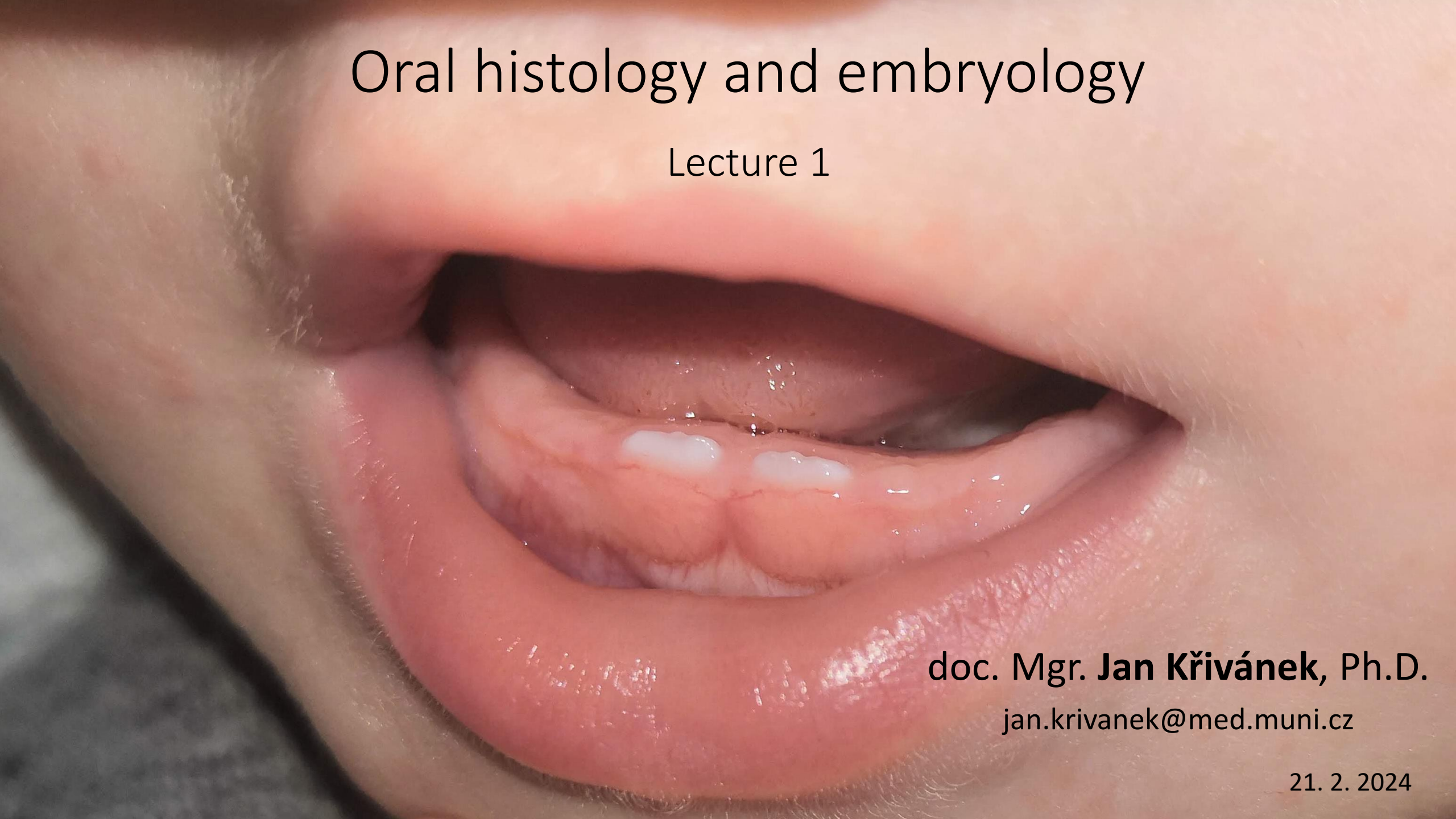
Oral histology and embryology

Lecture 1



doc. Mgr. **Jan Křivánek**, Ph.D.

jan.krivanek@med.muni.cz

21. 2. 2024

Objectives of the course

- **Microscopic structure** of the organs of the orofacial system
- Connections of **structure and function**
- Detailed **understanding of developmental processes**
- Understanding the background of congenital malformations

Lectures	Wednesday 8:30 – 10:10
Practicals	Wednesday 8:30 – 10:10

Invited lecture: Úterý 21. 5. 2024, 12:30 – 13:45, **B11/206** prof. Anamaria Balic

Teachers:

doc. Mgr. **Jan Křivánek**, Ph.D.

Marina Štruncová, DDS, Ph.D.

Invited lecture

prof. Anamaria Balic, MD, Ph.D.

Tuesday 21. 5. 2024, 12:30 – 13:45, **B11/206**

Mandatory participation = Instead of practices

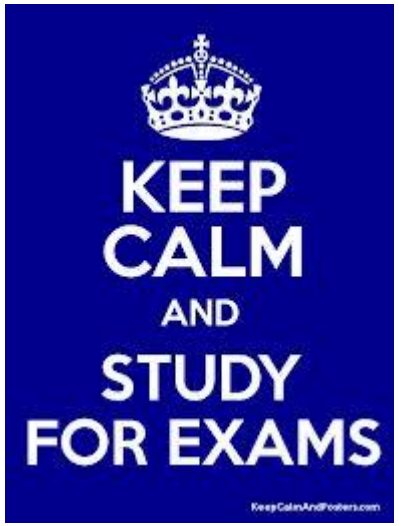
Research Interests:

- Dental stem cells and stem cell niches
- Tooth development
- Tooth agenesis
- Tooth regeneration
- Craniofacial development

University of Zurich[UZH]

Center for Dental Medicine

Conditions to successfully pass the course



Practicals: 100% attendance
Successfully completed credit test (8. 5. 2024)
Individually completed all ROPOTS
Attendance at the Invited Lecture on 21 May 2024

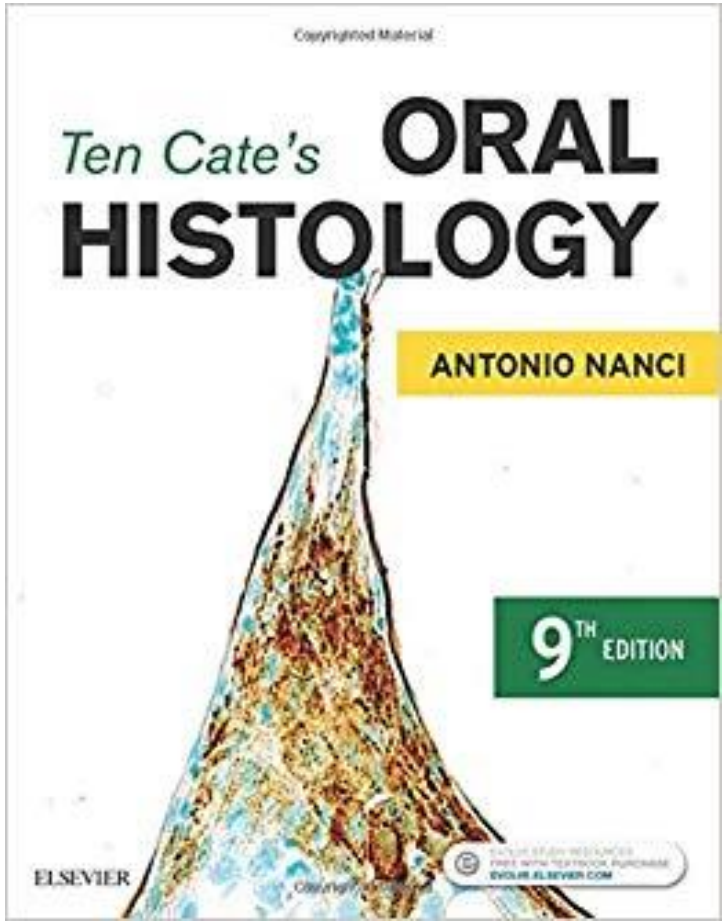
Exam: Successfully completed practicals
Written test (minimally 60 % of correct answers)
30 questions +1 bonus. Multiple choice + short written answers (upgraded tests)
Successful completion of Histology I + II is no longer a prerequisite for admission to the OHE examination
During lectures there may be opportunities to earn bonus points in the final test

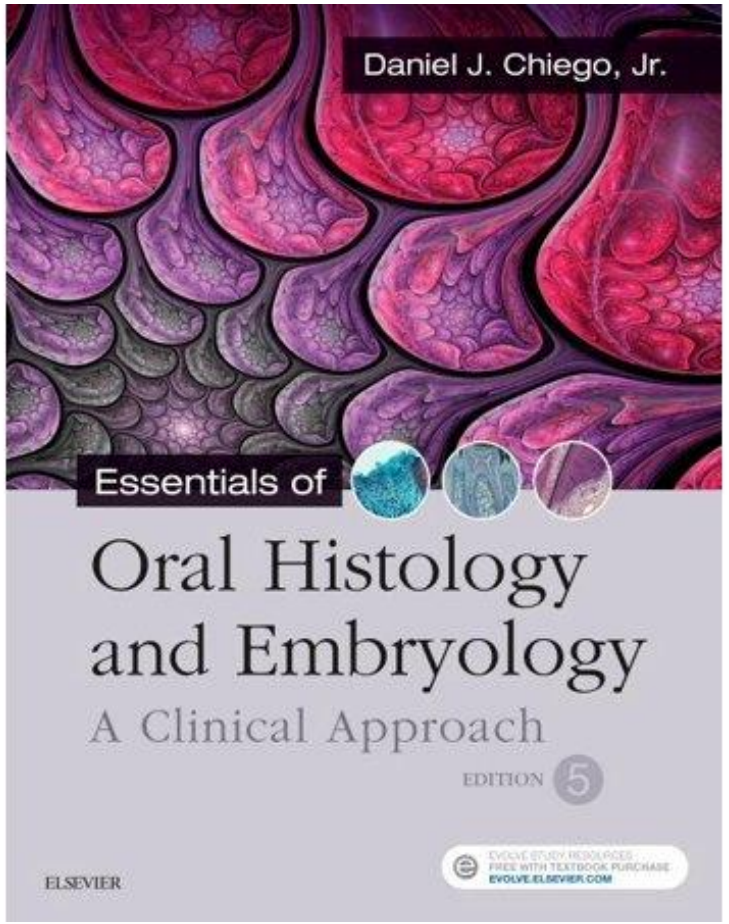
*The exam may include **questions from presentations in practicals and lectures** (written and **orally communicated** information), from **ROPOTS** and from **discussions** during practicals and lectures.*

For a more detailed understanding of the presented information, the study of comprehensive literature is recommended:
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

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

Antonio Nanci





Essentials of Oral Histology and Embryology: A Clinical Approach

Daniel J. Chiego

ROPOTS

- Every 14 days, one ROPOT
- The ROPOT will be published in the "lecture" week
- It has to be completed by the end of the week in which practicals are held
- Each answer sheet consists of about 10-15 questions to be answered **in your own words**

- The answer sheets should enable to practice the knowledge acquired
- **Questions from the ROPOTS may appear on the exam**

Timetable of lessons

Semester 4, Spring 2023

Programme of lectures and practicals in Oral histology and embryology (aZLOH) for the 2nd year of Dentistry

doc. Mgr. Jan Křivánek, Ph.D.
doc. RNDr. Petr Vaňhara, Ph.D.
Marina Štruncová, DDS, Ph.D.

Lectures (even weeks)	Practice (odd weeks)
1. **19. 2. – 23. 2. 2024** **Introduction**, information about the completion of the course, recommended literature. **Orofacial system**, its structural components, and functions. **Oral cavity -** walls and contents. Structure and functions of the **oral mucosa**, types of mucosae. **Taste buds**.	1. **19. 2. – 23. 2. 2024**
2. **26. 2. – 1. 3. 2024**	2. **26. 2. – 1. 3. 2024** Microscopic structure and functional histology: lips, palate, cheeks, tongue. Samples: *labium oris, palatum molle, apex linguae, papilla vallata, radix linguae.*
3. **4. 3. – 8. 3. 2024** **Salivary glands, TMJ** Microstructure and classification of salivary glands. Temporomandibular joint, microstructure and function.	3. **4. 3. – 8. 3. 2024**
4. **11. 3. – 15. 3. 2024**	4. **11. 3. – 15. 3. 2024** Salivary glands, TMJ – microstructure. Samples: *gl. parotis, gl. submandibularis, gl. sublingualis, gl. apicis linguae, TMJ.*
5. **18. 3. – 22. 3. 2024** **Alveolar process, Periodontium** Microstructure of the alveolar process and clinical aspects of its remodelling. Microstructure of the periodontium, its function and clinical aspects. Gingiva, sulcus gingivalis.	5. **18. 3. – 22. 3. 2024**
6. **25. 3. – 29. 3. 2024**	6. **25. 3. – 29. 3. 2024** **Tonsils, Introduction to the tooth** Samples: *Tonsilla palatina, tonsilla lingualis.*
7. **1. 4. – 5. 4. 2024** **Enamel, Cementum** Enamel microstructure, function, amelogenesis and age-related changes. Microstructure of cementum, types and its clinical significance.	7. **1. 4. – 5. 4. 2024**
8. **8. 4. – 12. 4. 2024**	8. **8. 4. – 12. 4. 2024** **Dentin-pulp complex** Dentin as living tissue. Microstructure of the dental pulp, functions. Samples: Tooth (ground section).
9. **15. 4. – 19. 4. 2024** **Development of the face, oral and nasal cavities** Development of the face, oral and nasal cavities, palate, nasal septum, atrium of the oral cavity, upper and lower jaws.	9. **15. 4. – 19. 4. 2024**
10. **22. 4. – 26. 4. 2024**	10. **22. 4. – 26. 4. 2024** **Tooth development** Samples: Different stages of tooth development - pig, human.
11. **29. 4. – 3. 5. 2024** **Development of the tongue, salivary glands, pharyngeal arches** Tongue development, defects. Development of salivary glands. Development and features of pharyngeal arches and their derivatives.	11. **29. 4. – 3. 5. 2024**
12. **6. 5. – 10. 5. 2024**	12. **6. 5. – 10. 5. 2024** **Science and research, regenerative dental medicine** Current focus of dental research, advances in the field of regenerative dentistry. Are we going to be able to repair or regenerate our teeth? Discussion. Credit test (the course will be credited only after attendance at the invited lecture)
13. **13. 5. – 17. 5. 2024** **Permanent dentition, defects** Development of permanent dentition and a time overview. Mixed dentition. Differences in the structure of primary and secondary teeth. Developmental defects of teeth.	13. **13. 5. – 17. 5. 2024**
14. **20. 5. – 24. 5. 2024**	14. **20. 5. – 24. 5. 2024** **INVITED LECTURE (COMPULSORY)**

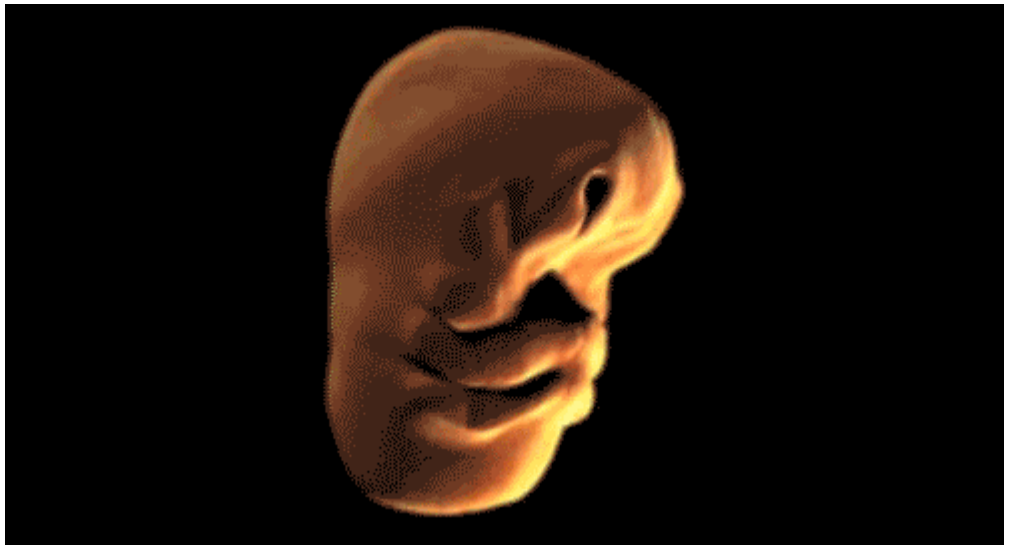
Doc. MVDr. Aleš **Hampl**, CSc.
Head of Department

Orofacial system

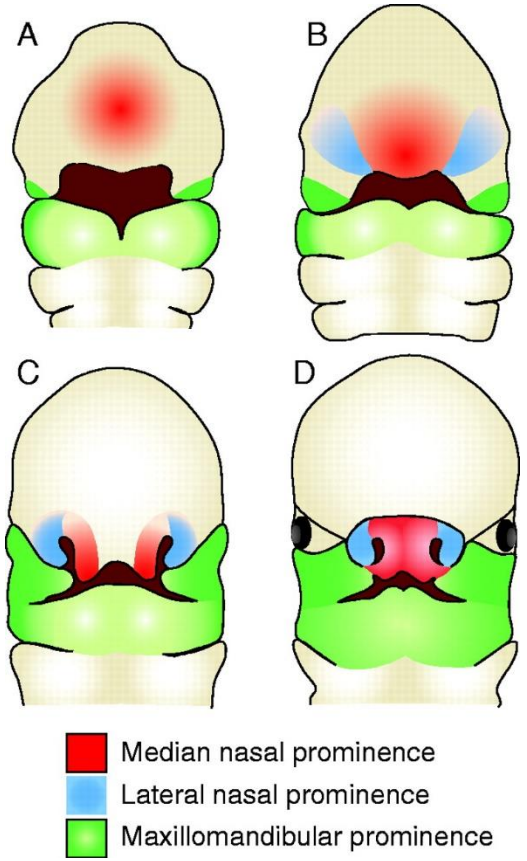
Orofacial system

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 arches, frontonasal prominence and maxillary and mandibular prominences

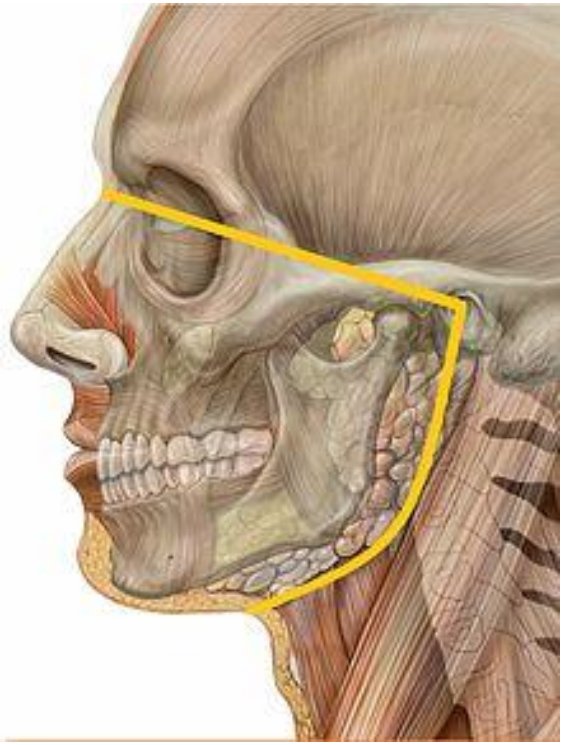


(Helms et al. 2005)

