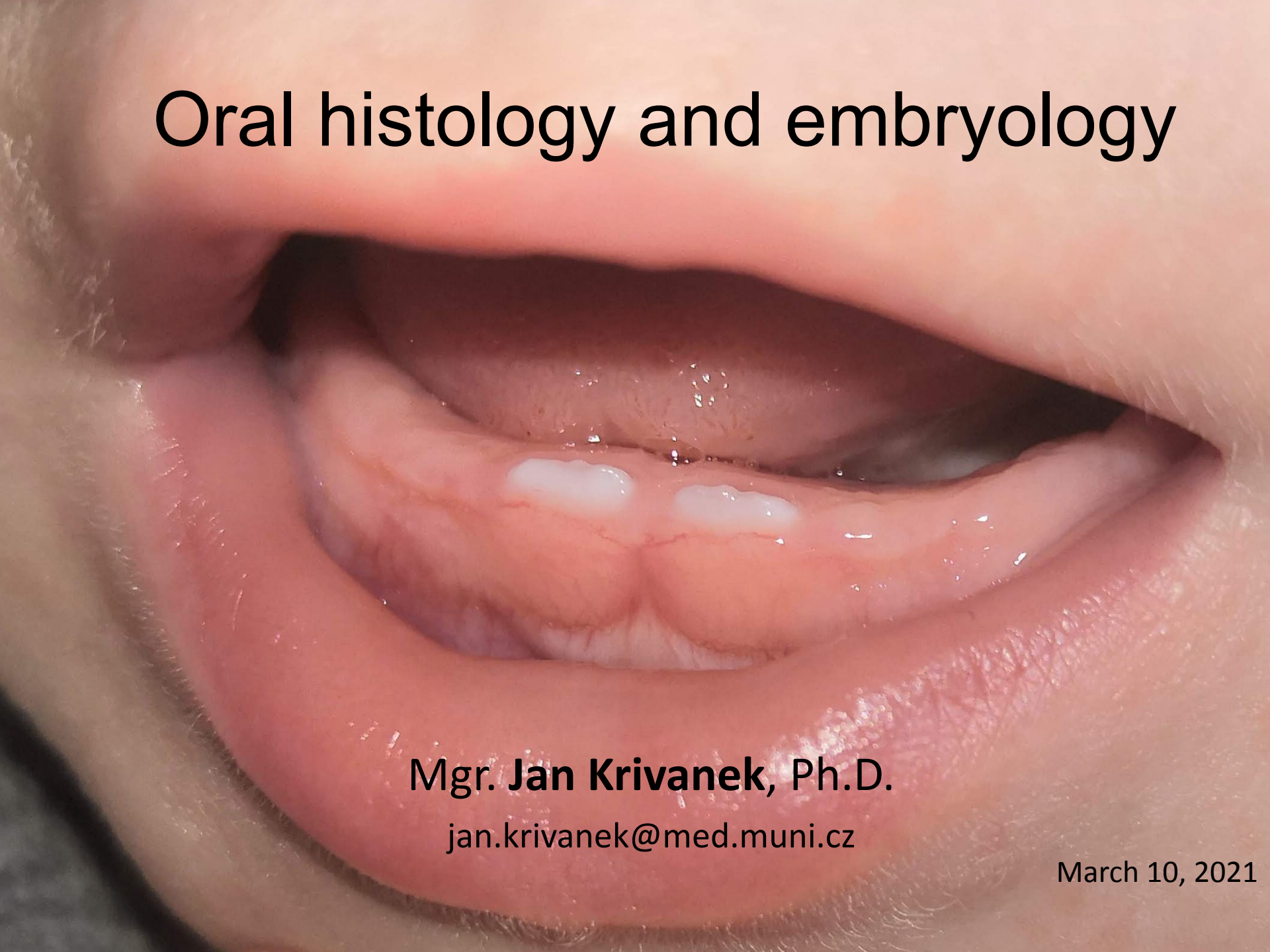
Oral histology and embryology



Mgr. **Jan Krivanek**, Ph.D.

jan.krivanek@med.muni.cz

March 10, 2021

Aims of the subject

- **Microskopic anatomy** of orofacial organs
- Connections of **structure and function**
- Detailed **understanding of developmental processes**
- Understanding of congenital malformations

Lectures: even Wednesdays 10:00 (online)

Practises: odd Wednesdays 10:00 Seminar room

Lecturers:

Mgr. **Jan Křivánek**, Ph.D.

(Mgr. **Eva Švandová**, Ph.D.)

http://www.med.muni.cz/histology/masters-degree-programmes

Needs to pass the course successfully

Practicals: 100% attendance
Tests

Exam: Successful Practicals
Written test
All ropots, individually fulfilled

Literature

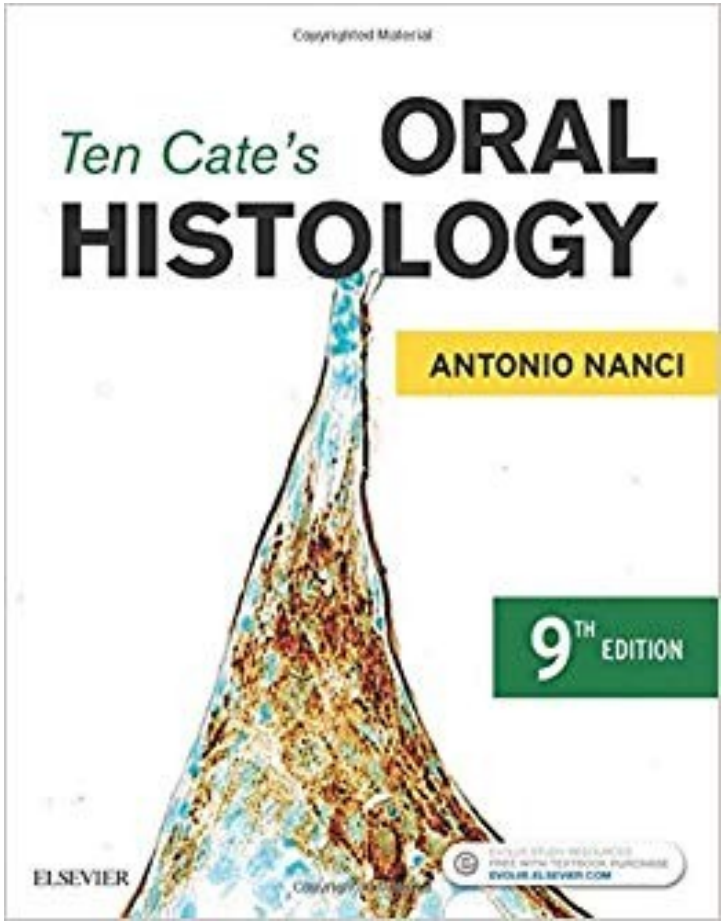
Ten Cate's Oral Histology: Development, Structure, and Function. Antonio Nanci
Essentials of Oral Histology and Embryology: A clinical Approach
Illustrated Dental Embryology, Histology and Anatomy, Fehrenbach and Popowics

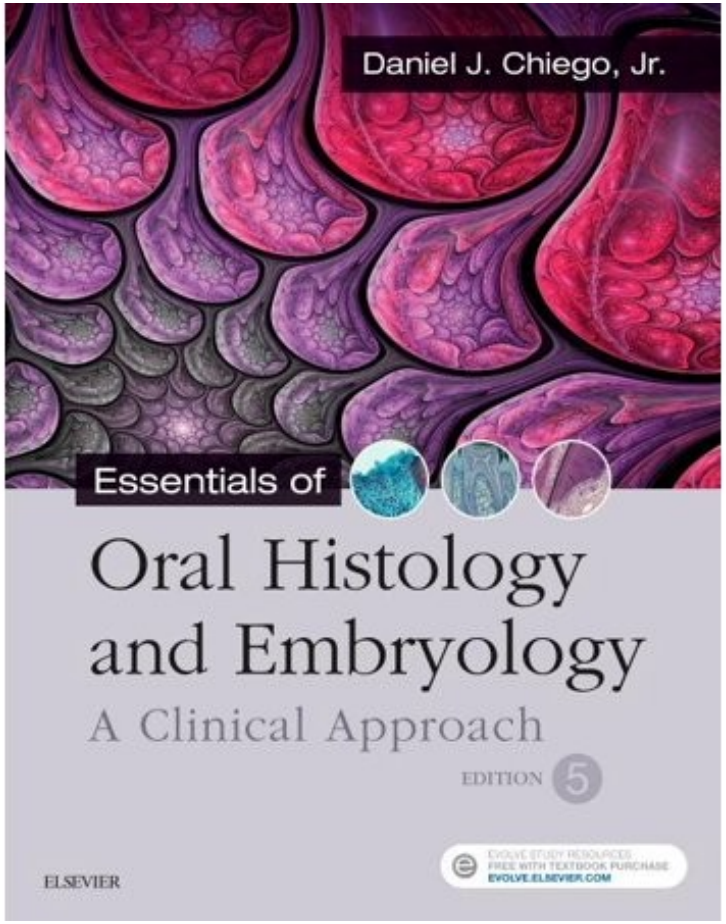
Oral Anatomy, histology and Embryology, Berkovitz, Holland, Moxham

Presentations (lectures + practicals)

Ten Cate's Oral Histology: Development, Structure, and Function.

Antonio Nanci





Essentials of Oral Histology and Embryology: A Clinical Approach

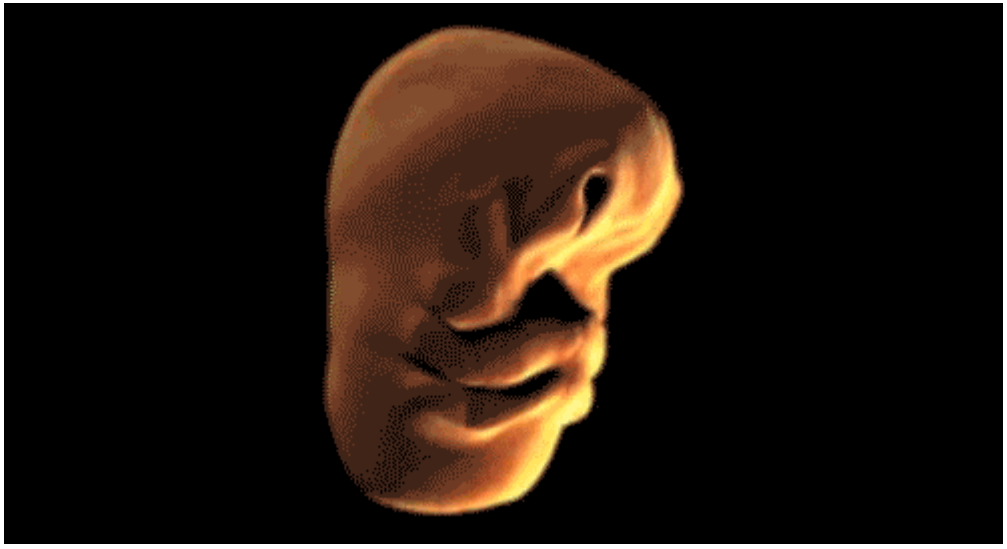
Daniel J. Chiego

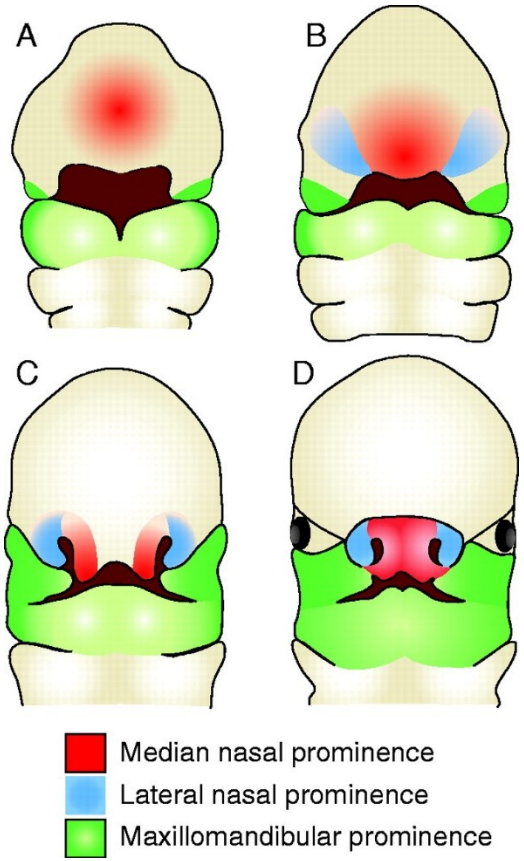
Lectures	Practice
1. **8. 03. – 12. 03. 2021** Introduction: Content of subject, literature recommended for its study, requirements to the exam. **Oral histology** Orofacial system - its structural components and function. Anatomy of the oral cavity. Specialty of the oral mucosa, its structure and types: the lining, masticatory and specialized oral mucosa. Structure and function of taste buds.	2. **15. 03. – 19. 03. 2021** **Oral histology** Microscopic structure of lips, cheek, palate and tongue. Slides: labium oris, palatum molle, apex linguae, papilla vallata, radix linguae.
3. **22. 03. – 26. 03. 2021** General structure and classsification of salivary glands. Histology of major and minor salivary glands. Saliva. Notes to the comparative anatomy of teeth. Dentition: the tooth and surrounding structures - periodontal ligament, alveolus and gingiva. Methods used for study of hard tooth tissues (sections of decalcified teeth, tooth grindings, and SEM).	4. **29. 03. – 2. 04. 2021** **Written test.** Microscopic structure and identifying criteria of major salivary glands. Slides: gl. apicis linguae, gl. parotis, gl. submandibularis, gl. sublingualis. Explanation: Hard tissues of teeth - their physical properties, chemical composition, and origin.
5. **5. 04. – 9. 04. 2021** Enamel – microstructure, function, amelogenesis and age changes. Microscopic structure of cementum and its clinical importance; hypercementosis.	6. **12. 04. – 16. 04. 2021** Tonsils (lymphatic ring of Waldeyer). Light microscopy of teeth. Slides: palatal tonsil, lingual tonsil. Longitudinal (or transverse) section of the decalcified tooth. Explanation: Microscopic structure of periodontal ligament, its function and clinical importance. Gingiva, gingival sulcus, mucogingival and dentogingival junctions, age changes and clinical implications.
7. **19. 04. – 23. 04. 2021** Dentin-pulp complex. Microstructure of dentin and clinical relevance. Dentin as a living tissue. Microstructure of dental pulp, age changes and function. Microscopic structure of the alveolar process, clinical aspects.. Anatomy, histology and function of the temporomandibular joint.	8. **26. 04. – 30. 04. 2021** **Written test.** **Oral embryology** Microscopic structure and changes of the alveolar process, clinical aspects. Anatomy, histology and function of the temporomandibular joint.
9. **3. 05. – 7. 05. 2021** **Oral embryology** Face development. Development of the oral cavity and vestibule. Development of the nasal cavities. Development of the mandible and maxilla. Formation of the primary and secondary palates.	10. **10. 05. – 14. 05. 2021** Exercise: Recapitulation of face development. Explanation: Congenital malformantions. Overview of clefts of the maxilla and palate. Development of the external nose including congenital defects.
11. **17. 05. – 21. 05. 2021** Odontogenesis (tooth development). Ectoderm- ectomesenchymal interactions during tooth development, staging of tooth development.	12. **24. 05. – 28. 05. 2021** **Written test.** Development of the tongue and overview of its congenital malformations. Development of the major salivary glands. Description of the pharyngeal apparatus of the embryo. Pharyngeal (branchial) arches and their derivatives. Derivatives of pharyngeal clefts and pouches. Exercise: Recapitulation of palatal clefts and clefts of jaws. Derivatives of pharyngeal apparatus. Slides: Demonstration of slides illustrating the early tooth development.
13. **31. 05. – 4. 06. 2021** Development of primary (deciduous) dentition, course of differentiation of ameloblasts and odontoblasts; crown and root formation. Deciduous tooth eruption - mechanism and timing. Development of the periodontal ligament. Repair and regeneration. Recent advances in dental development and regenerative medicine.	14. **7. 06. – 11. 06. 2021** Exercise: Recapitulation of primary dentition development and eruption of teeth. Explanation: Development of secondary (permanent) dentition and its eruption. Period of mixed dentition. Development of the alveolar process. Overview of congenital tooth defects. **Credits.**

Orofacial system

- Structures of the head and neck which:
  - Are essential for intake, grinding and **processing of food**
  - Maintain **taste and tactile** sensations
  - Forms an interface for **social interactions** (phonetic, aesthetic-physiognomic function, mimics, speak)

Development from pharyngeal or branchial arches, projections of frontal (frontonasal) prominence, upper and maxillomandibular prominence



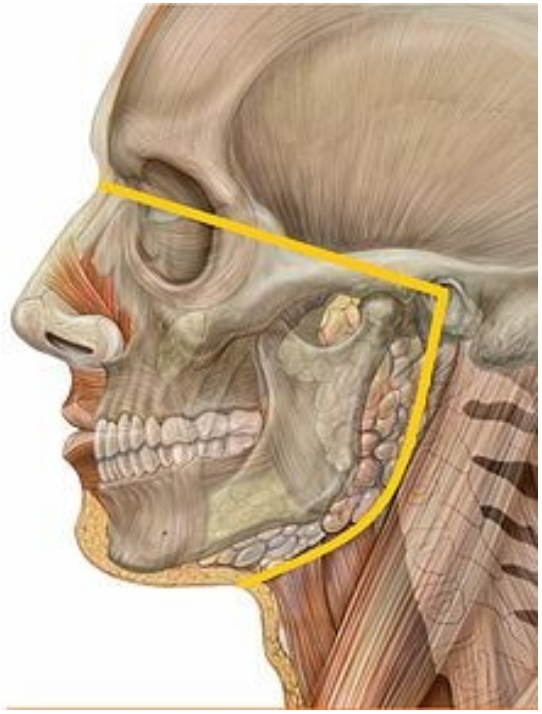


(Helms et al. 2005)

Orofaciální systém

Orofacial system is composed of:

- **Skeleton faciei** - (facial skeleton) mandible, maxilla, ossa zygomatica, os ethmoides, ossa nasalia et lacrimalia, vomer, ossa palatina, os hyoides) + art. temporomandibularis)
- **Cavitas oris** - *lingua* (tongue), *dentes*, periodontium, salivary glands (*glandulae salivariae*)
- **Art. temporomandibularis**
- **Mimic muscles and muscles of mastication**
- **Soft tissues of the face** – lips, cheeks
- **Hard and soft palate – (***palatum durum a palatum molle*)
- **Isthmus of the fauces** – (*isthmus faucium*)
- **Palatinal and tongue tonsils**



Oral cavity (*cavitas oris)*

- Basic anatomy

- Oral mucosa and microscopic structure
  - Lining mucosa
  - Masticatory mucosa
  - Specialized mucosa

- Lips
- Microscopic structure of tongue
- Taste buds

Oral cavity *(cavitas oris)*

vestibulum oris / cavitas oris propria

Borders

Lips, cheeks, hard and soft palates, caudally floor of cavity, faucial isthmus (connection to oropharynx)

