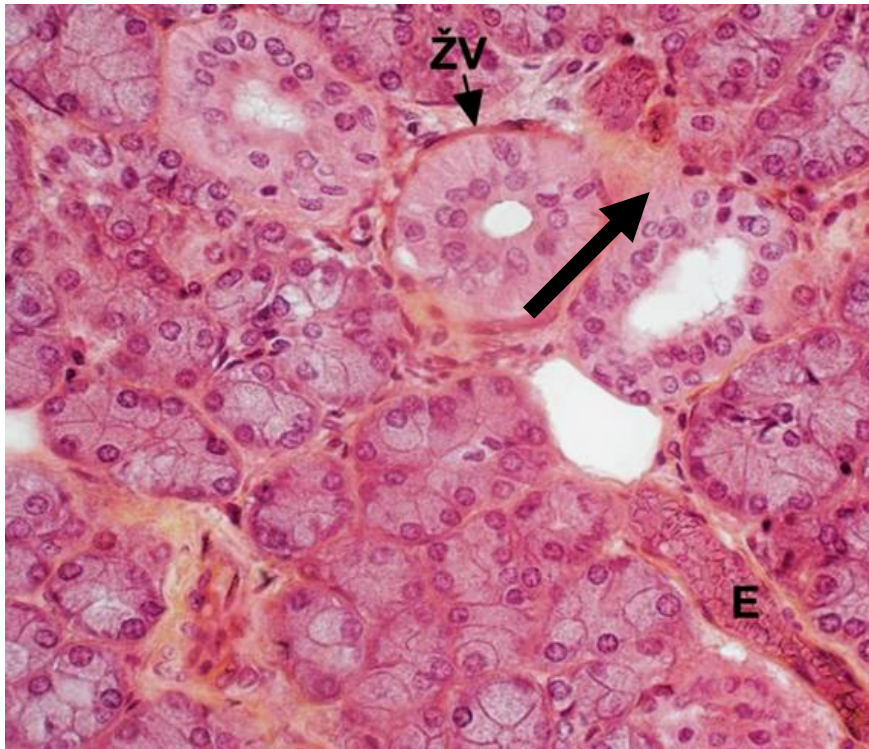
# Striated ducts

Wider than the intercalated ducts (easy to find), usually in the middle of lobe

**Wall:** Basal membrane and simple cuboidal/low columnar ep.

**Microvilli on apices and an bases characteristic striation (basolateral labyrinth)**

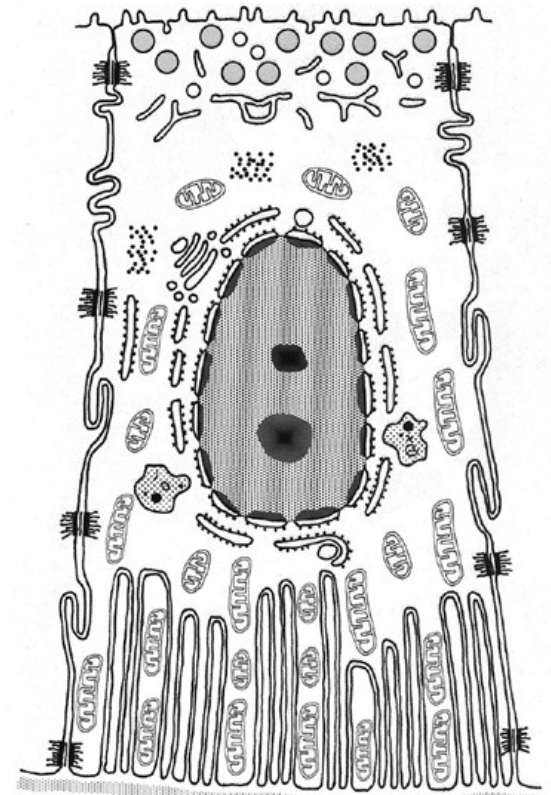
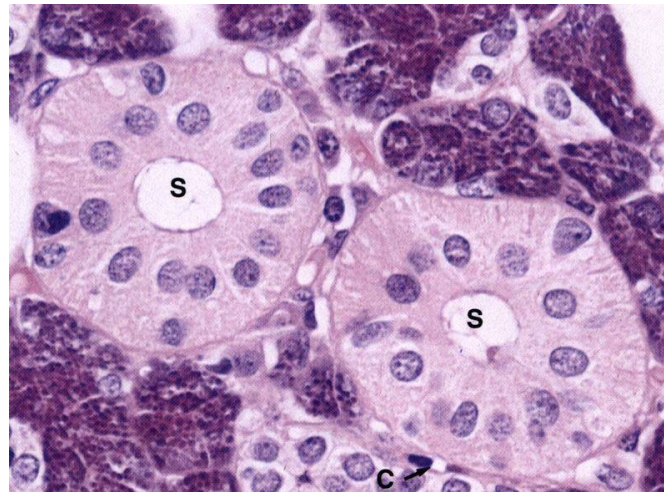
In the cytoplasm of cytokeratin filaments



Glandula submandibularis

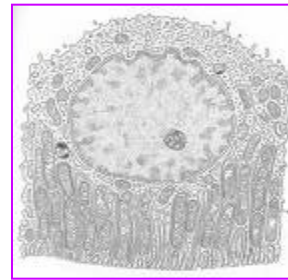
The cells of striated ducts regulate the content of water and electrolytes ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{HCO}_3^-$ ) in the secretion.

**Resorption of  $\text{Na}^+$ , and  $\text{Cl}^-$**   
**Secretion of  $\text{K}^+$  and  $\text{HCO}_3^-$**   
nerve control

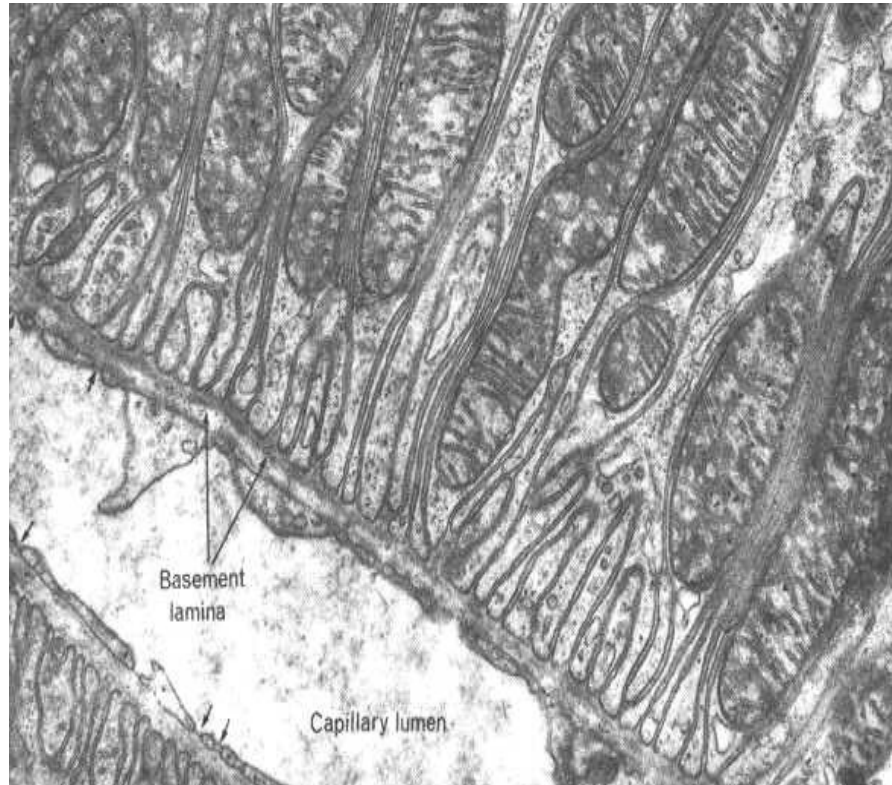




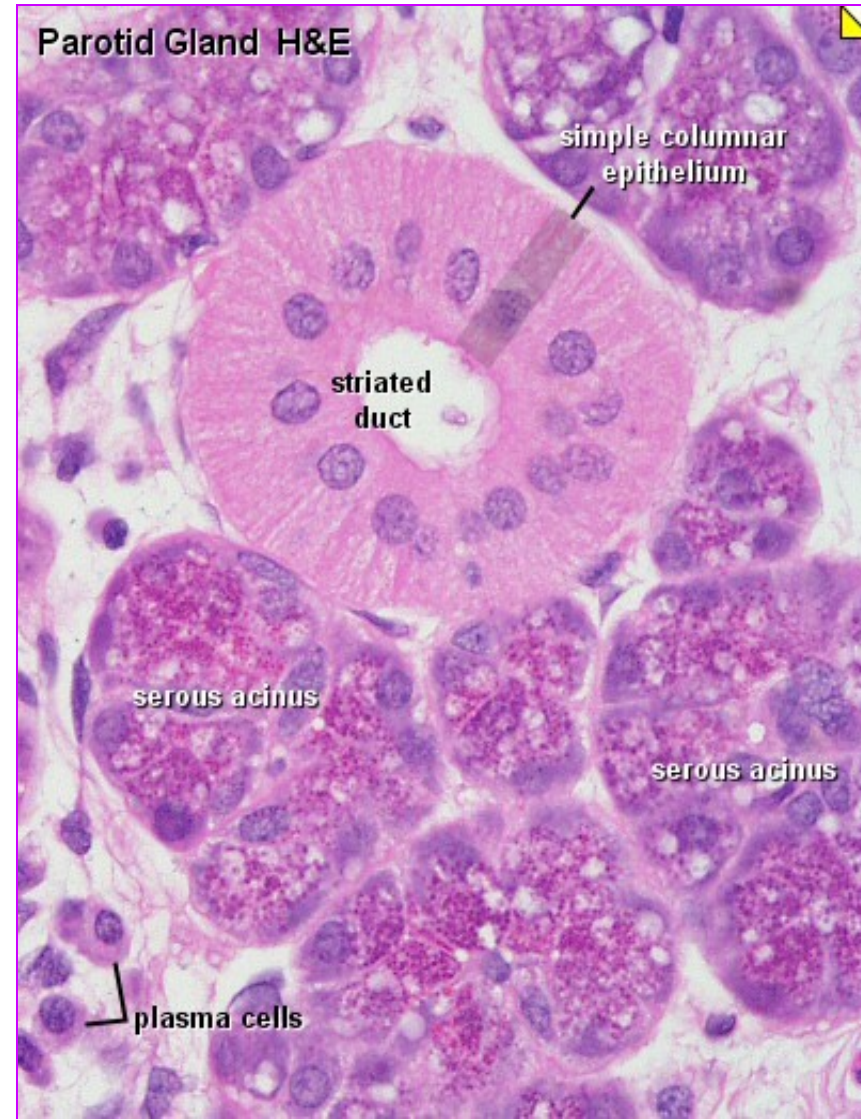
# Striated duct – basal labyrinth



*Epithelial cell*



**Base of epithelial cell:**  
Invagination of cytoplasmic membrane,  
numerous mitochondria





# Interlobular and main ducts

## Interlobular ducts

Located in fibrous septae between the lobes (columnar or stratified columnar epithelium)

They are formed by the **connection of several striated ducts**

Lined by a **high single-layer columnar** and in the terminal sections also a **stratified columnar** epithelium