Orofacial system

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

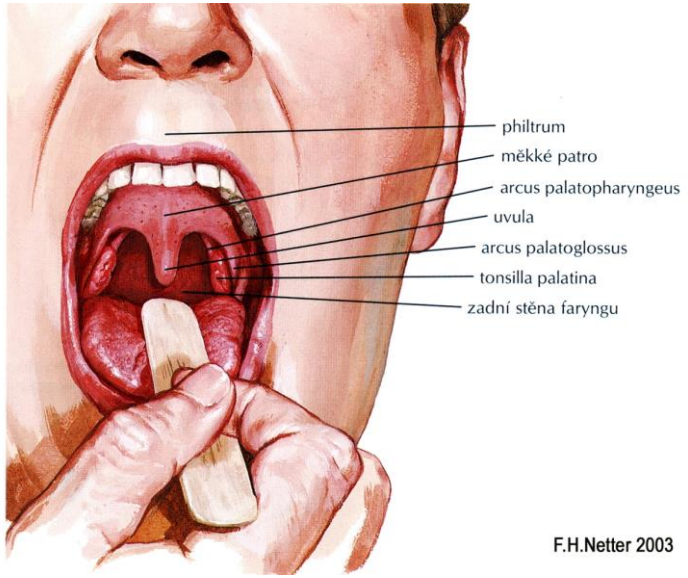
Tongue, teeth, gums, tonsilla palatina

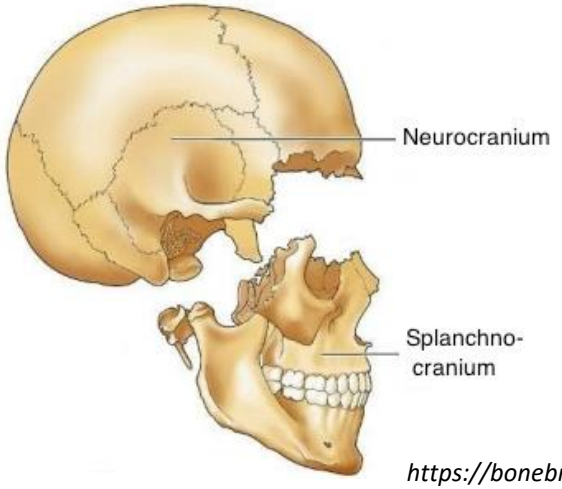
Major salivary glands:

gl. submandibulatis

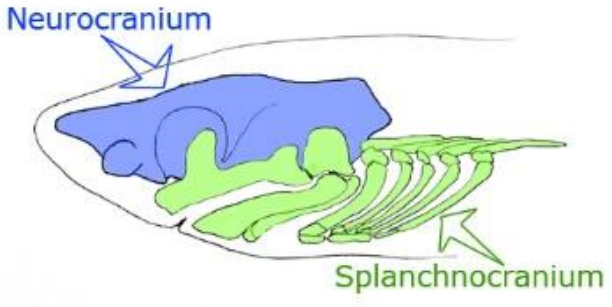
gl. sublingualis

gl. parotis (positioned outside)





https://bonebroke.org/



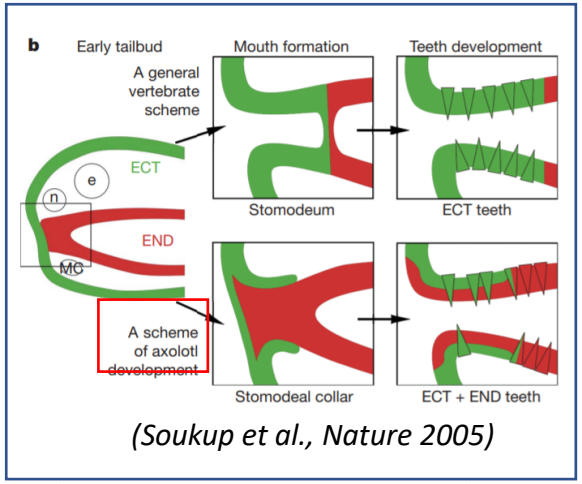
https://inside.ucumberlands.edu

Oral mucosa

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)
- **Food processing**



(Soukup et al., Nature 2005)

Features of the oral mucosa :

- 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 (ectomesenchyme – neural crest)**, while elsewhere from the entoderm or mesoderm and mesenchyme of mesodermal origin.
- **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)**

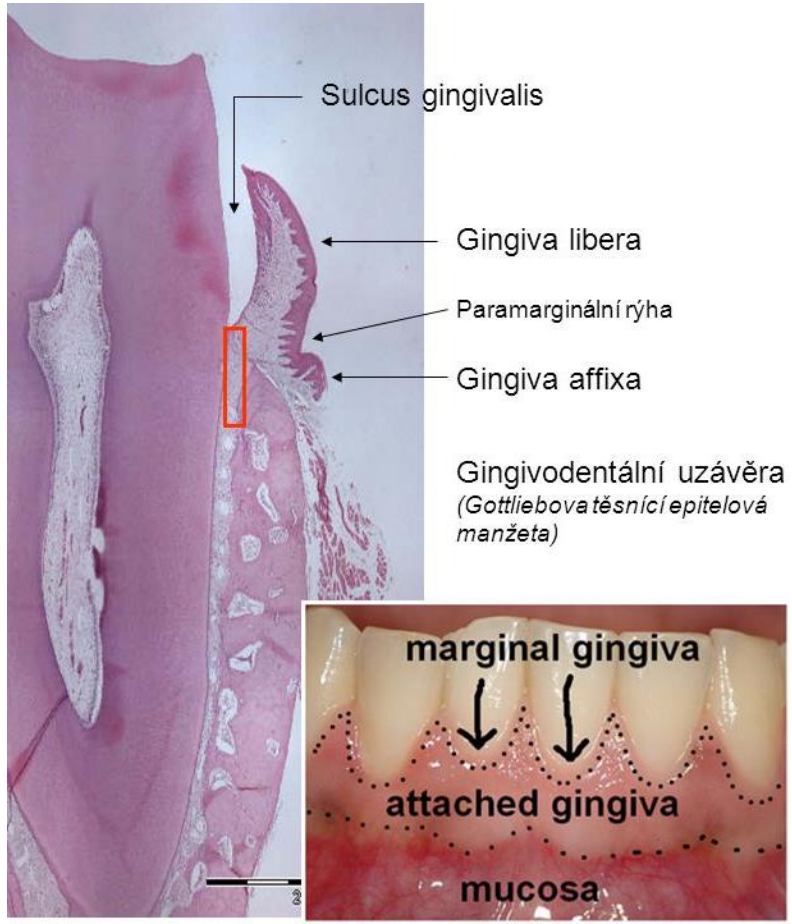
Oral mucosa regeneration

Oral epithelium turnover time: 4 - 24 days

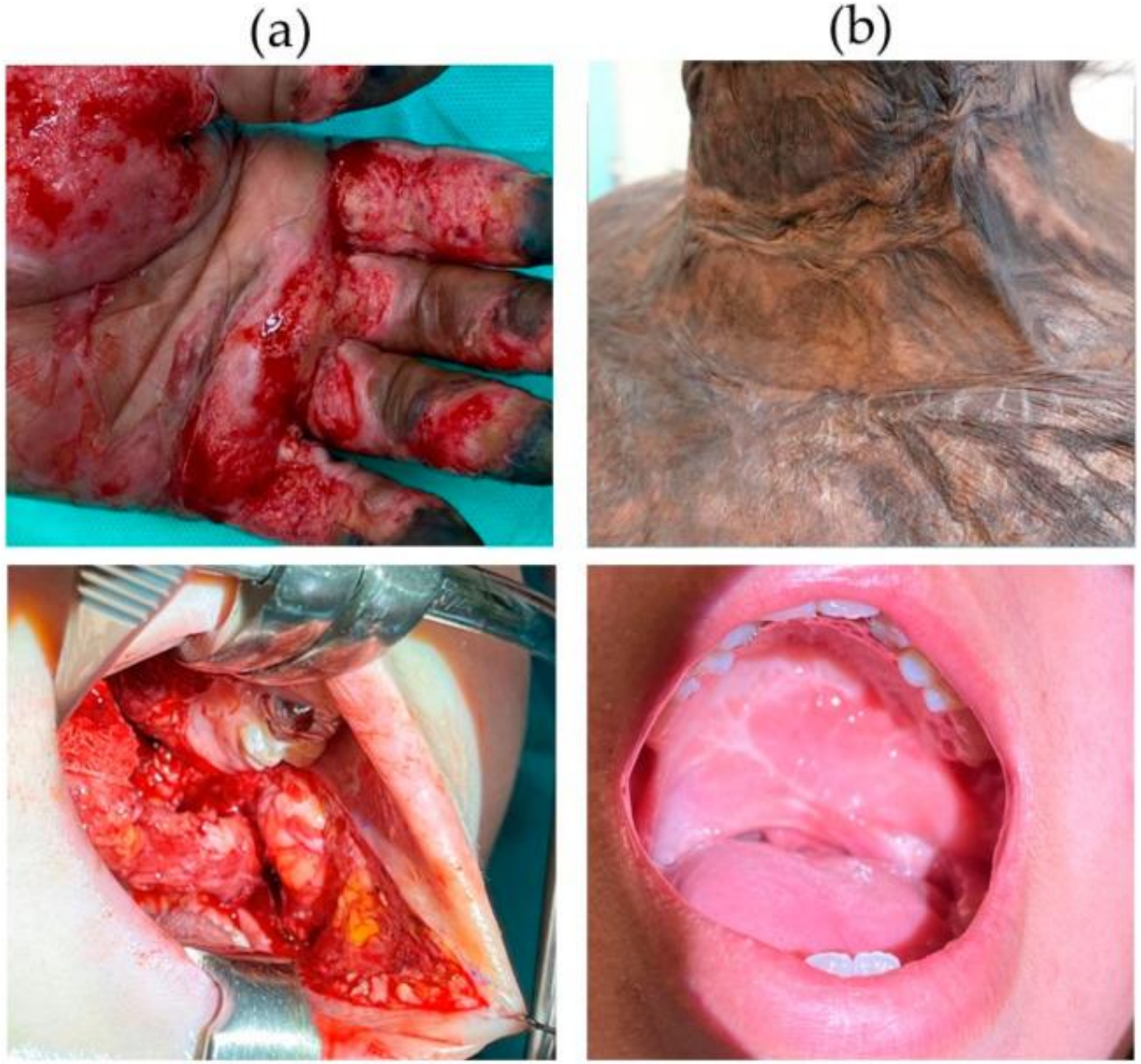
Significant local differences

Gingivo-dental junctional epithelium	4-6 days
Gingiva affixa epith. (masticatory mucosa)	10 days
Taste buds	10 - 14 days
Lining epith. of lips and cheeks mucosa	14 days
Lining epith. of the floor of mouth	20 days
Masticatory epithl. of hard palate	24 days

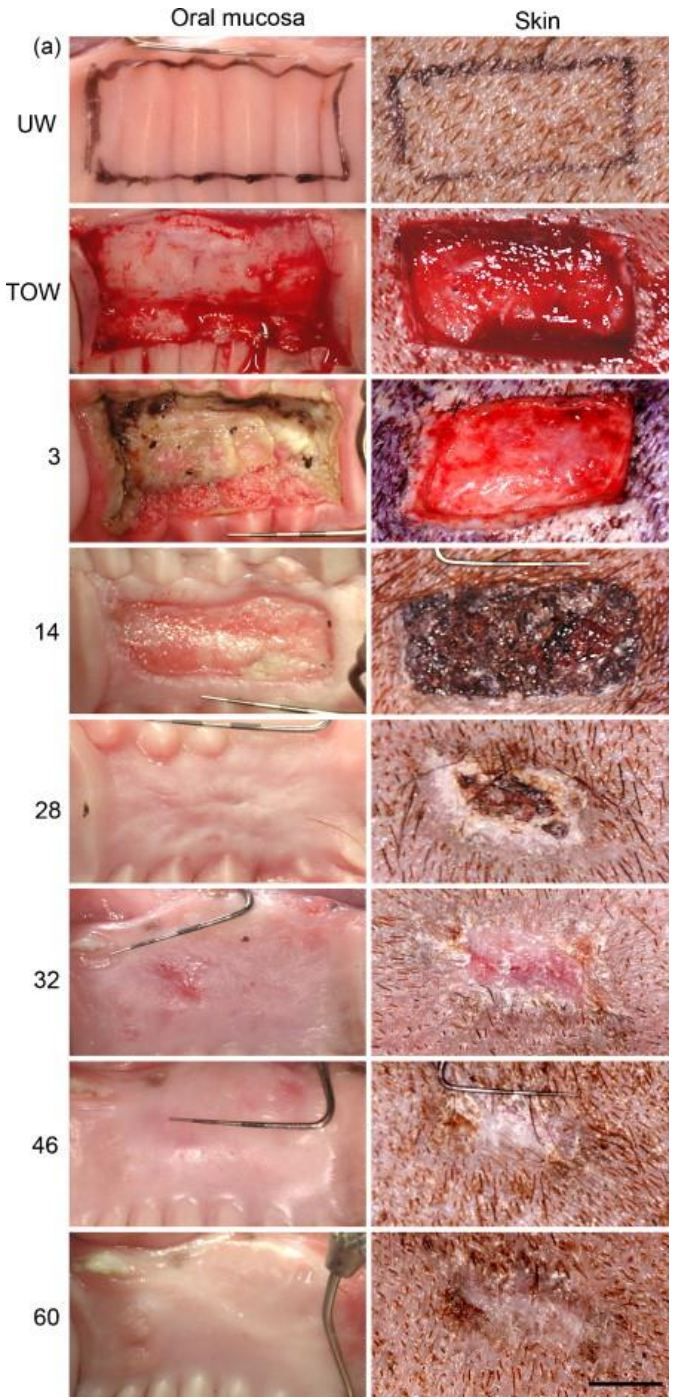
Epidermis of the face and neck frontal side	*7* days
Epidermis (rest)	*30* days



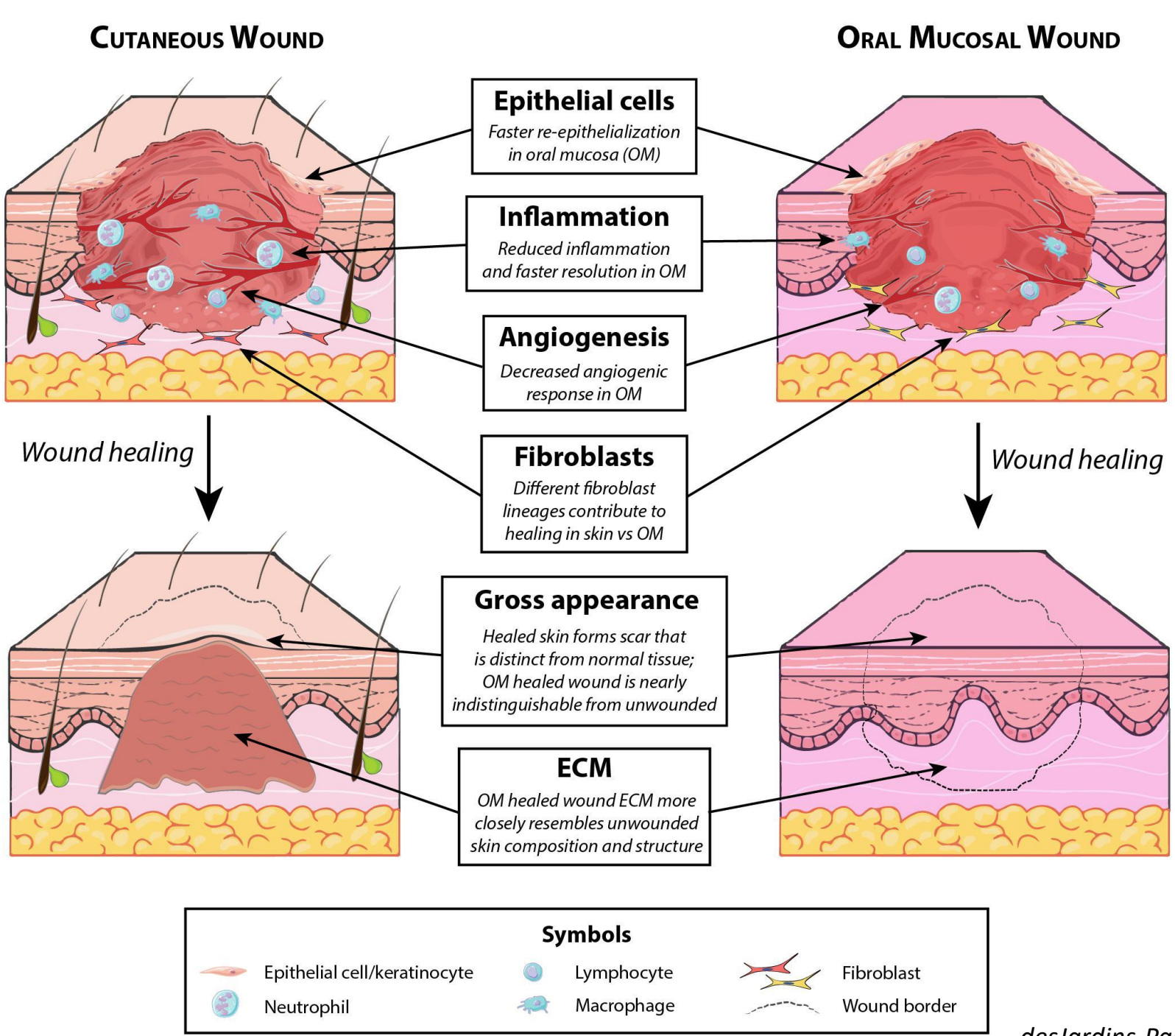
(faster turnover time in case of the face is probably caused by inductive effect of the ectomezenchyme)



Waasdorp, et al., 2021

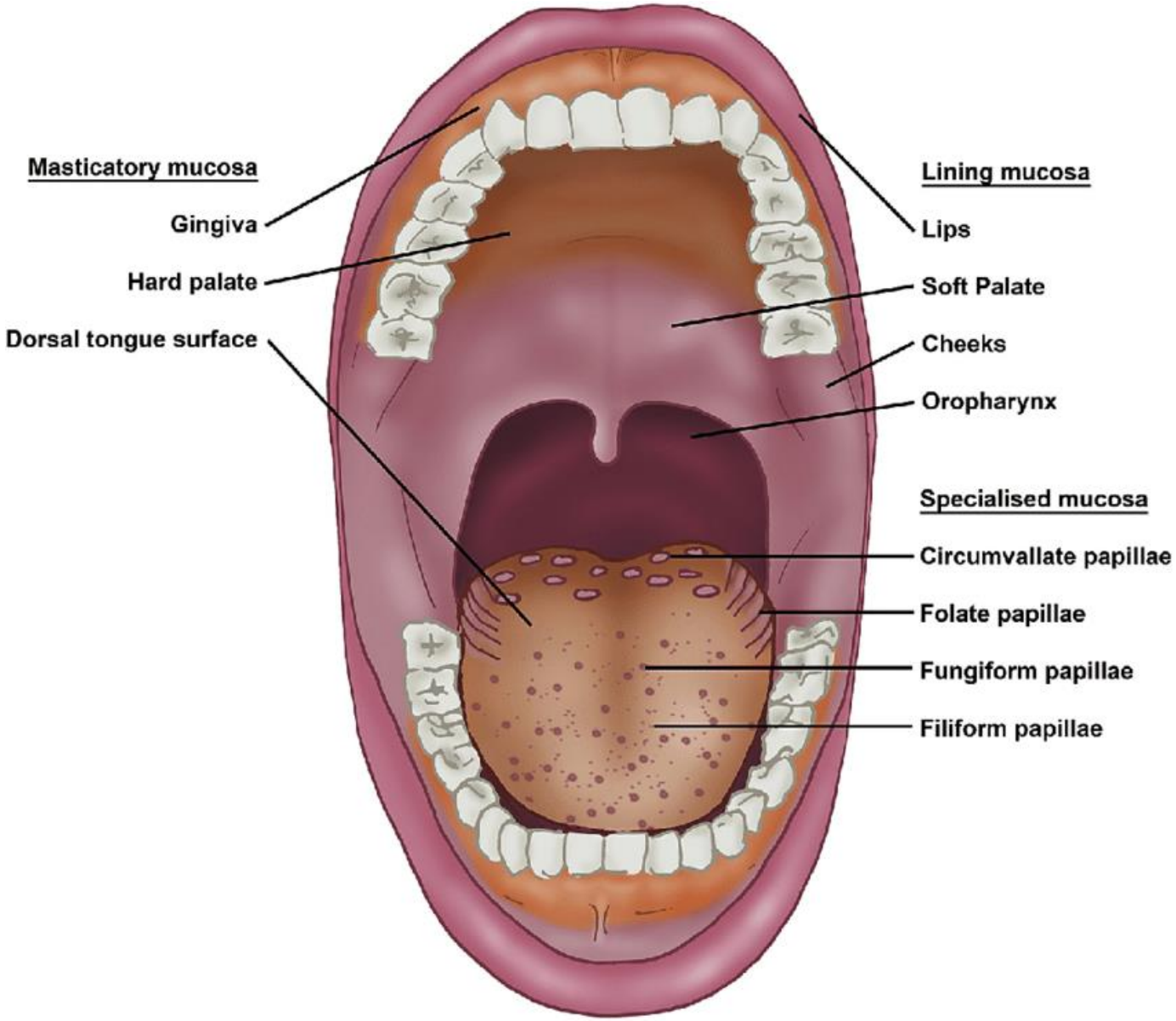


Mak, et al., 2009



desJardins-Park, et al., 2019

Oral mucosa



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

Classification of oral mucosa

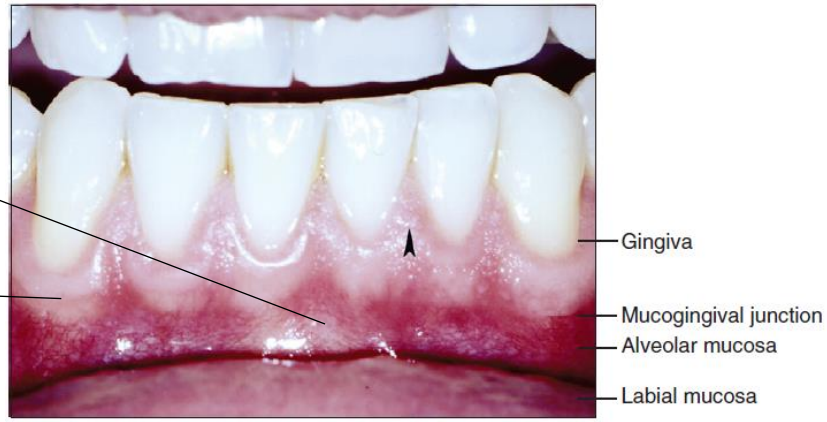
Lining (65 %)