Inside

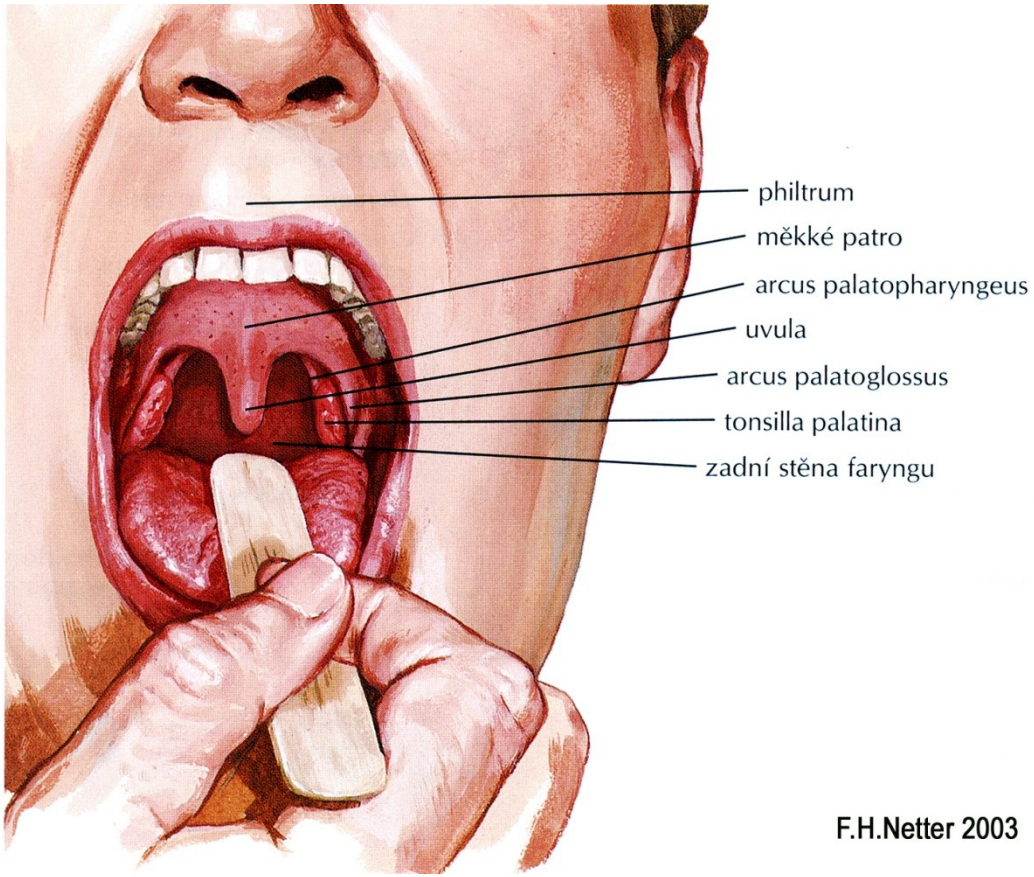
Tongue, teeth, gums, tonsilla palatina

Major salivary glands:

gl. submandibulatis

gl. sublingualis

gl. parotis



Mucosa of oral cavity

Except of teeth it covers all surfaces inside the oral cavity
Oral mucosa has 2 layers (epithelium + *lamina propria mucosae*)
At some places is between mucosa and the base (bone/muscles) located connective tissue - *tela submucosa*

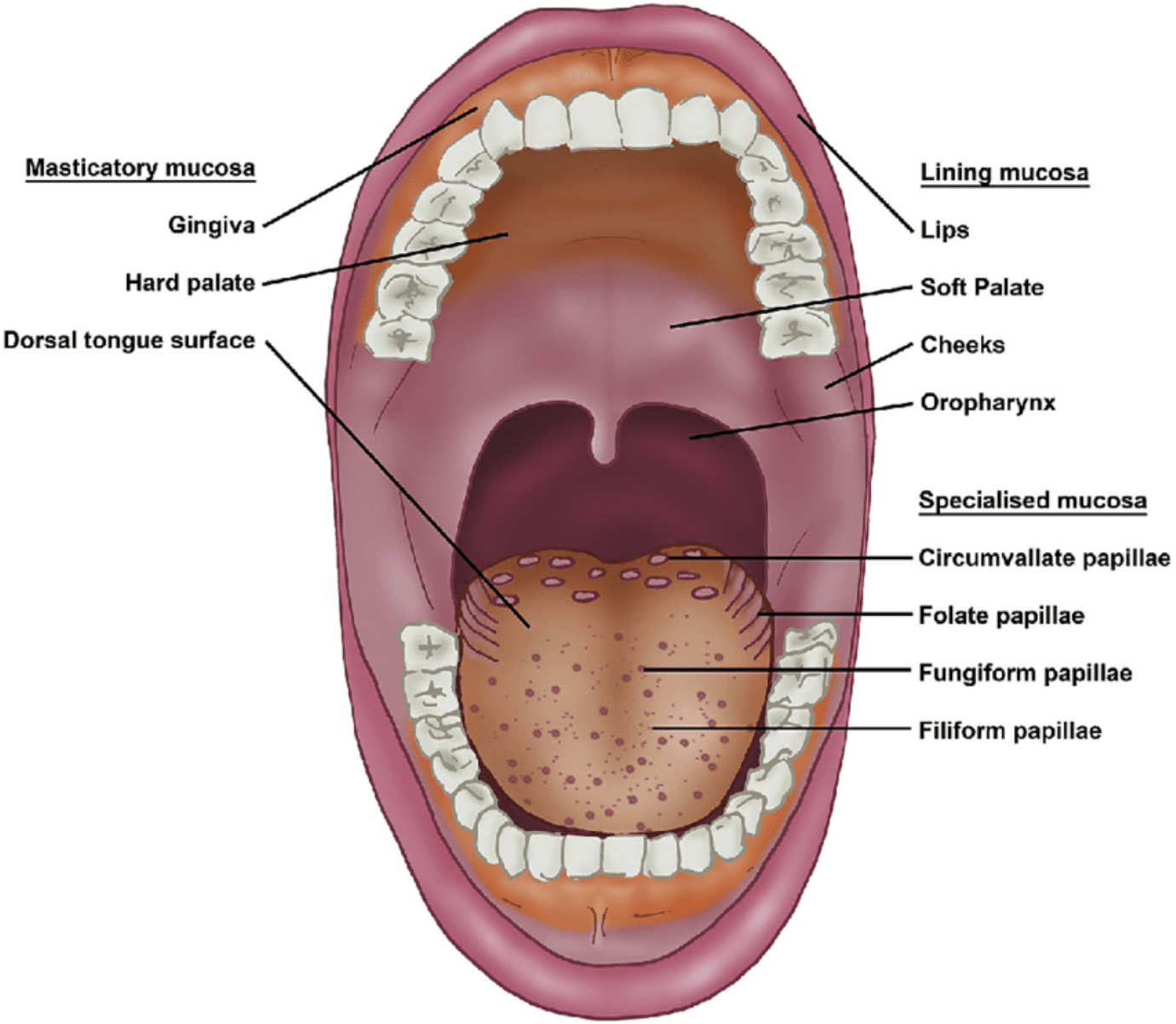
Functions of oral mucosa:

- **Protective** - resistant to mechanical and chemical forces or effects of the bacterial flora
- **Secretory** - saliva - a product of small and large salivary glands
- **Sensory** - contains receptors for perception of temperature, pain, touch and taste
- **Thermoregulatory** - in animals - (protruding tongue)

Forms special **transitory zone** inserted between the skin and the mucosa of the alimentary canal (starts in the pharynx)

The oral mucosa differs from mucosa of the alimentary canal or mucosa other tubular organs by the origin - **it was developed from the ectoderm and head mesenchyme of ectodermal origin** (while elsewhere from the entoderm or mesoderm and mesenchyme of mesodermal provenience)
Thanks to these circumstances) the oral mucosa shows some characteristics of the skin: keratinization of the epithelium, presence of lamina propria protrusions against the epithelium (papillae)

Oral mucosa



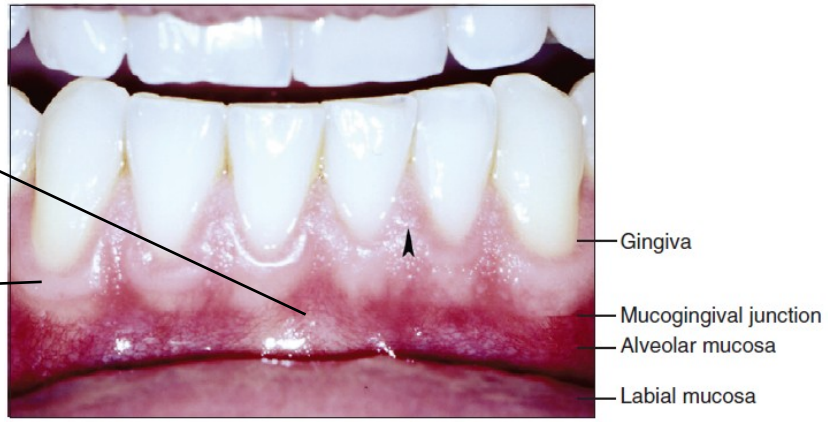
Cook, Sarah et al. A food perspective. Food Hydrocolloids. 2017.

Oral mucosa classification

Lining (65 %)

Inner part of lips, cheeks soft palate, inferior aspect of the tongue, floor of the mouth and alveolar process (except of the gingiva)

- tela submucosa located under mucosa
- soft and slightly movable (submucous coat)
- lamina propria from loose connective tissue



Masticatory (25 %)

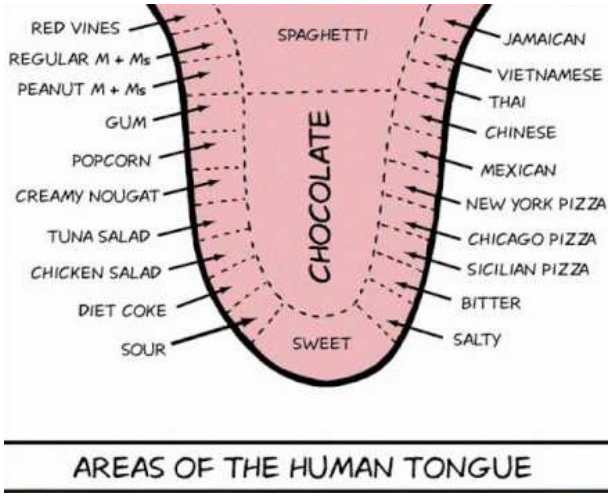
Hard palate and gingiva

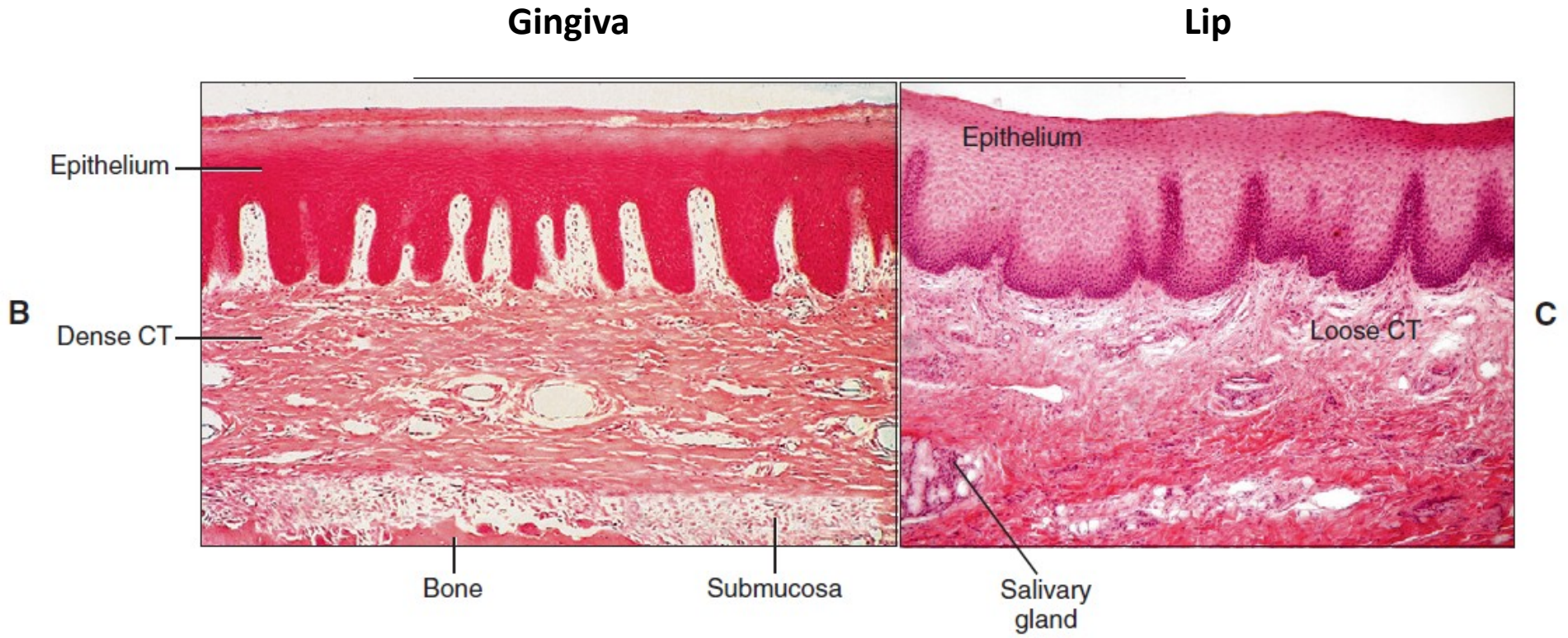
- epithelium keratinized
- tela submucosa is missing
- lamina propria composed from dense collagenous of irregular type and firmly connected with periosteum (mucoperiosteum)

Specialized (10 %)

dorsal surface of the tongue

- mucosa protrudes into papillae
- tela submucosa is missing
- lamina propria connected with aponeurosis linguae





- Lamina propria from dense collagenous connective tissue of irregular type
- Firmly connected to periosteum (mucoperiosteum)

- Lamina propria from loose collagenous tissue
- Tela submucosa under mucosa
- Mucosa is slightly movable

B, In histologic sections, the **gingival** epithelium is seen to be tightly bound to bone by a dense fibrous connective tissue (CT), whereas the epithelium of the **lip (C)** is supported by a much looser connective tissue.

Oral mucosa

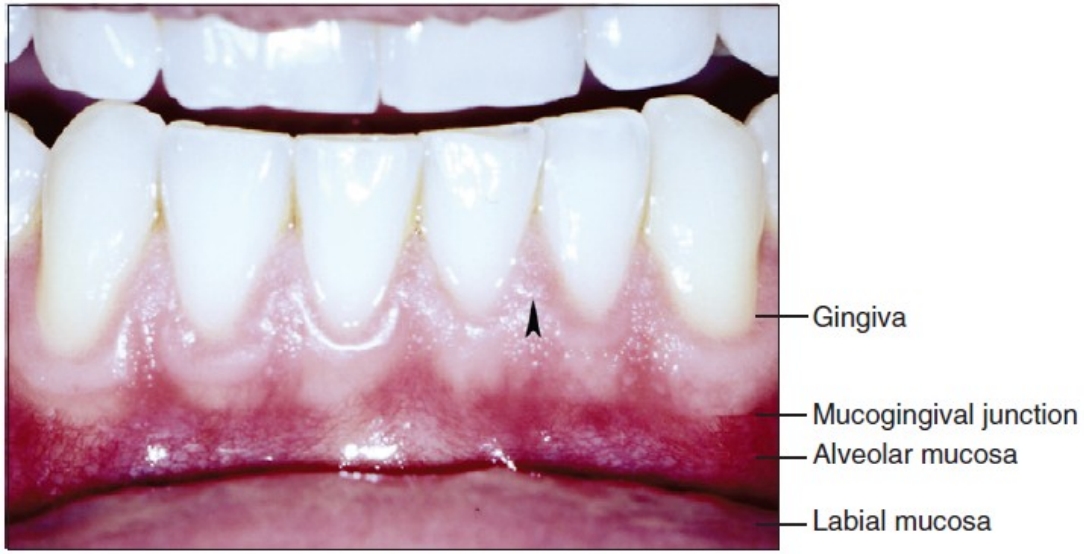
epithelium
stratified squamous

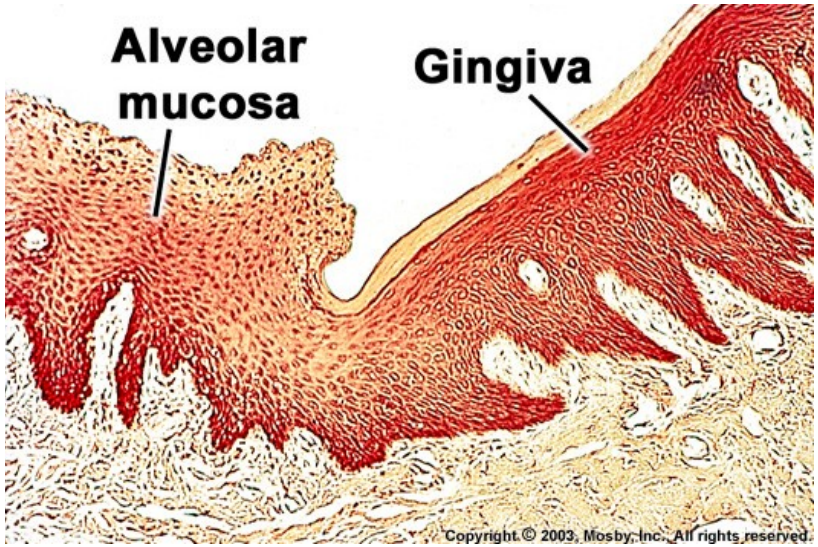
nonkeratinized

- Lining mucosa

keratinized

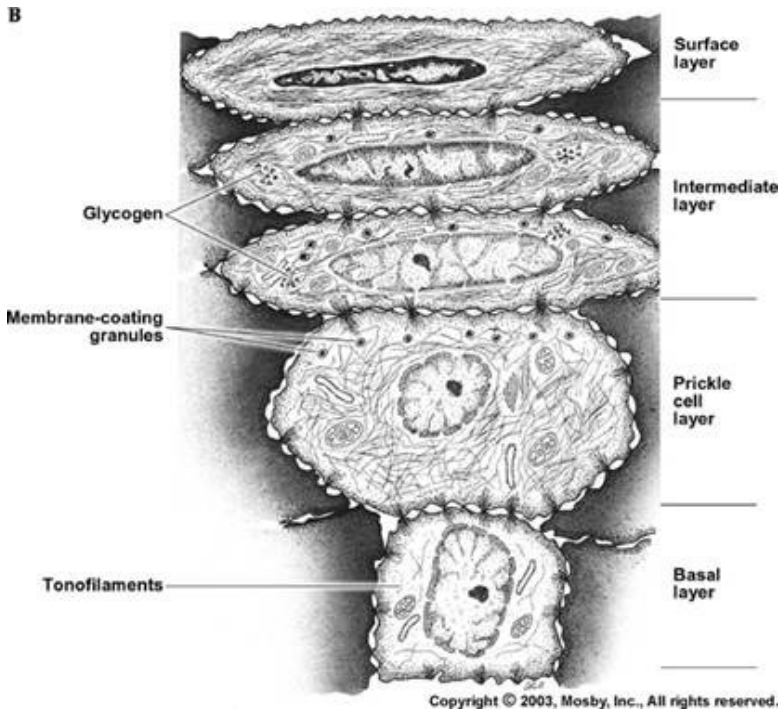
- Masticatory mucusa
- (Specialized mucosa)

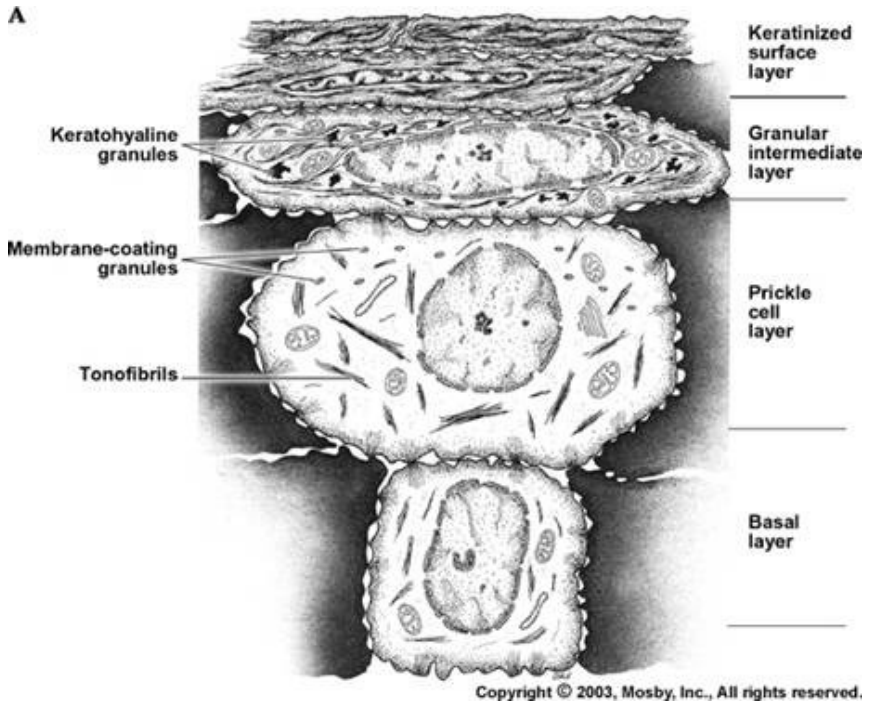




Lamina propria mucosae
Contains numerous of melanocytes or melanophages
Multiple papilae projected against the epithelium. Their shape and density are spatially different (depends on different mechanical needs of oral mucosa)