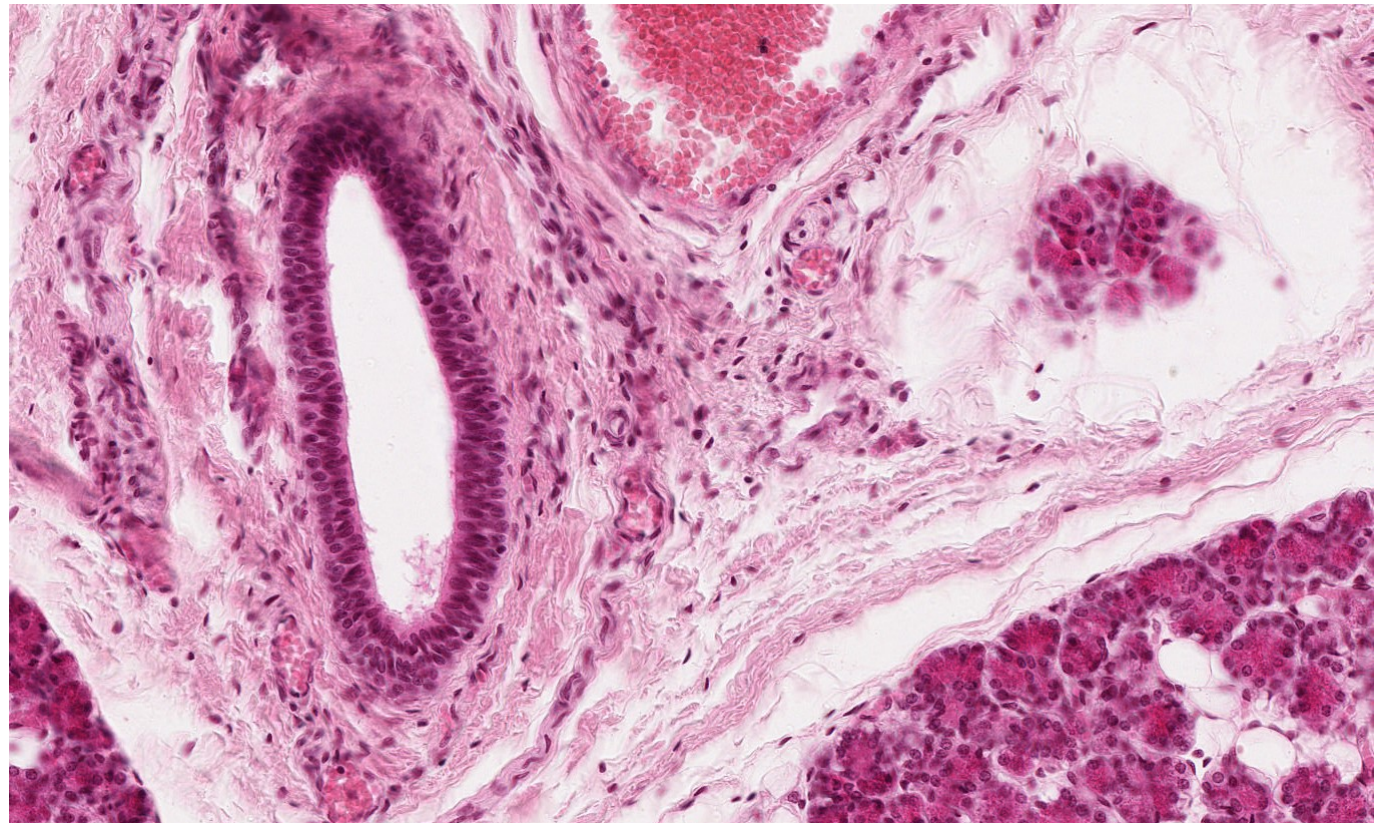
## Main ducts

Stratified columnar ep. with goblet cells

*Ductus parotideus*

*Ductus submandibularis*

*Ductus sublinguales (major et minores)*

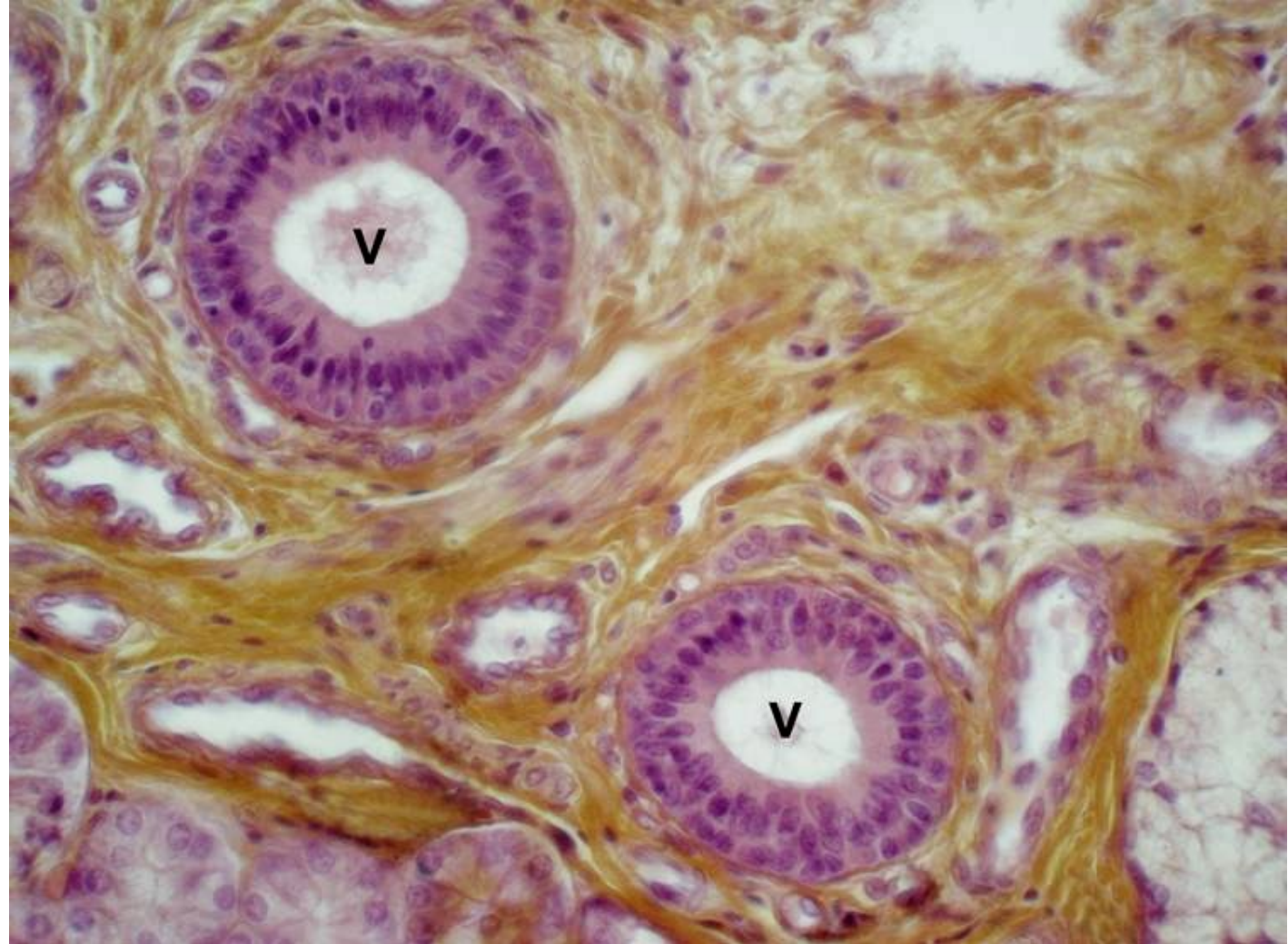


## Main ducts

**Stratified columnar ep.**

In epithelium **Goblet cells**

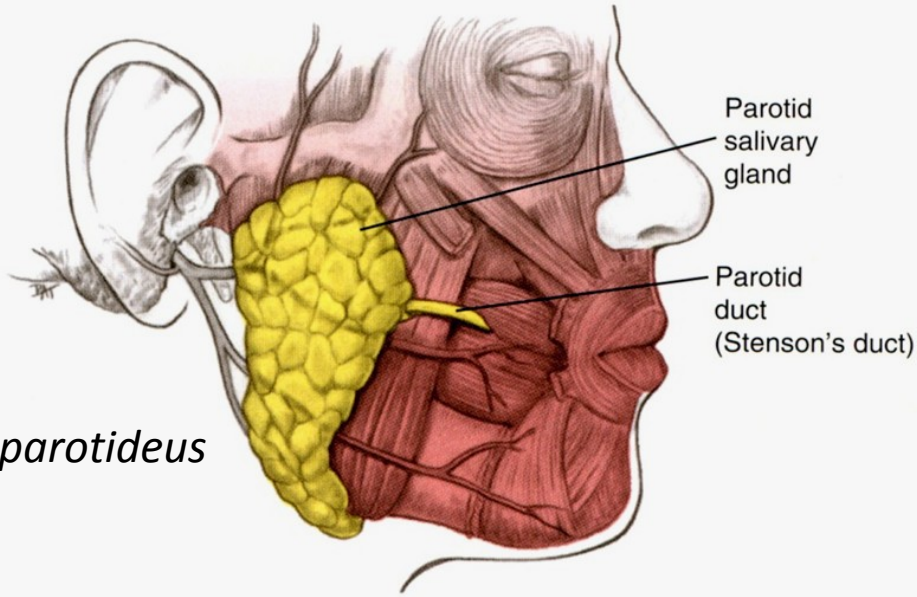
**Wall supported by the dense collagenous connective tissue and smooth muscle cells**



Ductus Rivini (V) – septum of *gl. sublingualis*.



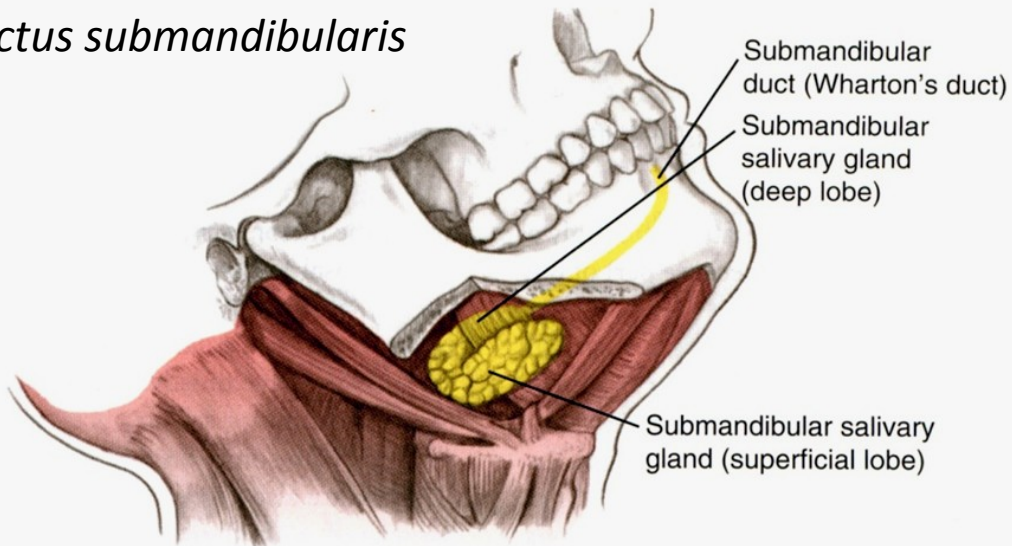
# Topography of large salivary glands



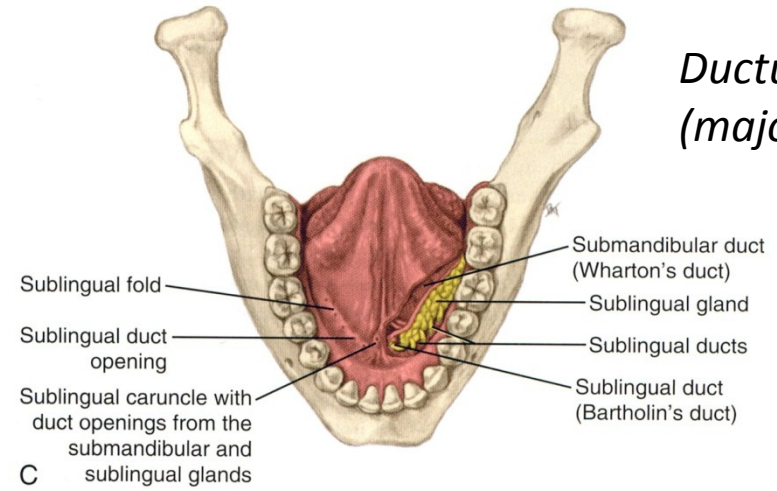
*Ductus parotideus*

A

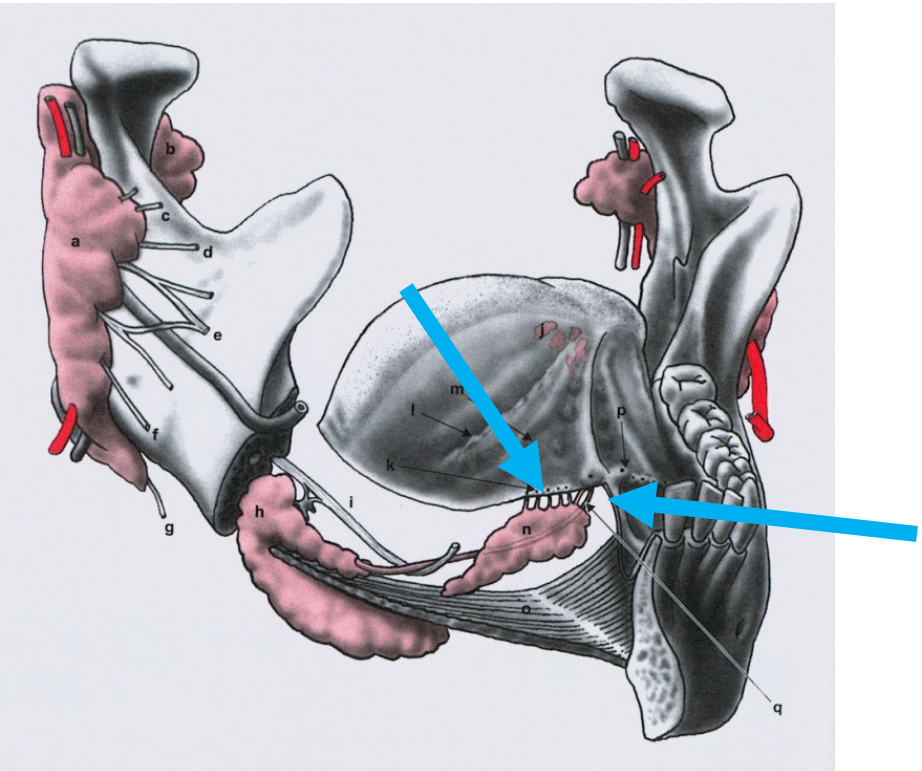
*Ductus submandibularis*



B

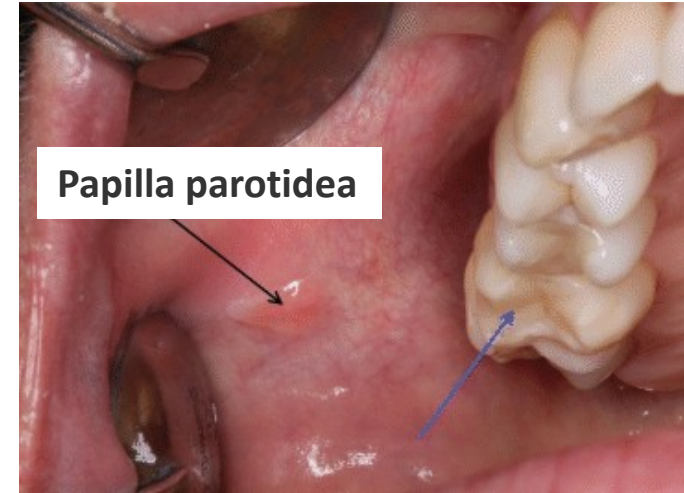
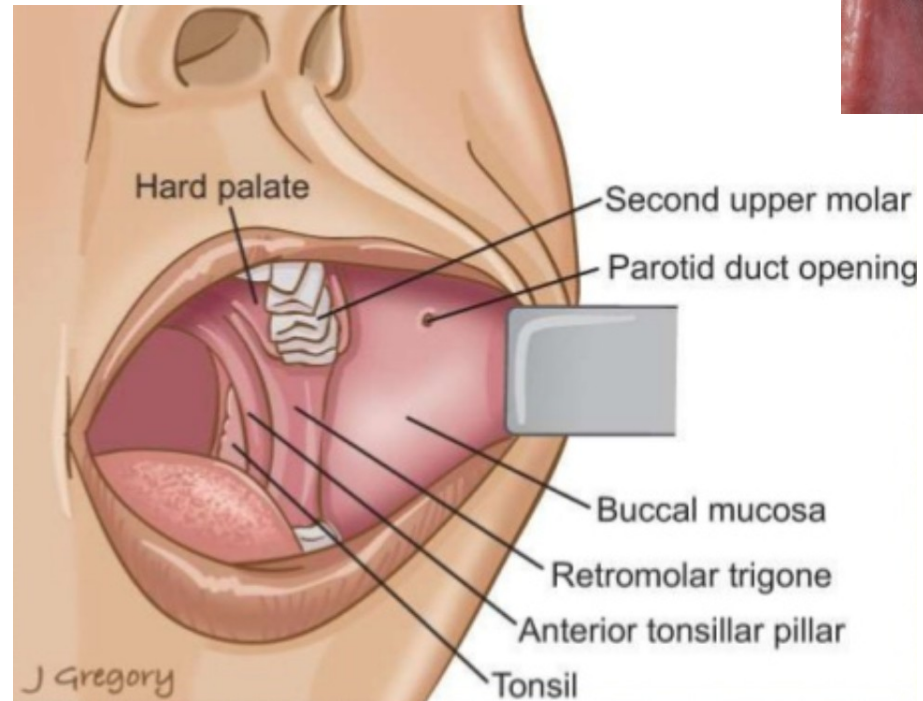
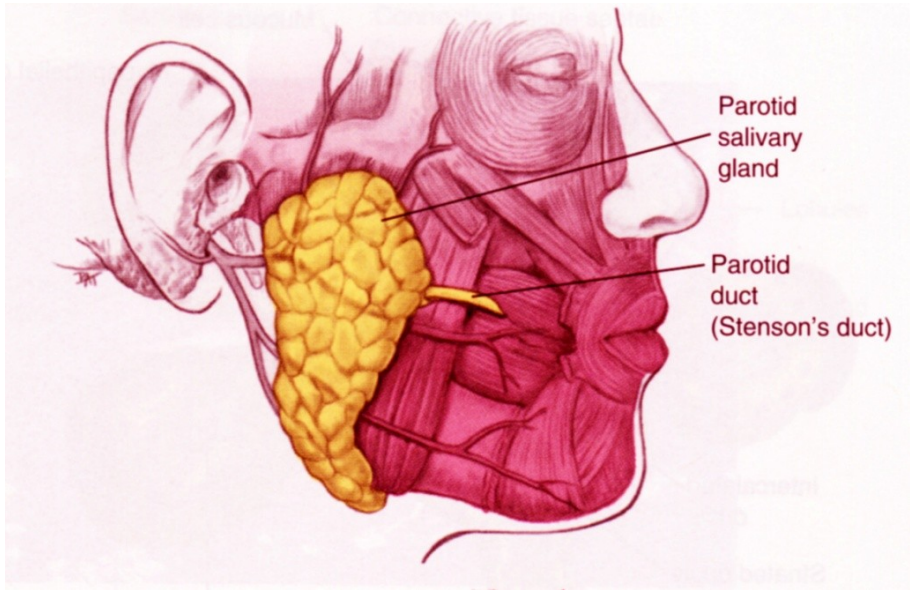