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

Keratinized epithelium

Tela submucosa is usually missing

Lamina propria is composed from dense collagenous of irregular type and firmly connected with periosteum (mucoperiosteum)

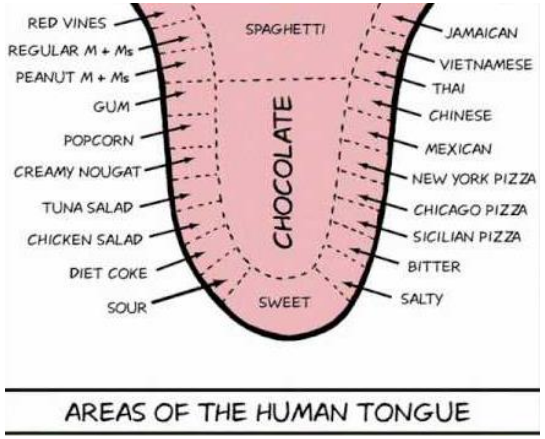
Specialized (10 %)

Dorsal surface of the tongue

Mucosa protrudes into papillae

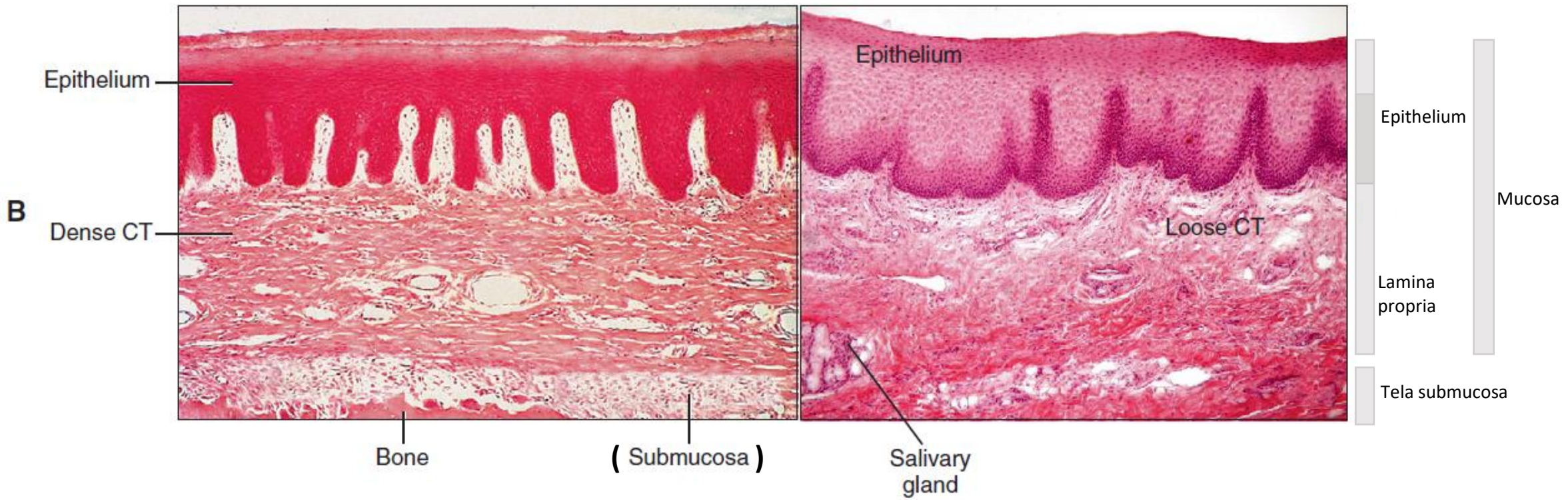
Tela submucosa is missing

Lamina propria connected with aponeurosis linguae



Gingiva

Lip



Masticatory mucosa

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

Lining mucosa

- *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

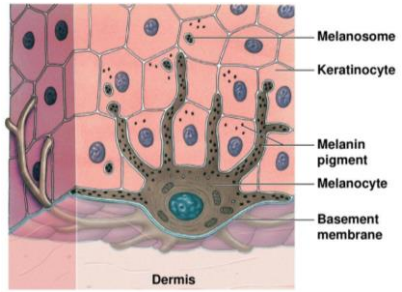
Lamina epithelialis:
tlustý vrstevnatý
dlaždicový epitel

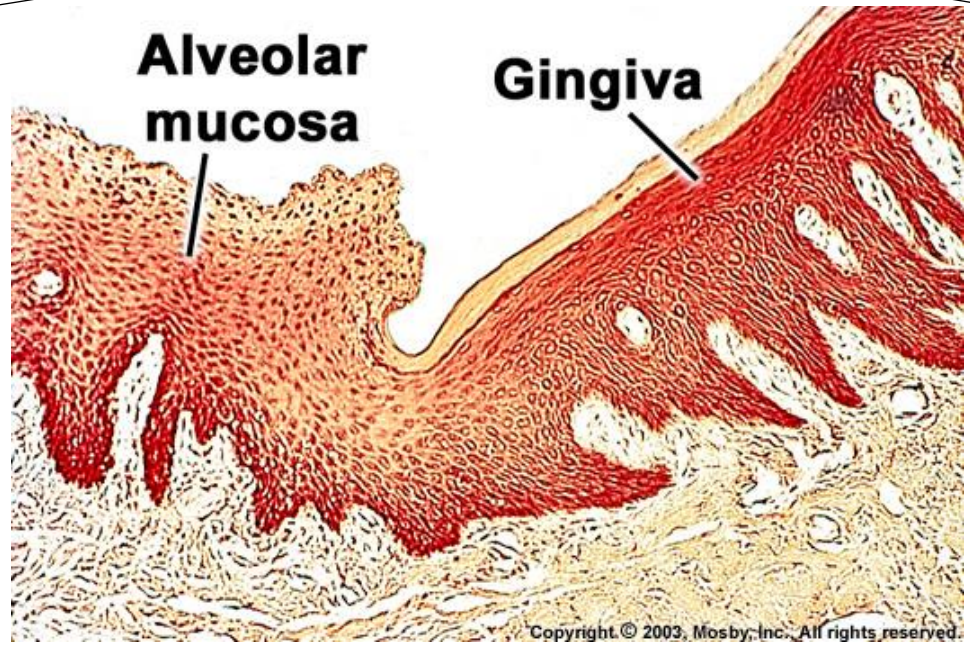
epithelium
stratified squamous

! !

nonkeratinized

- Lining mucosa





keratinized

- Masticatory mucusa
- Specialized mucosa*

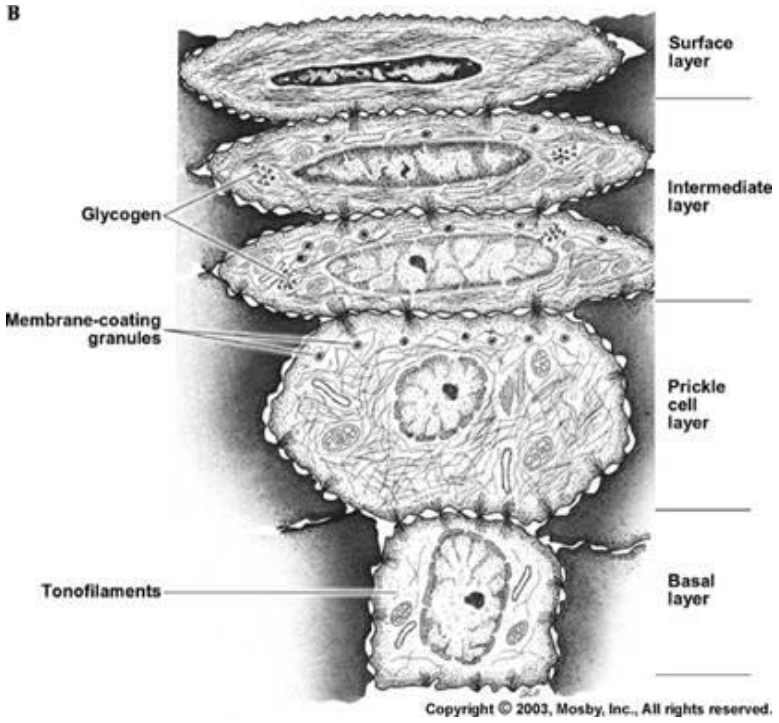
(Yadav et al., 2012)

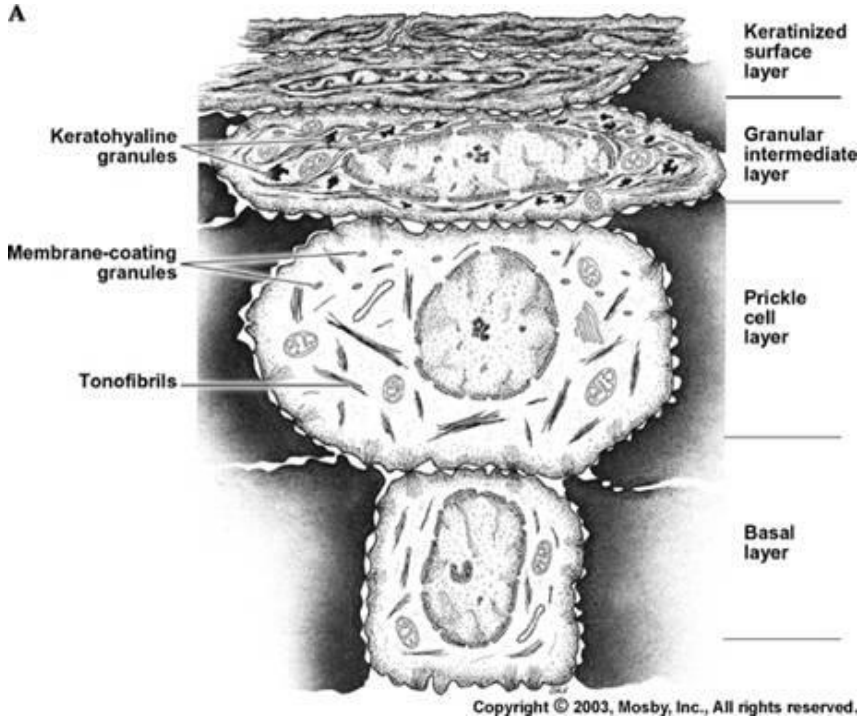
Lamina propria mucosae

- Contains numerous of melanocytes or melanophages; Merkel cells
- Multiple papilae projected against the epithelium. Their shape and density are spatially different
- (depends on different mechanical needs of oral mucosa)
- Differences between: Melanophages, melanocytes, (melanophores), melanosomes a melanin

Squid skin
https://youtu.be/0wtLrlIKvJE?t=12

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





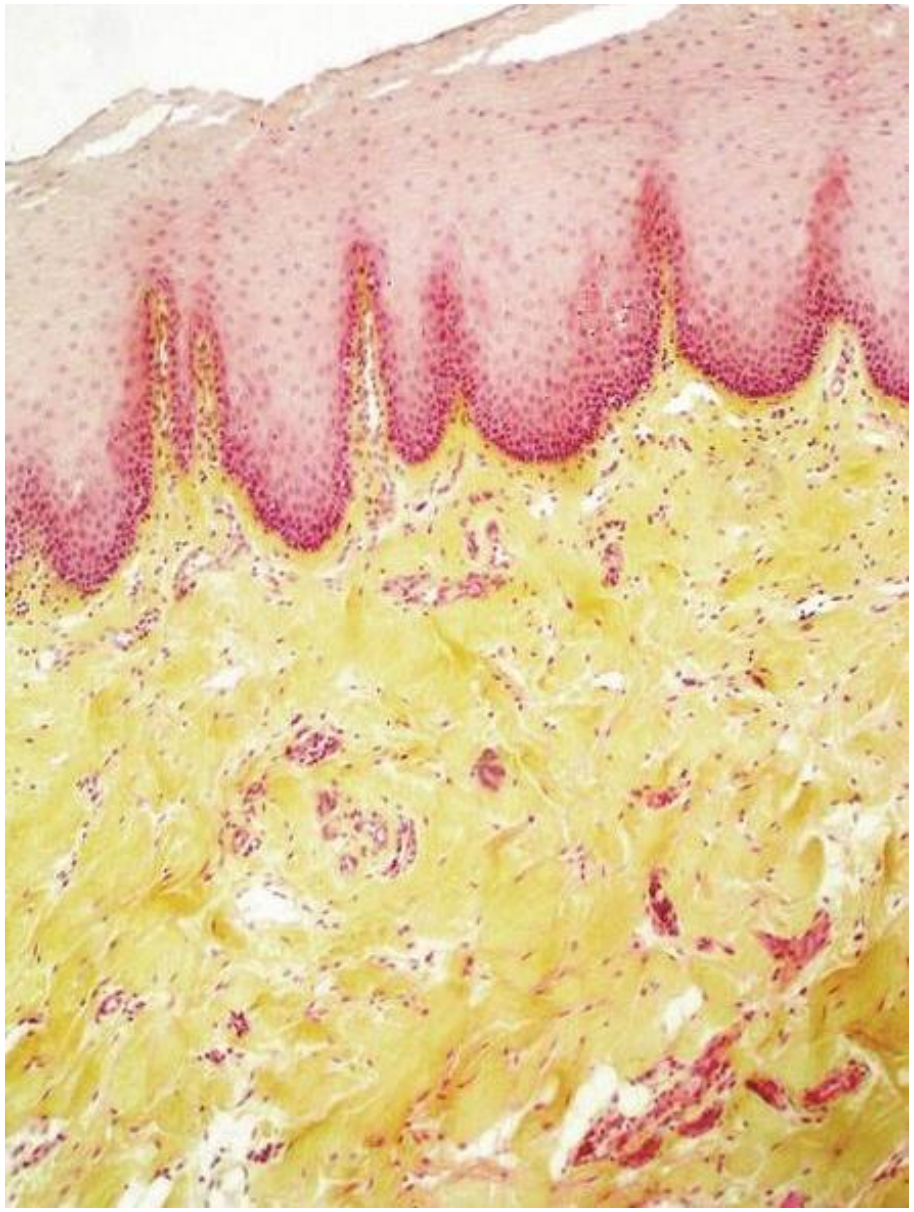
Nonkeratinized

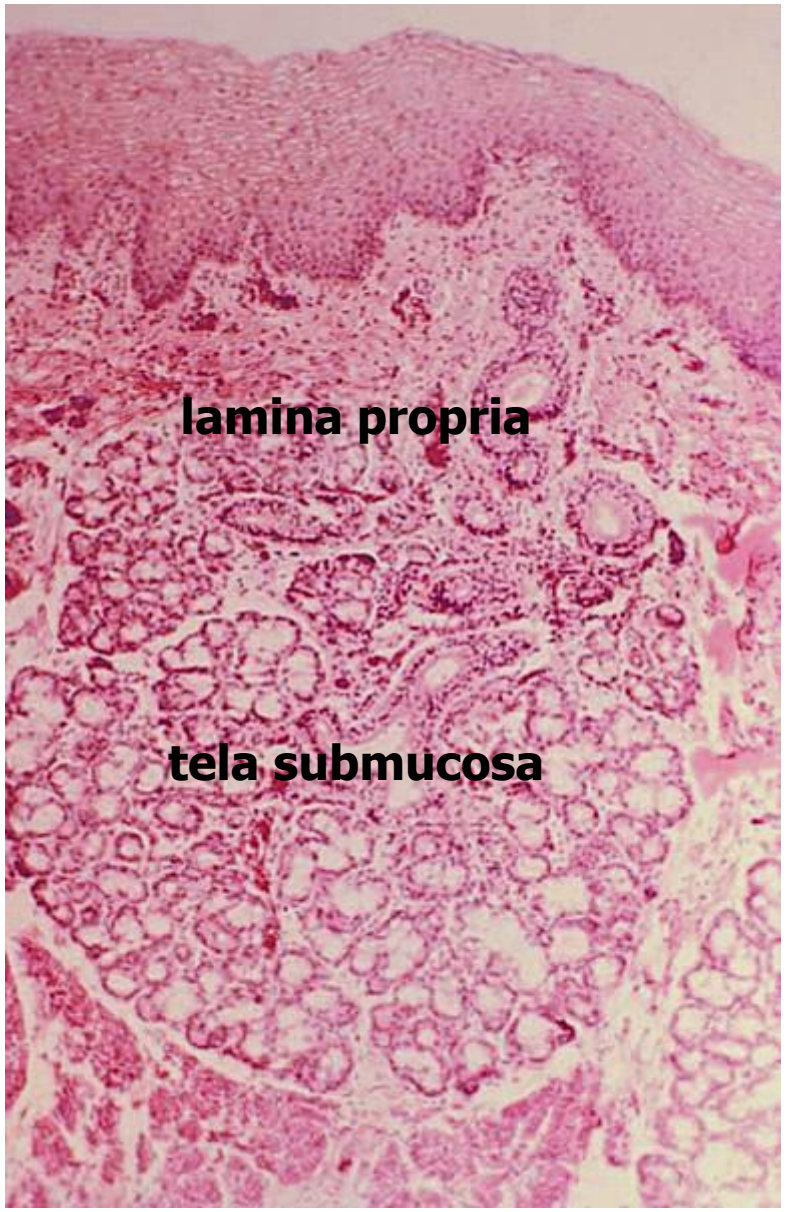
Stratum basale - melanin
Stratum spinosum
Stratum intermedium
Stratum superficiale