Classification of cell layers in the epithelium - similar as in the epidermis





nonkeratinized type

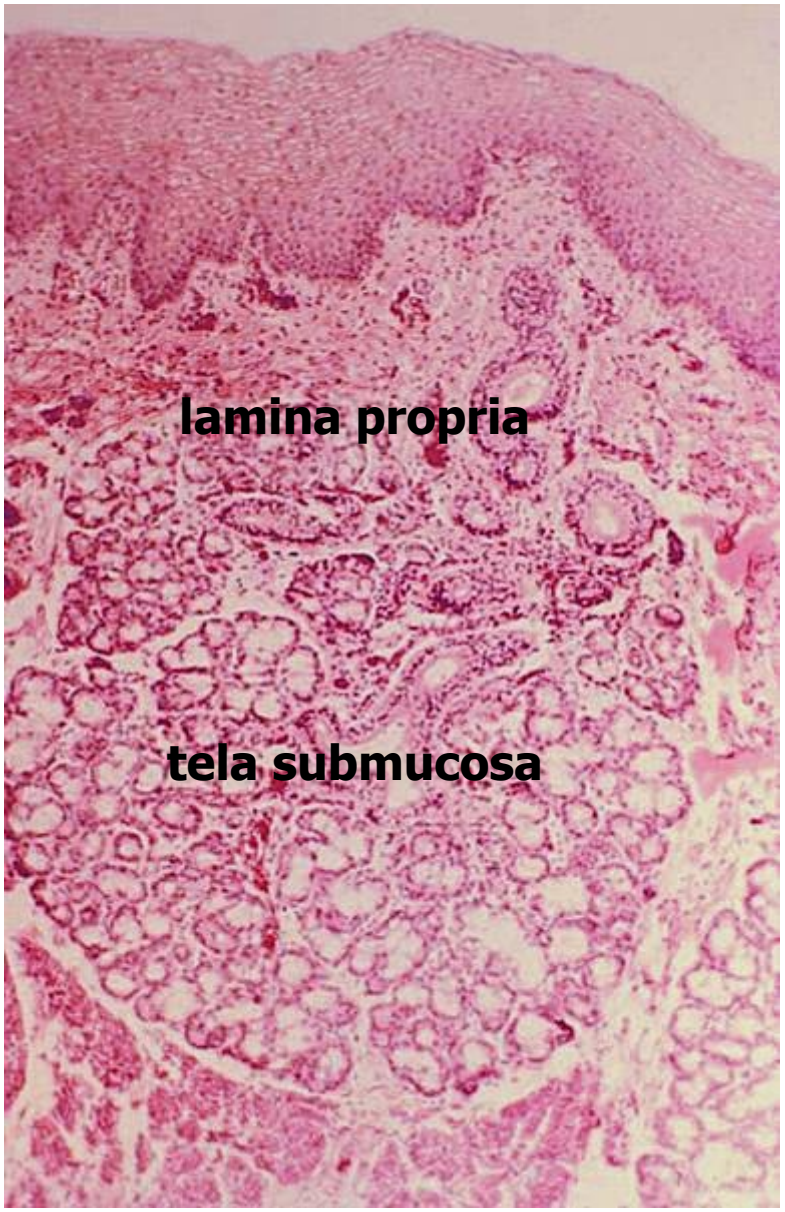
stratum basale - melanin
stratum spinosum
stratum intermedium - glycogen
stratum superficiale

keratinized type

stratum basale - melanin
stratum spinosum
stratum granulosum - keratohyalin
stratum corneum - keratin

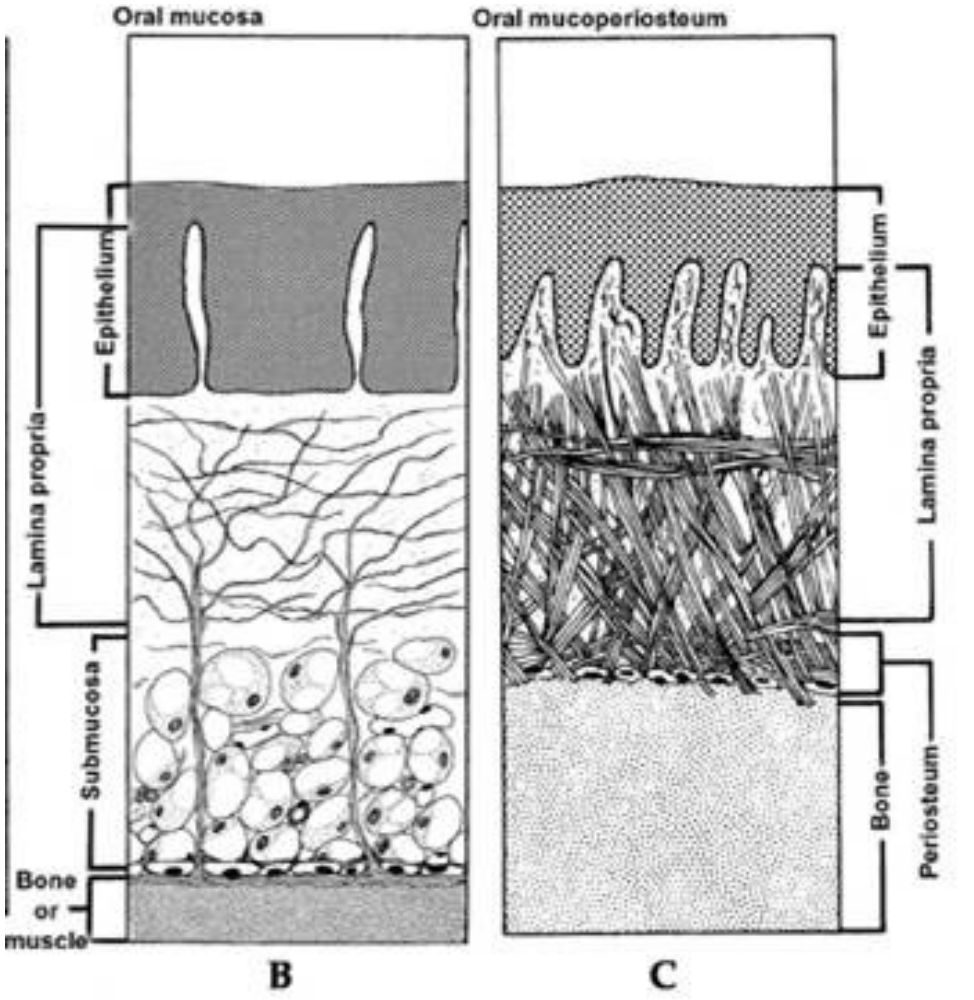
The lamina propria mucose: loose connective tissue – it contains numerous melanophages (= cells with ingested melanin, which was extruded from melanocytes in the epithelium). It protrudes into papillae whose shape, size and density correspond with mechanical forces

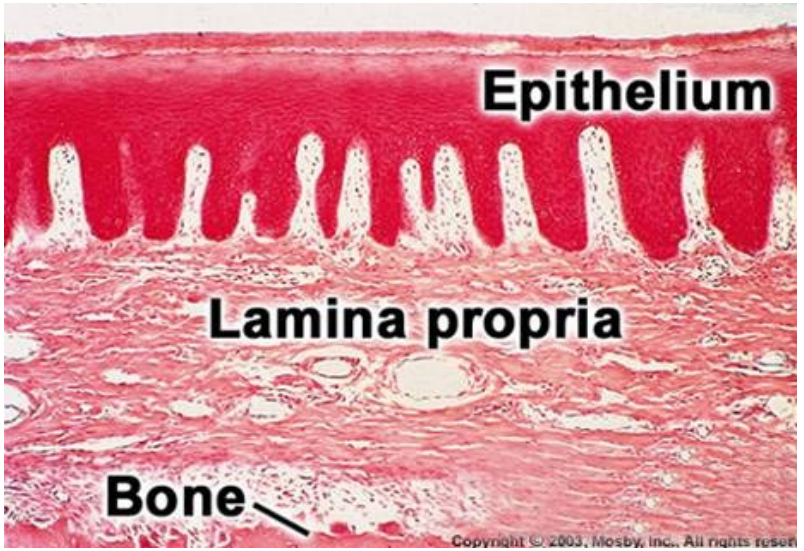
The lining mucosa

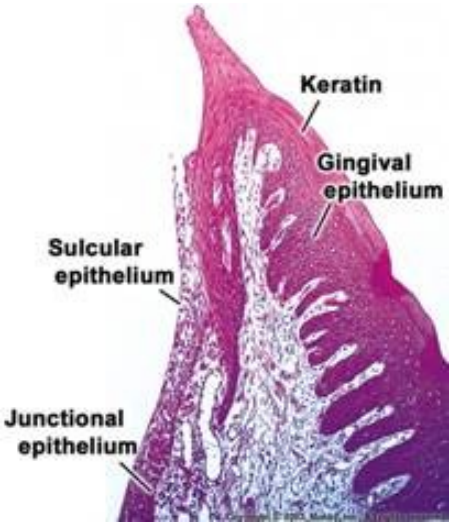


Masticatory mucosa

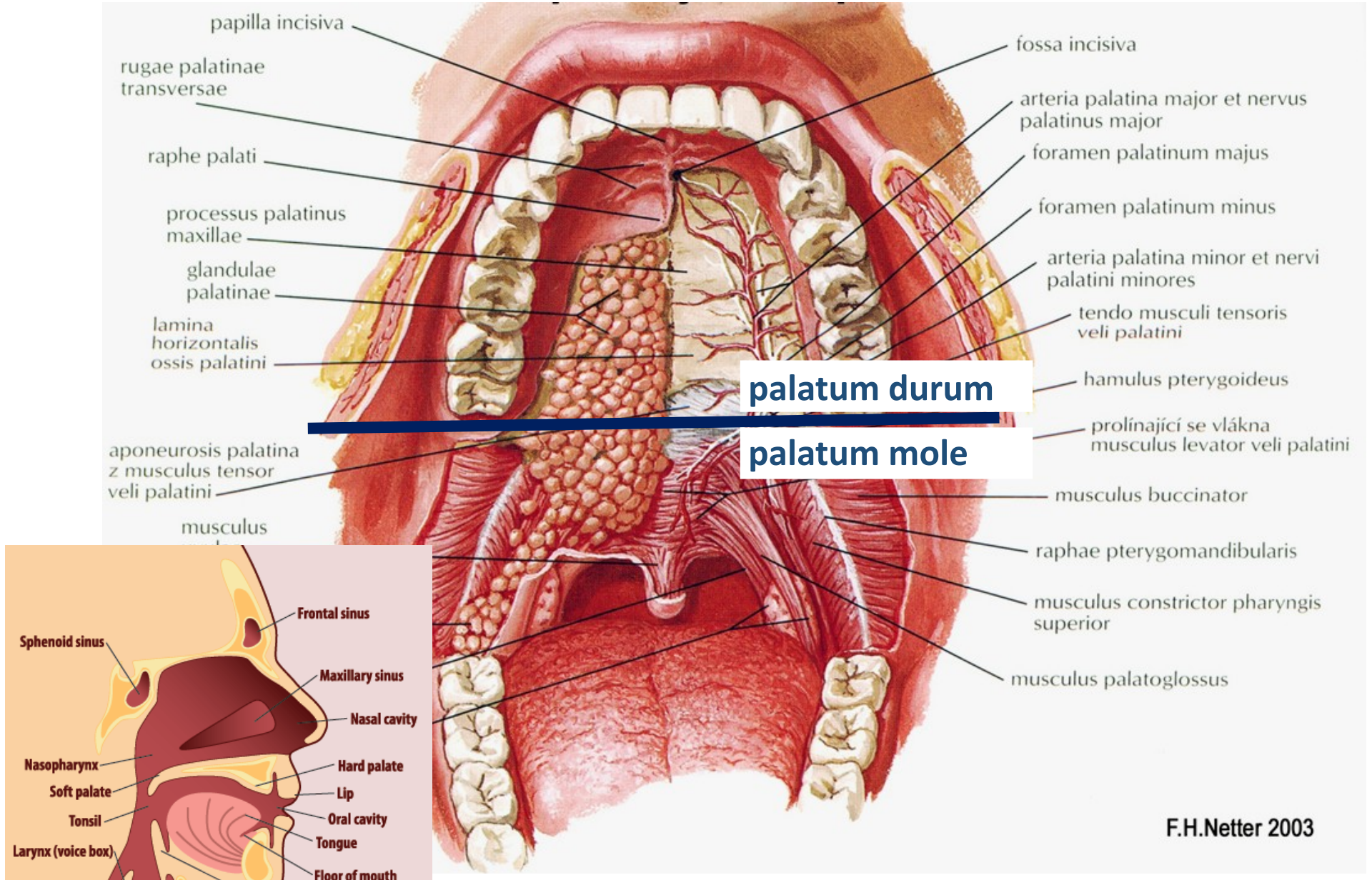
clinnically: **mucoperiost**







gingiva


papilla incisiva
rugae palatinae transversae
raphe palati
processus palatinus maxillae
glandulae palatinae
lamina horizontalis ossis palatini
aponeurosis palatina z musculus tensor veli palatini
musculus
fossa incisiva
arteria palatina major et nervus palatinus major
foramen palatinum majus
foramen palatinum minus
arteria palatina minor et nervi palatini minores
tendo musculi tensoris veli palatini
hamulus pterygoideus
prolínající se vlákna musculus levator veli palatini
musculus buccinator
raphae pterygomandibularis
musculus constrictor pharyngis superior
musculus palatoglossus
palatum durum
palatum mole
F.H.Netter 2003

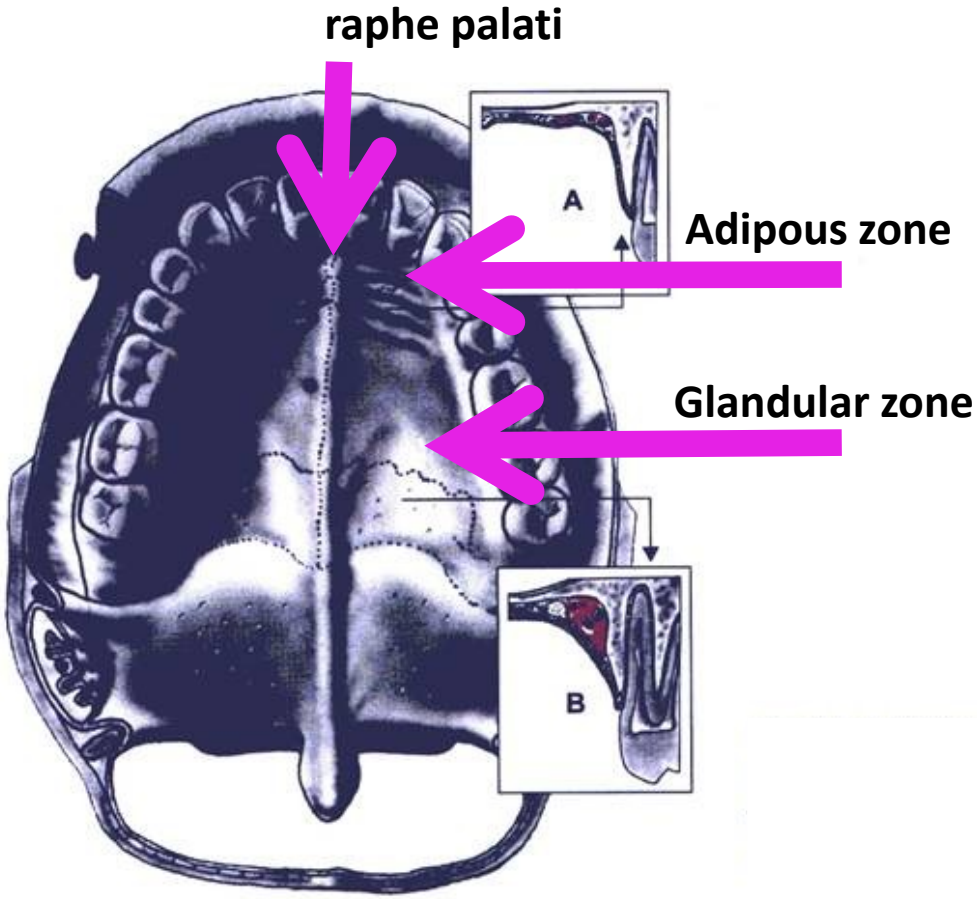
Frontal sinus
Sphenoid sinus
Maxillary sinus
Nasal cavity
Nasopharynx
Hard palate
Soft palate
Lip
Tonsil
Oral cavity
Tongue
Larynx (voice box)
Floor of mouth
Epiglottis

Hard palate *(palatum durum)*

Masticatory mucosa:

- Epithelium stratified squamous keratinizing
- Tela submucosa missing

Huge regional variability:



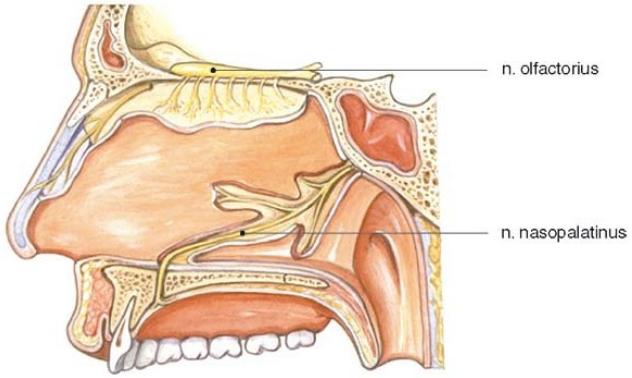
Local differences in hard palate structure

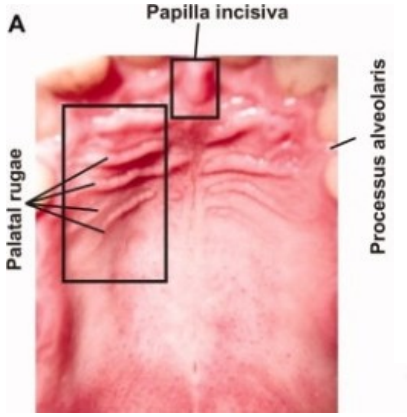
Palatal raphe

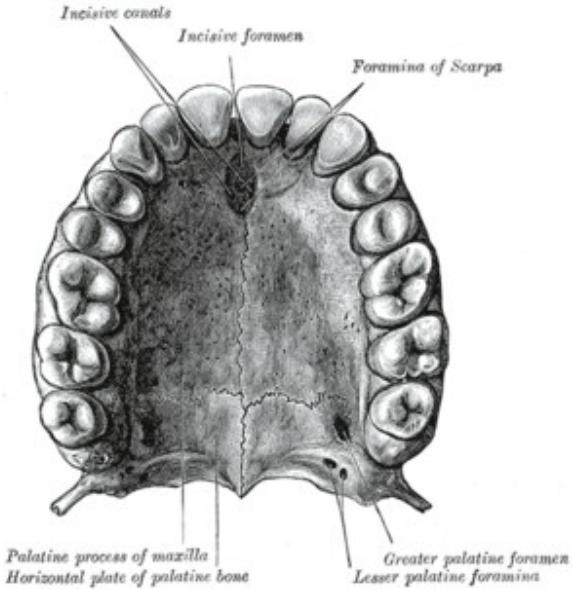
- Midline from the incisive papilla to soft palate, mucosa without glandulae and adipocytes

Foramen incisivum

- Location on the *papilla incisiva*
- Maintains connection with nasal cavity before birth is closed