*Ductus sublinguales (major et minores)*



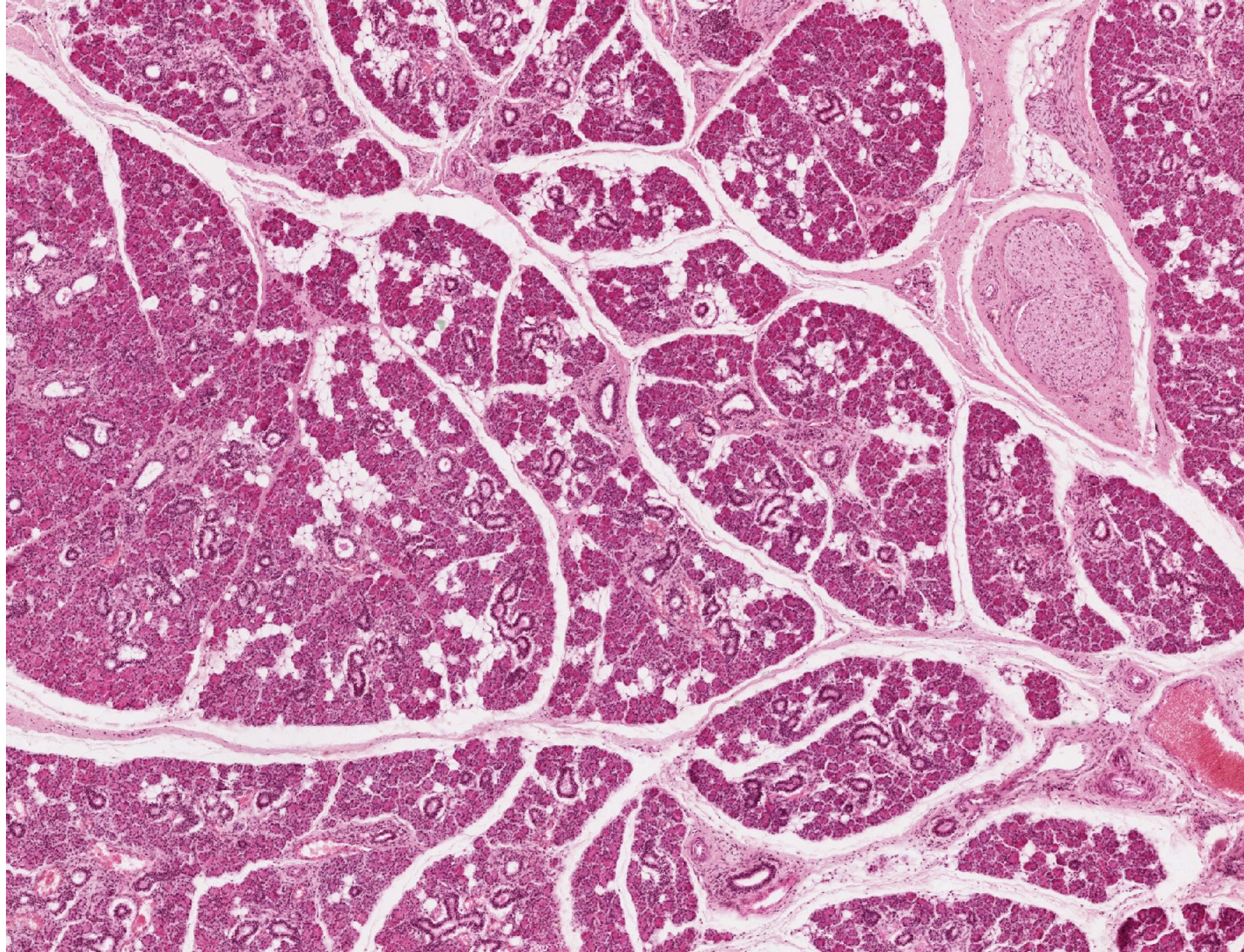
# Glandula parotis

- **SEROUS** gland
- 14 - 28 g
- capsule, septs and lobules
- Serous acini, ducts: **long** intercalated ducts, **numerous** of striated ducts
- **ductus parotideus (Stenoni)** - 2. upper molar (Steno/Stensen, Niels)
- adipocytes

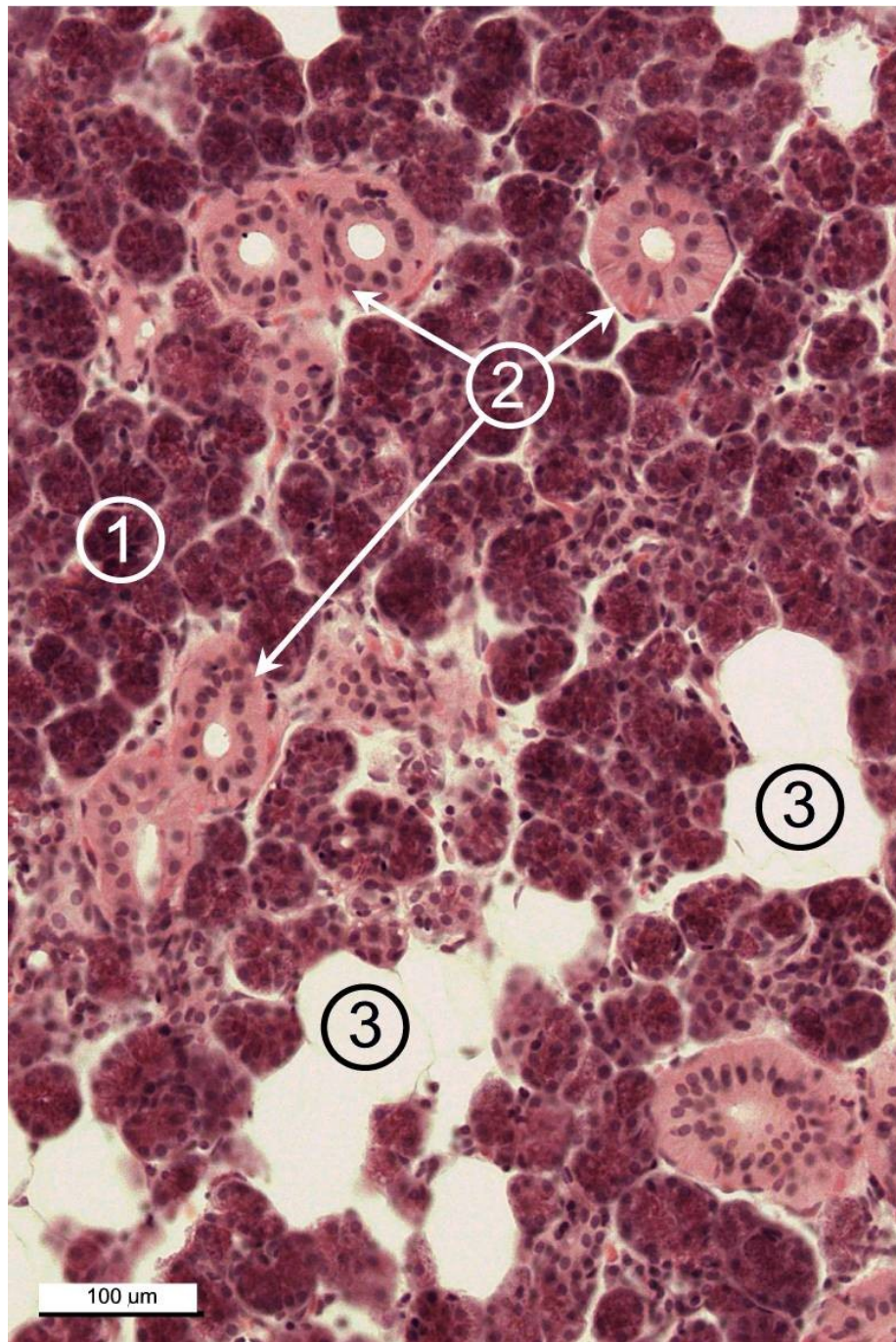




## Glandula parotis



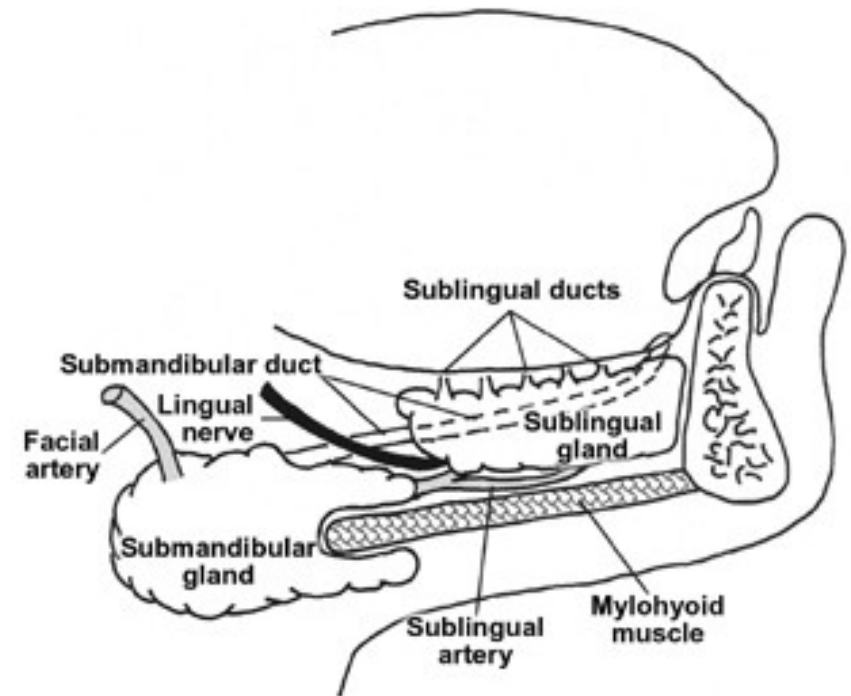
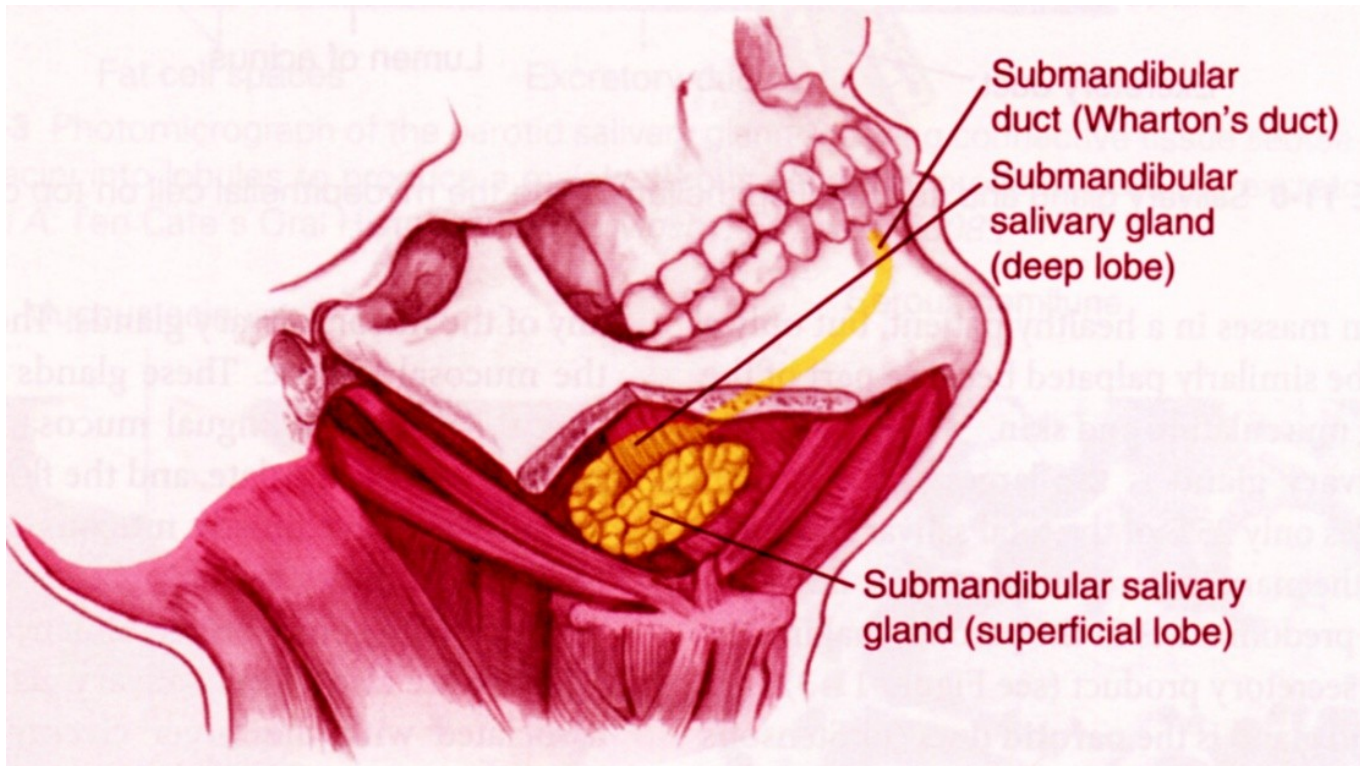