Keratinized

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

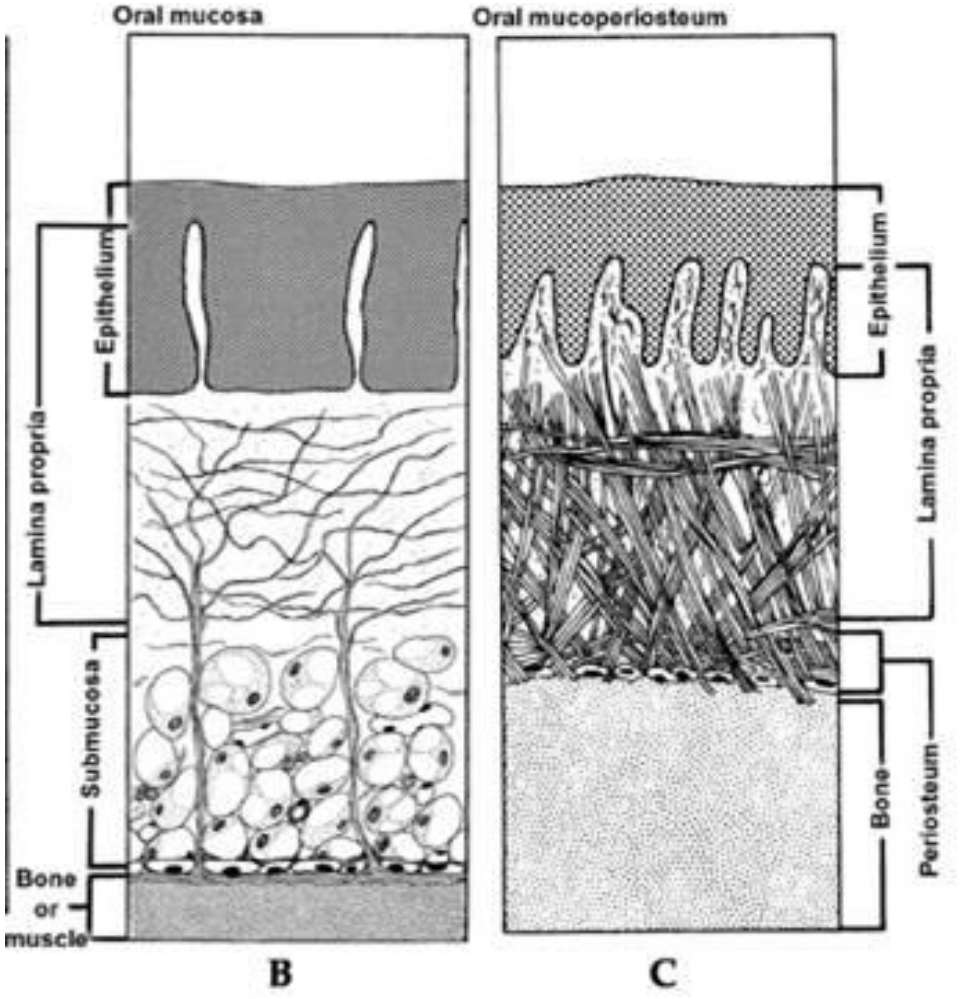
Lining mucosa

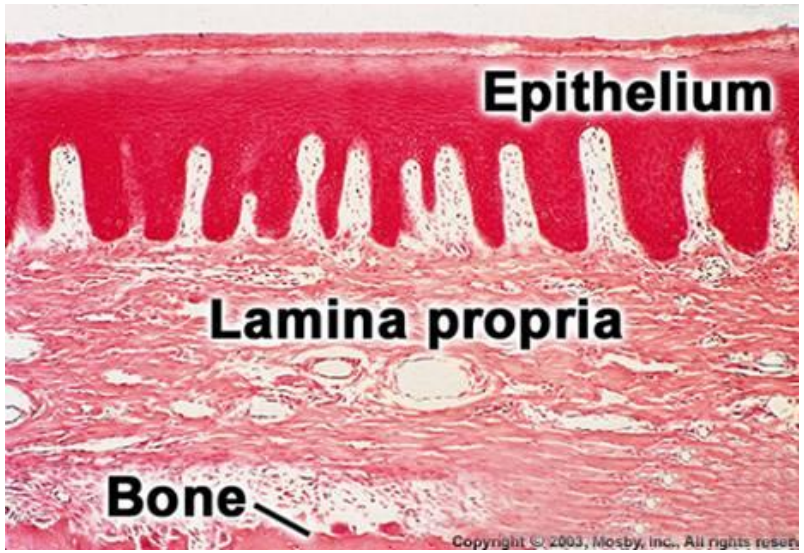


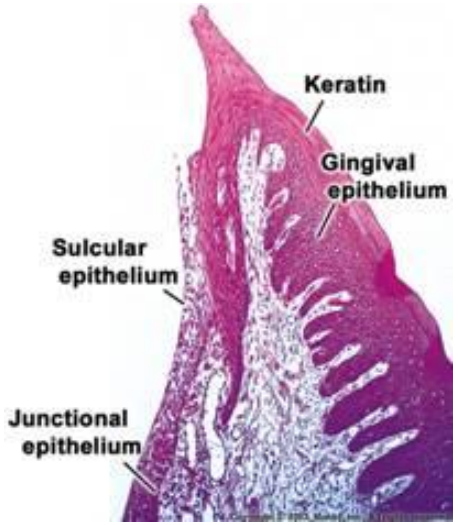


Masticatory mucosa

mucoperiosteum

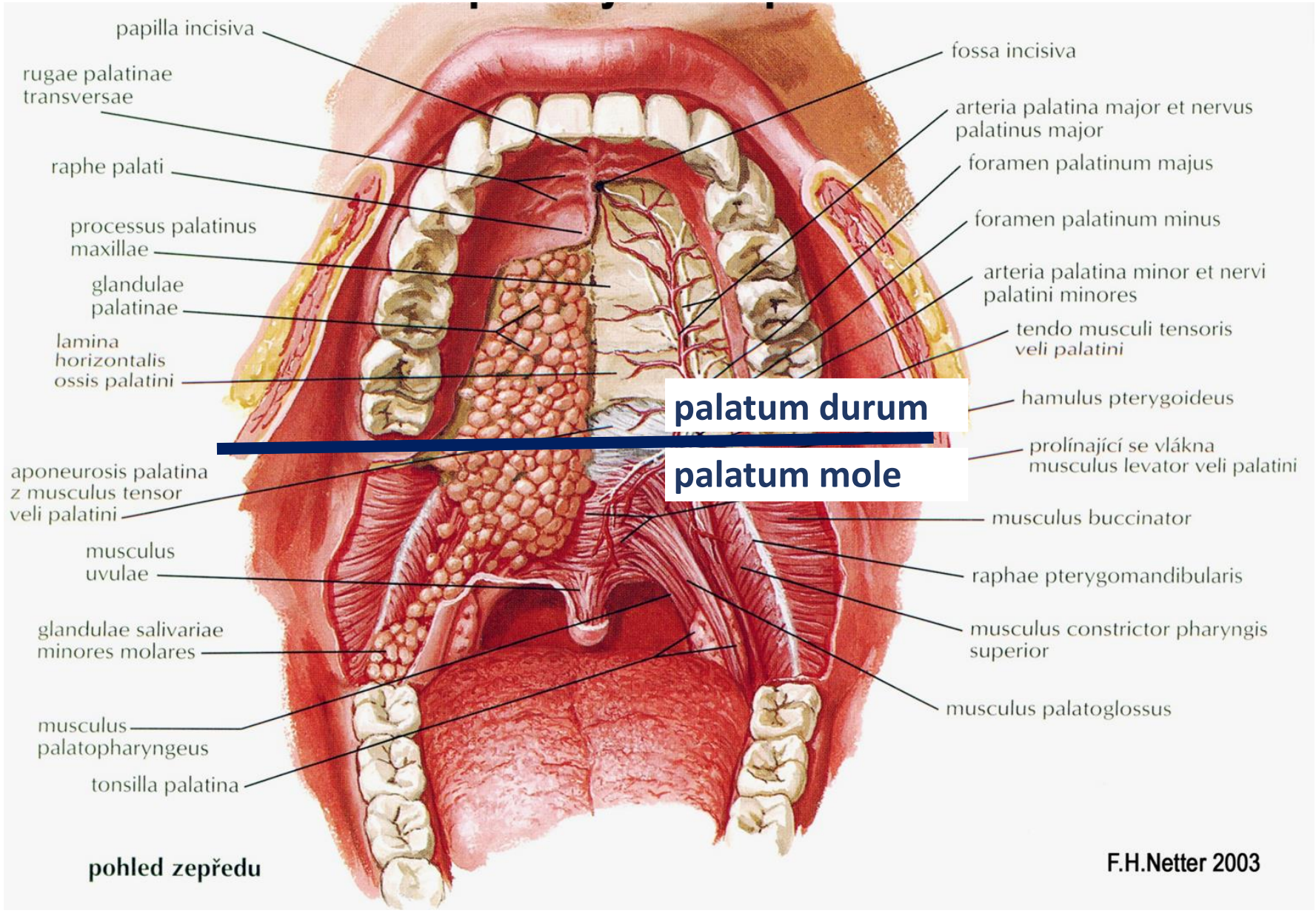


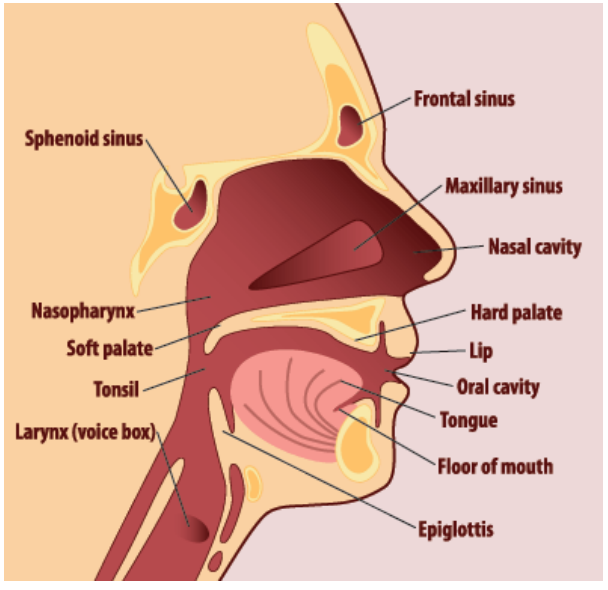




gingiva

Palate


papilla incisiva
rugae palatinae transversae
raphe palati
processus palatinus maxillae
glandulae palatinae
lamina horizontalis ossis palatini
aponeurosis palatina z musculus tensor veli palatini
musculus uvulae
glandulae salivariae minores molares
musculus palatopharyngeus
tonsilla palatina
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
pohled zepředu
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

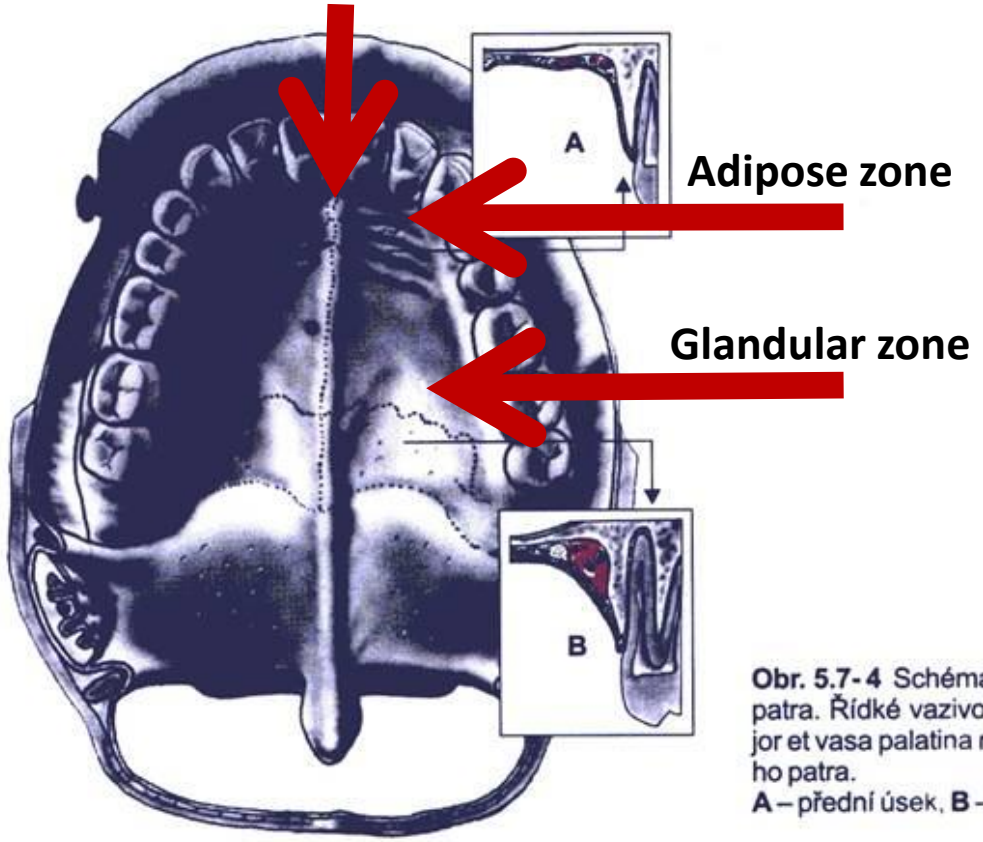
Hard palate (*palatum durum*)

Masticatory mucosa:

- Epithelium stratified squamous **keratinizing**
- Tela submucosa is usually missing

High regional variability:

raphe palati (in the middle line)



Obr. 5.7-4 Schéma uspořádání měkkých tkání tvrdého patra. Řídké vazivo (růžově) obsahuje n. palatinus major et vasa palatina majora. Znázorněn průběh švů tvrdého patra.
A – přední úsek, **B** – zadní úsek

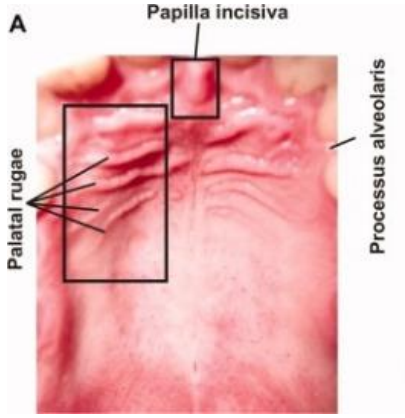
Local differences in hard palate structure

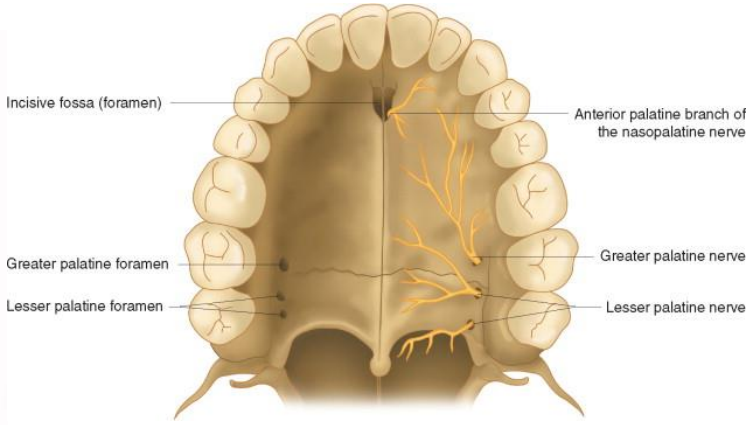
Raphe palati

- Midline area from papilla incisiva to soft palate, mucosa of raphe palati is without glands and adipocytes
- Formed by fusion of the maxillary processes (origin of clefts)

Foramen incisivum

- Location on the papilla incisiva
- In the fetal period, forms opening between the nasal and oral cavities
- Before or shortly after birth, the connection is closed