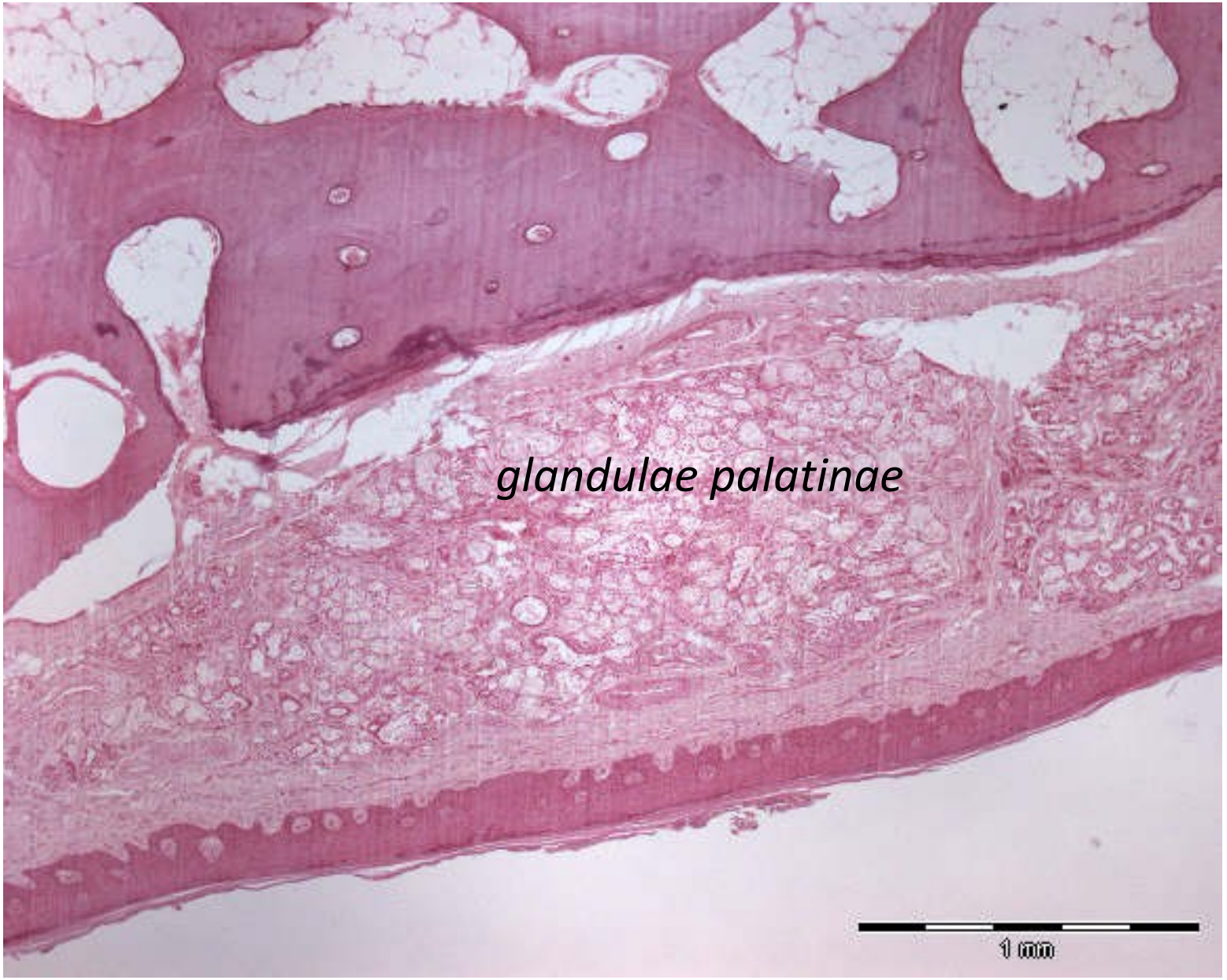


Adipose zone

- Paired structure
- Medially divided by papilla incisiva and raphe palati, Laterally bordered by gingiva and premolars
- Mucosa is thickened into 3-5 transversal plicae - *plicae palatinae transversae*, core of plicae is formed by stripes of dense colagenous connective tissue interlaced with adipocytes

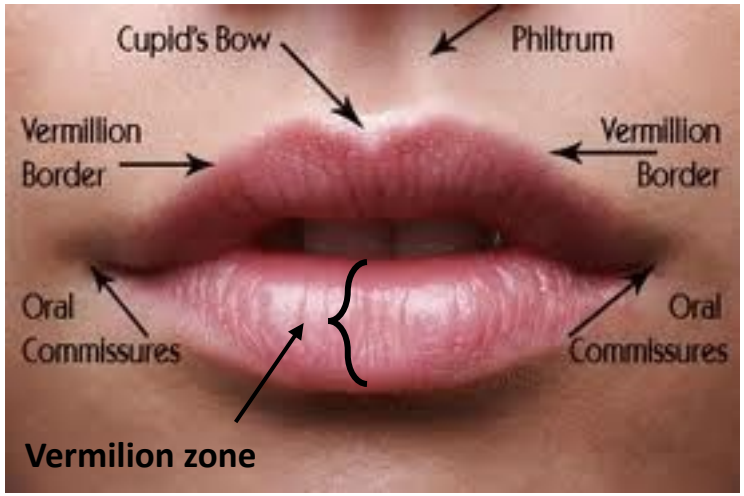
Glandular zone

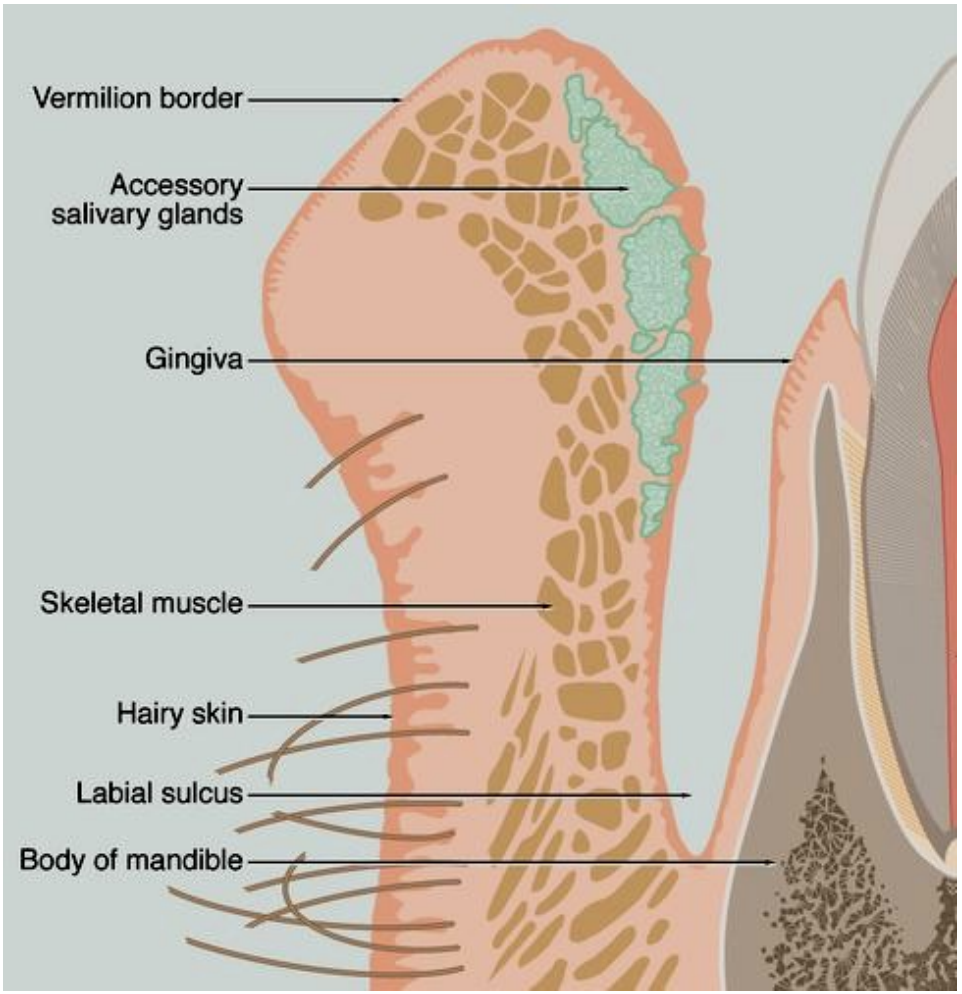
- Paired structure
- Mucosa is smooth and contains true mucous glands – *gll. palatinae*



Hard palate – glandular zone

Lip





Sagitally:

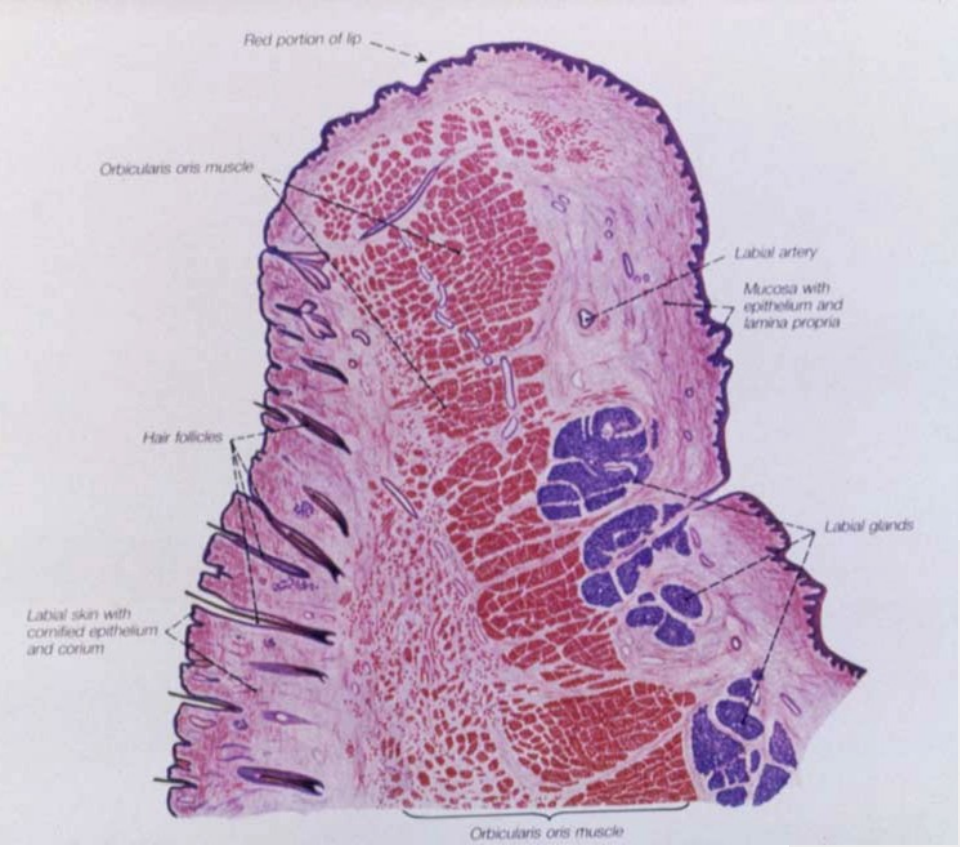
- ventral aspect of the lip
- dorsal aspect of the lip

a) lamina epithelialis mucosae - stratified squamous epithelium

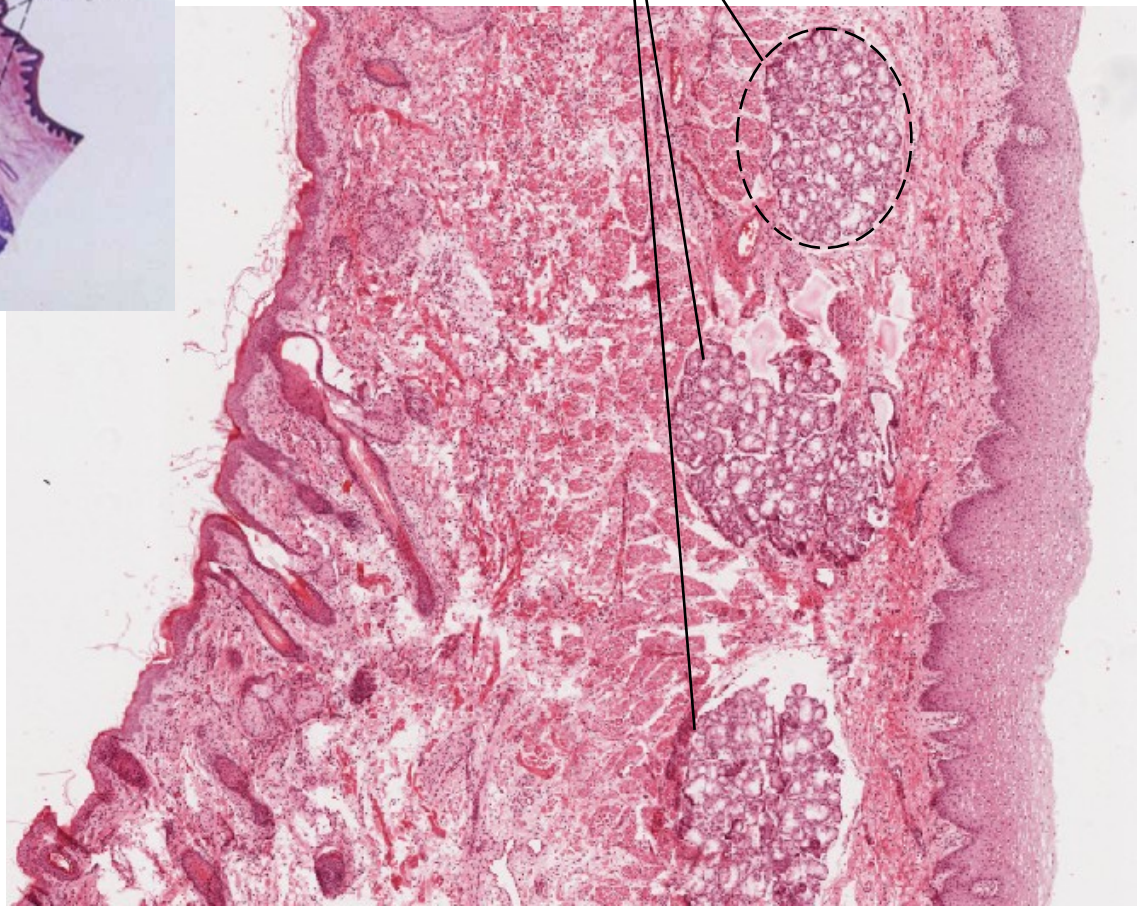
b) lamina propria mucosae - loose areolar connective tissue

- m. orbicularis oris
- vermilion zone

Why do the lips have a red color?

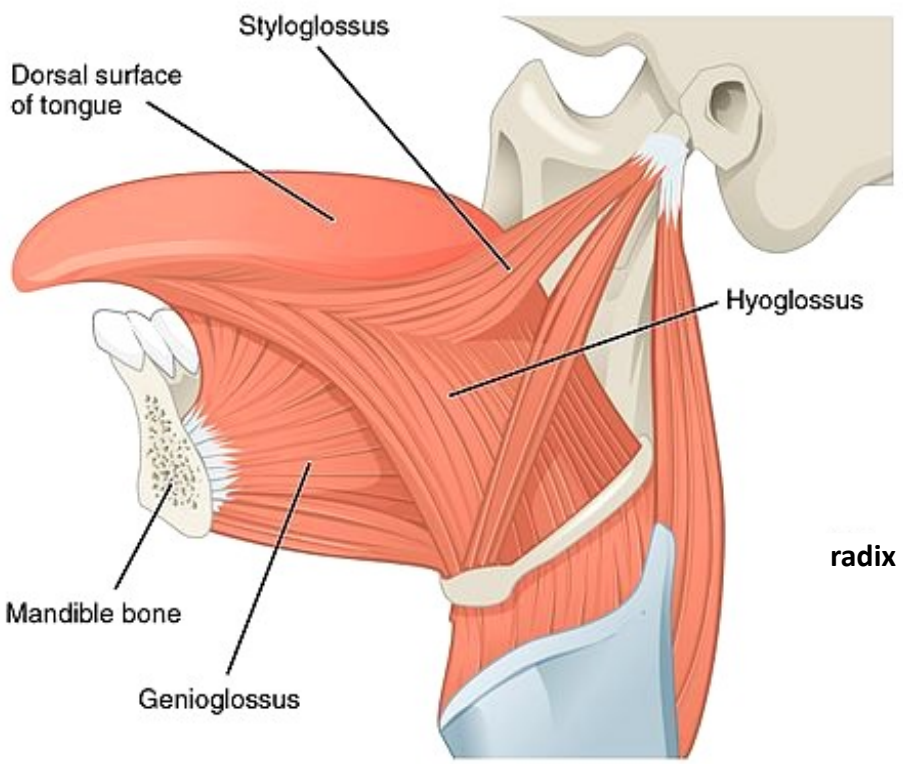


glandulae labiales
(mixed)

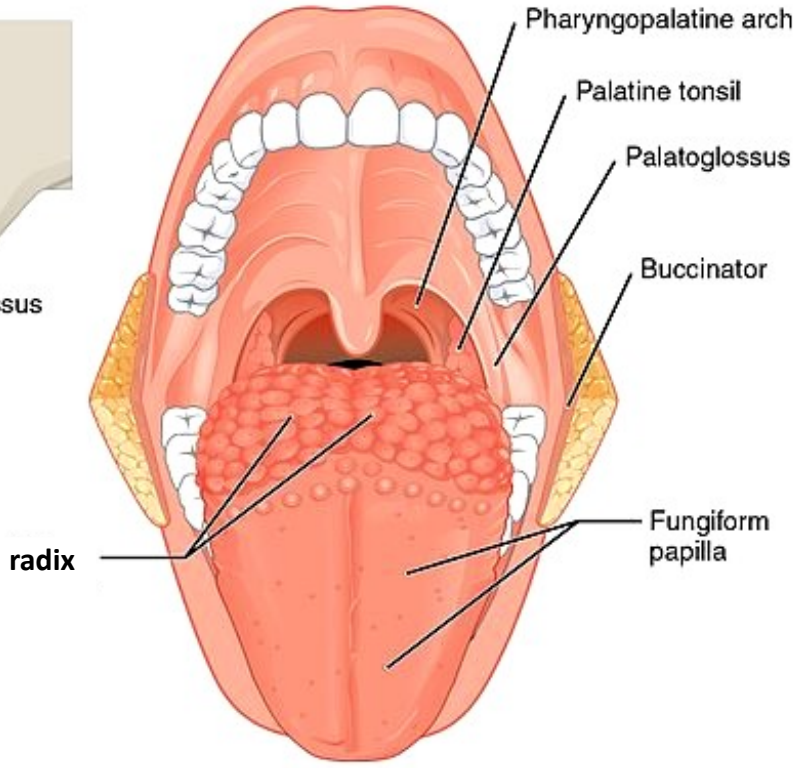


Tongue

Lingua (lat.)
Glossa (gr.)