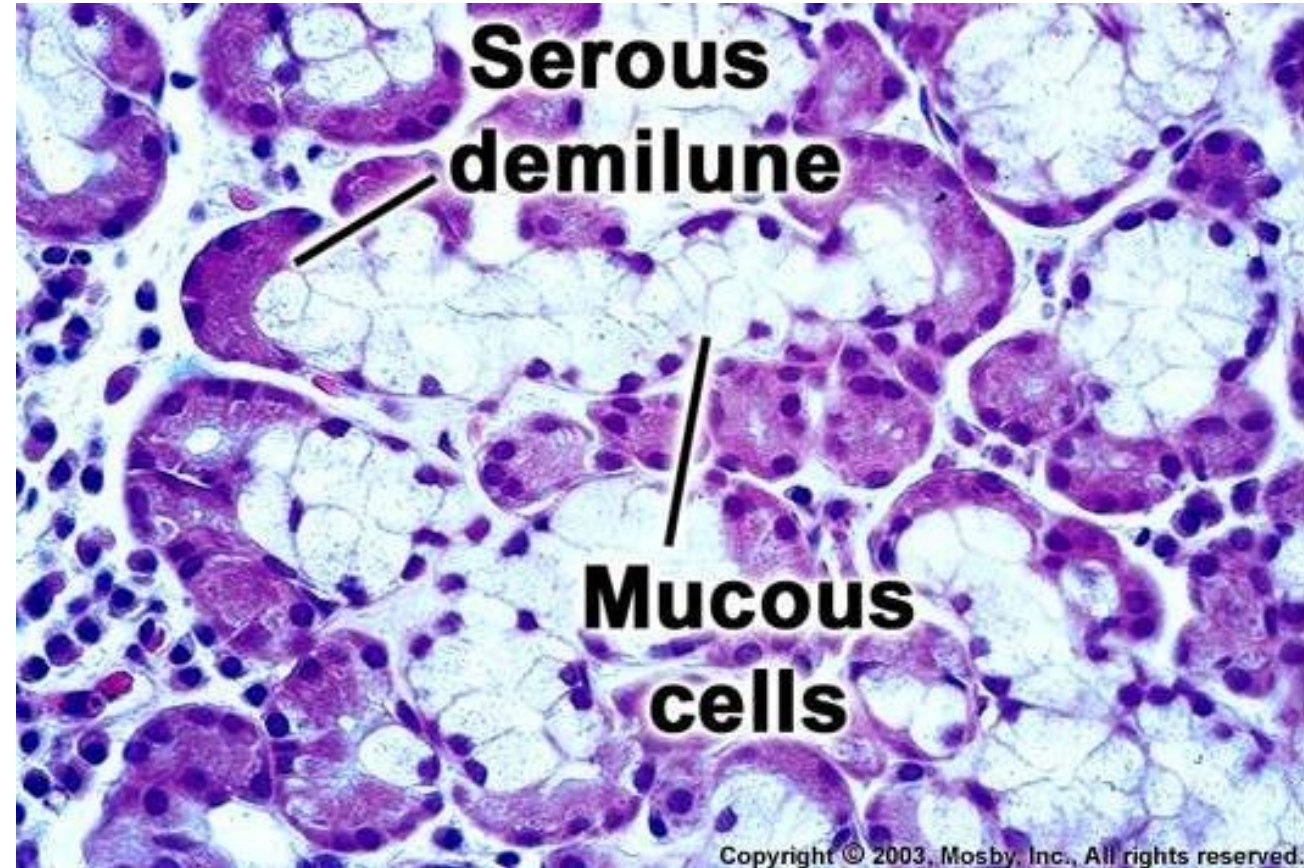
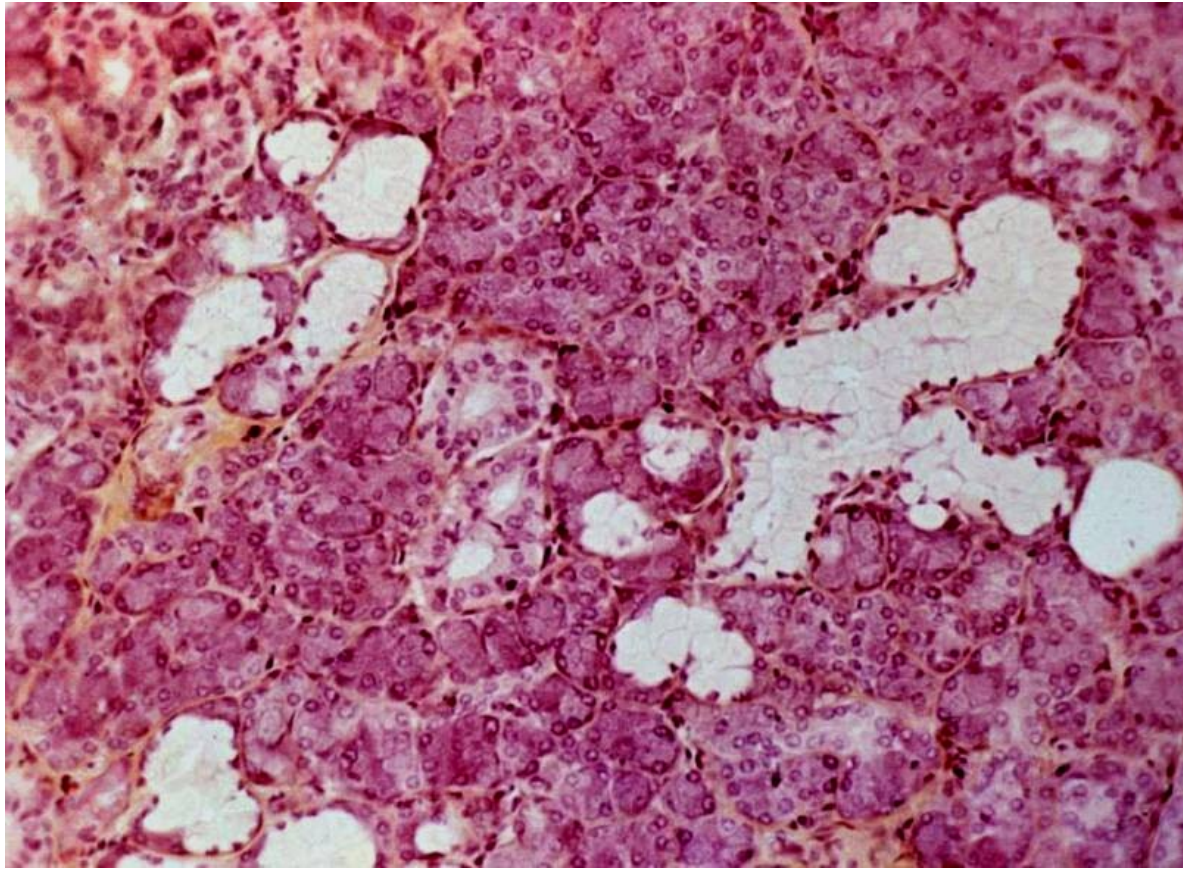
# Glandula submandibularis

- **MIXED** tuboalveolar gland, predominantly **SEROUS**
- 10-15 g
- serous acini - 80 %, rest are mucinous tubules with **Gianuzzi demilunes**
- intercalated and striated ducts
- **ductus submandibularis (Whartoni) - frenulum linguae**





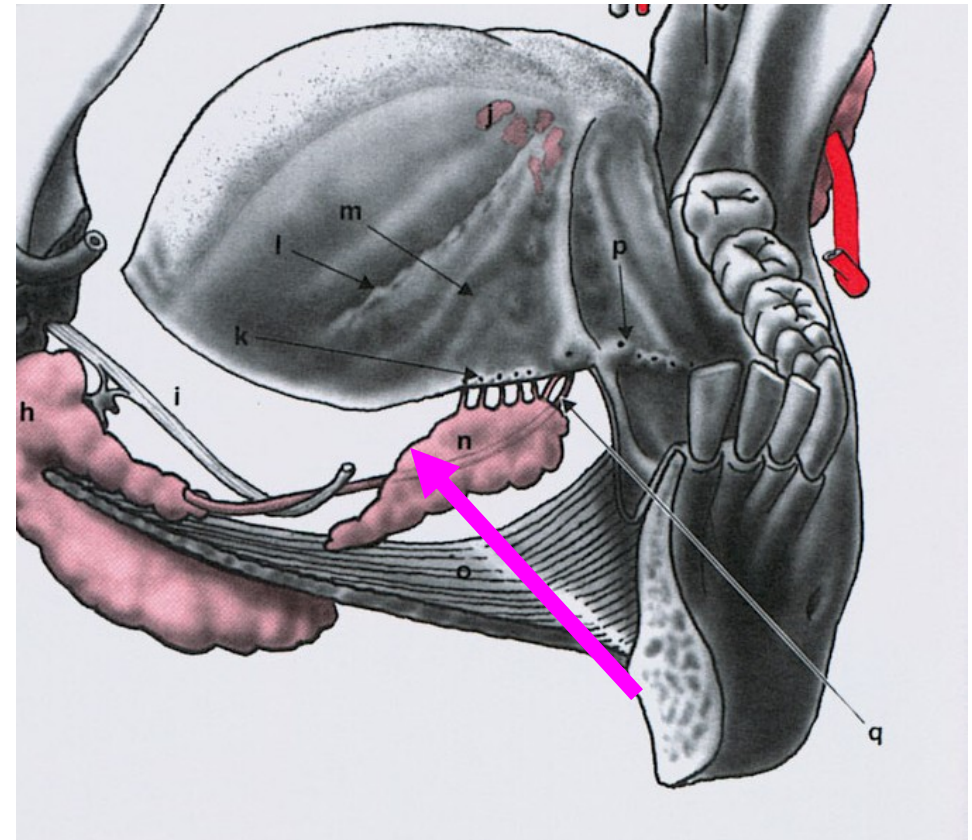
# Glandula submandibularis





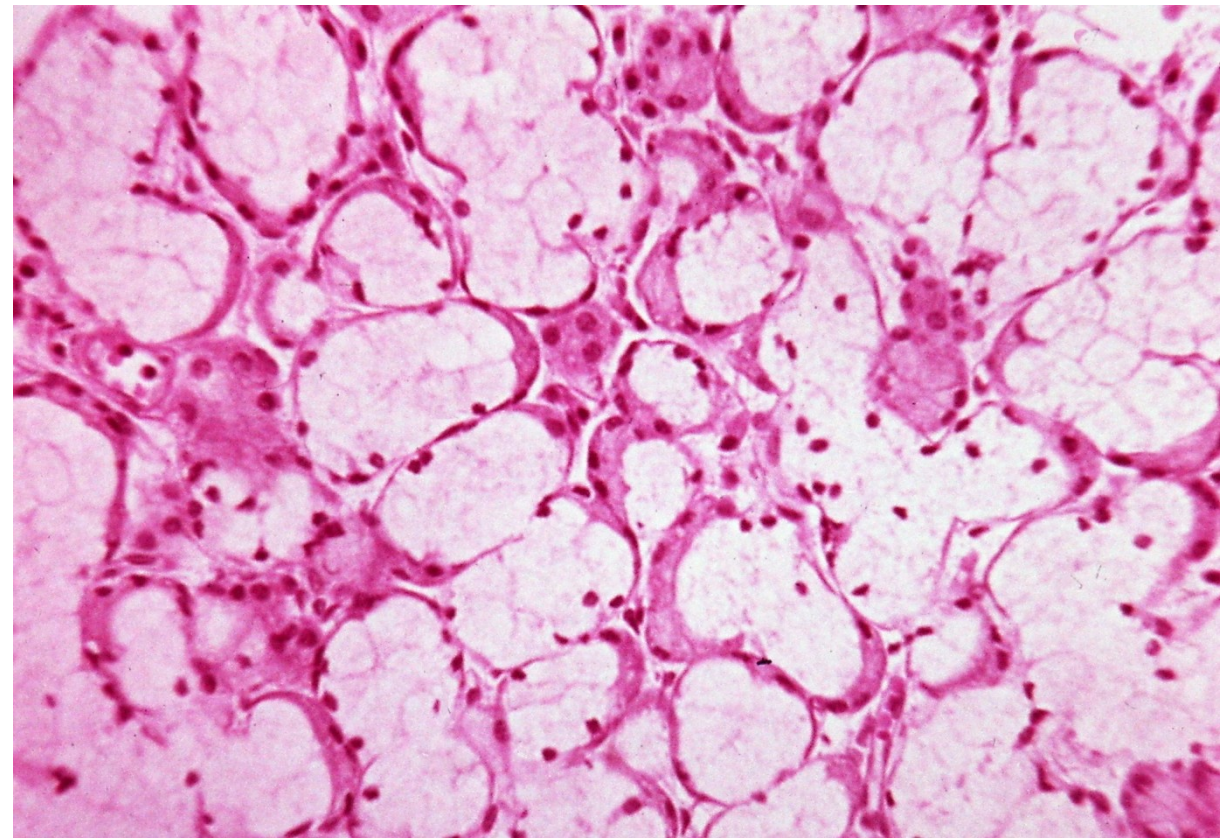
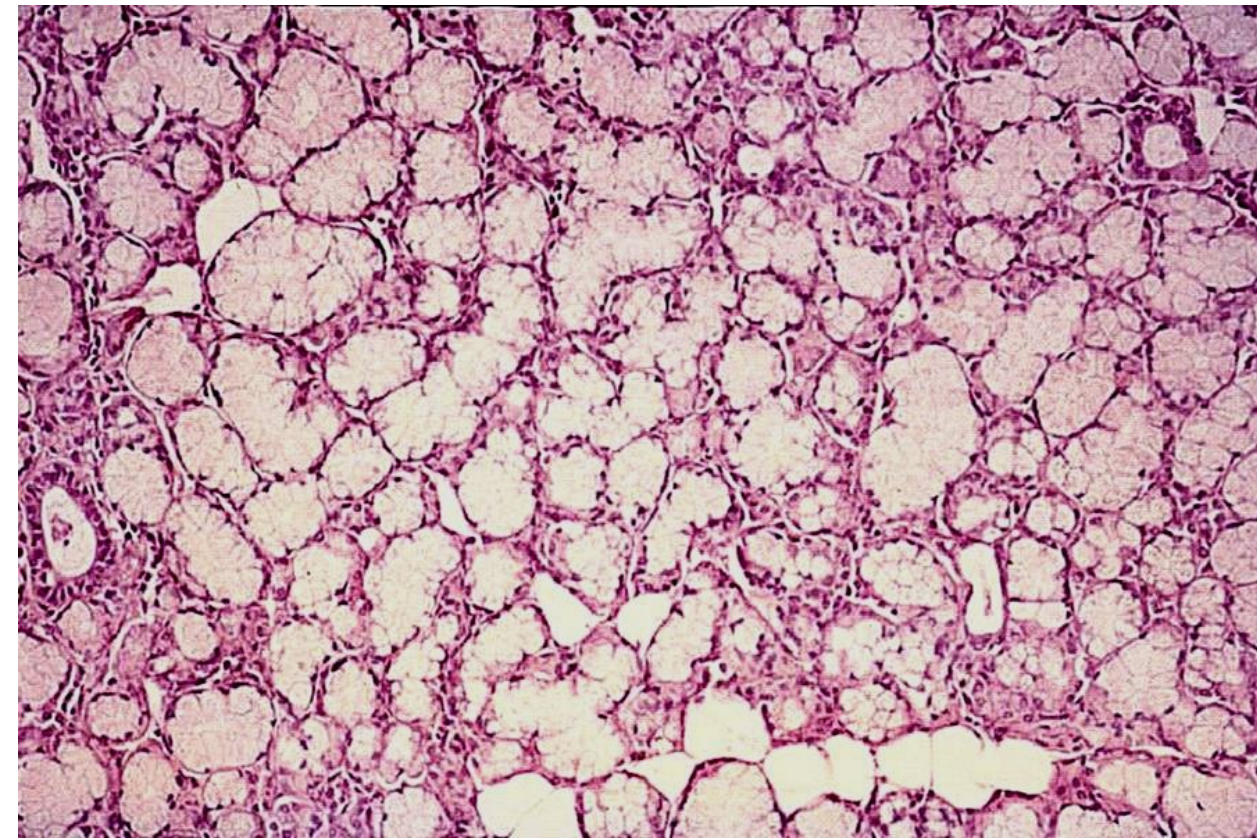
# Glandula sublingualis