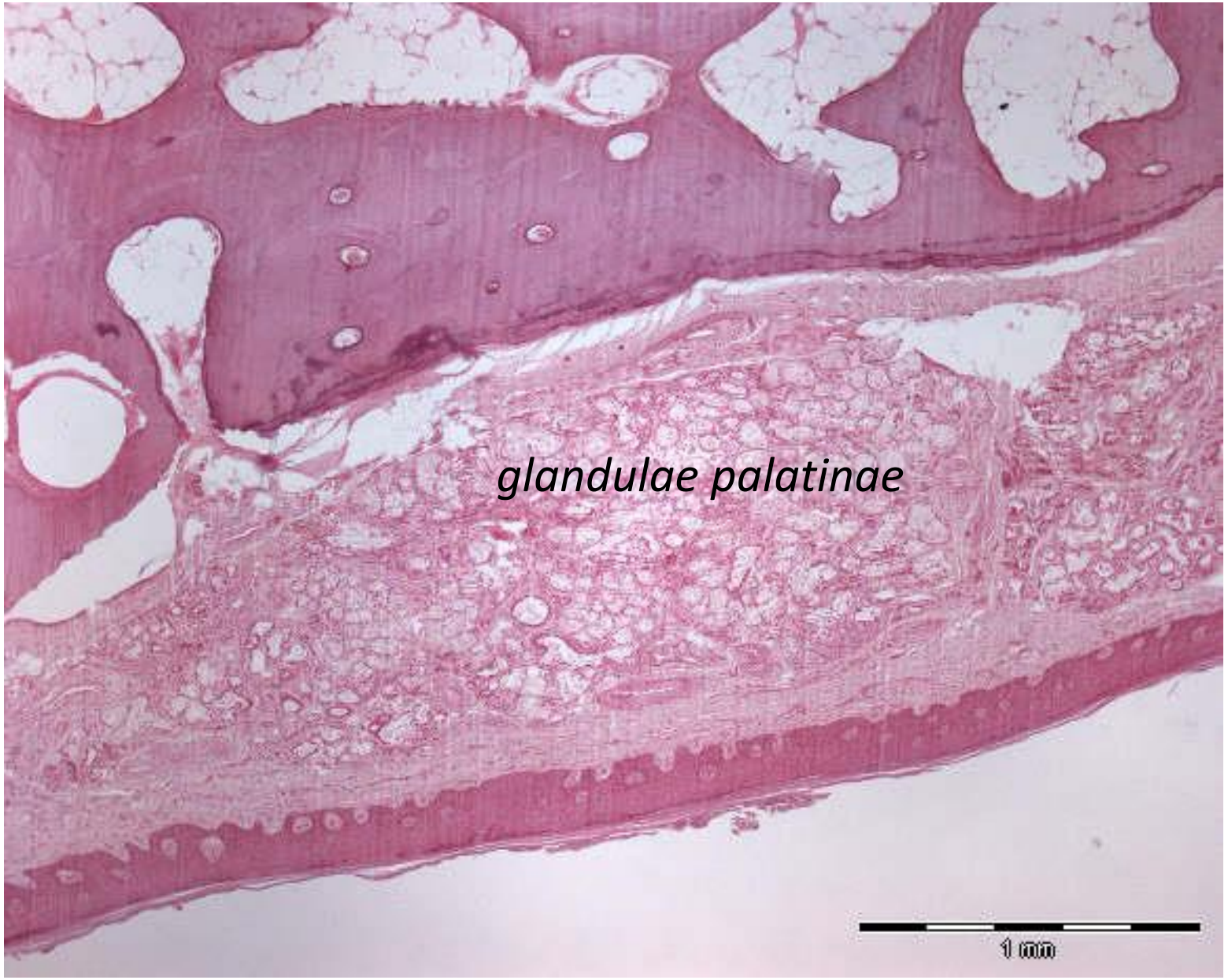


Adipose zone

- 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

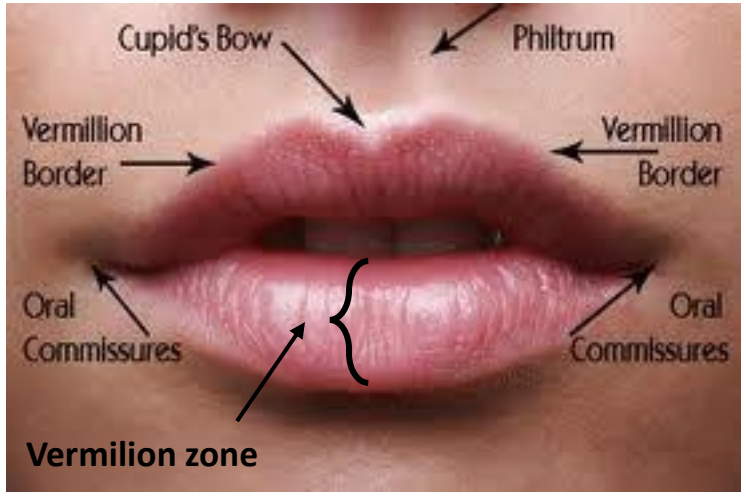
Glandular zone

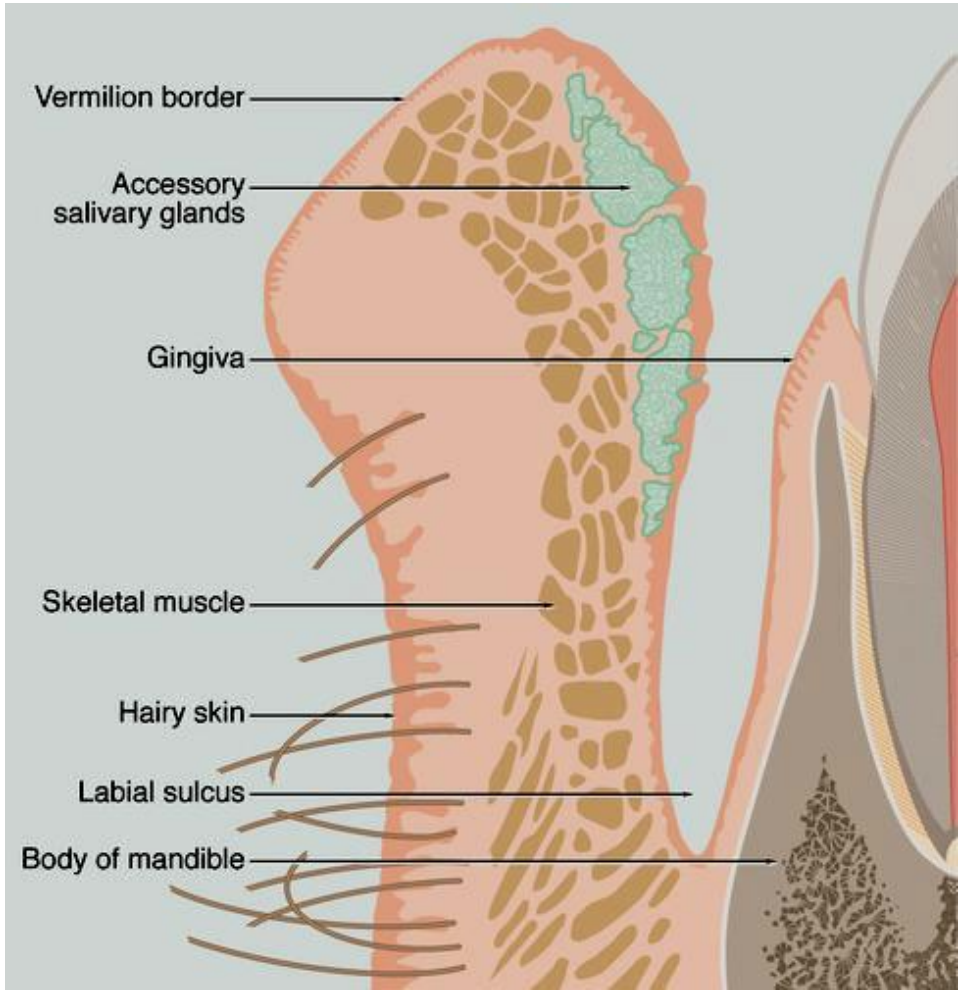
- Paired structure
- Mucosa is smooth and contains mucous glands – *gll. palatinae*



Hard palate – glandular zone

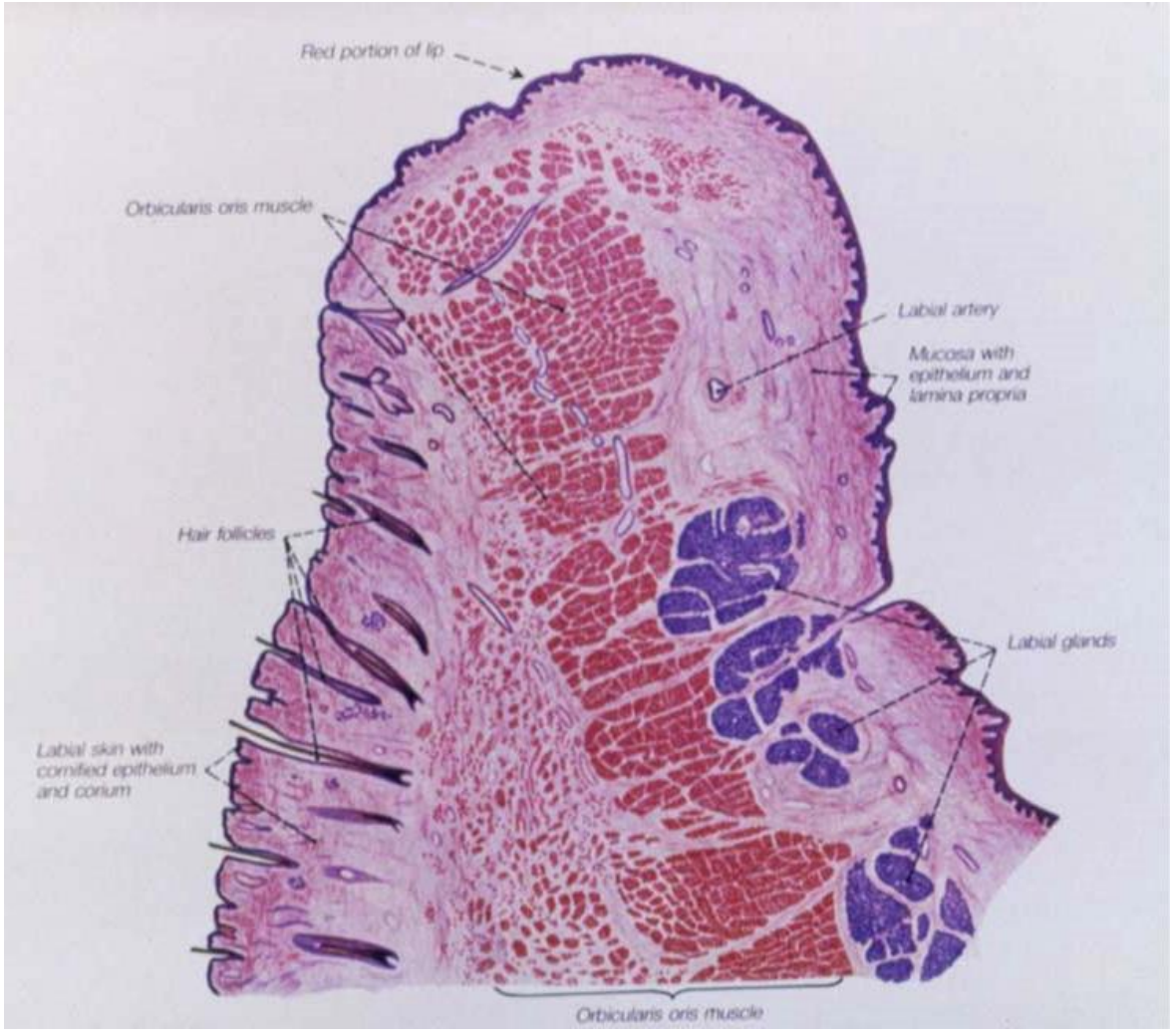
Lips



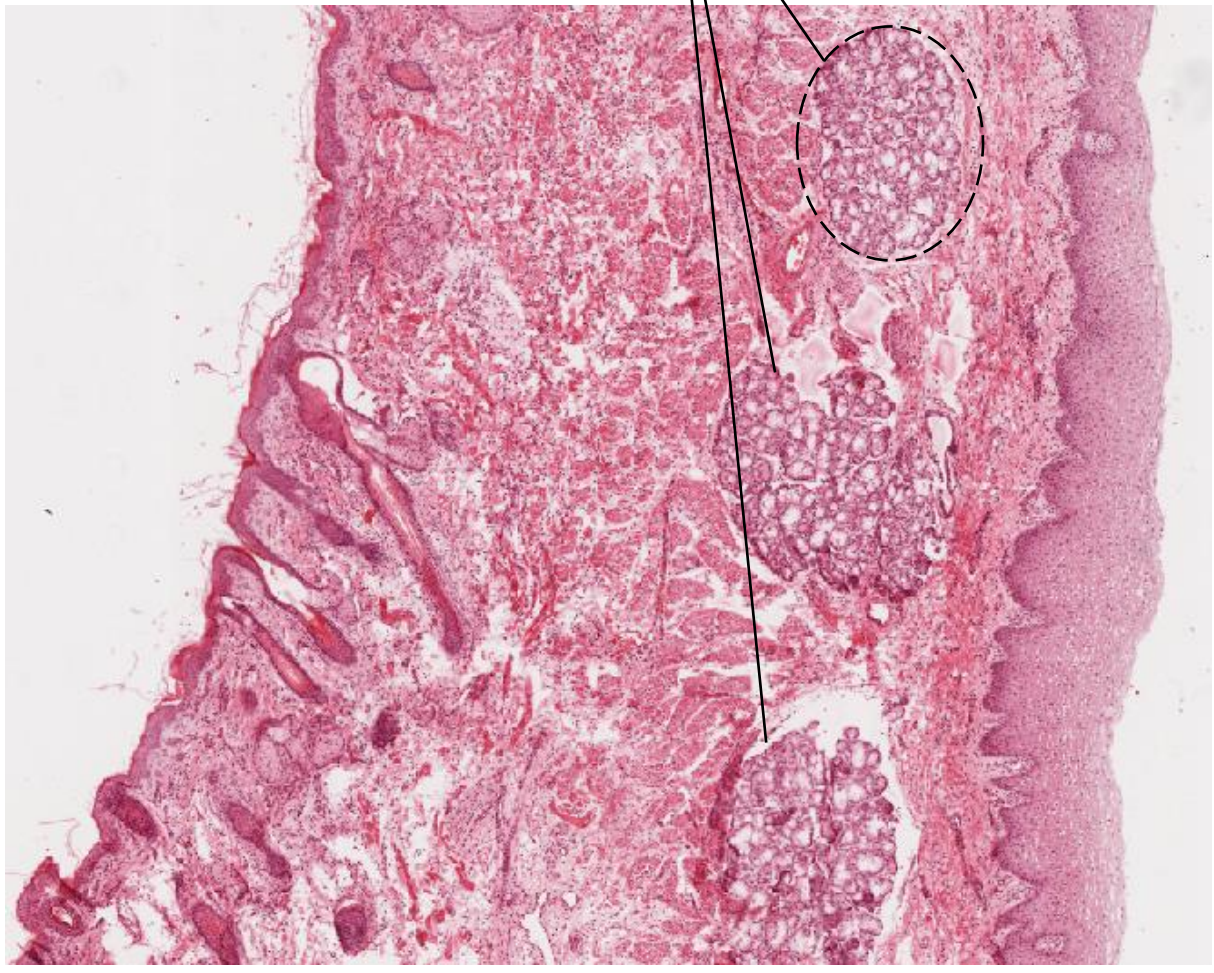


Sagitally:

- ventral aspect of the lip (skin)
- dorsal aspect of the lip (mucosa)
- Structural support: *m. orbicularis oris*
- Vermilion zone

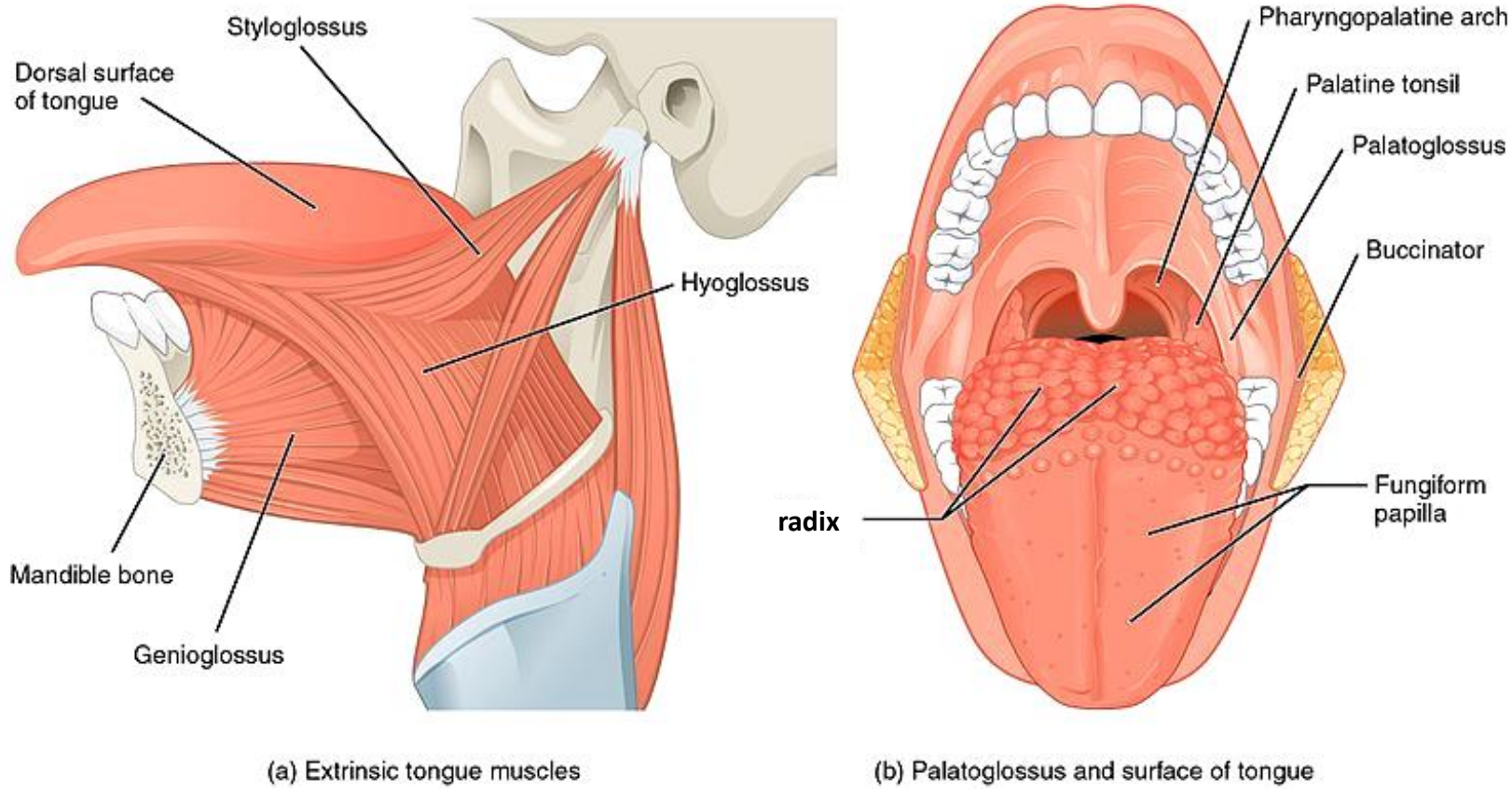


glandulae labiales
(mixed glands)



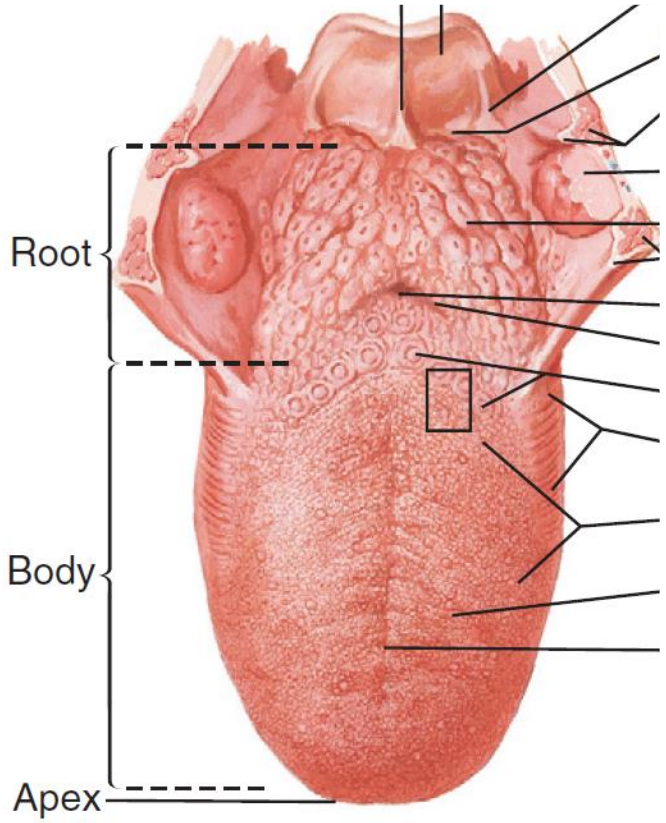
Tongue

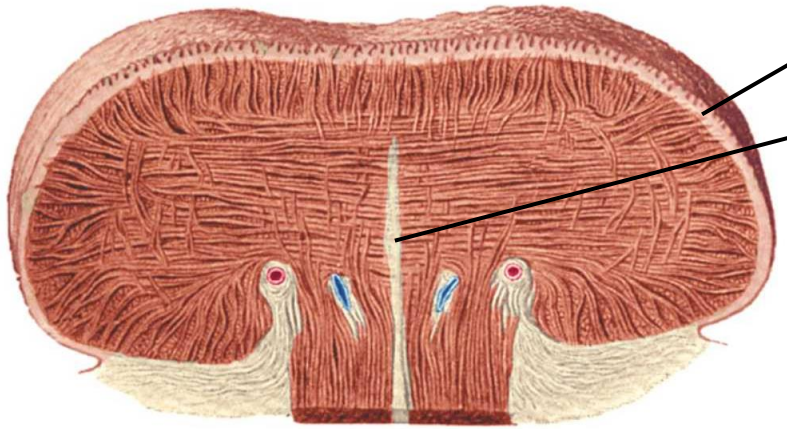
Lingua (lat.)
Glossa (gr.)