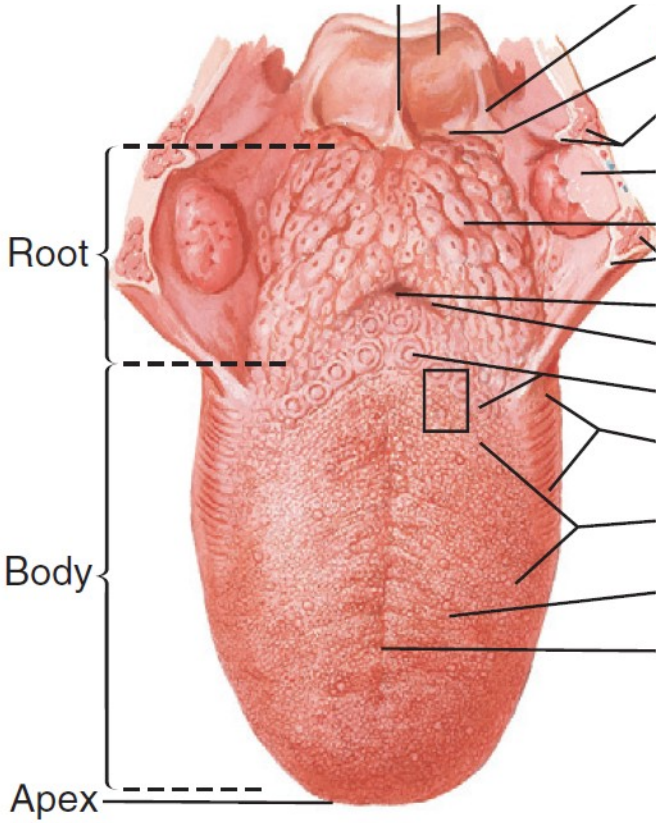
(a) Extrinsic tongue muscles

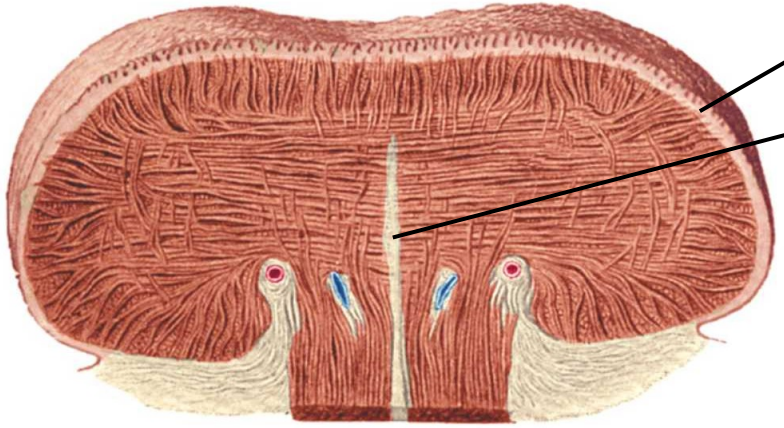


(b) Palatoglossus and surface of tongue

Base: intra- and extraglossal striated muscles

Evulutionary: developed in terrestrial vertebrates and amphibians (tetrapods) from muscles of oral floor





Surface

Dorsum linguae

Specialized oral mucosa

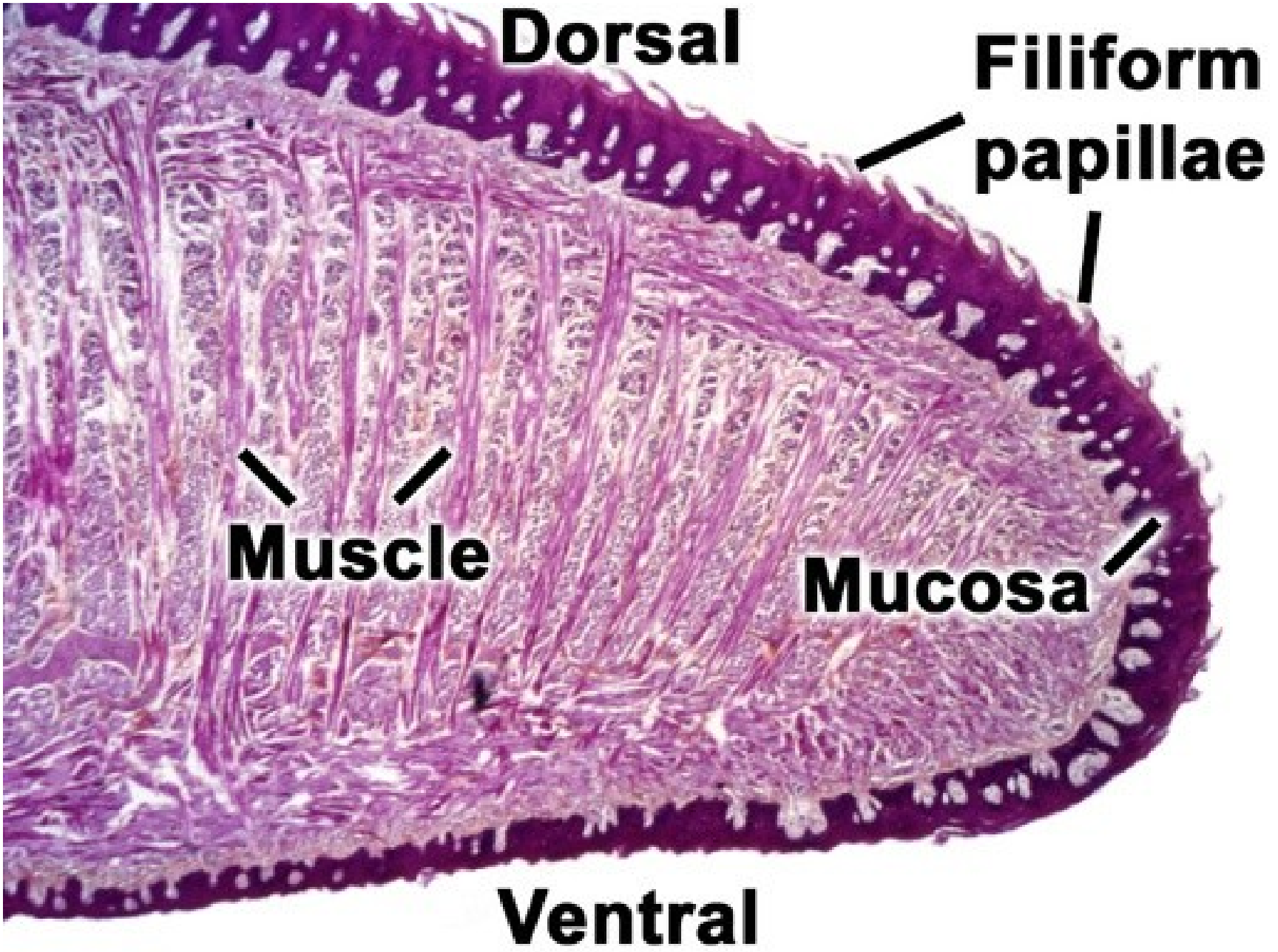
Inferior aspect

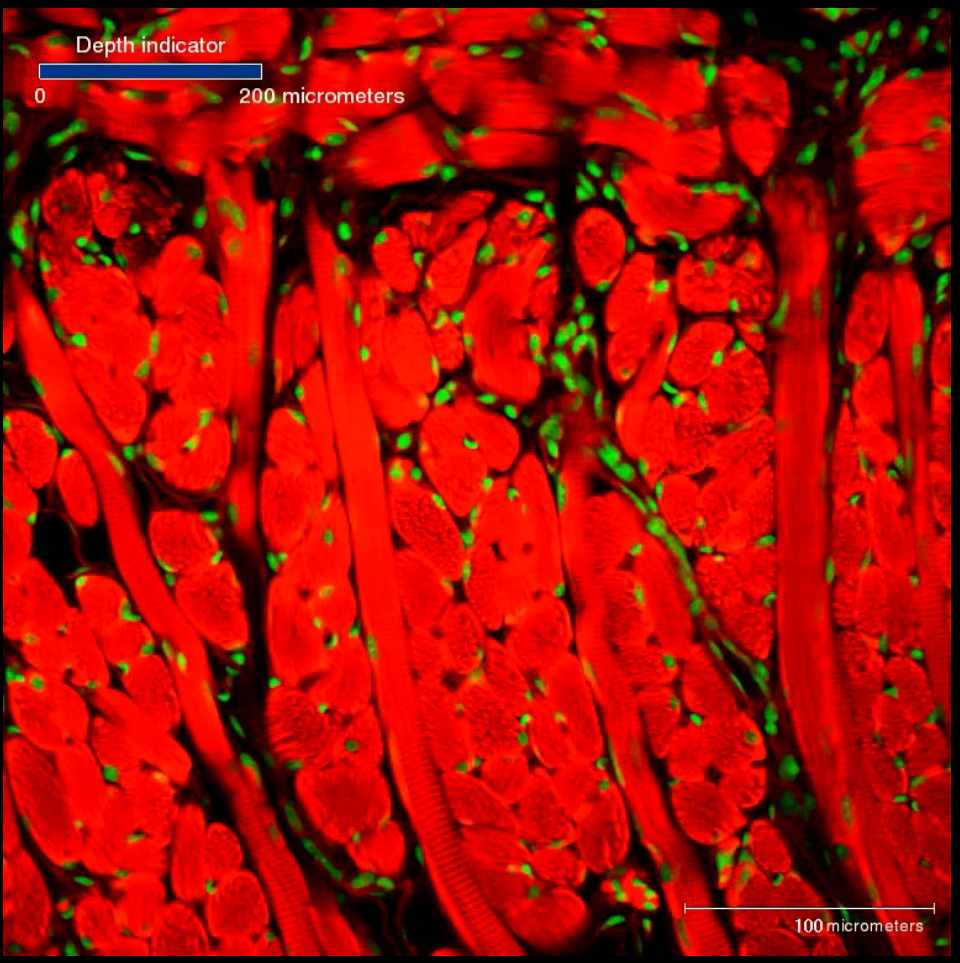
Lining mucosa

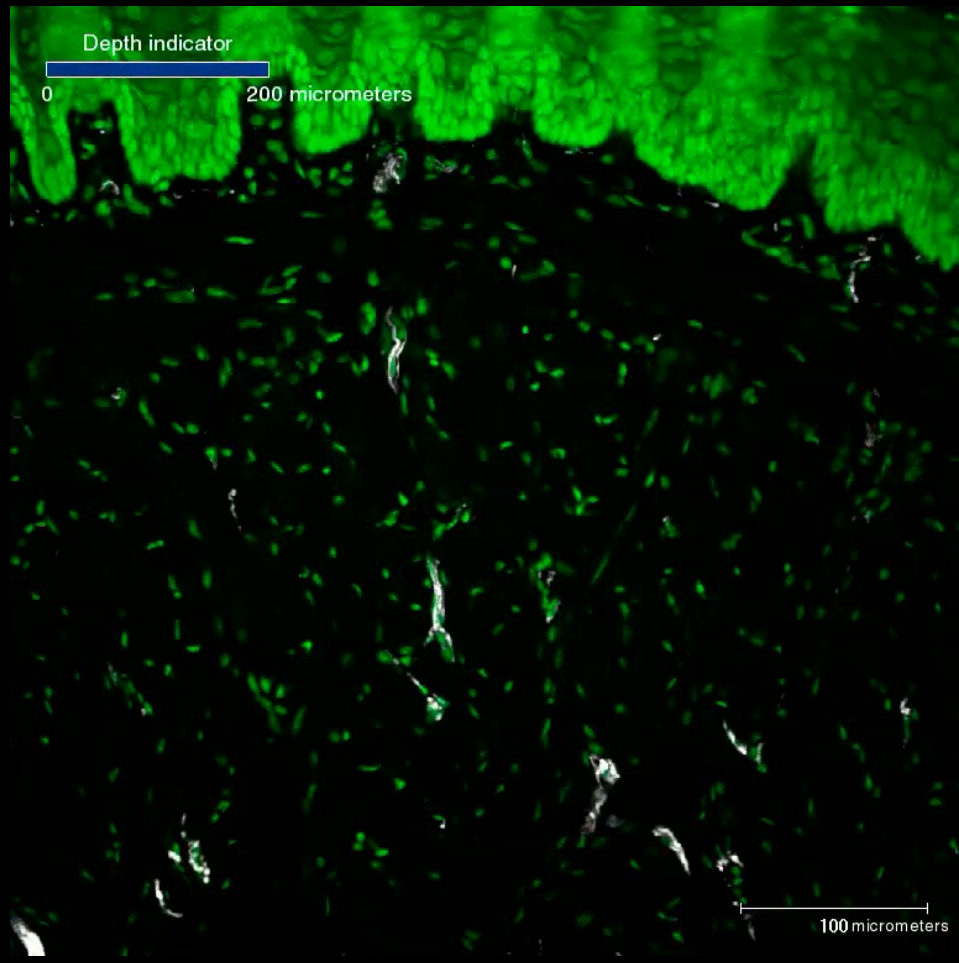
Fibrous parts

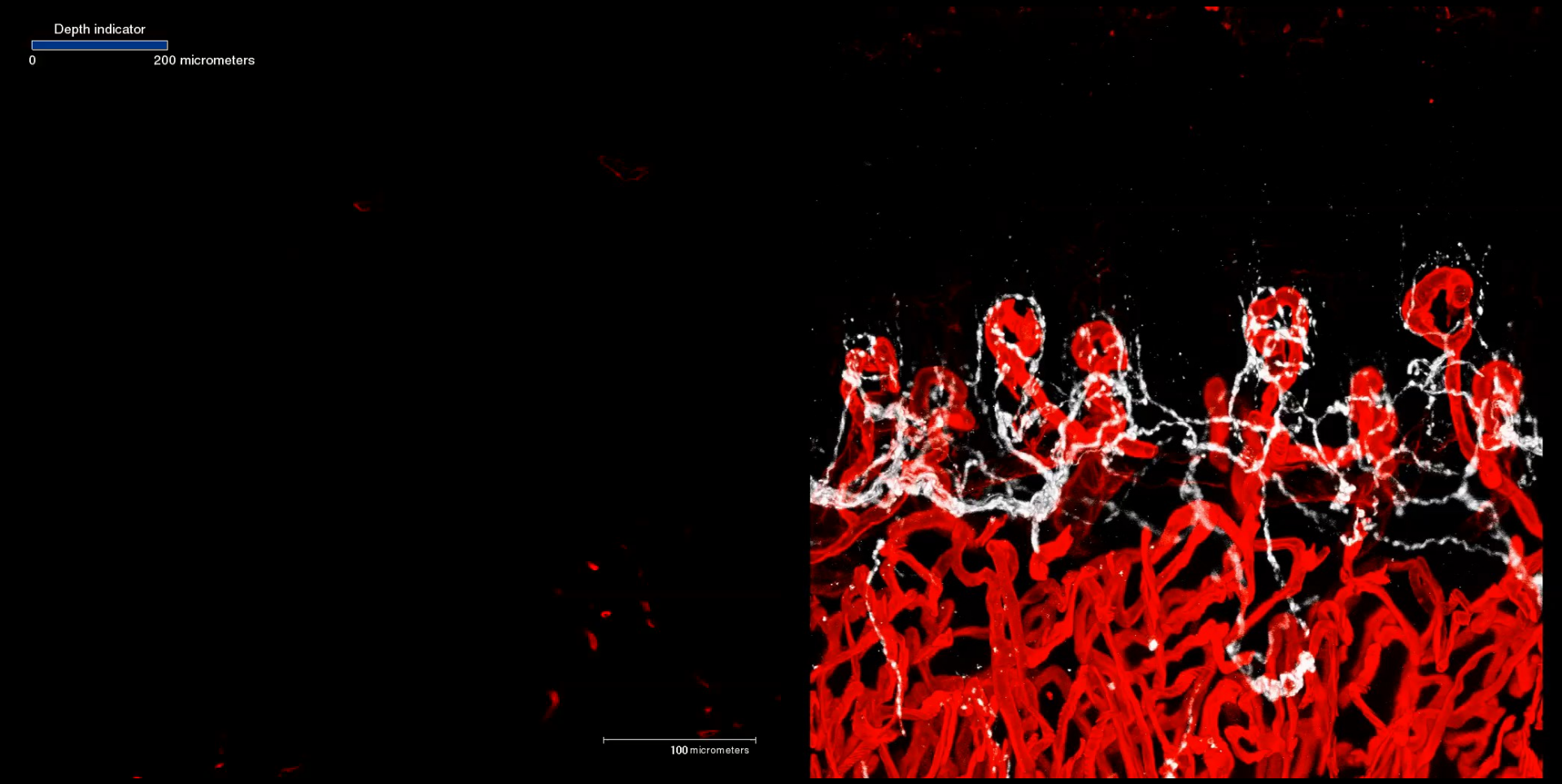
aponeurosis linguae
very stiff fibrous membrane

septum linguae
Composed from dense collagenous tissue


Dorsal
Filiform papillae
Muscle
Mucosa
Ventral

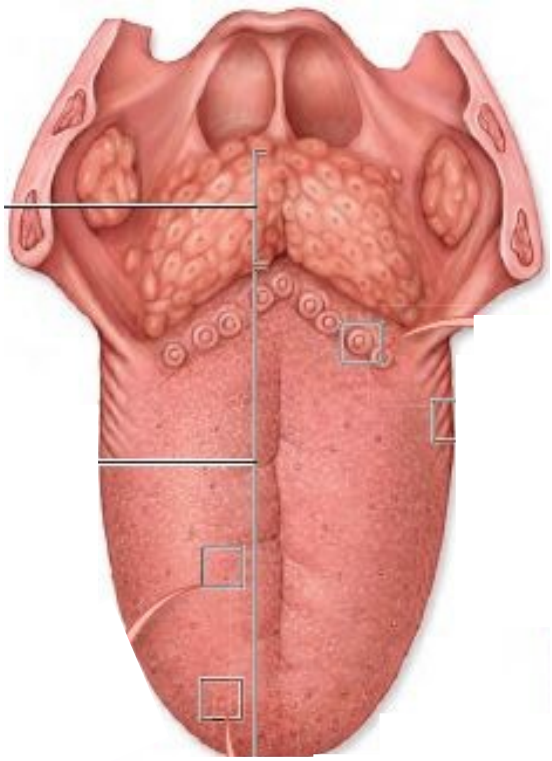

Depth indicator
0
200 micrometers
100 micrometers


Depth indicator
0
200 micrometers
100 micrometers


Depth indicator
0
200 micrometers
100 micrometers

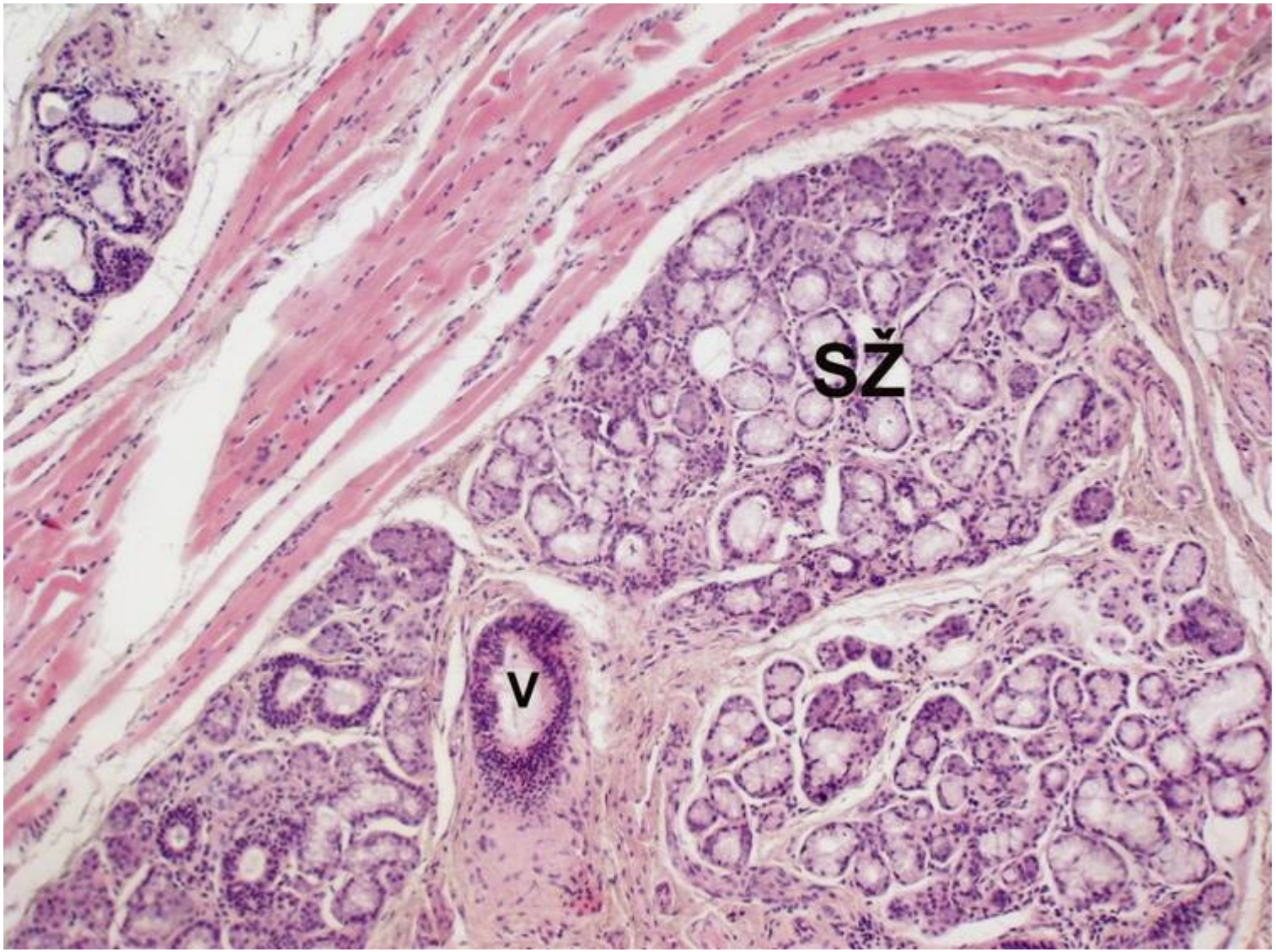
Glands of tongue

Glandula apicis linguae	(*gl. Blandini*)	mixed
Ebner‘s glands	(*gll. gustatoriae*)	serous
Weber‘s glands	(gll. linguales post)	mucinous