- **MIXED** tuboalveolar gland, predominantly **MUCOUS**
- 2g
- located on the floor of the mouth on mylohyoid muscle near the midline
- Mucinous tubules, **serous acini are rare**, instead of them: **Gianuzzi demilunes**
- Intercalated ducts are missing, striated ducta are present, but are reduced in number and short
- **ductus sublingualis major** (Bartholini)
- **ductus sublinguales minores** (Rivini) along the crest of the plica sublingualis





# Glandula sublingualis



<b>Comparison of major salivary glands</b>			
	<b>PAROTID</b>	<b>SUBMANDIBULAR</b>	<b>SUBLINGUAL</b>
<b>Size</b>	<b>Largest, encapsulated</b>	<b>Intermediate, encapsulated</b>	<b>Smallest, no capsule</b>
<b>Location</b>	<b>Behind mandibular ramus, anterior and inferior to ear</b>	<b>Beneath the mandible</b>	<b>Floor of the mouth</b>
<b>Main ducts</b>	<b>Parotid duct (Stenson's): opens opposite maxillary second molar on buccal mucosa</b>	<b>Submandibular duct (Wharton's): opens near lingual frenum on floor of mouth</b>	<b>Sublingual duct (Bartholin's): opens at same area as submandibular duct; may have additional ducts (Rivini) at submandibular folds</b>
<b>Striated ducts</b>	<b>Short</b>	<b>Long</b>	<b>Rare or absent</b>
<b>Intercalated ducts</b>	<b>Long</b>	<b>Short</b>	<b>Absent</b>
<b>Feature of gland</b>	<b>True serous</b>	<b>Mixed (the serous component outnumber the mucous)</b>	<b>Mixed (the mucous component outnumber the serous)</b>
<b>% of total saliva volume</b>	<b>25%</b>	<b>55-65%</b>	<b>5-10%</b>

# Saliva

Product of all salivary glands of the oral cavity

**1.0-1.5 liters / day** (0.3-0.6 ml / min)

**Small glands 10 % / large glands 90 %** (gl. Parotis 25 %, gl. Submand. 60-65 %, gl. Sublingualis 10 %)

Clear or slightly opalescent viscous liquid, **slightly acidic pH: 6.8** (6.5 - 7.2)

It consists of a liquid and solid component:

**Liquid:** water (95%)

ions - Na +, K +, Cl-, Ca<sup>2+</sup>, Mg<sup>2+</sup>, HCO<sub>3</sub><sup>-</sup>, etc.

proteins: amylase (ptyalin) and maltase, peroxidase, lysozyme, lactoferrin

glycoproteins - mucus (mucin)

immunoglobulins (Ig A, IgG and IgM)

small organic molecules (glucose, amino acids, urea, uric acid, etc.)

**Formed:** removed dead cells of the epithelium of the oral cavity,

salivary bodies (altered lymphocytes) and

non-pathogenic saprophytic bacteria

2 stages of saliva production: **primary saliva (isotonic)** – before passing through striated ducts and **definitive saliva (hypotonic)** - was modified by striated ducts



# Saliva function

- Protective:** forms a thin film on the surface of the mucosa and teeth - a salivary film  
stimulates repair processes in the oral cavity  
participates in remineralization and maintains tooth integrity  
ensures moisture and self-cleaning of the oral mucosa  
protects teeth from bacteria
- Antimicrobial:** proteins with bacteriostatic effect - lysozyme, peroxidase, lactoferrin, etc.
- Moisturizing:** moisturizes dry food and makes them easier to swallow
- Digestive:** initiates cleavage of polysaccharides (salivary amylase)

saliva is a **sensitive indicator of oral health**  
(changes during periodontal disease, caries, candidiasis, etc.)

Location		Name	Type	Size
<b>Lips</b>		gll. labiales sup. et inf.	mixed, pred. mucinous	minor
<b>Cheeks</b>		gll. buccales	mixed, pred. mucinous	minor
		gll. molares (retromolares)	mixed, pred. mucinous	minor
		<b>GL. PAROTIS</b>	serous	<b>MAJOR</b>
<b>Palate</b>	hard	gll. palatinae (glandular zone)	mucinous	minor
	soft	gll. palatinae	mucinous	minor
<b>Tongue</b>	Apex	gl. apicis lingue (Blandini-Nuhni)	mixed, pred. mucinous	<b>minor/ major</b>
	Terminal sulcus	gll. Ebner's (gll. papillae vallatae)	serous	minor
	Base	gll. Weber's (gll. linguales post.)	mucinous	minor
<b>Floor of the mouth</b>		<b>GL. SUBMANDIBULARIS</b>	mixed, pred. serous	<b>MAJOR</b>
		<b>GL. SUBLINGUALIS</b>	mixed, pred. mucinous	<b>MAJOR</b>

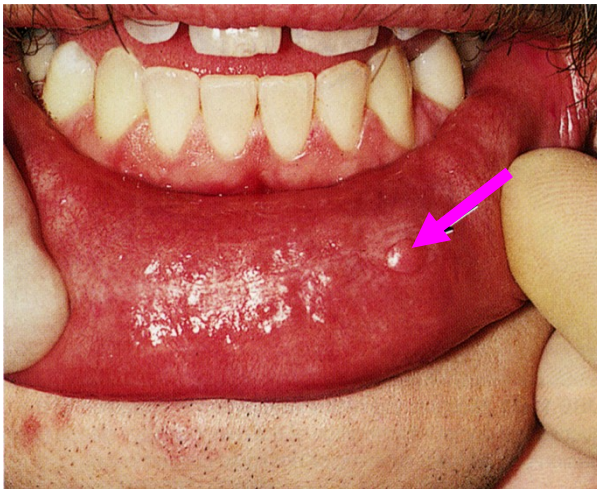
# Pathology (diseases) of the salivary glands

**Sialadenitis (sialoadenitis)** – inflammation of the salivary glands, of bacterial or viral origin

**Sialolithiasis** - saliva in the ducts becomes a viscous to such an extent that the concentrated secretion can secondary calcify - prevents drainage - impermeability of the outlets

Sialolithiasis in small salivary glands - dilatation of secretory compartments (mucocele), and enlargement of glands

In case of obstruction of the ductus submandibularis - large retention cyst located at the base of the oral cavity - **ranula**





# Control of salivary gland function

**Autonomic nervous system:** efferent fibers enter the glands from the parasympathetic and thoracic sympathetic fibers, forming dense network on the surface of the secretory compartments and ducts

Stimulation of **sympathetic** fibers **reduces** saliva production

Stimulation of **parasympathetic** fibers **increases** saliva production

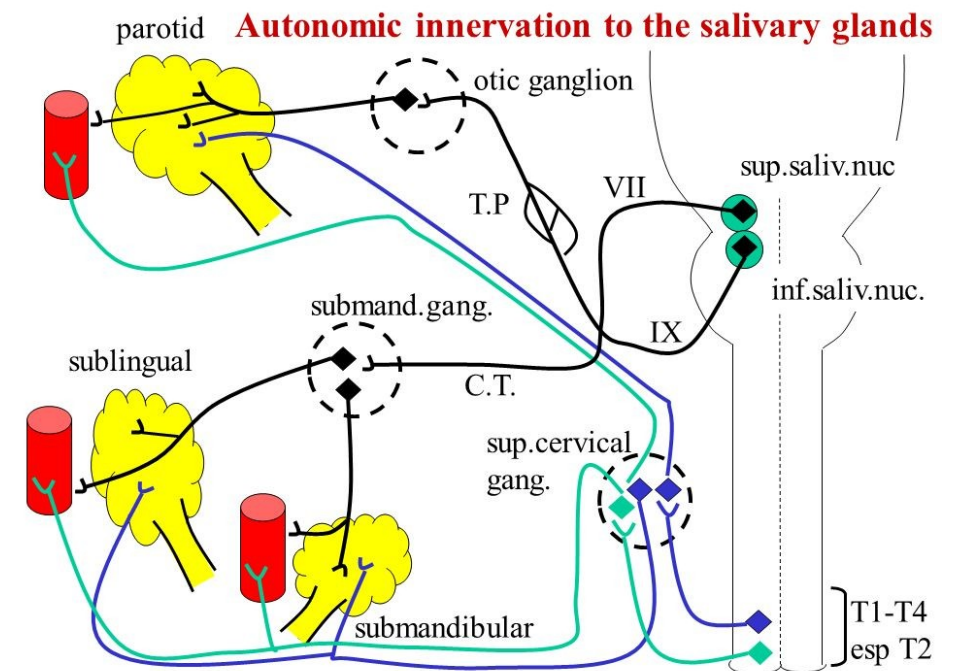
**small salivary glands secrete constantly**

the large salivary glands secrete only on stimulus  
(eg chemical, mechanical, etc.).

**Atrophy of the glandular parenchyma**

atrophy accompanies some systemic diseases,  
drug-induced, irradiation

Consequence: **hyposalivation - xerostomia ("dry mouth")**

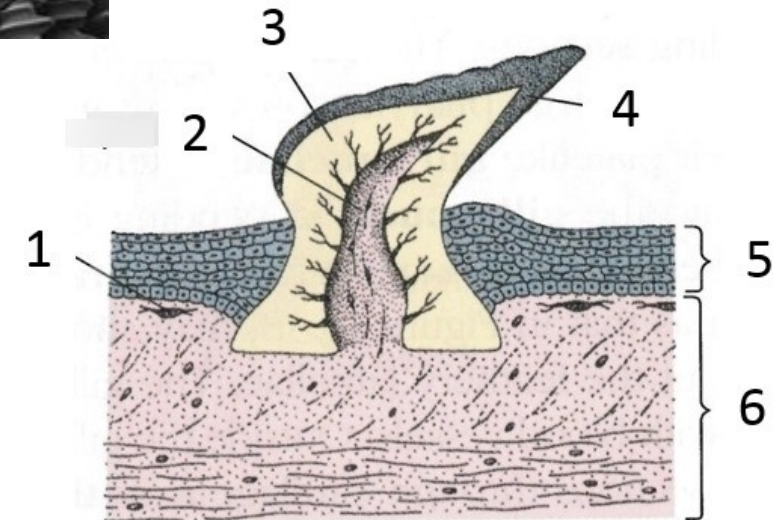
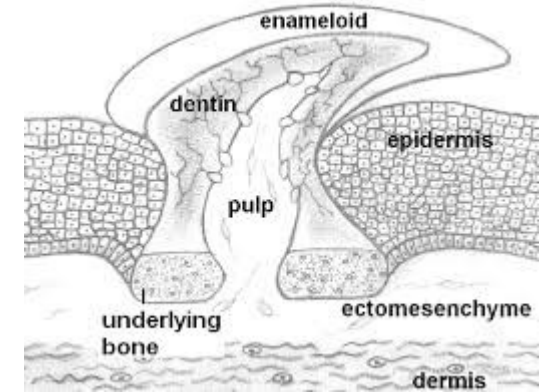
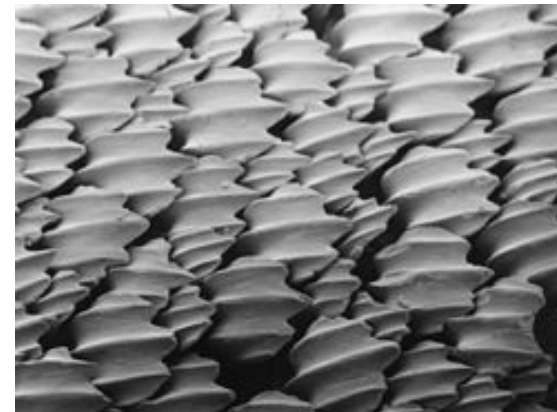
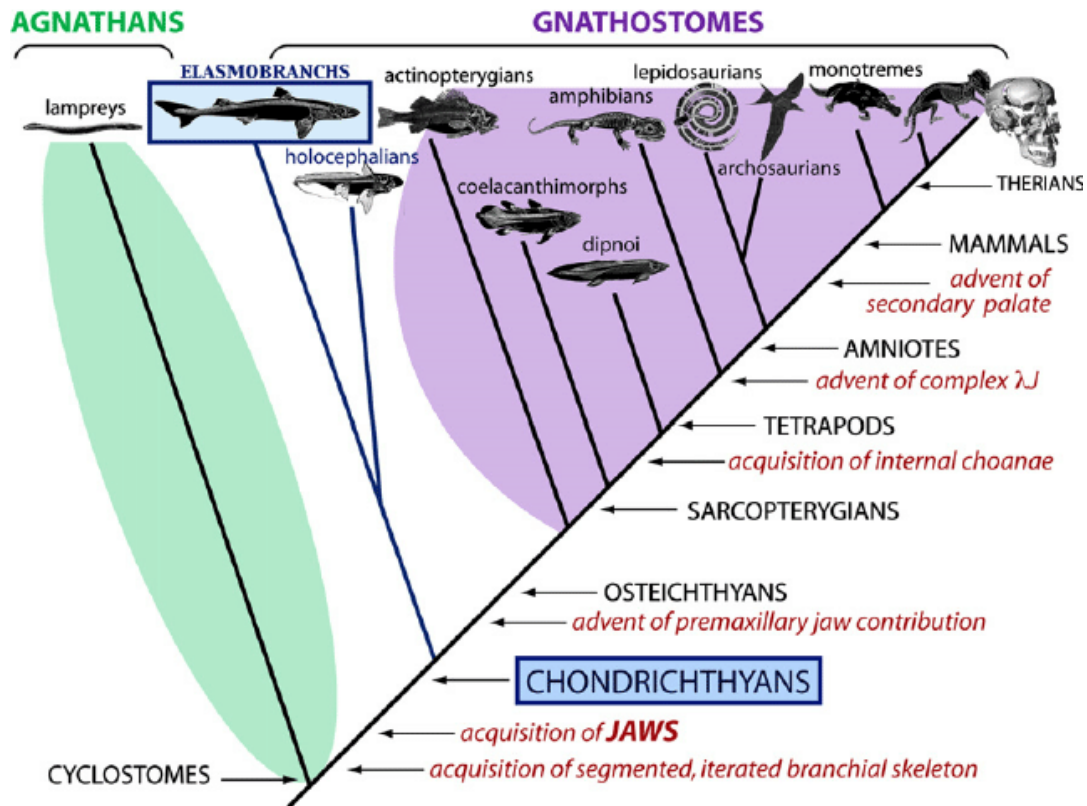