Base: intra- and extraglossal striated muscles

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





Surface

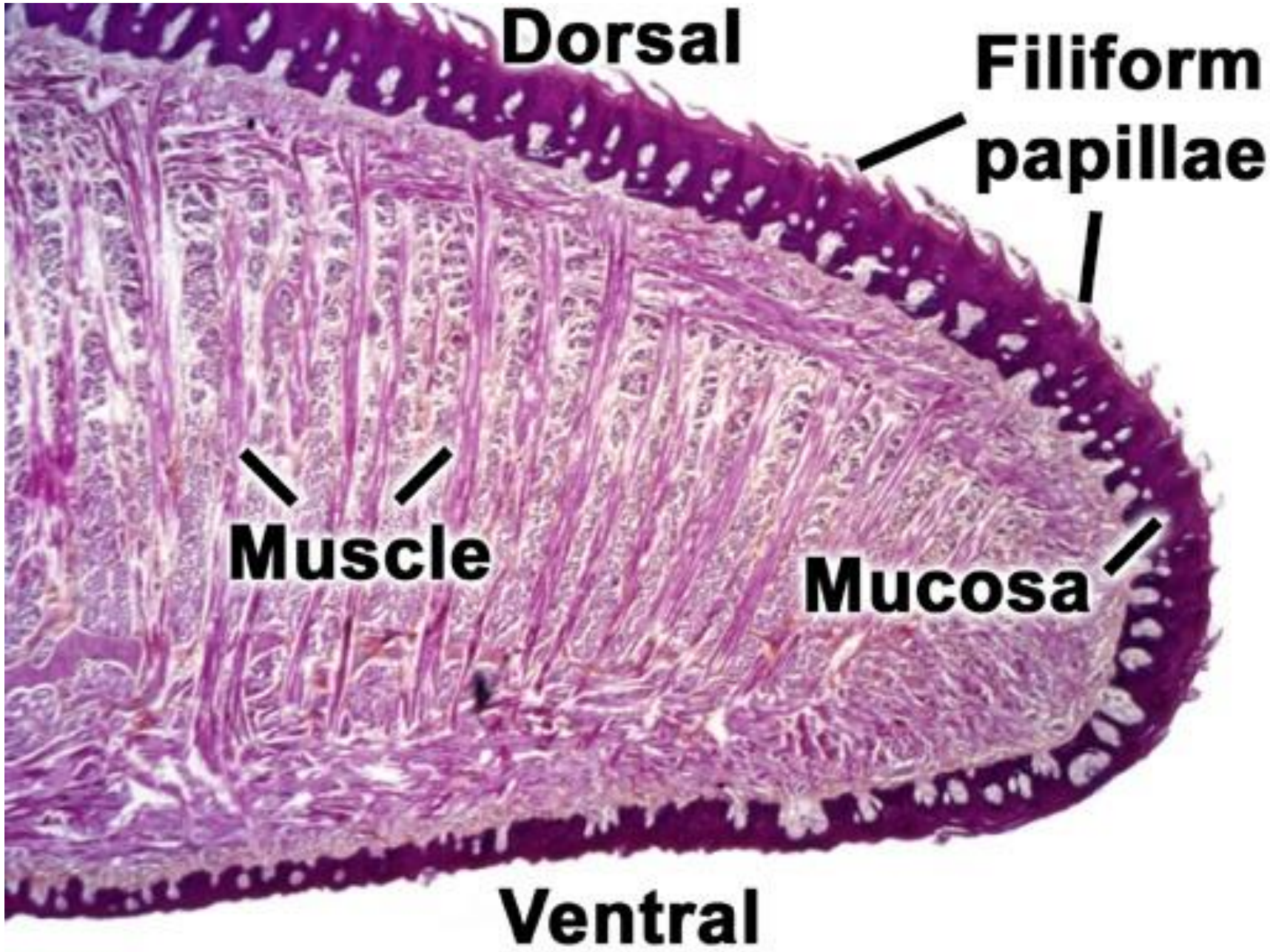
Dorsum linguae
Specialized oral mucosa

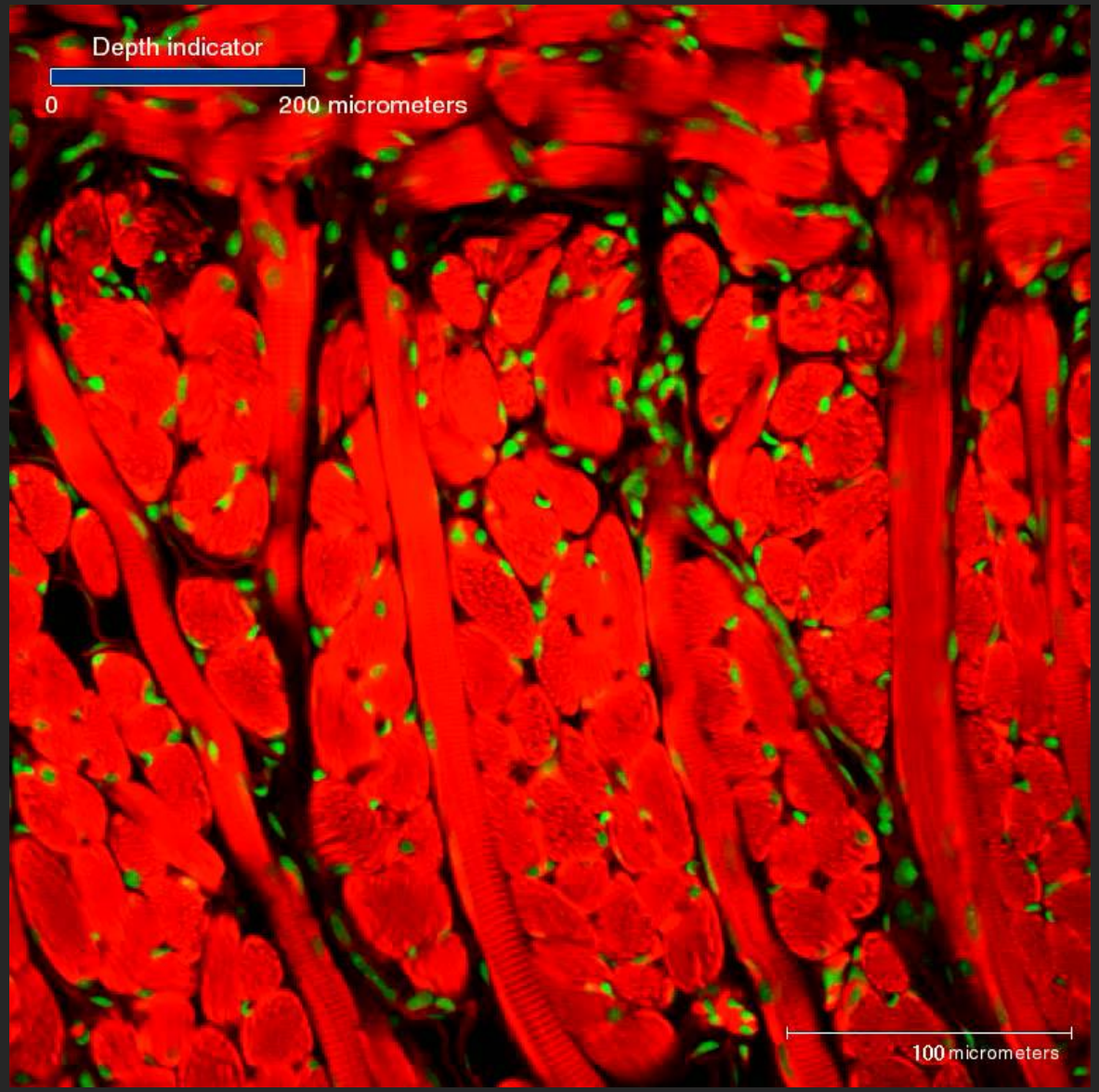
Inferior aspect
Lining mucosa

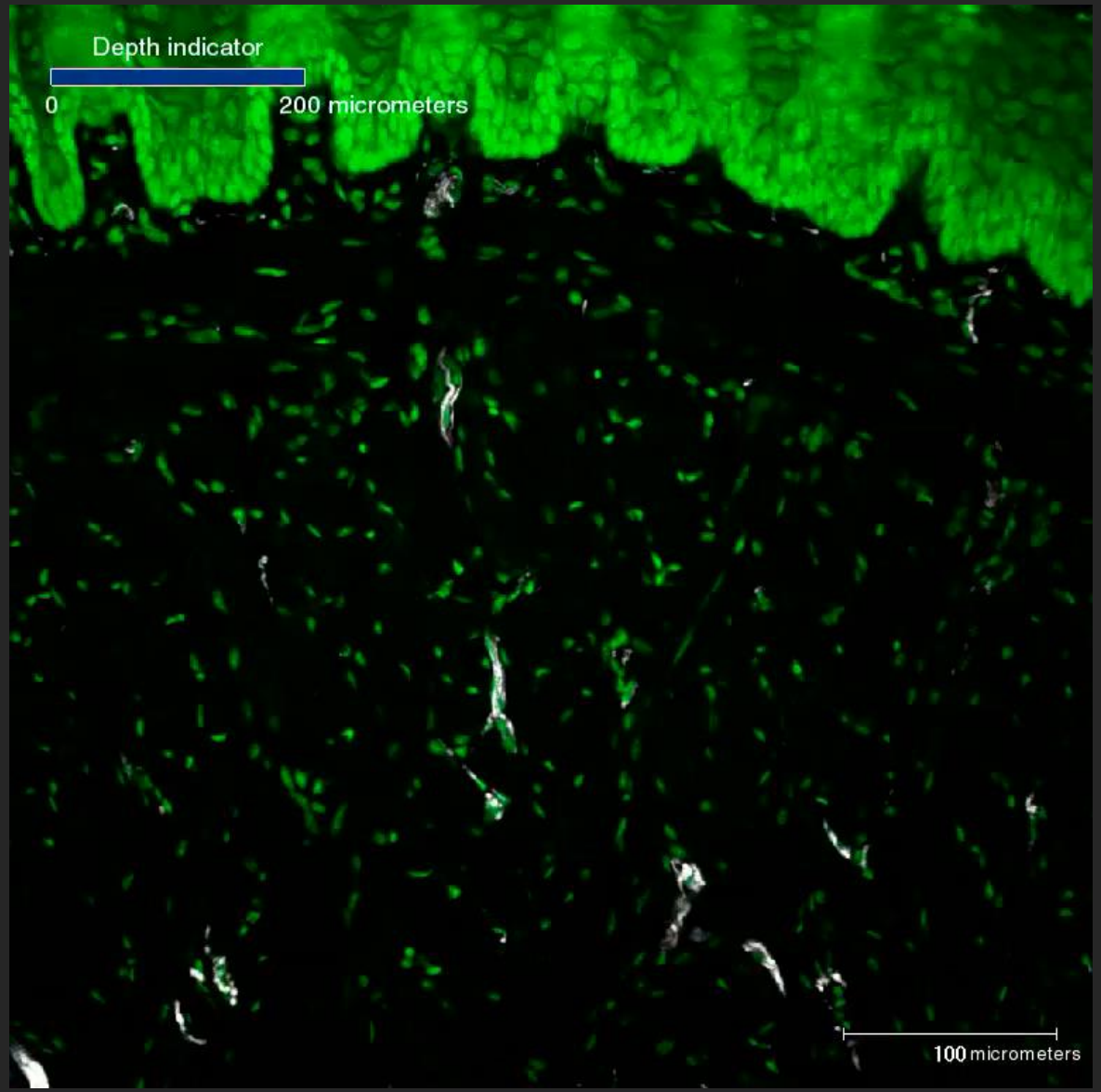
Fibrous parts

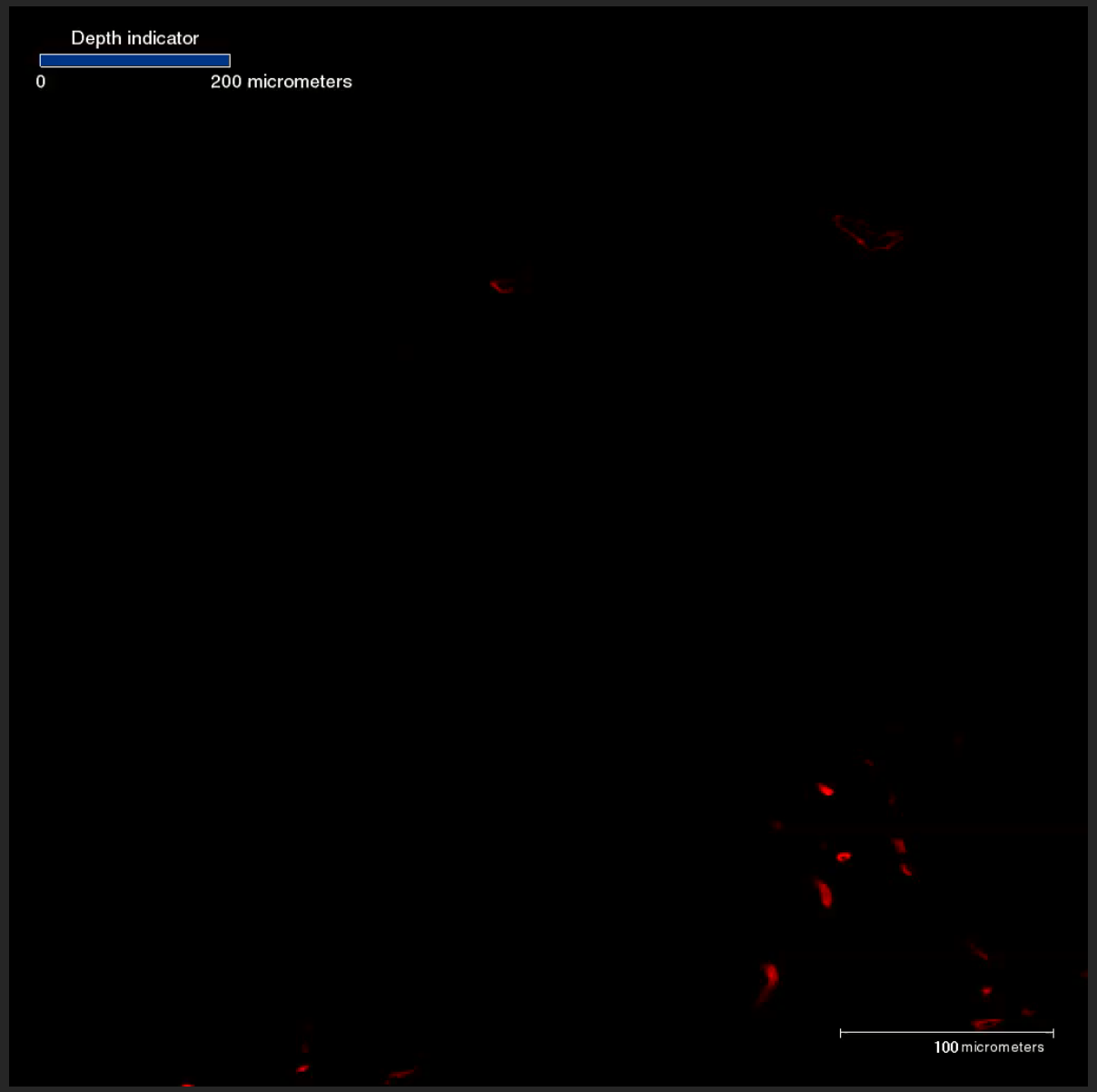
Aponeurosis linguae
- very stiff fibrous membrane