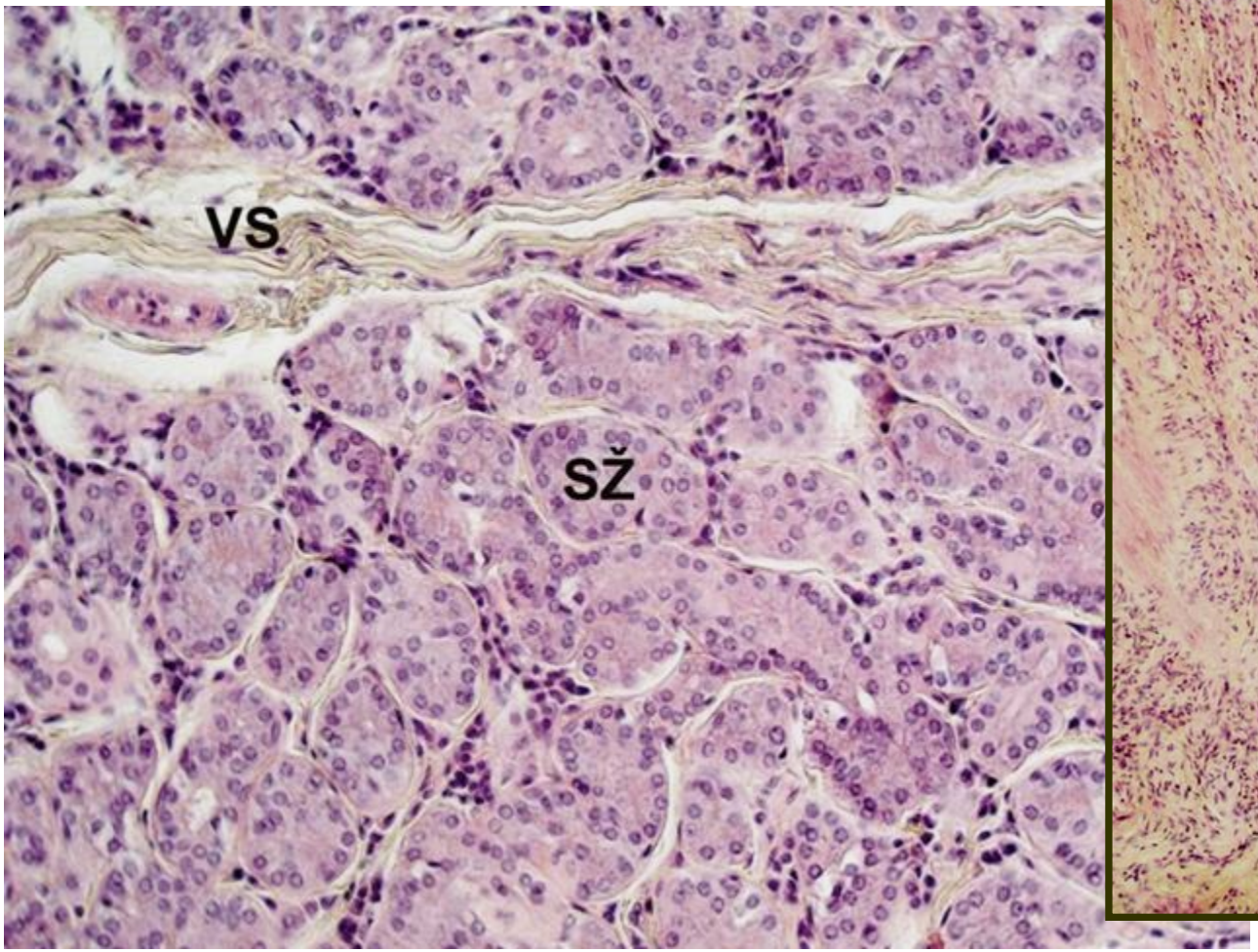


Glands of tongue

Glandula apicis linguae (gl. Blandini)
mixed



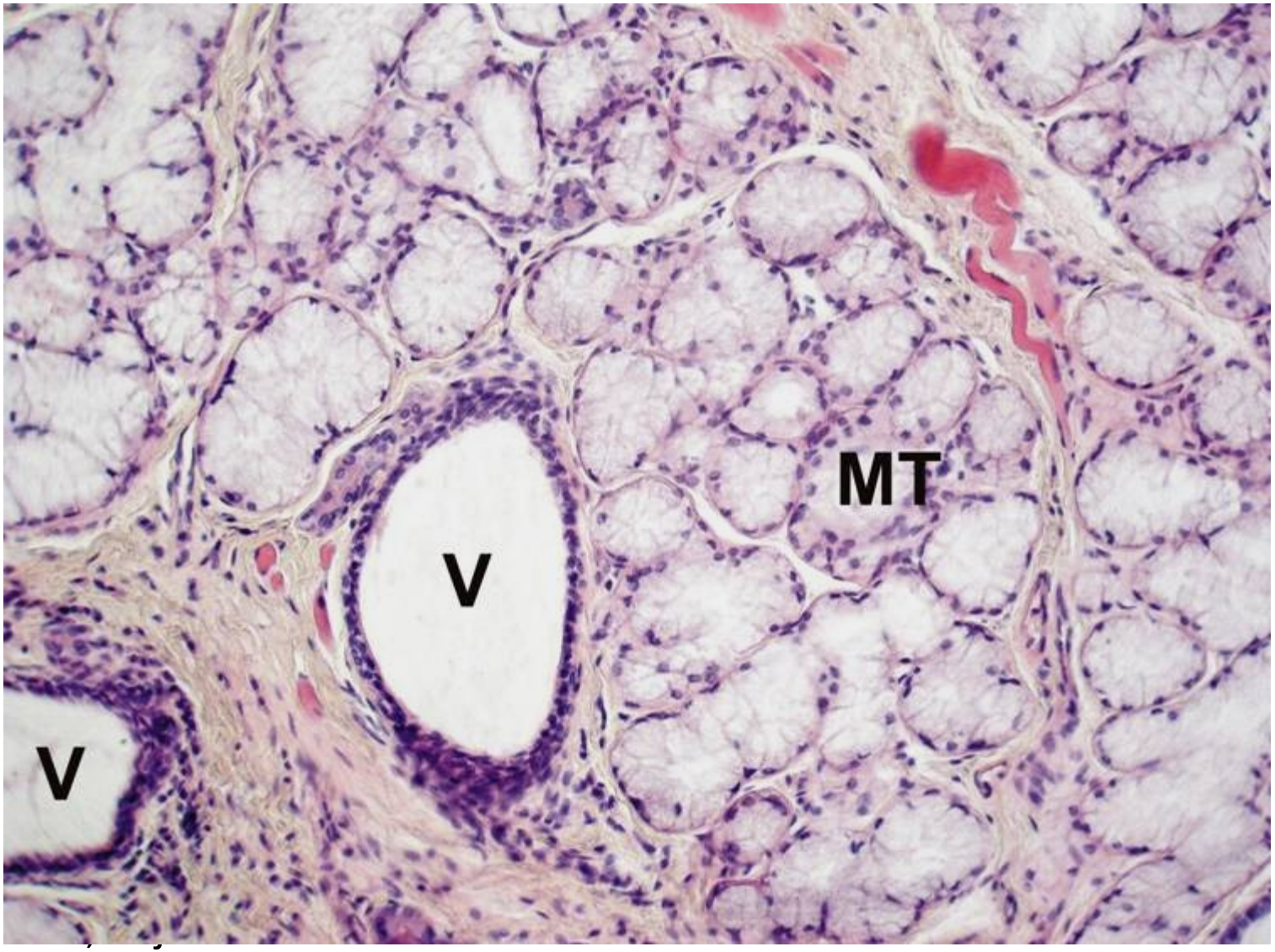
Ebner‘s glands - gll. gustatoriae
serous

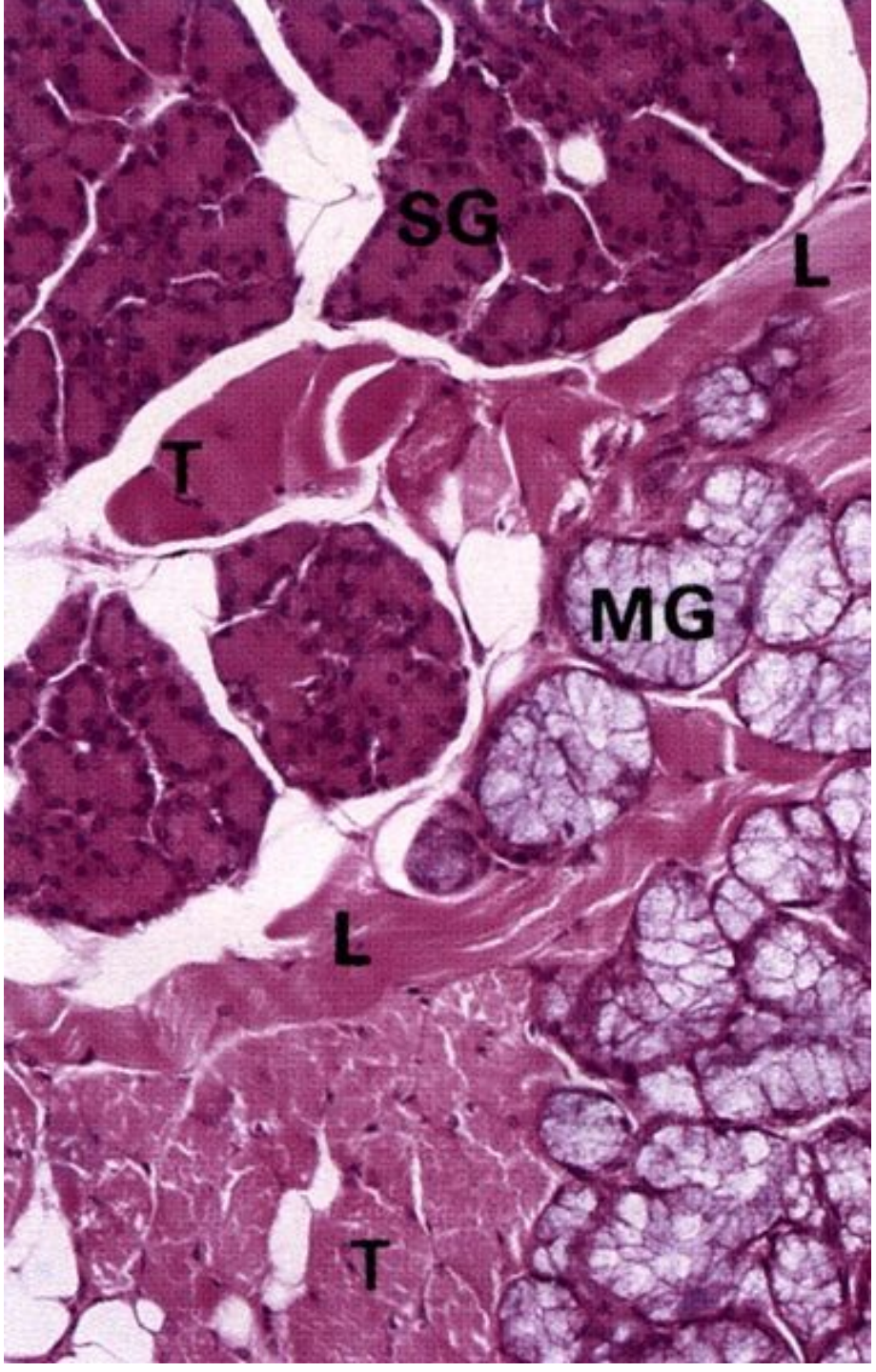


Ebner‘s serous glands

Duct of Ebner s gland (V); H.E., obj. 10x

Weber‘s glands - *gll. linguales post*
mucinous





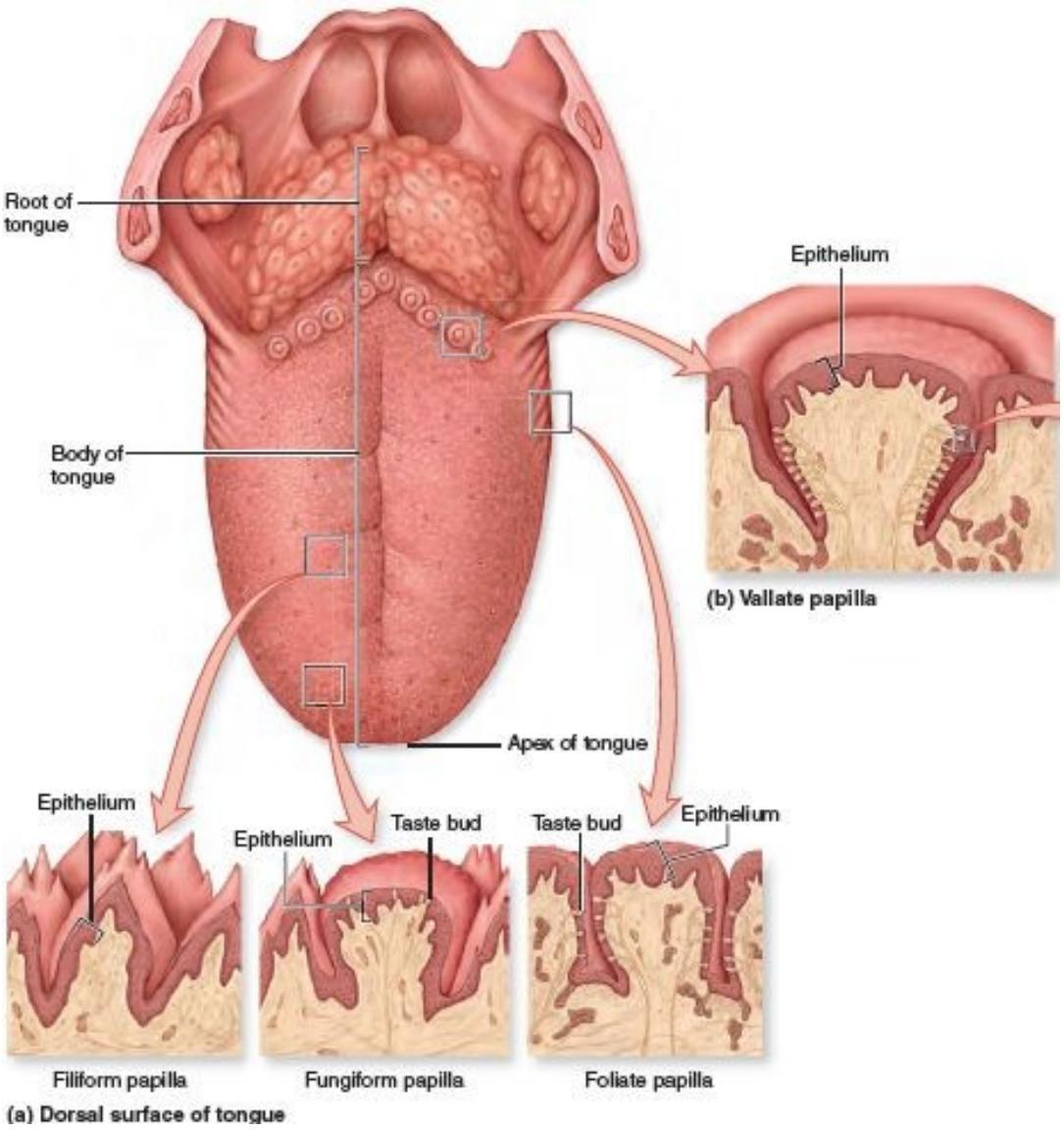
Ebner's glands
gll. gustatoriae
serous

Weber's glands
gll. linguales post
mucinous

Dorsum lingue

Specialized oral mucosa

- Firmly connected with *aponeurosis linguae*
- Rough surface
- Mucosal outgrowths - **lingual papillae**
- Covered by nonkeratinized squamous stratified epithelium (except of papillae filiformes)

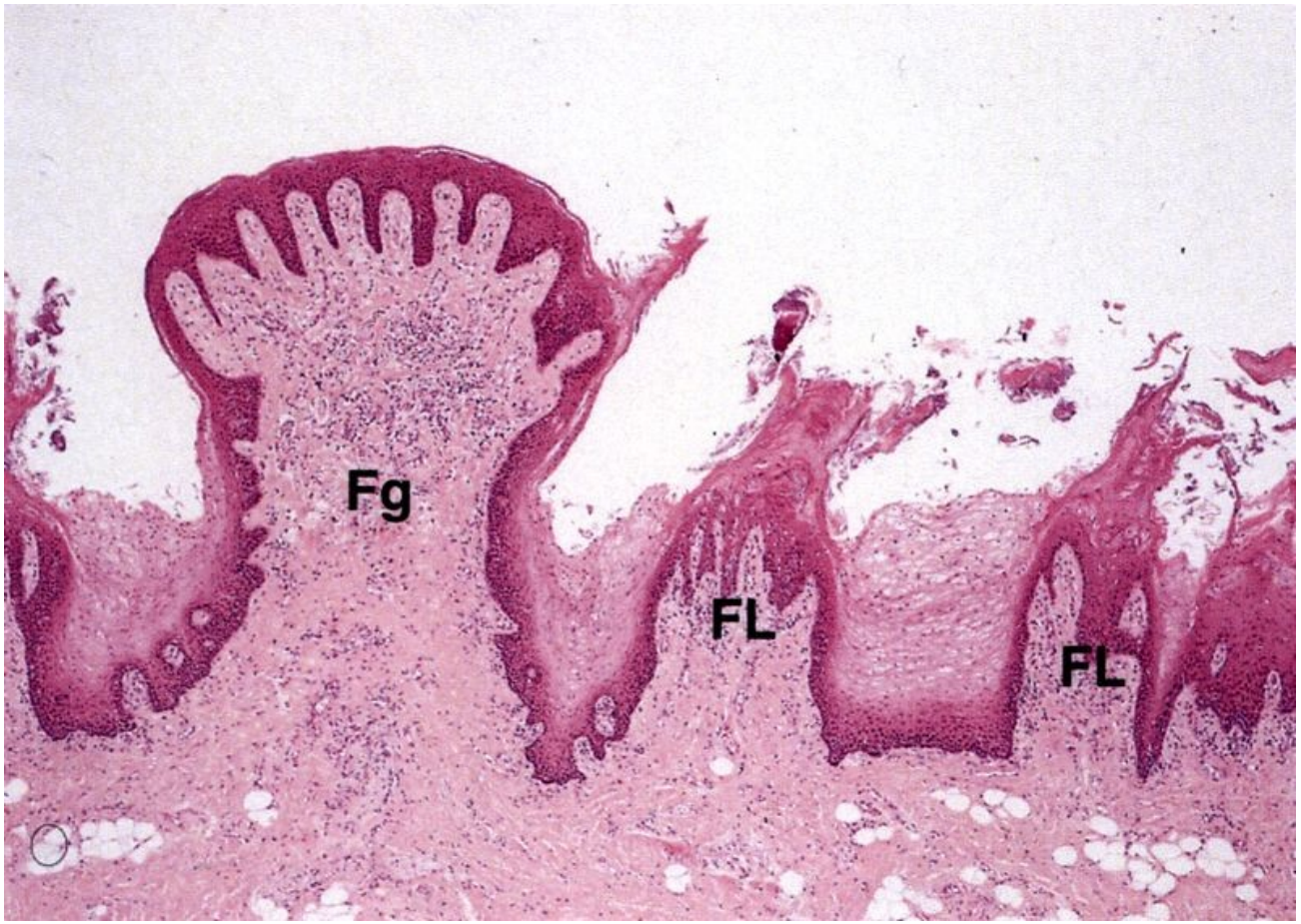


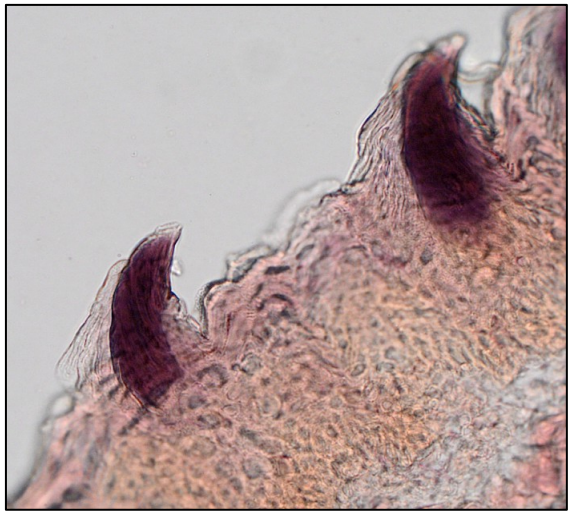
Papillae filiformes

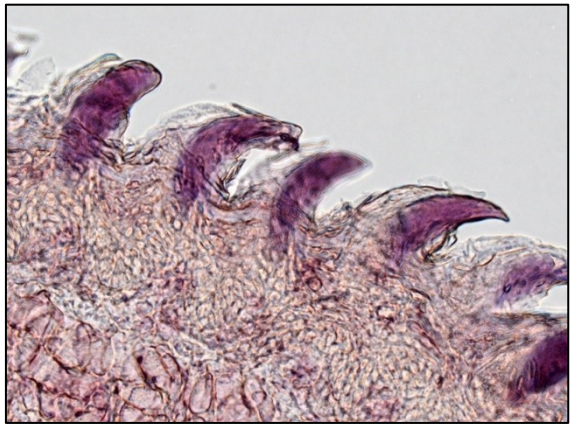
The most abundant and distributed over the entire dorsal surface of the tongue;
Brush-like appearance (0.5-1 mm in height, 0.2-0.3 mm in width);
The stratified squamous epithelium is often cornified