# Basics in the phylogenesis and comparative tooth anatomy

Teeth - calcified structures that derive from the ectoderm and ectomesenchyme (neural crest)

Evolutionarily in phylogeny, they appear only in **the jawed vertebrates – Gnathostomata**

Ancestor of teeth - **placoid scales** in fishes that covered the surface of the body and the oral cavity



# Phylogenetic classification of teeth

According to the shape of the tooth and the shape of the crown:

**Haplodontic teeth** - shape of simple cones (preserved in some fish and amphibians) - picture C

**Protodont teeth** - they also have a conical shape, but the crown is distinguished into anterior and posterior humps (fossil marsupials)

**Triconodontal teeth** - with a crown consisting of 3 bumps, which are placed in one row in the direction of the dental arch (ancestors of mammals) - Fig. D

**Tritubercular teeth** - crowns also have 3 bumps, which formed 2 rows: buccal and lingual (marsupials, insectivores, beasts and ungulates) - fig.E

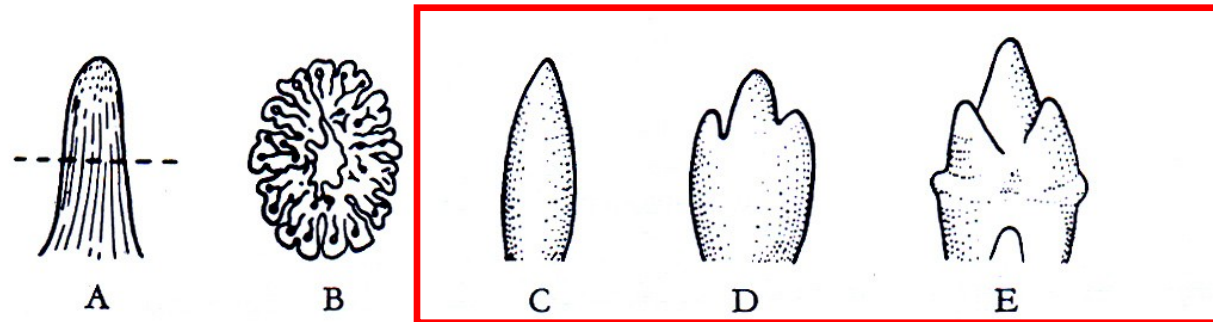
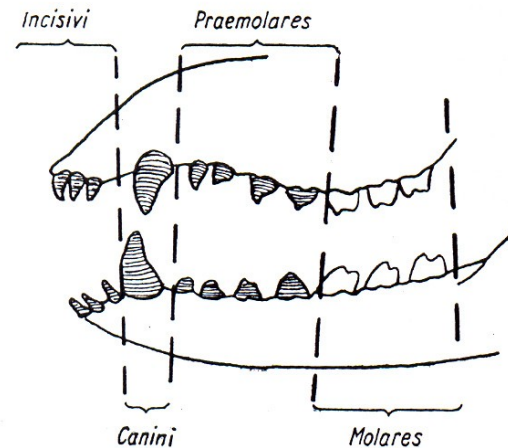


Abb. 71. Zahntypen von Wirbeltieren. A: labyrinthodonte Zahn (Crossopterygier); B: Querschnitt durch einen labyrinthodonten Zahn (vergrößert); C: Kegeldahn (Reptilien); D: triconodonte Zahn (ancestrale Säugetiere); E: trituberculater Zahn (Marsupialier, Insektivoren). (Kombiniert nach BYSTROW und PORTMANN)

**Number of teeth** - species characteristic, variable, approx. 15 - 170 teeth.  
 The number of teeth is an important taxonomic feature.



links nach rechts beginnt man mit der Zahl der Incisiven und beschränkt sich im allgemeinen auf die Darstellung einer Kieferhälfte. Als Formel für ursprüngliche Säugetiere wird folgende angenommen (s. Abb. 73):

3	I	4	3
3	I	4	3

Abb. 73. Permanentes Gebiß eines ursprünglichen Säugetieres. Schraffiert: Zähne, die bereits im Milchgebiß angelegt sind. (Verändert nach ROMER)

Human: 32

permanentní dentice – LH kvadrant

$I_1$   $I_2$  C  $P_1$   $P_2$   $M_1$   $M_2$   $M_3$



# Set of all teeth = dentition

Brachyodont  
Taurodont  
Bilophodont  
Haplodont  
Polyprotodont  
Acrodont Cynodont Protodont  
Labyrinthodont Secodont  
Loxodont  
orthodont  
Pleurodont Homodont Tritubercular  
Hypsodont Diprotodont  
Lophodont Heterodont  
Monophyodont Selenodont  
Polyphyodont Thecodont Diphyodont  
Triconodont

# Set of all teeth = **dentition**

## Types of dentition

**Shape of teeth:** **homodont** - identical in shape  
**heterodont** - different in shape  
(in mammals *dentes incisivi*, *canini*, *praemolares* and *molares*)

According to the **number of replacements** (sets of teeth) during life:

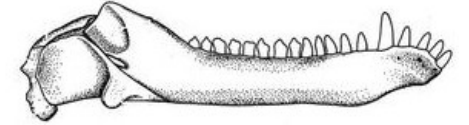
**monofyodont** - e.g., *Holocephala* - chimeras)  
**difyodont** (*dentes decidui*, *dentes permanentes*) – e.g. mammals  
**polyphyodont** - e.g., fish, lower amphibians

According to the **attachment** of the teeth to the jaw:

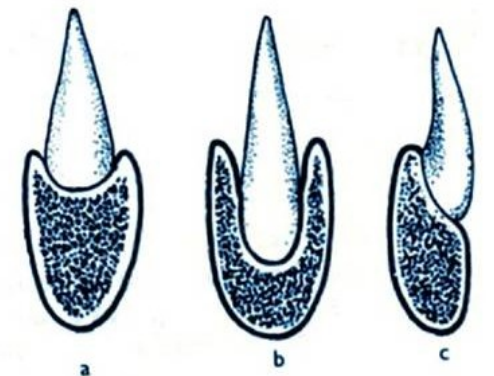
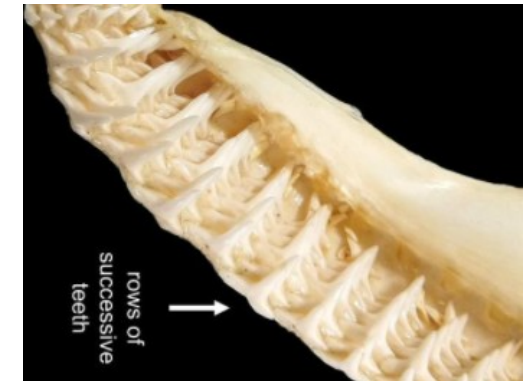
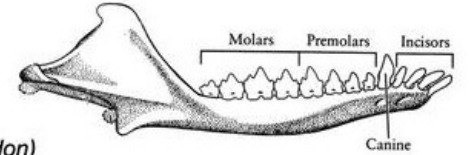
**acrodont** - attach to the jaw from above (bony fish, amphibians)  
**pleurodont** - on the jaw from the side (for reptiles)  
**thecodont** - inserted into dental sockets –  
recent mammals (dinosaurs, crocodiles)

## “REPTILIAN” vs MAMMALIAN DENTITION

Homodont  
(cynodont)



Heterodont  
(*Morganucodon*)





# Set of all teeth = **dentition**

Podle **typu rústu** zubů:

**Brachydont**

- Long root

**Hypselodont**

- No root – continuously-growing

**Hypsodont**

- High crown

**Mesodont**

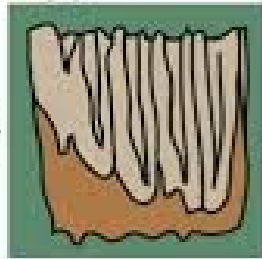
**Brachydont**



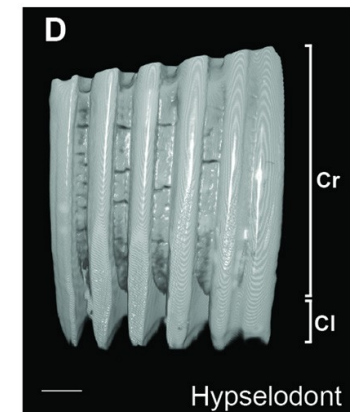
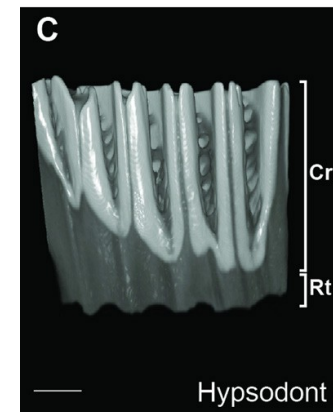
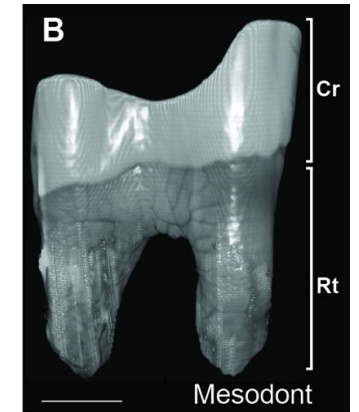
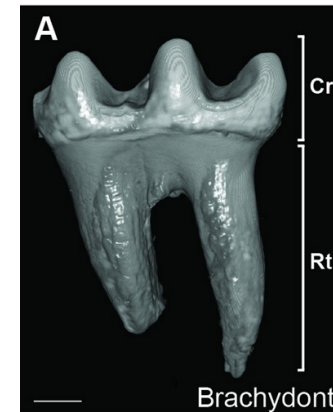
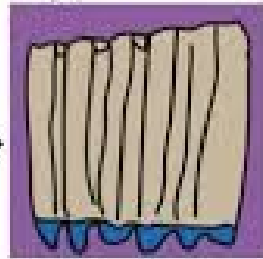
**Mesodont**



**Hypsodont**

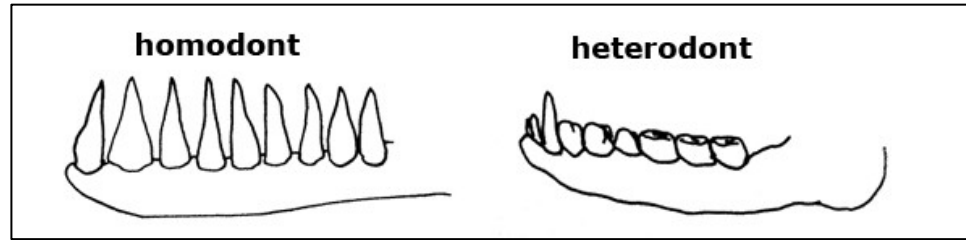


**Hypselodont**

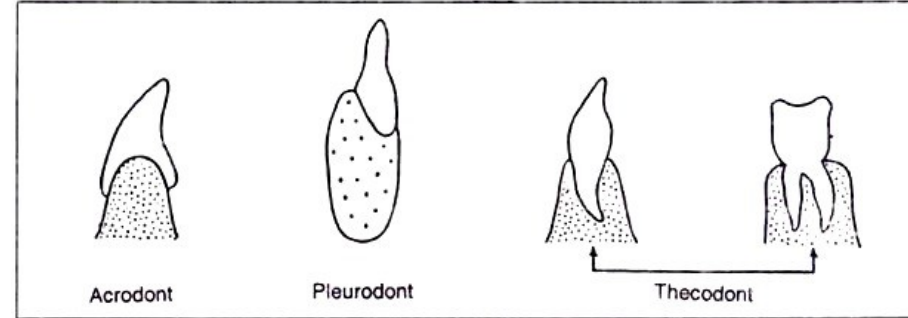


**Human dentition is:**

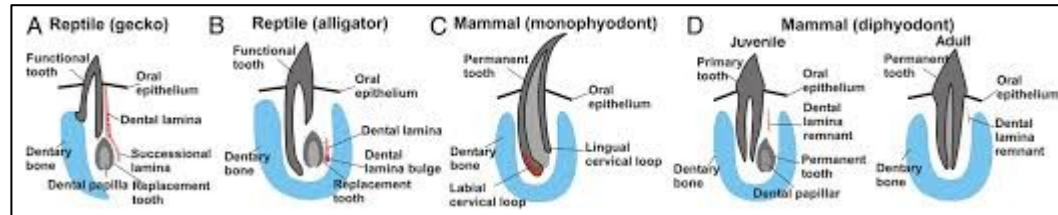
Heterodont



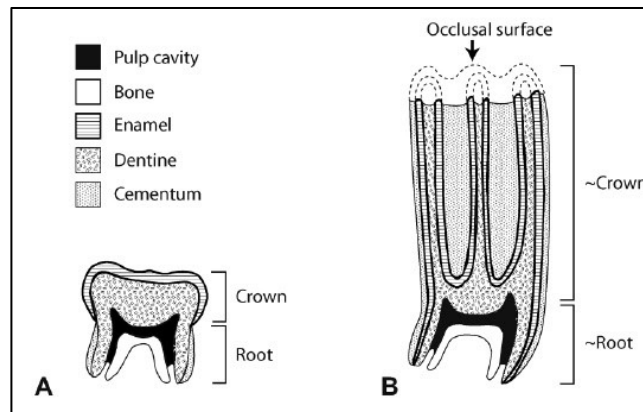
Thecodont



Diphyodont



Brachyodont





# Tooth numbering

## Several possibilities

### Beginning letter

incisors – dentes incisivi

$I_1, I_2 / i_1, i_2$

canines – dens caninus

$C / c$

premolars – dentes premolares

$P_1, P_2 / p_1, p_2$

molars – dentes molares

$M_1, M_2, M_3 / m_1, m_2, m_3$

### Number

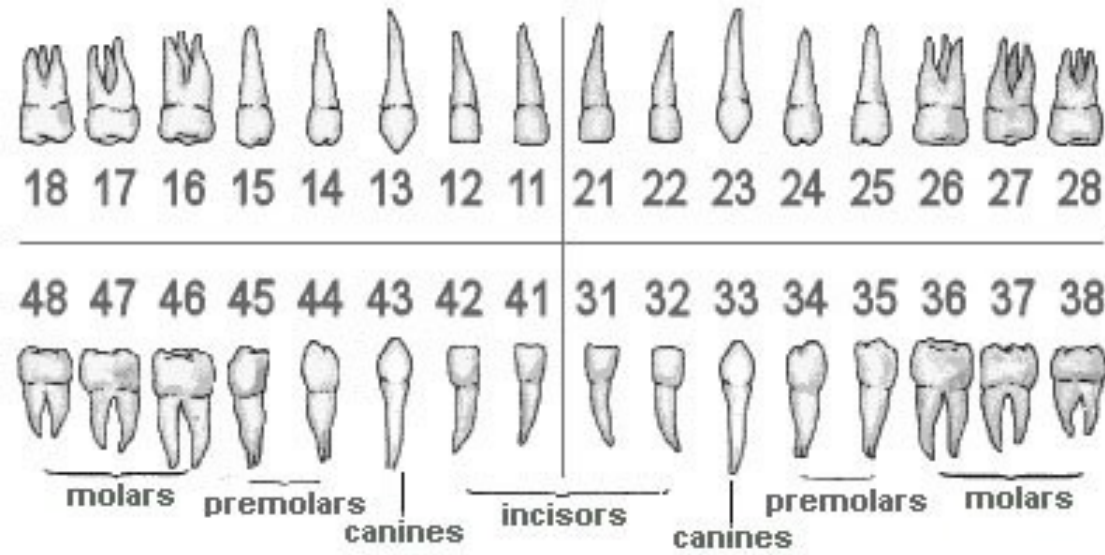
international marking using "two-digit code"