Septum linguae
- composed by dense collagenous tissue

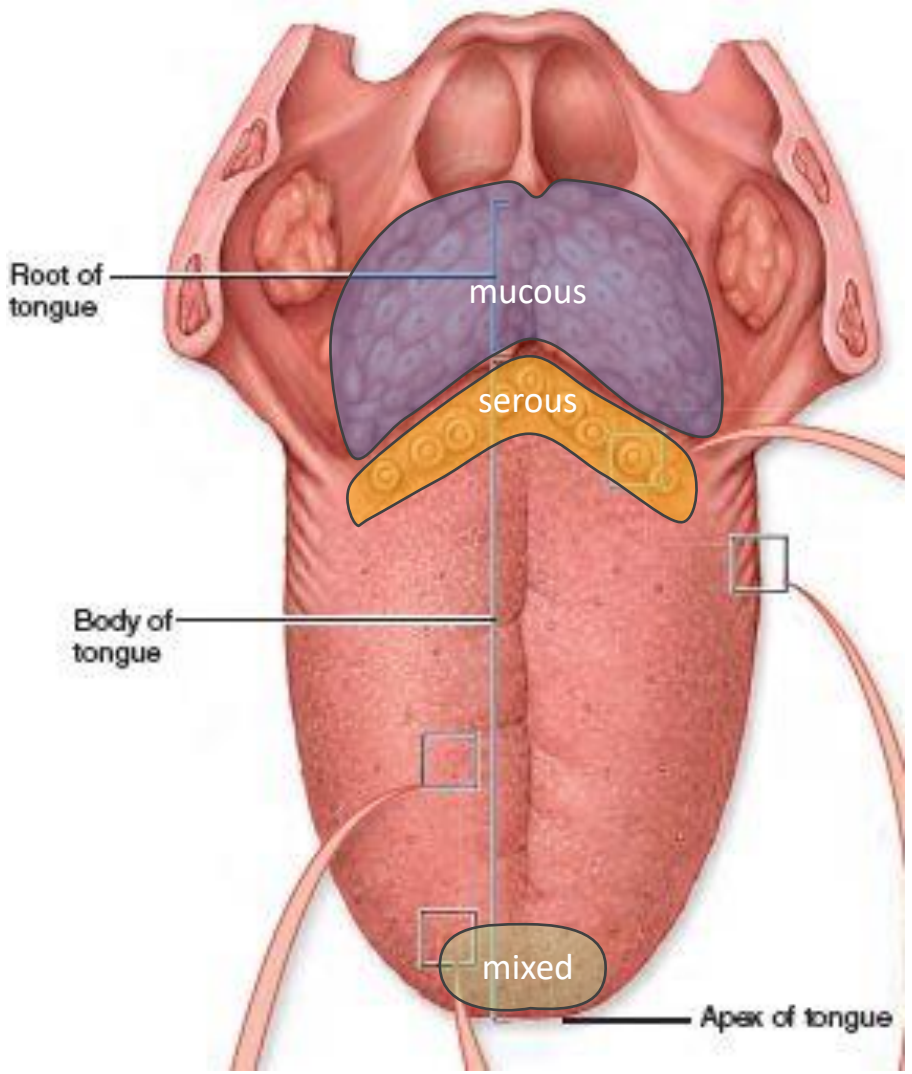

Dorsal
Filiform
papillae
Muscle
Mucosa
Ventral


Depth indicator
0
200 micrometers
100 micrometers

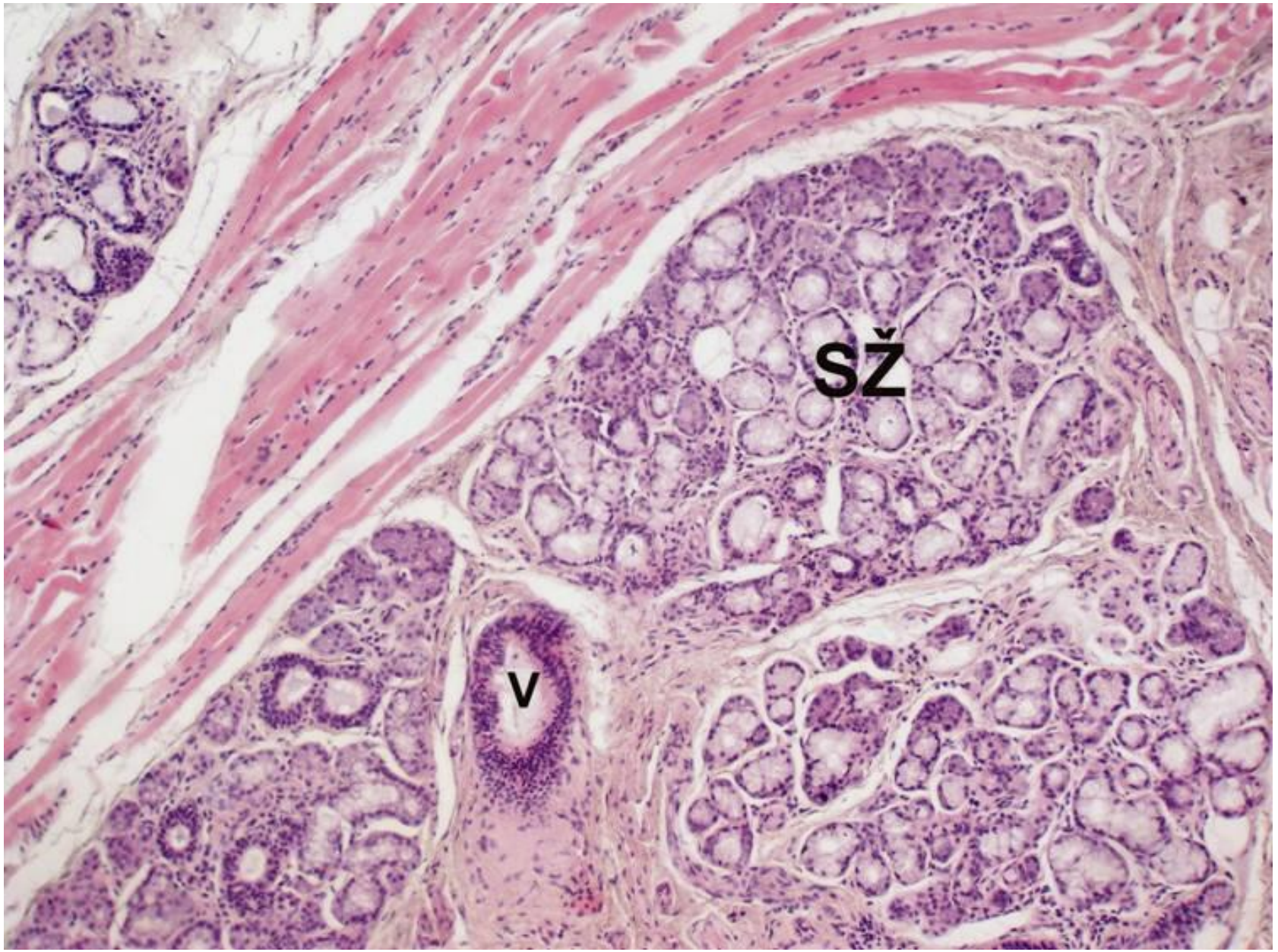

Depth indicator
0
200 micrometers
100 micrometers


Depth indicator
0
200 micrometers
100 micrometers

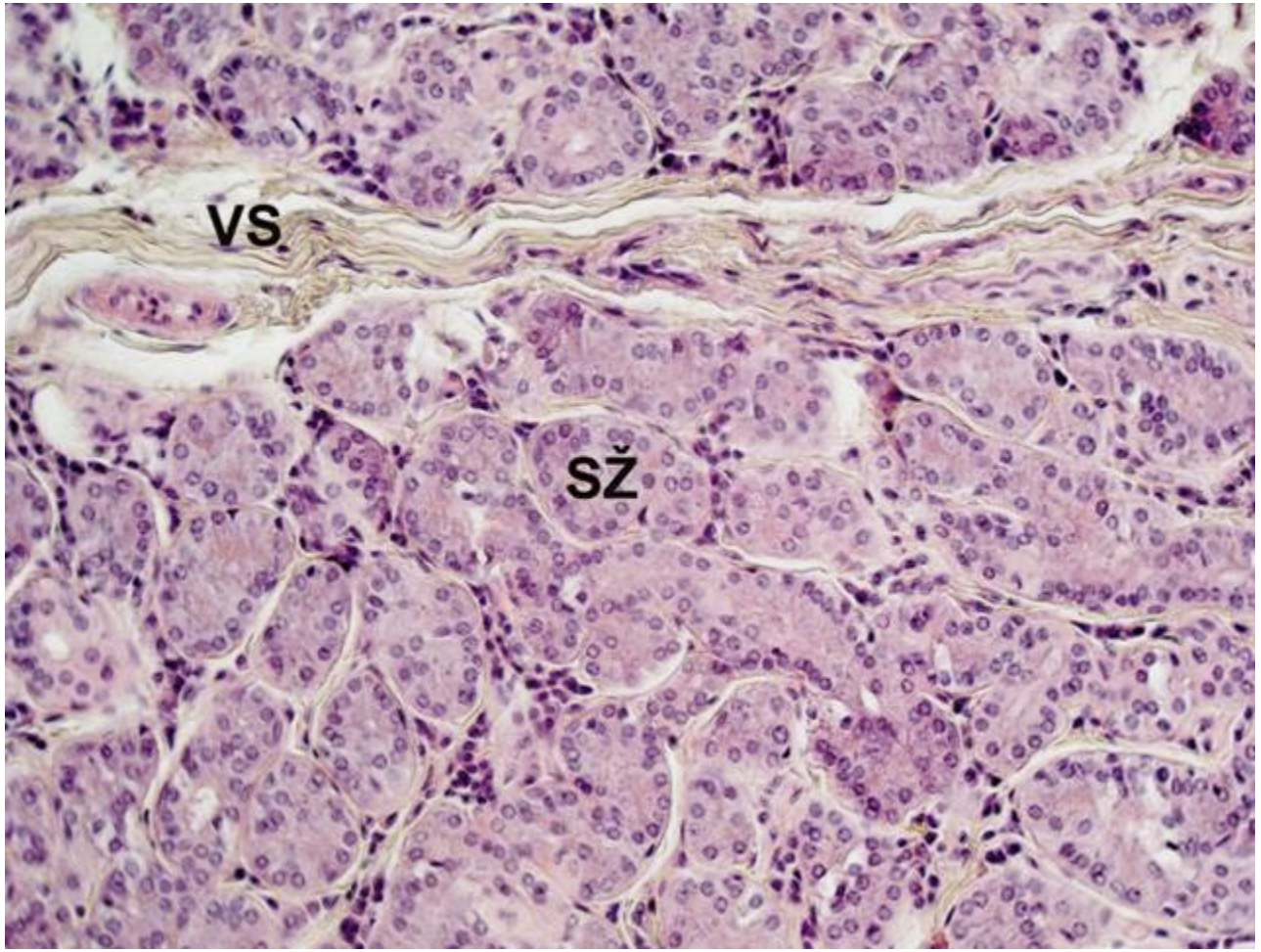
Glands of tongue



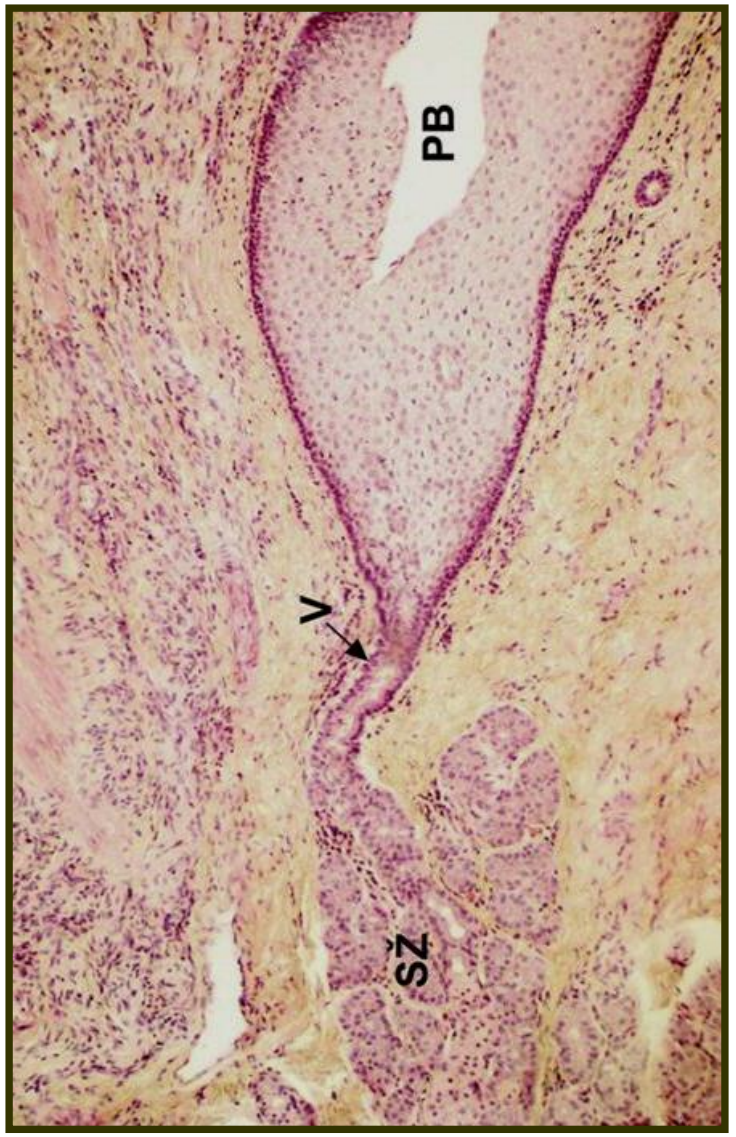
Glandula apicis linguae *(gl. Blandini)*
mixed gland



Ebner‘s glands - *gll. gustatoriae*
serous

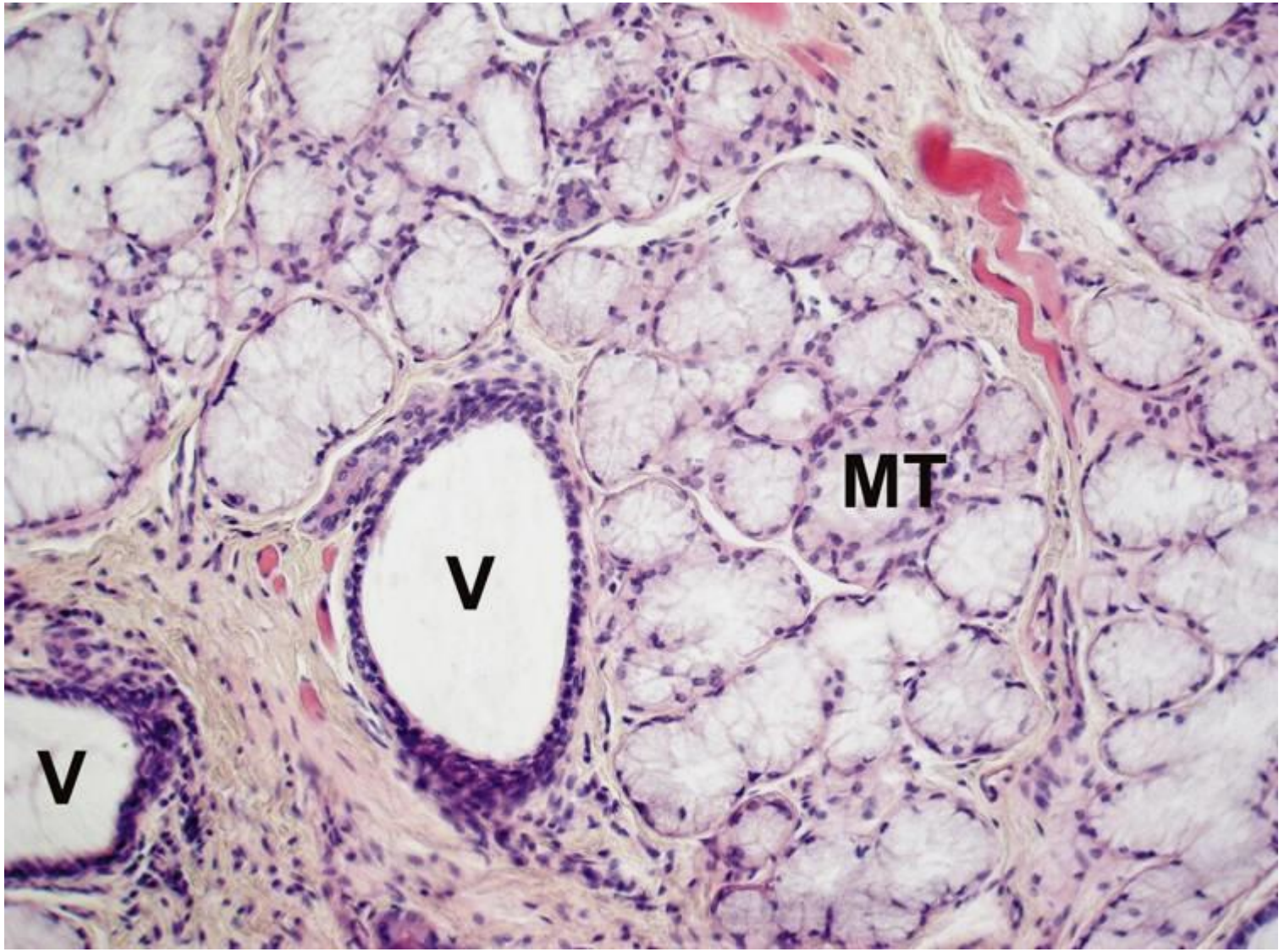


Ebner‘s serous glands (SŽ) with secretory parts of tubular character (VS – septum of connective tissue)

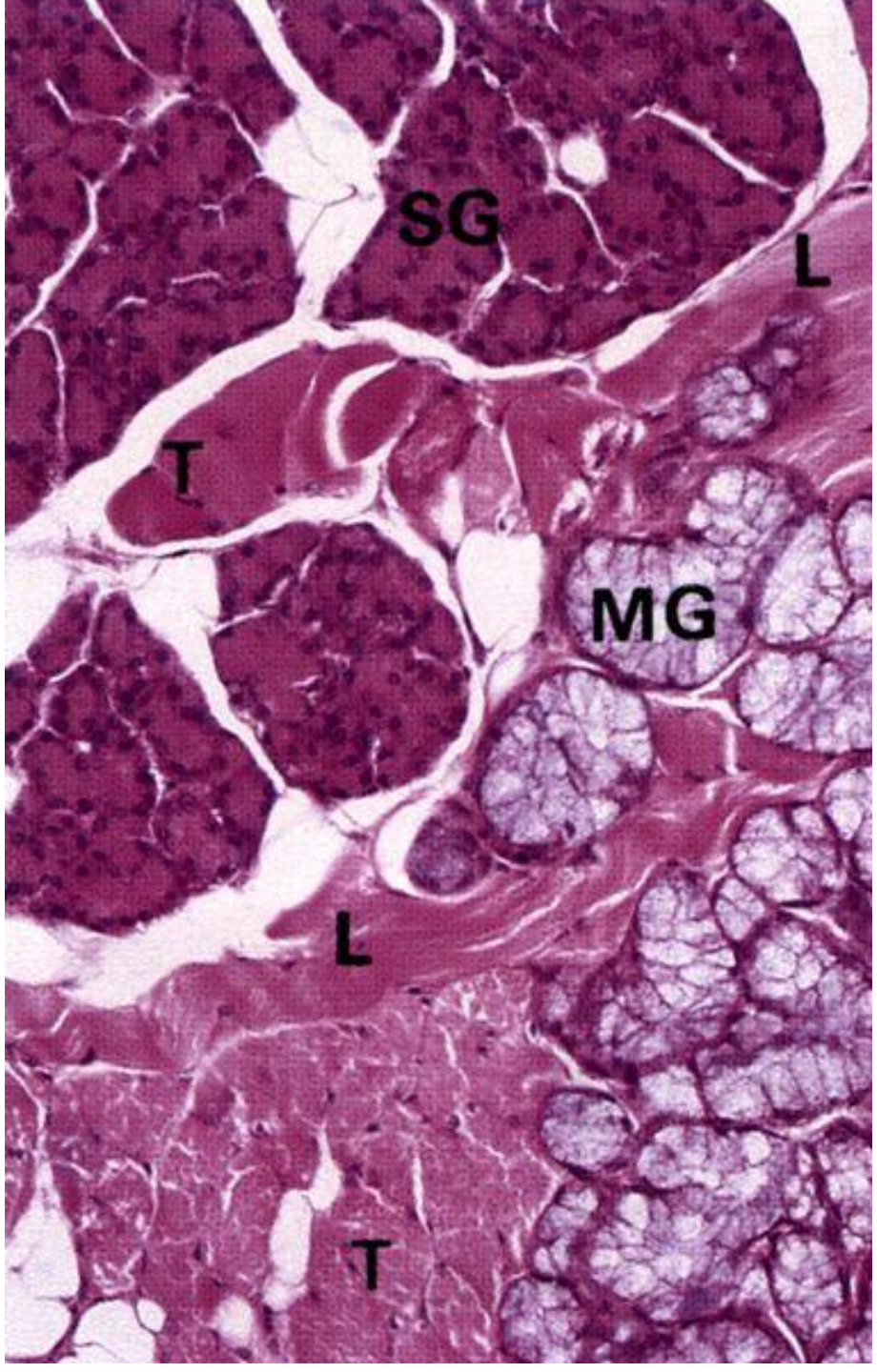


Duct (V) of Ebner´s gland (SŽ)

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



Weber‘s mucinous glands
MT – mucinous tubules, V – duct.



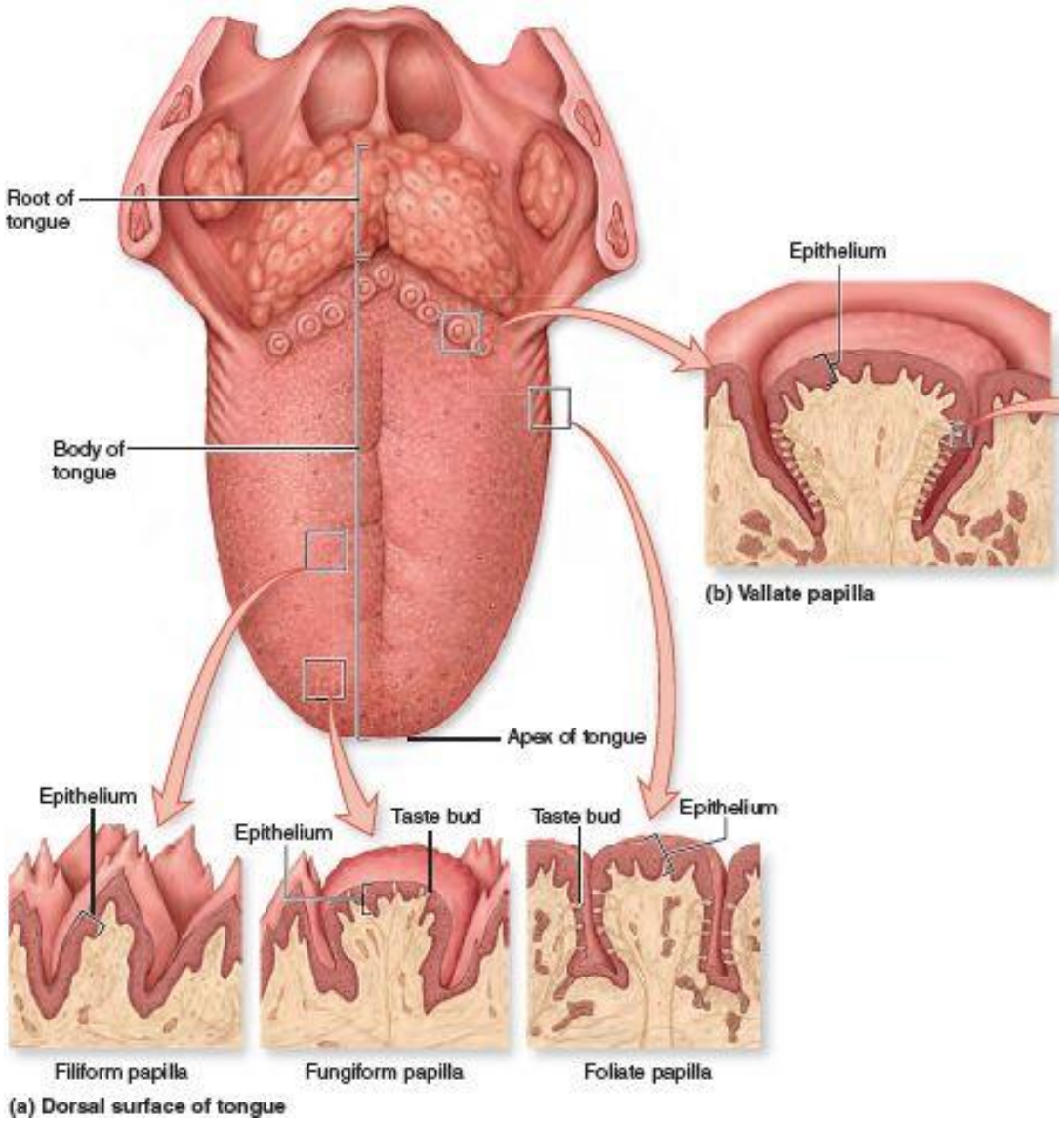
Ebner‘s glands - *gll. gustatoriae*
serous