Papillae fungiformes

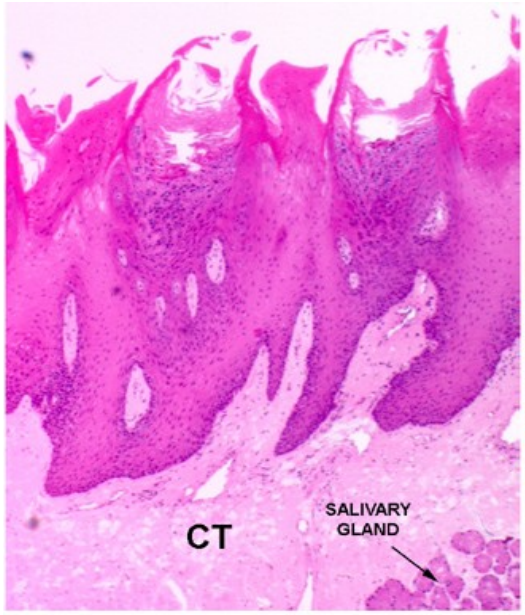
Mushroom-shape (0.5-1.5 in height, 0.5–1.0 mm in width)
Taste buds in epithelium

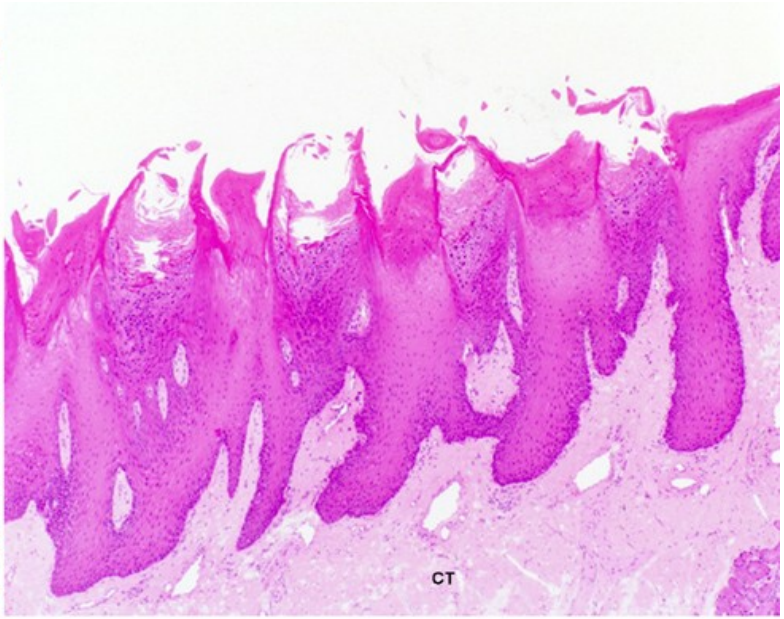


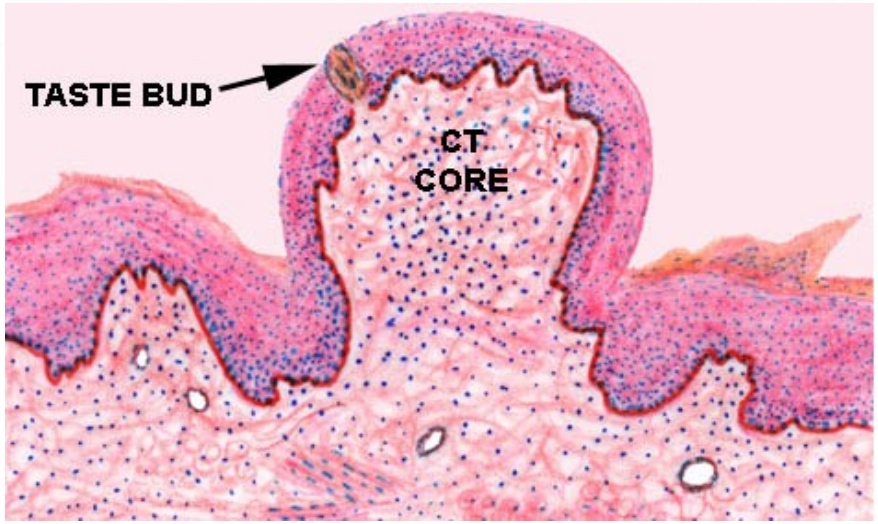


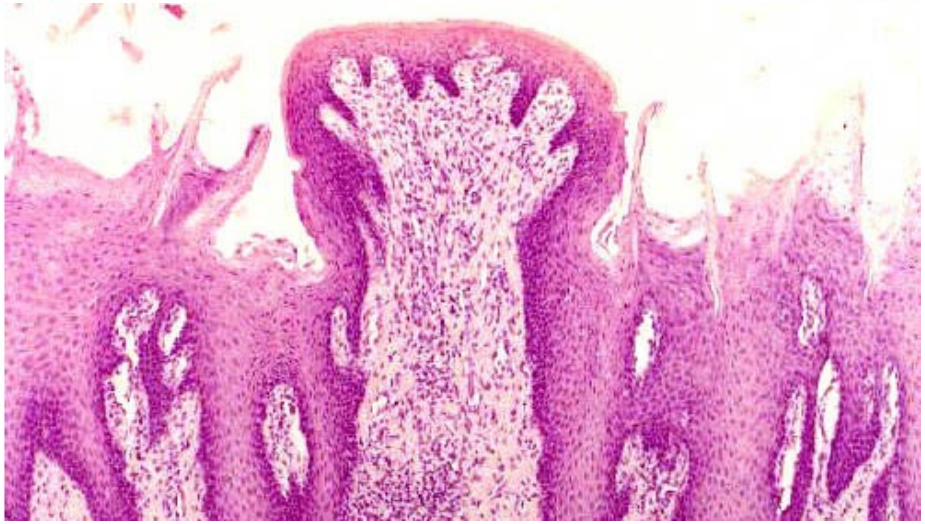


Papillae filiformes vs. Papillae fungiformes









Keratinisation differences

Papillae foliatae

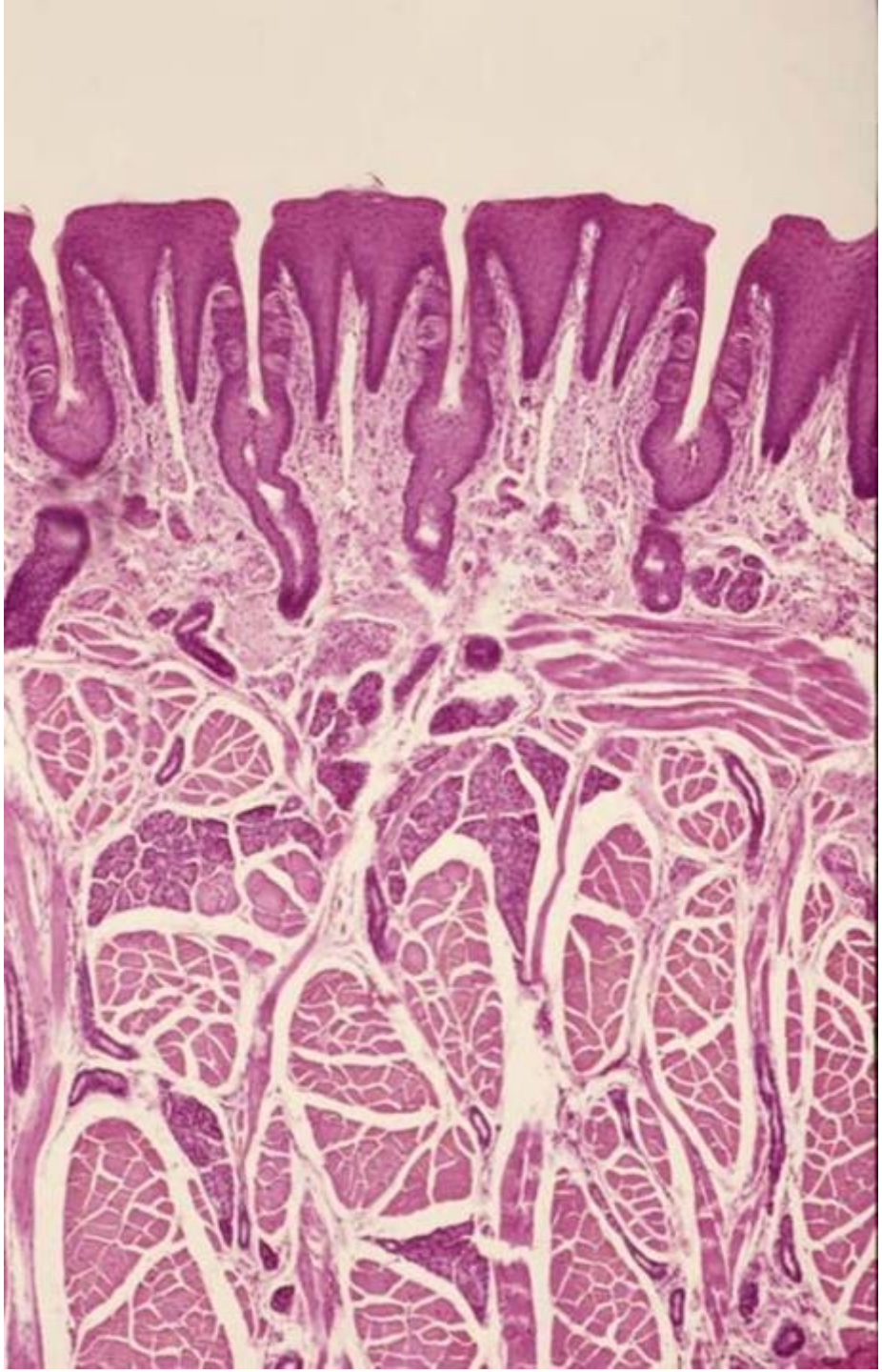
Count: 3 - 8

Vertically-oriented

Rudimental

Laterally on the edge of the main body and root of tongue

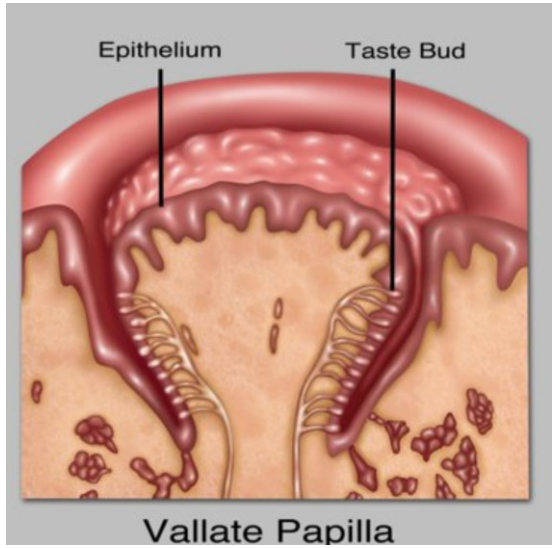
Taste buds

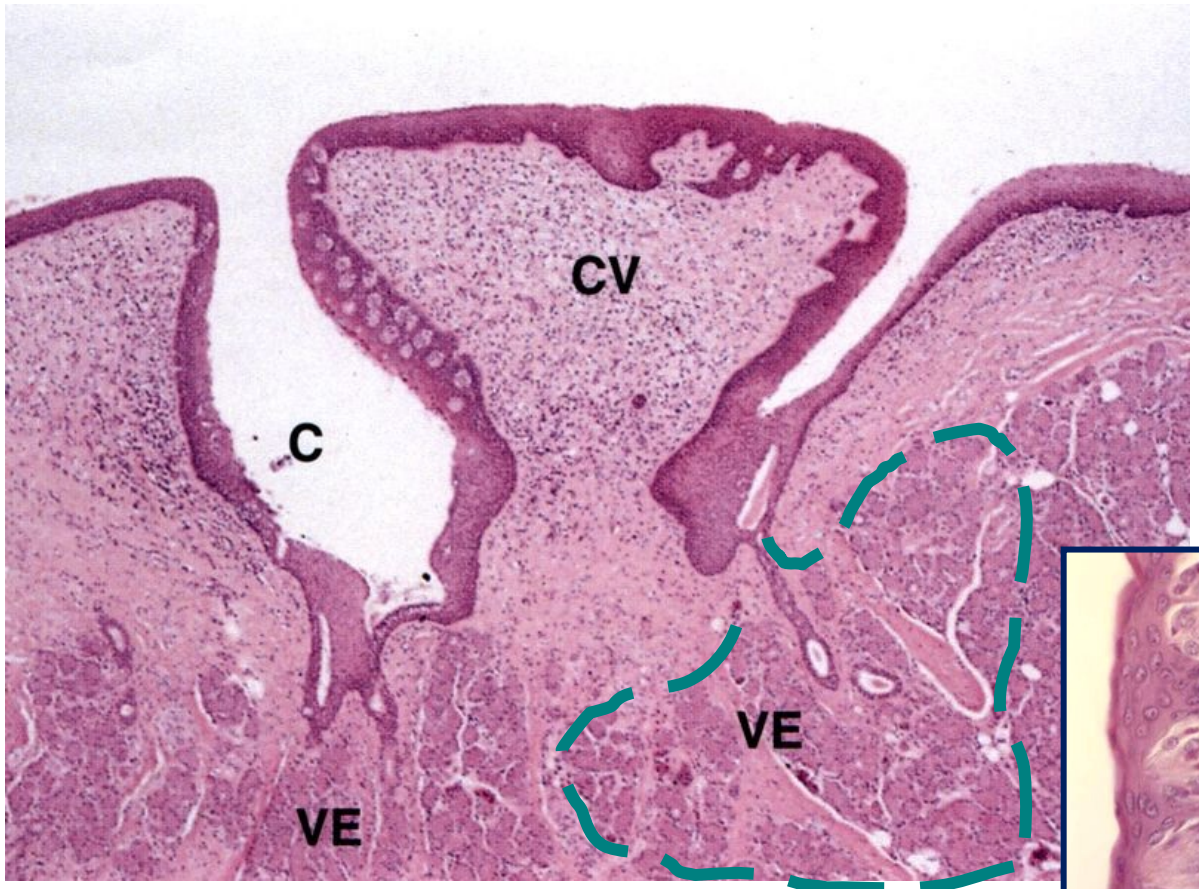


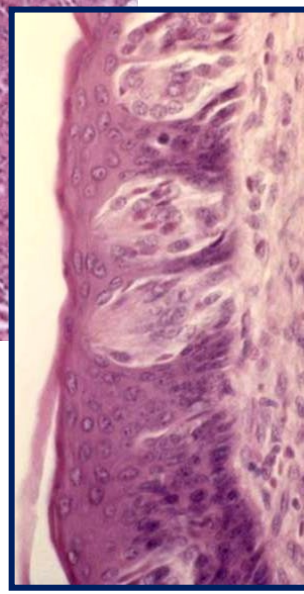
Papillae vallatae (Papila circumvallata)

Largest (1-4 mm in height, 1-3 mm in width), 7–12 just in front of sulcus terminalis, submerged into mucosa. Deep circumpapillary furrow.

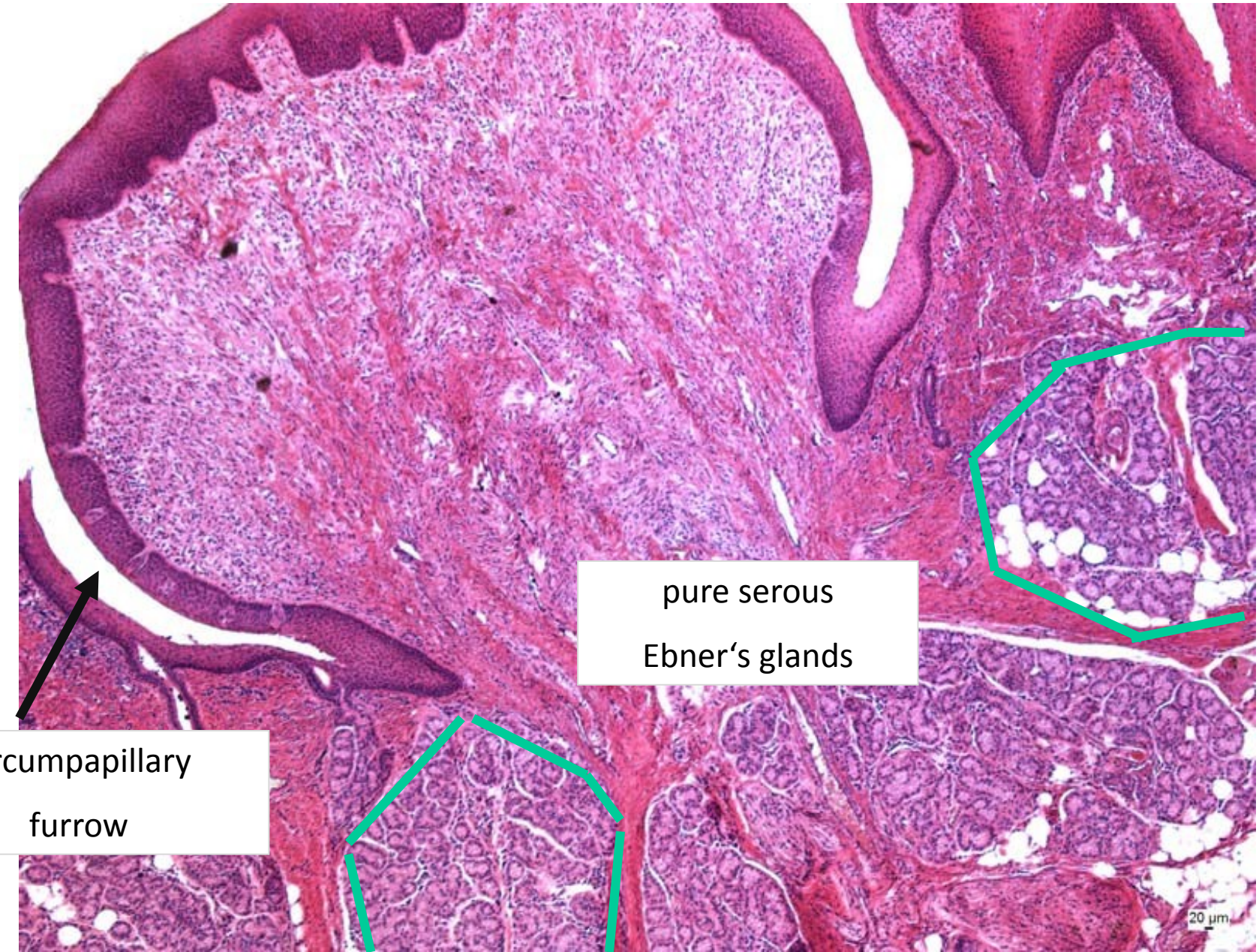
Taste buds







Papilla vallata



Taste buds

(caliculi gustatorii)