(ISO System - International Standards Organization Designation system: teeth divided into quadrants (clockwise):

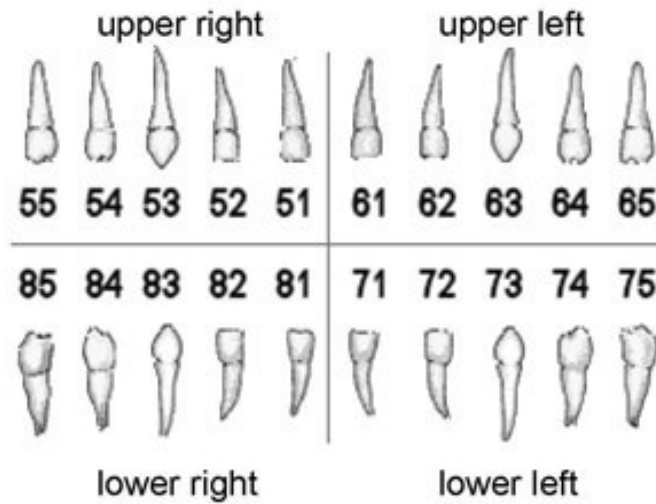
1 - 4      dentes permanentes

5 - 8      dentes decidui

Dentes permanentes



Dentes decidui



Primary teeth notation system



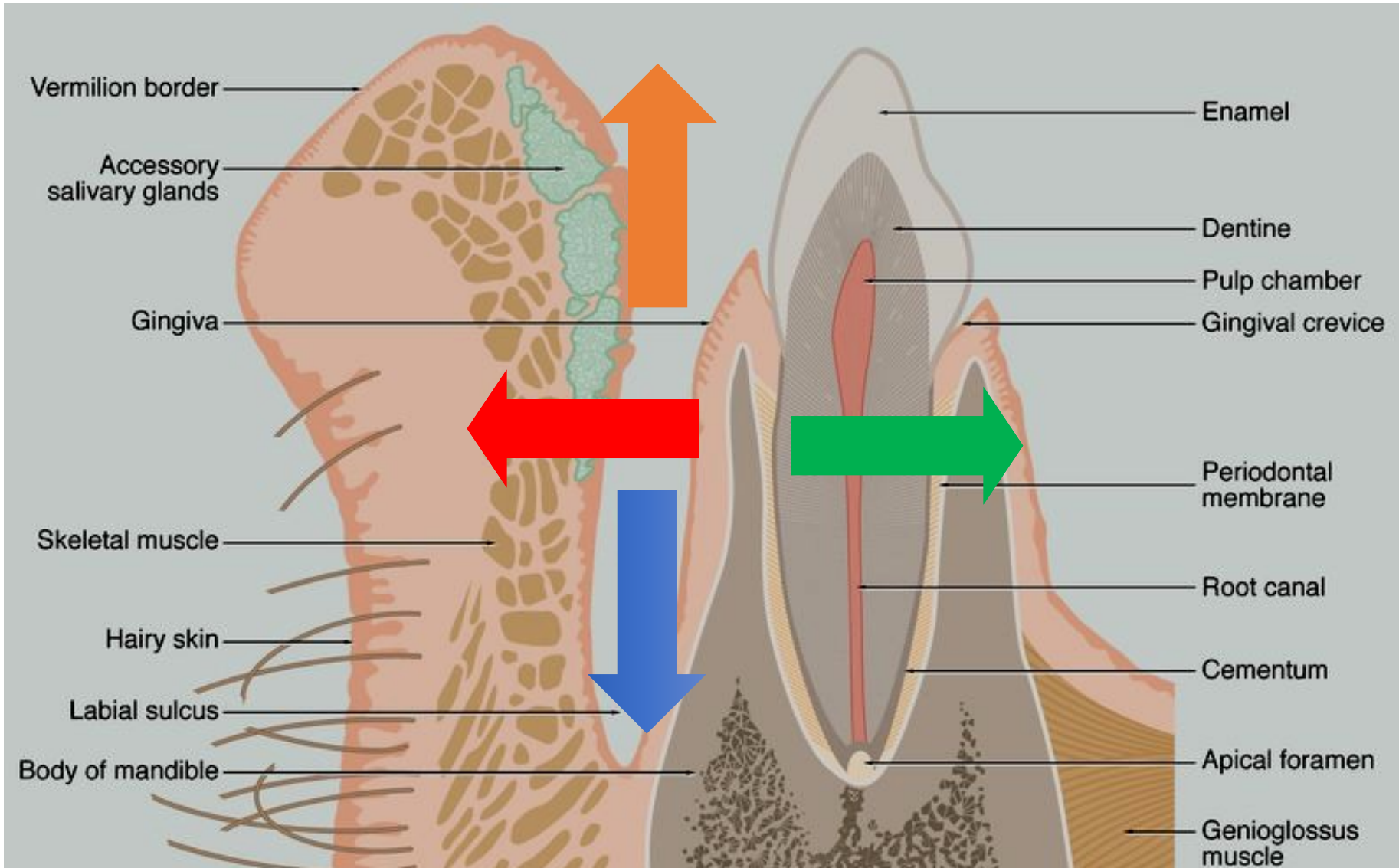
# Directions

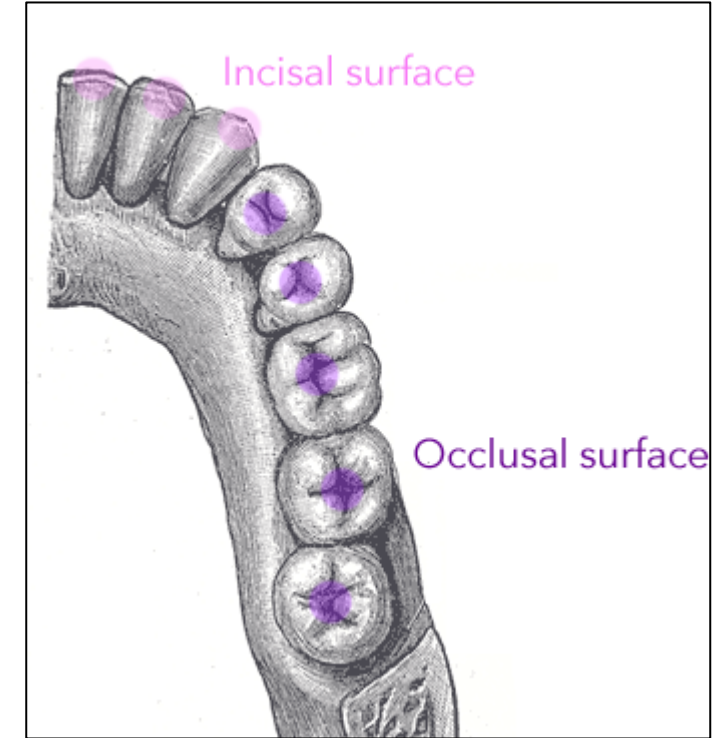
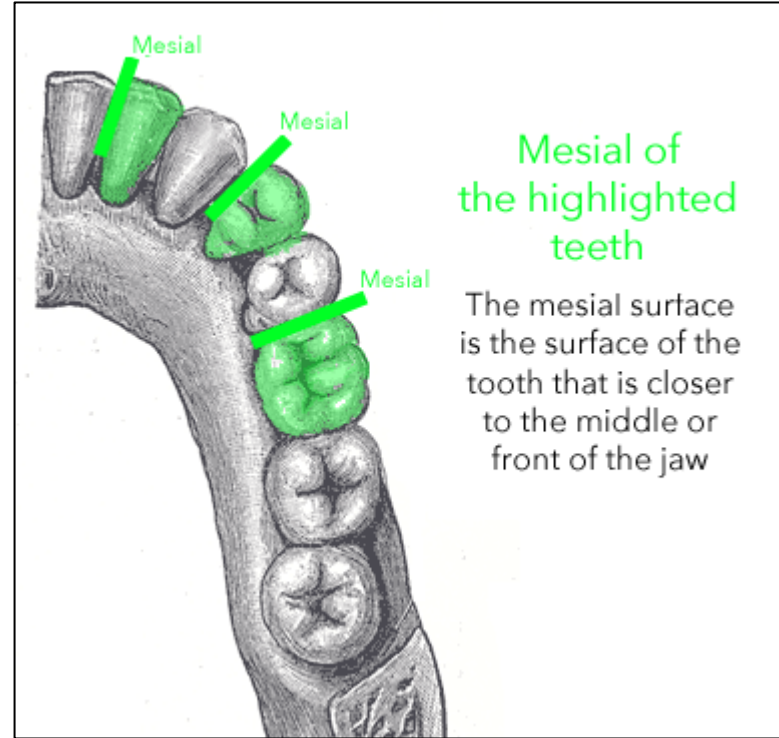
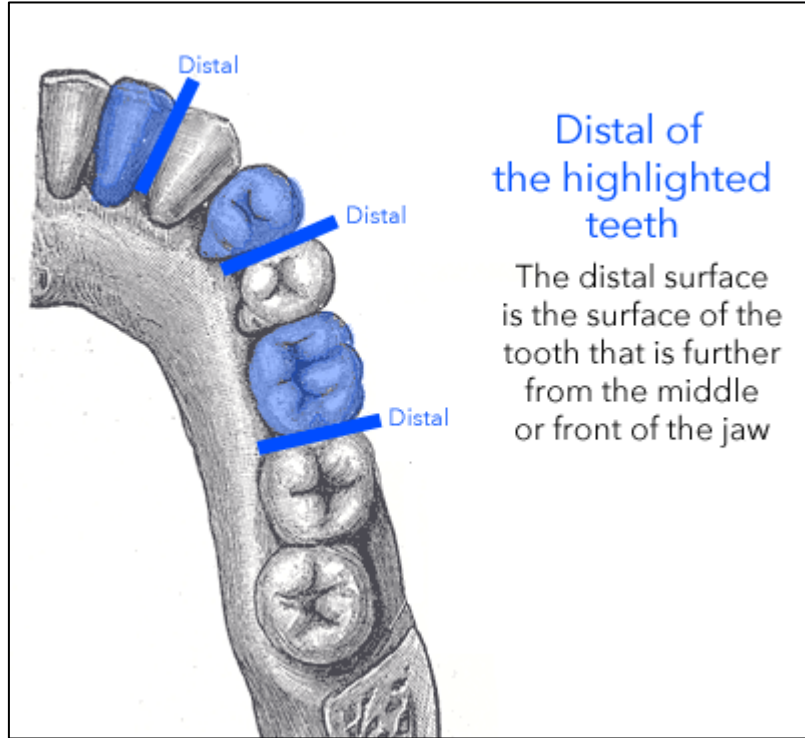
coronal

vestibular (labial, bucal)

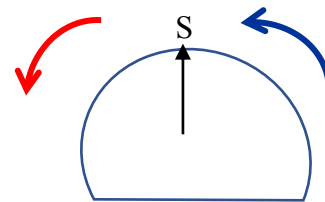
apical

lingual (palatinal)





**Distal**  
(towards the last molar)

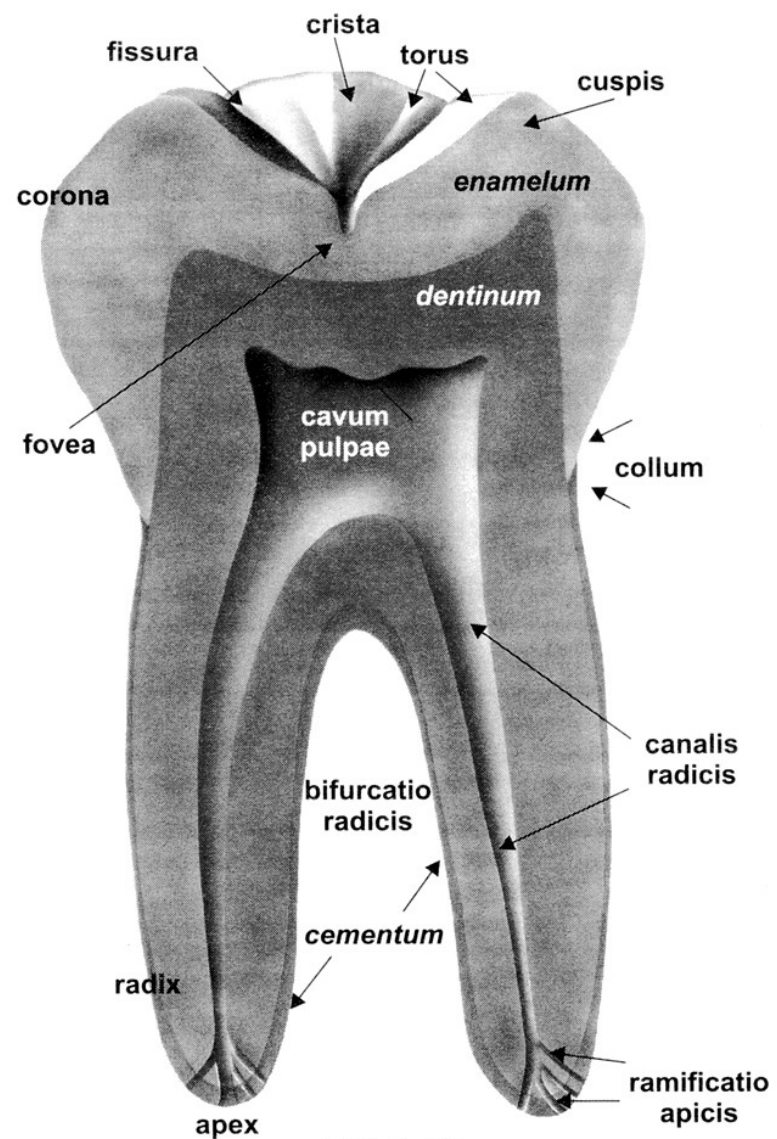


**Mesial**  
(towards the midline)



# Tooth and dental socket, periodontium, gingiva crown, neck, root

Části zuby:

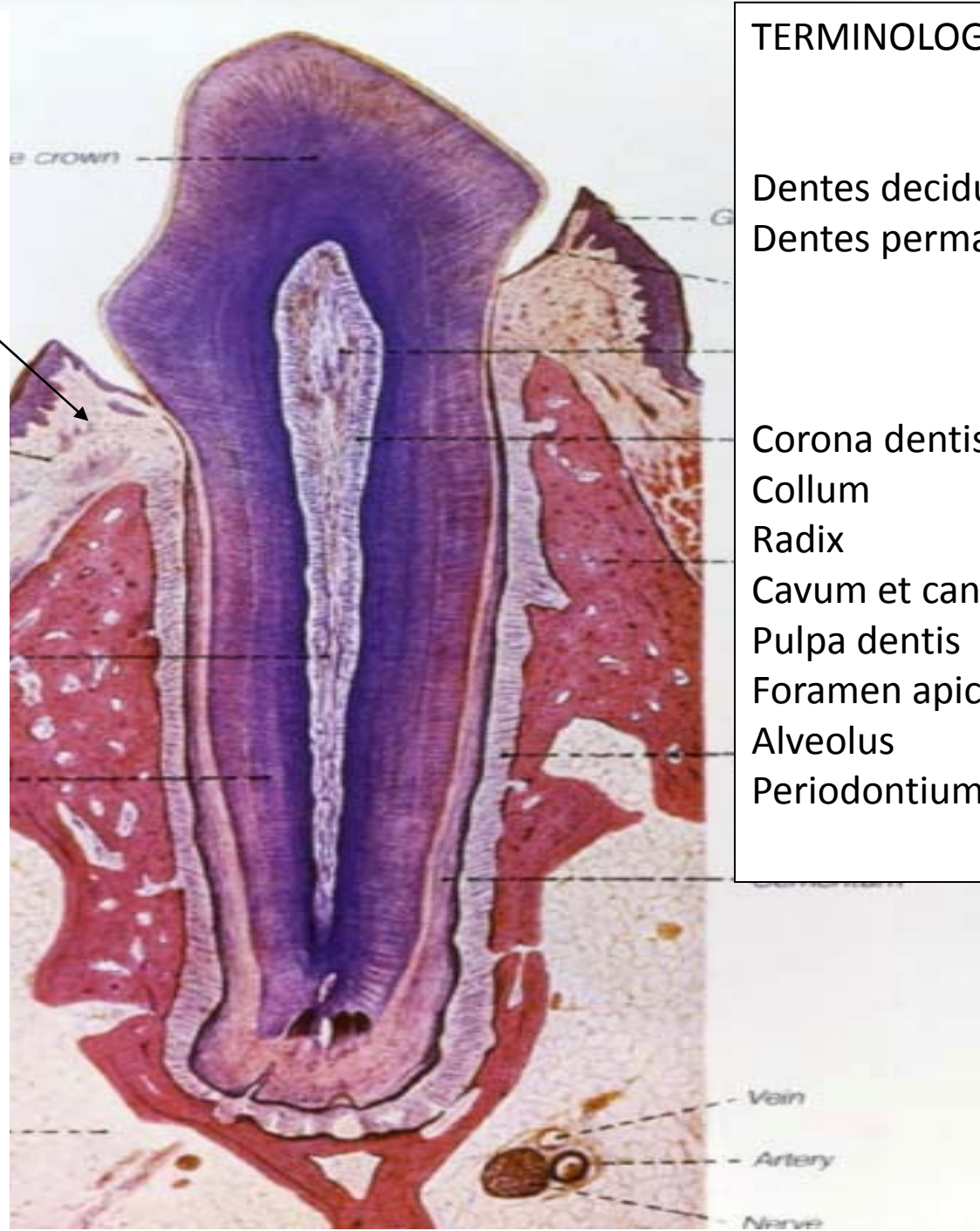


Klepáček, Mazánek a kol. 2001



# Tooth (dens)

gingiva



## TERMINOLOGIE:

Dentes decidui (lactei)	20	
Dentes permanentes	28-32	
Corona dentis	(crown)	
Collum	(neck)	
Radix	(root)	1-3
Cavum et canalis radices dentis (cavity and root canal)		
Pulpa dentis	(pulp)	
Foramen apicis radices	(opening at the tip of the root)	
Alveolus		
Periodontium		

Vein  
Artery  
Nerve

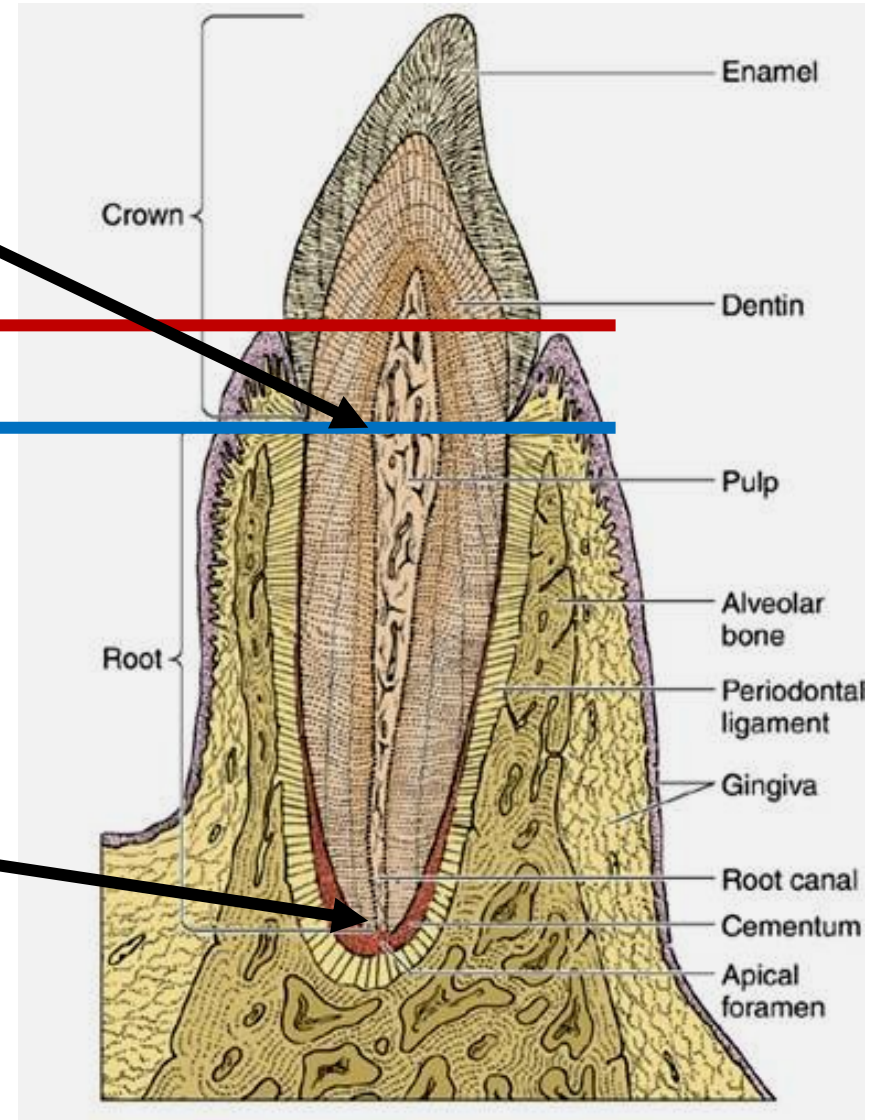


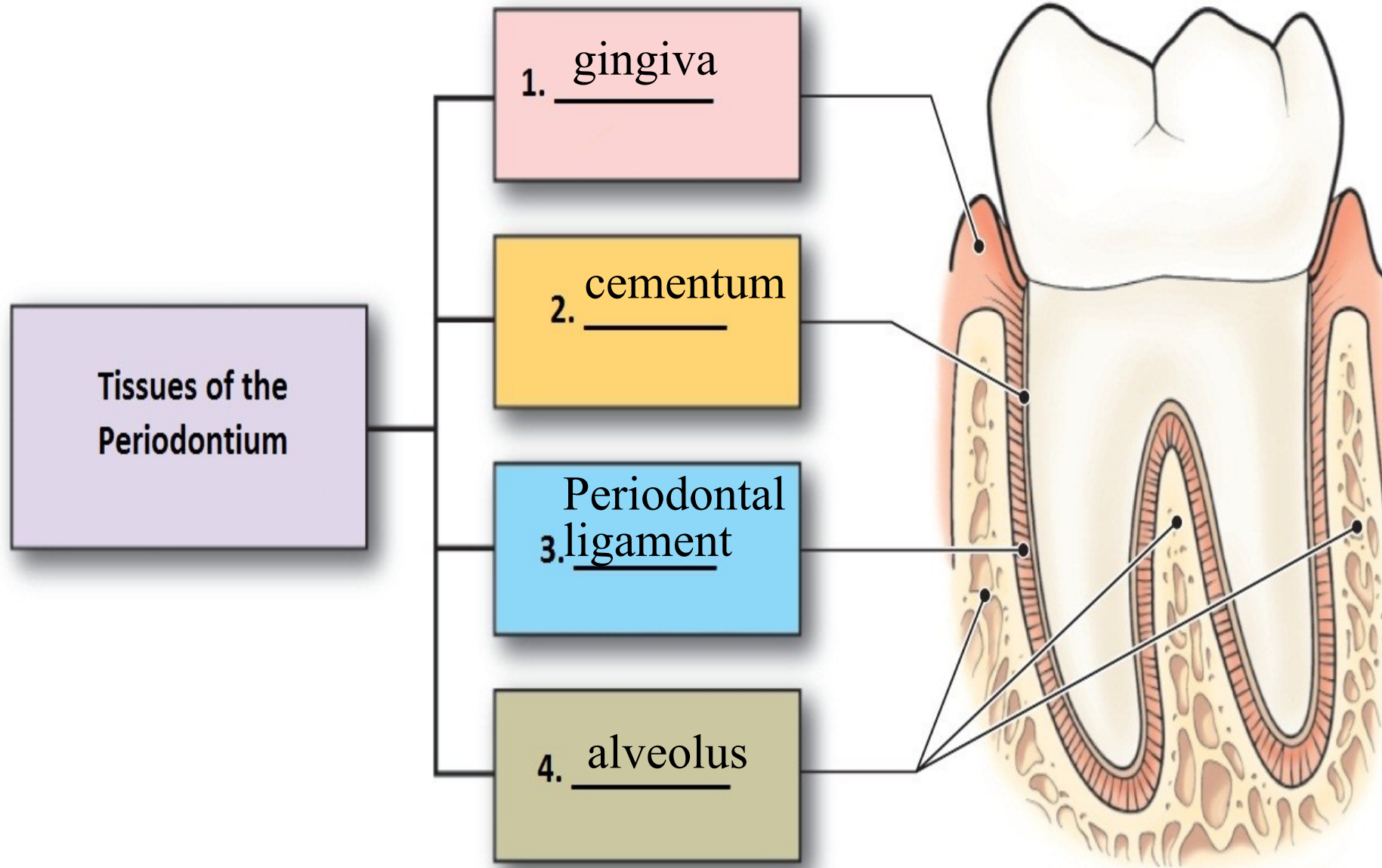
# Cavitas dentis passing to canalis radicus dentis

Anatomical vs clinical crown

Anatomical vs klinical root

Foramen apicis radicus Dentis







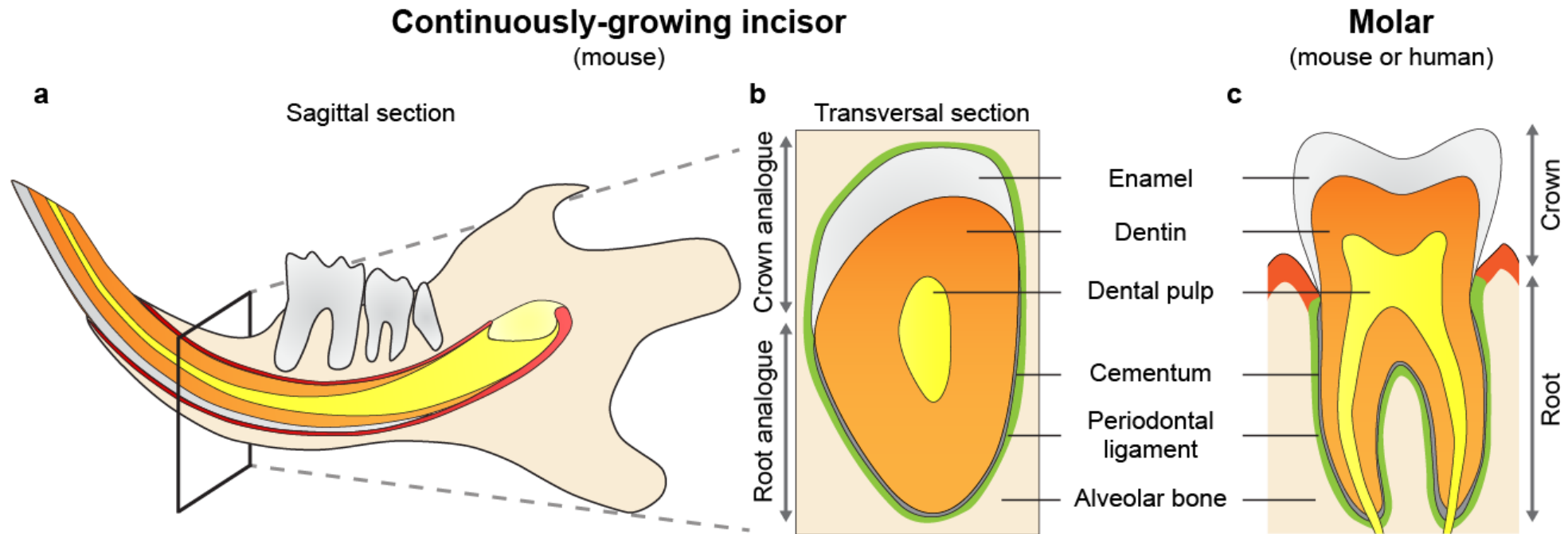
# Tissues of tooth

**Enamel** - enamel, subst. adamantina (row adamas, adamantos = diamond steel), substantia vitrea (lat. vitrum = glass)

**Dentin** - dentin, substantia eburnea (l. Ebur = ivory)

**Cementum** - substantia ossea, crusta petrosa

**Dental pulp** - pulpa dentis



## Comparison of the hard tooth tissues (and lamellar bone)

	Enamel	Dentin	Cementum	Lamellar bone
<b>Colour</b>	White (to light blue)	Ivory	Brown-yellow	Brown-yellow
<b>Inorganic (%)</b>	96 (86)	70 (45)	61 (33)	45 (23)
<b>Organic (%)</b>	1 (2)	20 (30)	27 (31)	30 (37)
<b>H<sub>2</sub>O (%)</b>	3 (11)	10 (25)	12 (36)	25 (40)
<b>Collagen fibres</b>	NO	YES (perpendicular to the dentinal tubules)	YES (in all directions)	YES (same direction in lamellas)
<b>Cells</b>	<b>Ameloblasts</b> (missing in adults)	<b>Odontoblasts</b> (on the pulpal side of dentin)	<b>Cementoblasts</b> (cementocytes)	<b>Osteoblasts</b> osteocytes
<b>Blood vessels</b>	NO	NO	NO	YES (in Haversian canals)
<b>Nerves</b>	NO	YES (on entry of dentinal tubules)	NO	YES (in Haversian canals)





Lampres, cyclostomata





# Babirusa





# Tusks