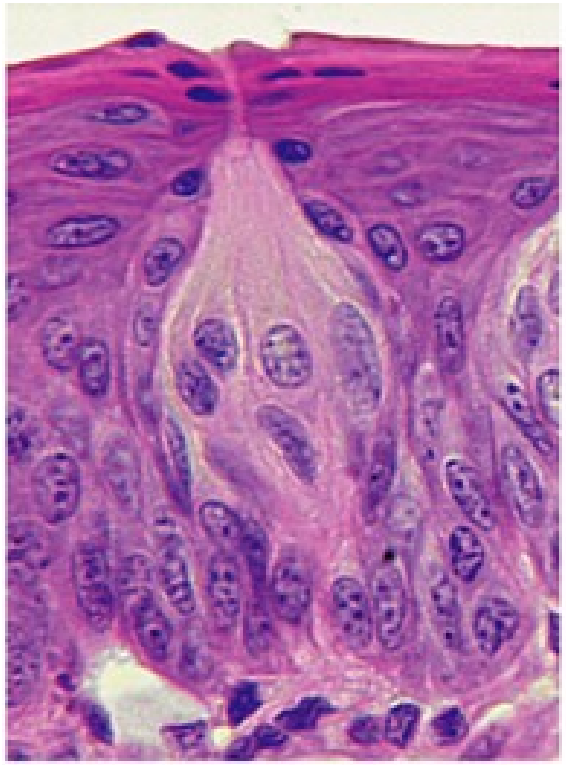
Intraepithelial structures

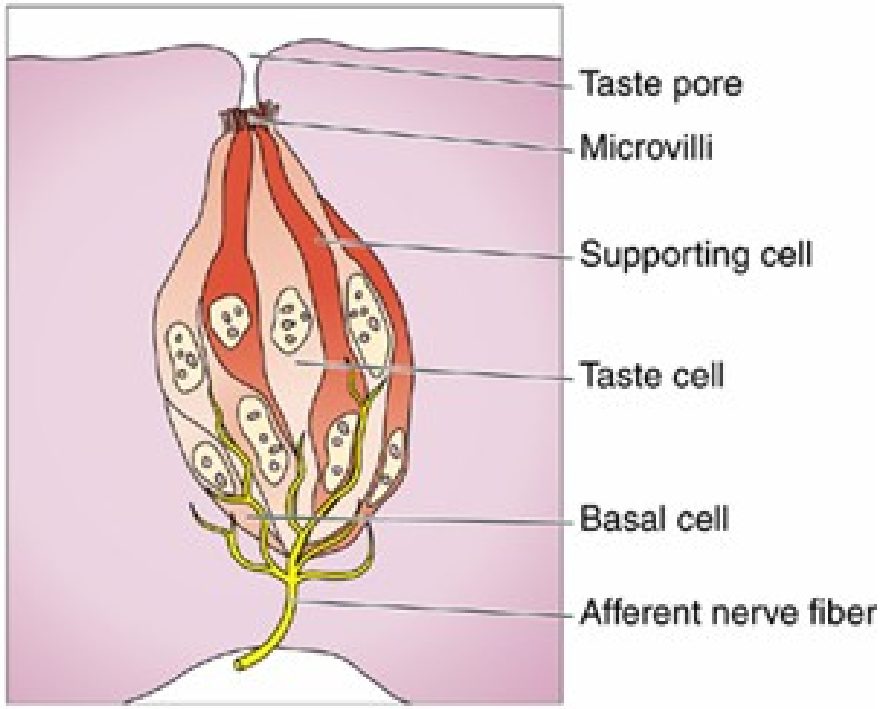
Localization:

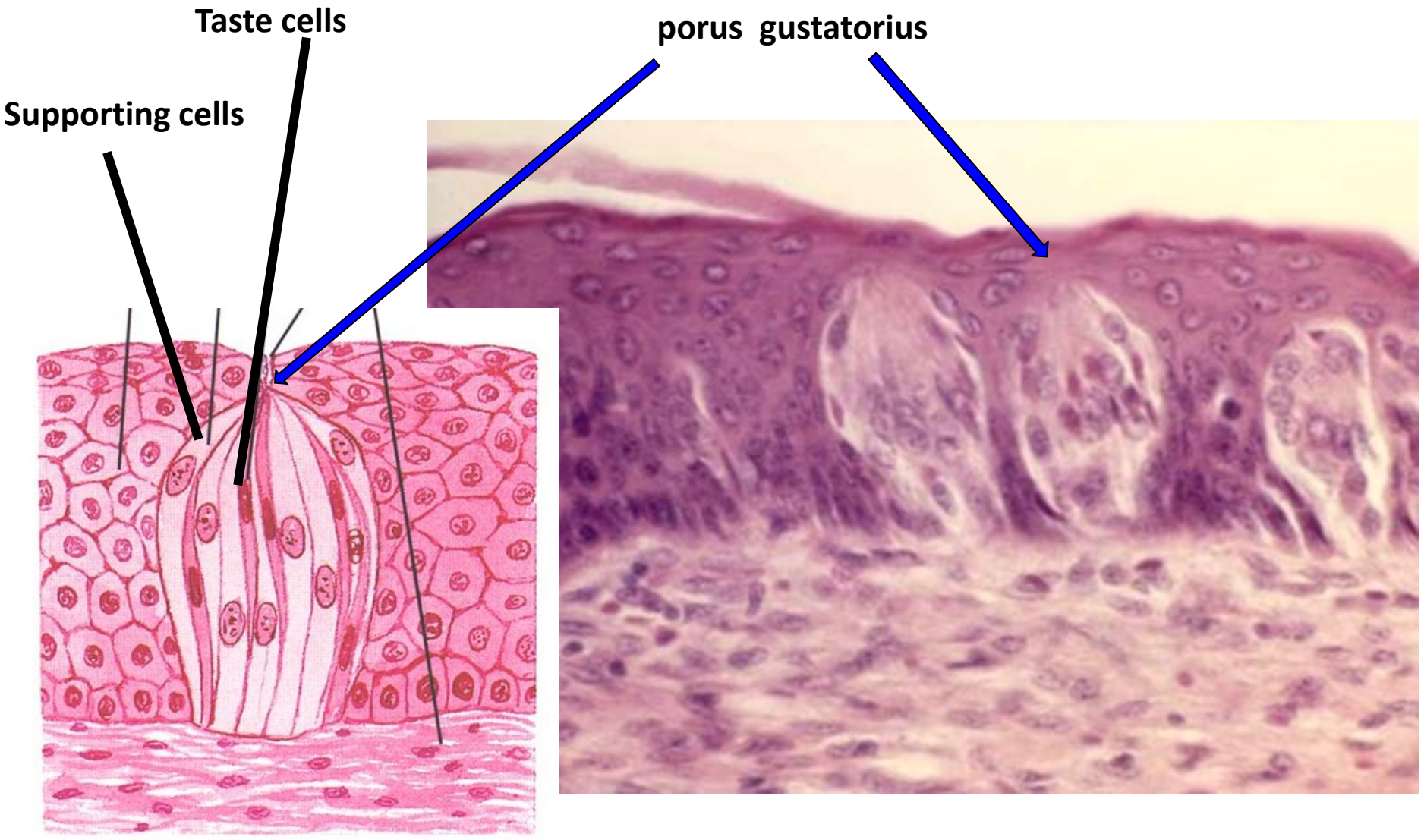
- epithelium of vallate papillae + circumpapillar furrows
- epithelium of fungiform papillae and foliate papillae

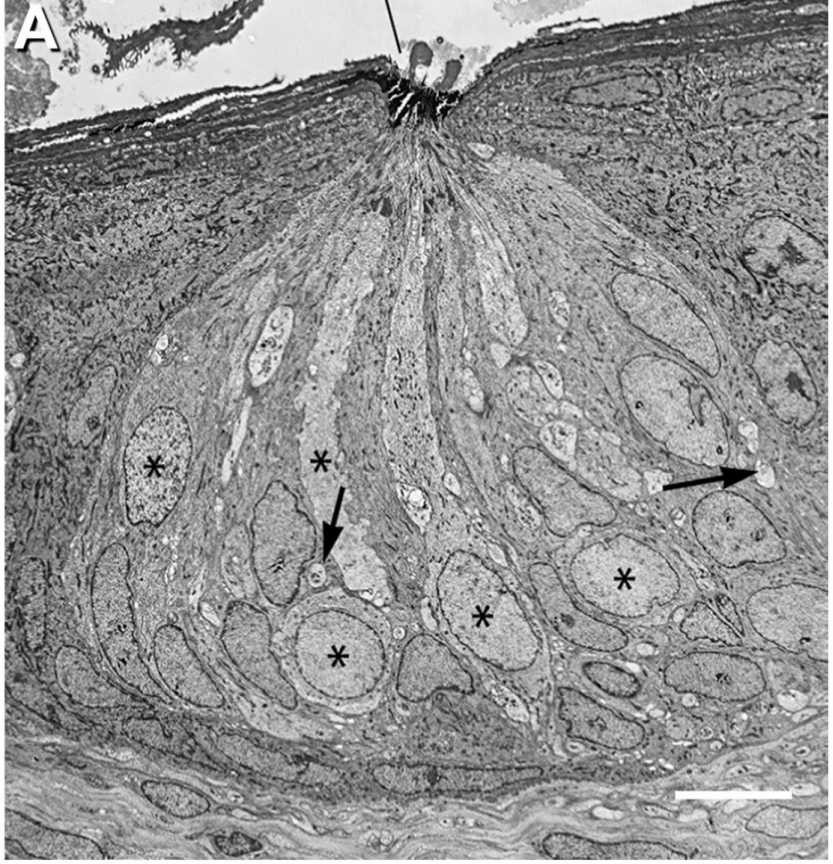
Number: around **2000 – 2500** in young individual, reduction with age up to 1/3

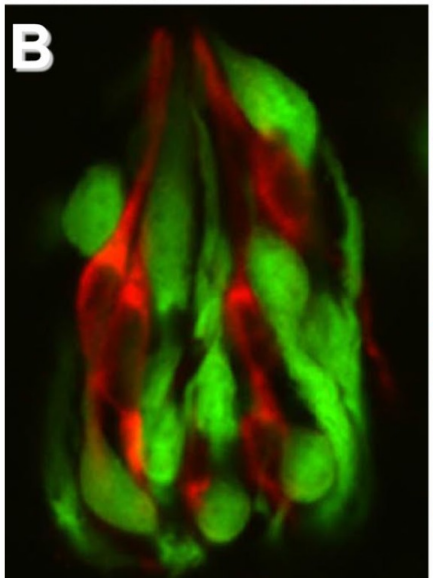
Every taste bud is composed of 80-100 cells

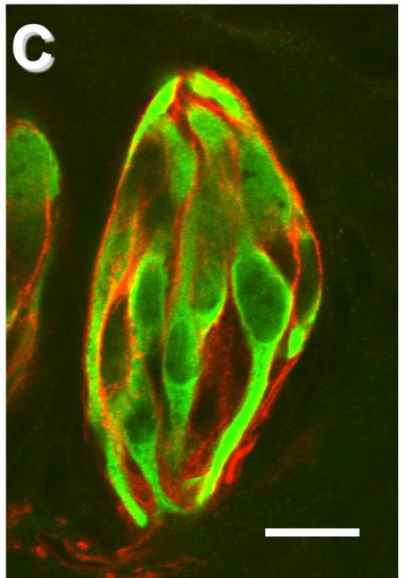





Taste cells
porus gustatorius
Supporting cells





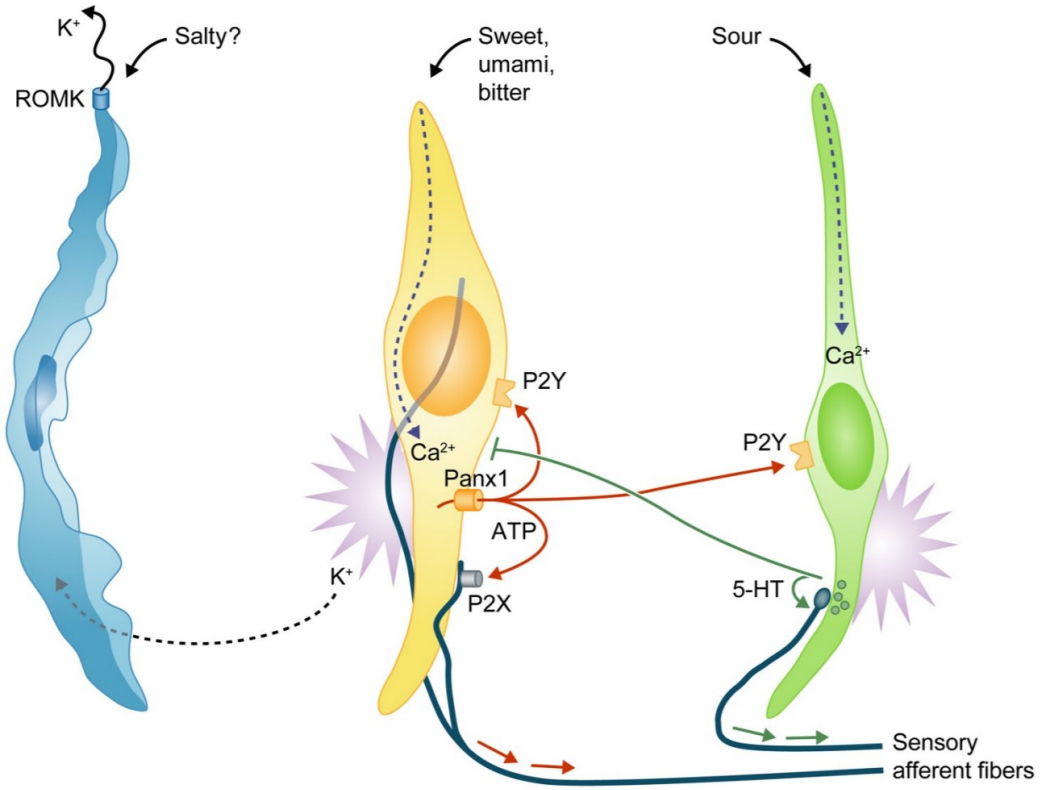


TASTE ?

Basic tastes:
Sweet
Salty
Sour
Bitter
Umami

Suggested:
Fatty
Metalic

?



Type I glial-like cell	
Neurotransmitter clearance	
GLAST	Glutamate reuptake
NTPDase2	Ecto-ATPase
NET	Norepinephrine uptake
Ion redistribution and transport	
ROMK	K^+ homeostasis
Other	
OXTR	Oxytocin signaling?

Type II receptor cell	
Taste transduction	
T1Rs, T2Rs	Taste GPCRs
mGluRs	Taste GPCRs
Gα-gus, Gγ13	G protein subunits
PLCβ2	Synthesis of IP3
TRPM5	Depolarizing cation current
Excitation and transmitter release	
$Na_v1.7$, $Na_v1.3$	Action potential generation
Panx1	ATP release channel

Type III presynaptic cell	
Surface glycoproteins, ion channels	
NCAM	Neuronal adhesion
PKD channels	Sour taste?
Neurotransmitter synthesis	
AADC	Biogenic amine synthesis
GAD67	GABA synthesis
5-HT	Neurotransmitter
Chromogranin	Vesicle packaging
Excitation, transmitter release	
$Na_v1.2$	Action potential generation
$Ca_v2.1$, $Ca_v1.2$	Voltage-gated Ca^{2+} current
SNAP25	SNARE protein, exocytosis

Signal transmission

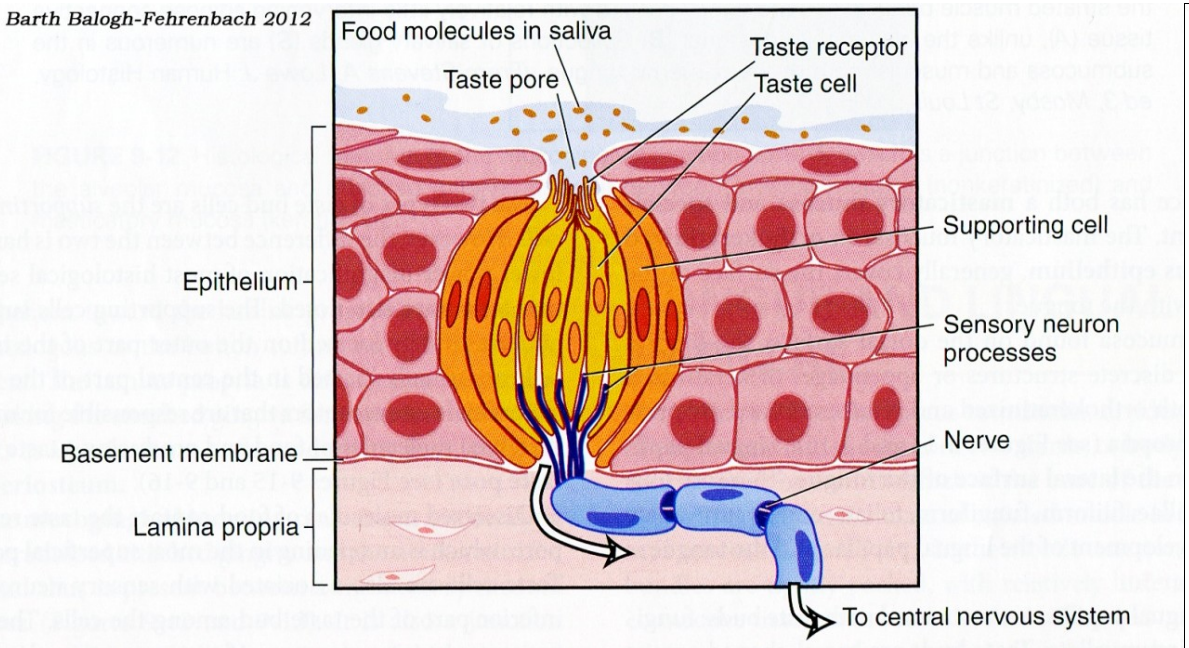
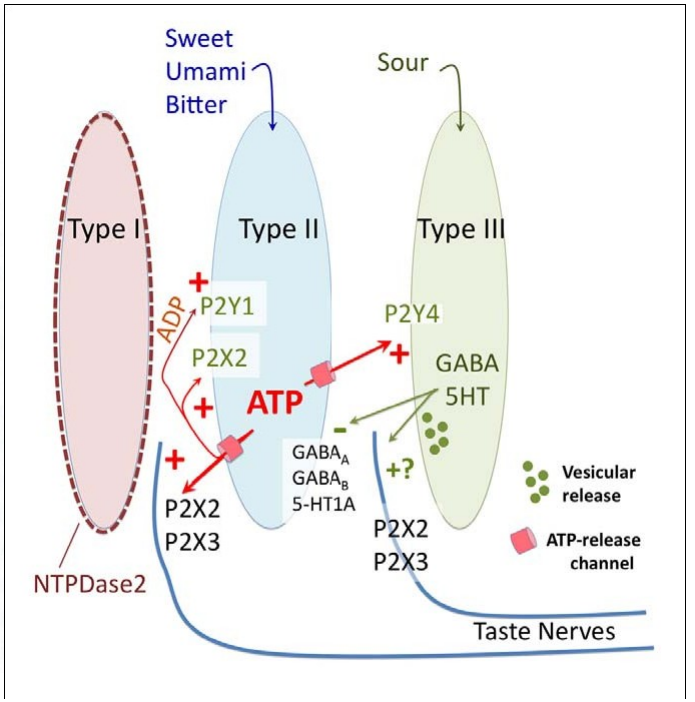


FIGURE 9-16 Events involved in taste sensation with a taste bud. Dissolved food contacts the taste



Inervation of taste buds

- taste buds on fungigorm papillae - **facial nerve** - chorda tympani (through lingual nerve)
- taste buds on foliate papillae and vallate papillae - **n. glossopharyngeus**
- taste buds in other locations (radix of the tongue, the isthmus faucium - **n. vagus**

Thank you for your attention!