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

Dorsum linguae

Specialized oral mucosa

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

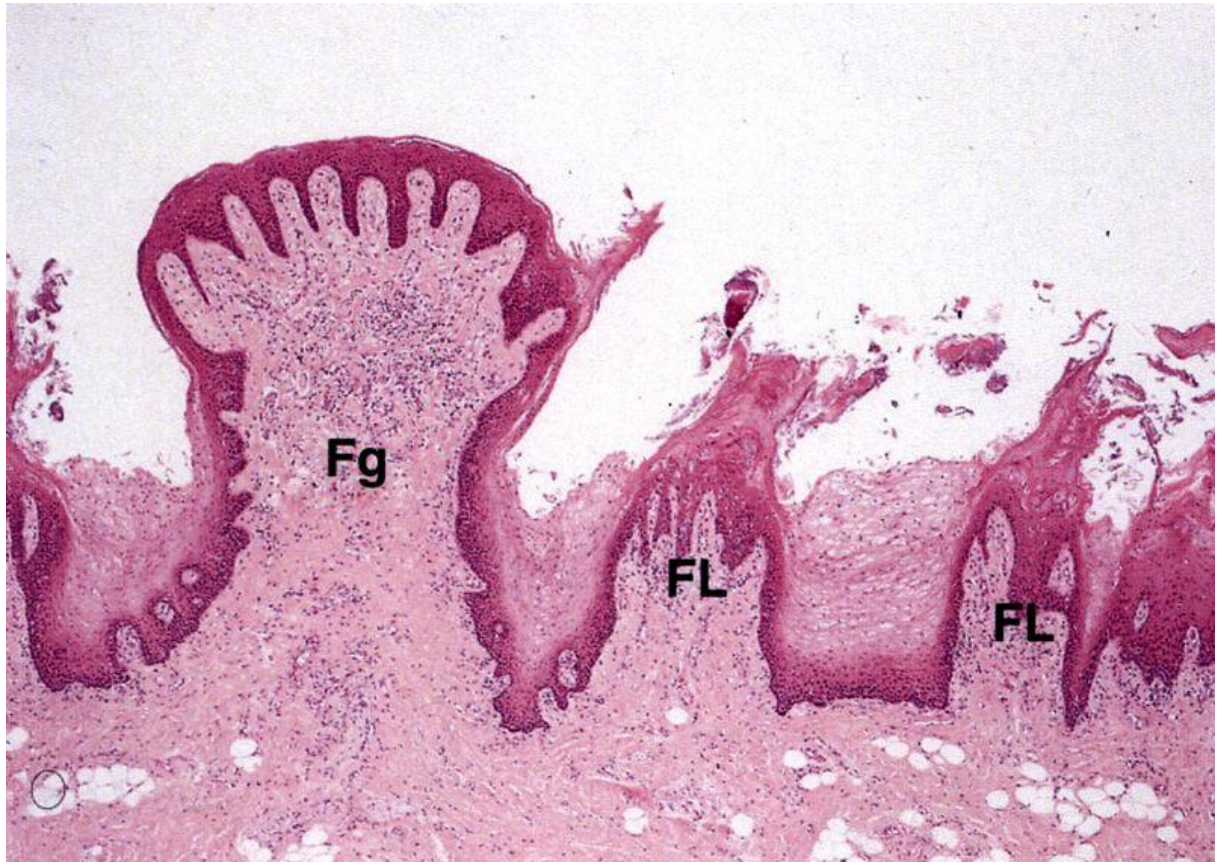


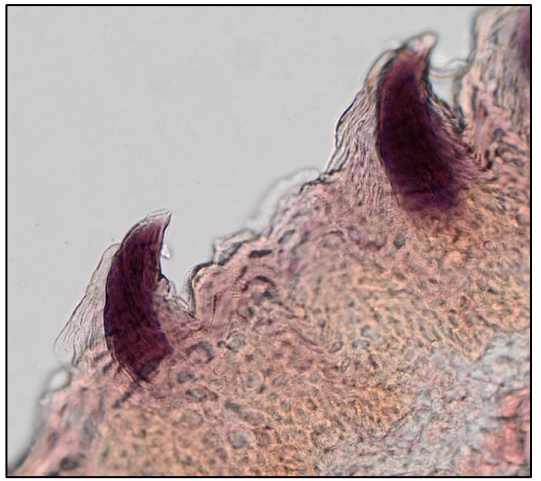
Papillae filiformes

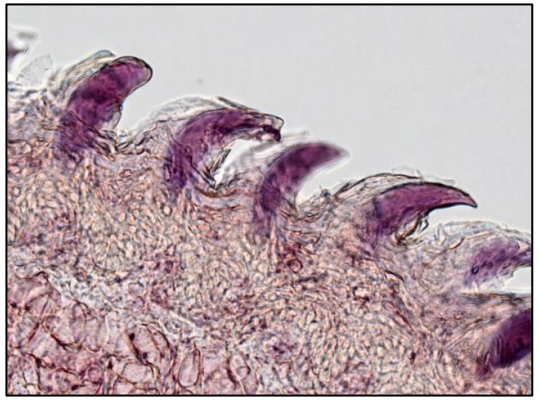
The most abundant and distributed over the entire dorsal surface of the tongue;
Brush-like appearance (0.5 - 1 mm in height, 0.2 - 0.3 mm in width);
The stratified squamous epithelium is often keratinized

Papillae fungiformes

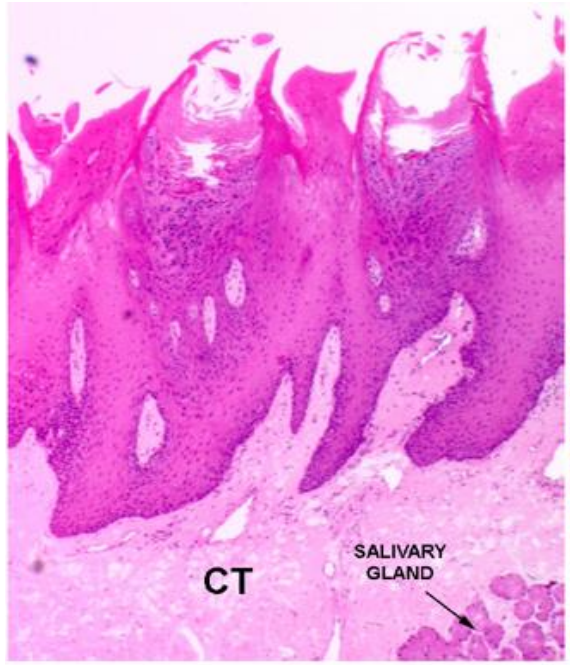
Apex; Mushroom-shape (0.5 - 1.5 in height, 0.5 - 1.0 mm in width)
Taste buds in epithelium

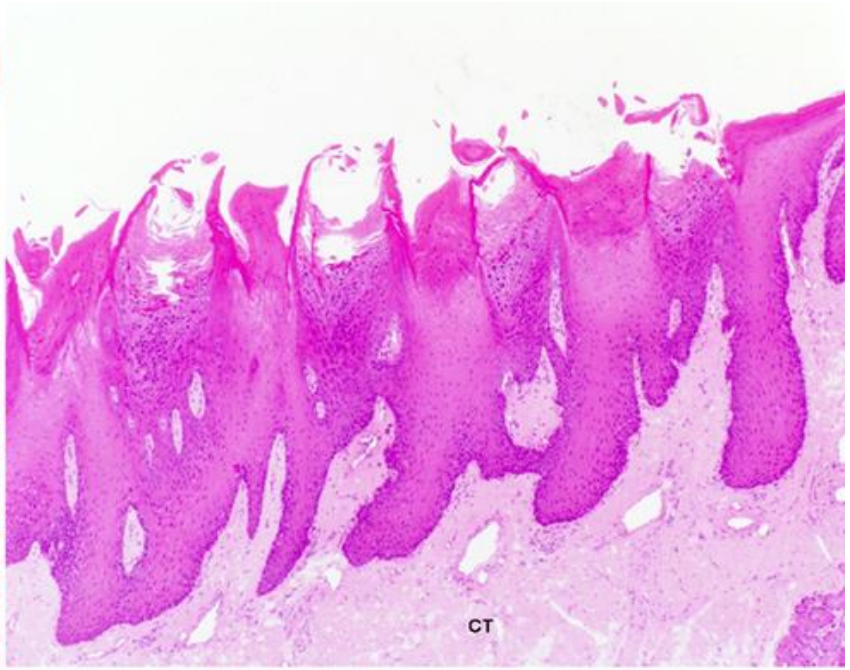


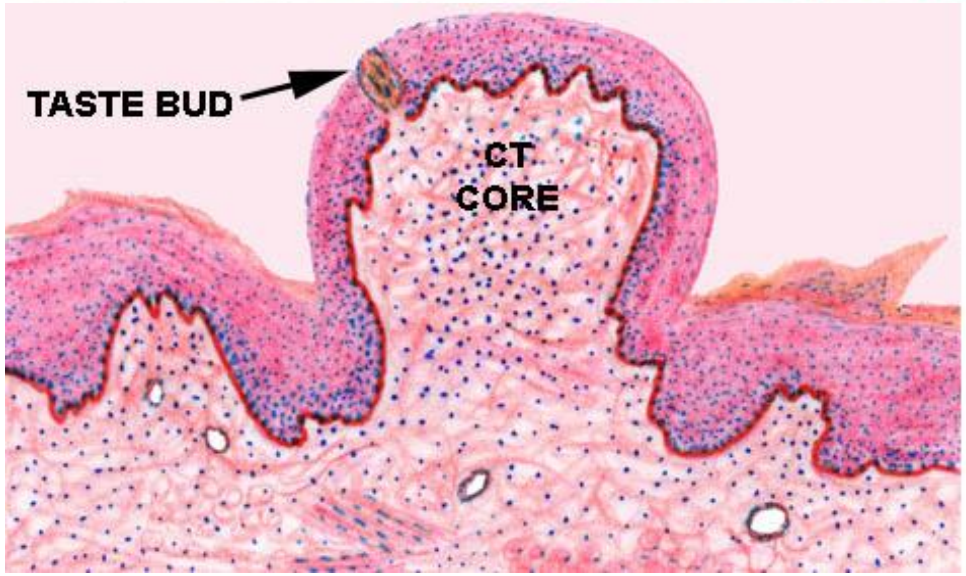


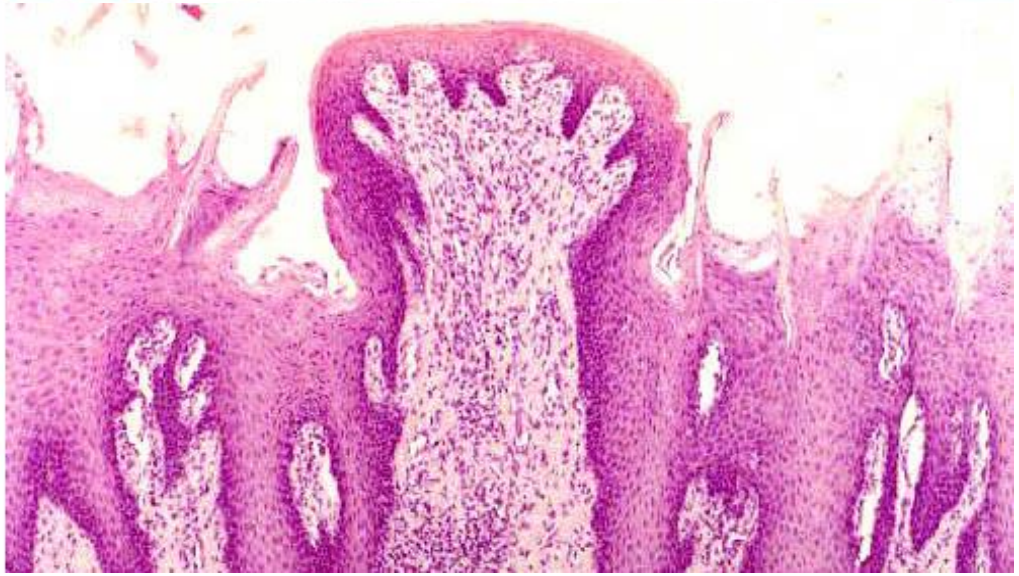


Papillae filiformes vs. Papillae fungiformes

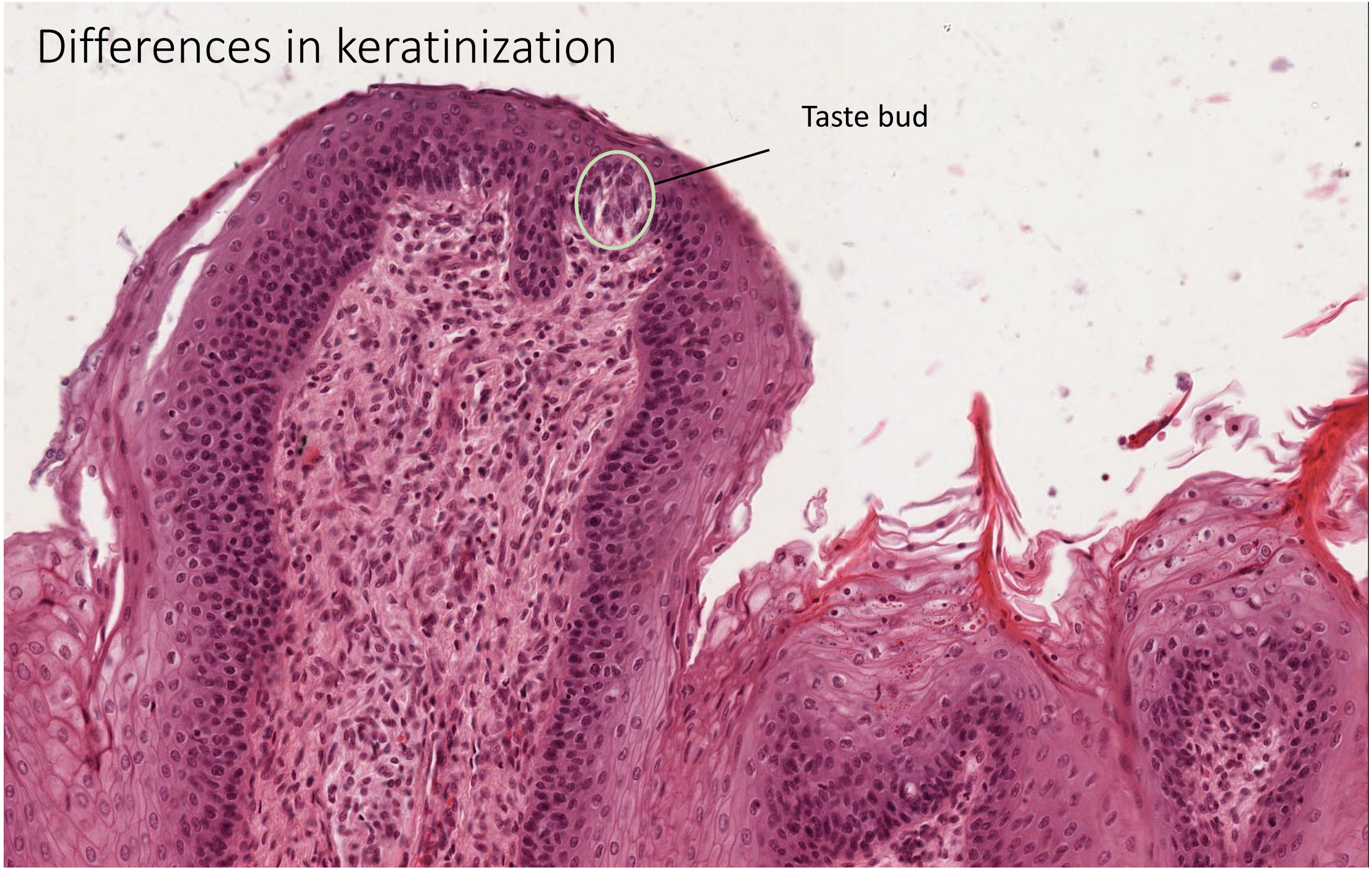






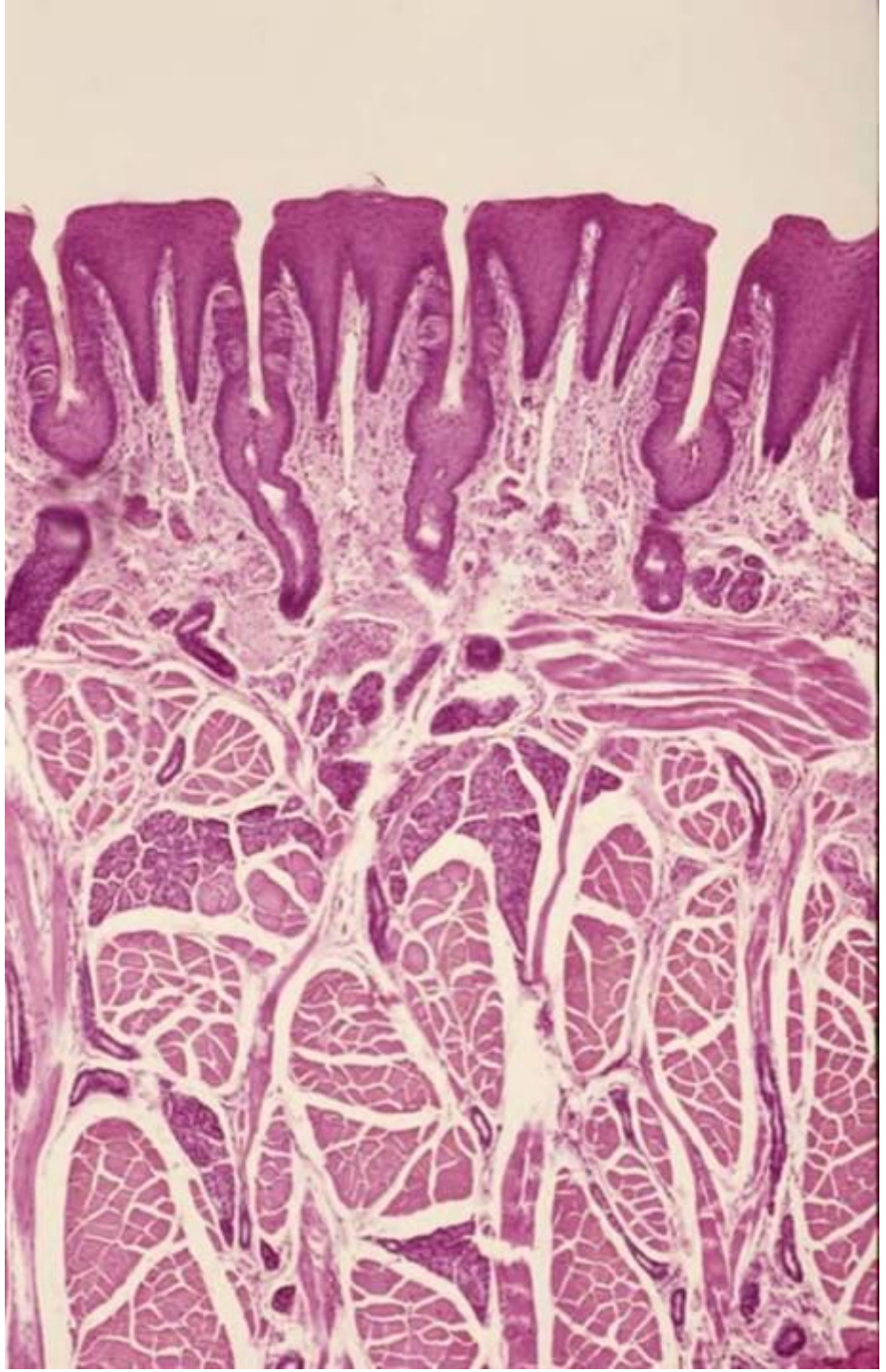


Differences in keratinization



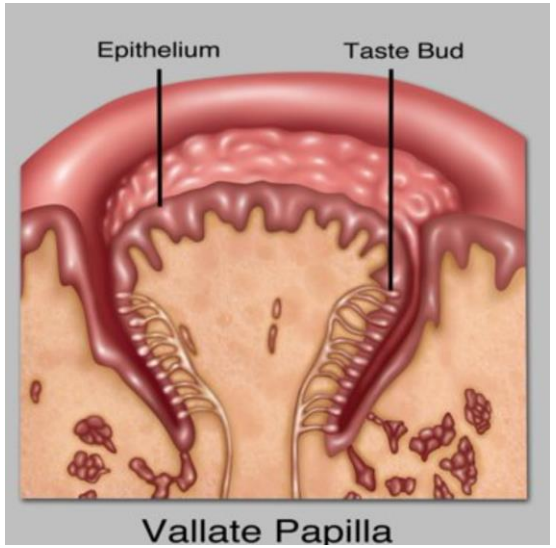
Papillae foliatae

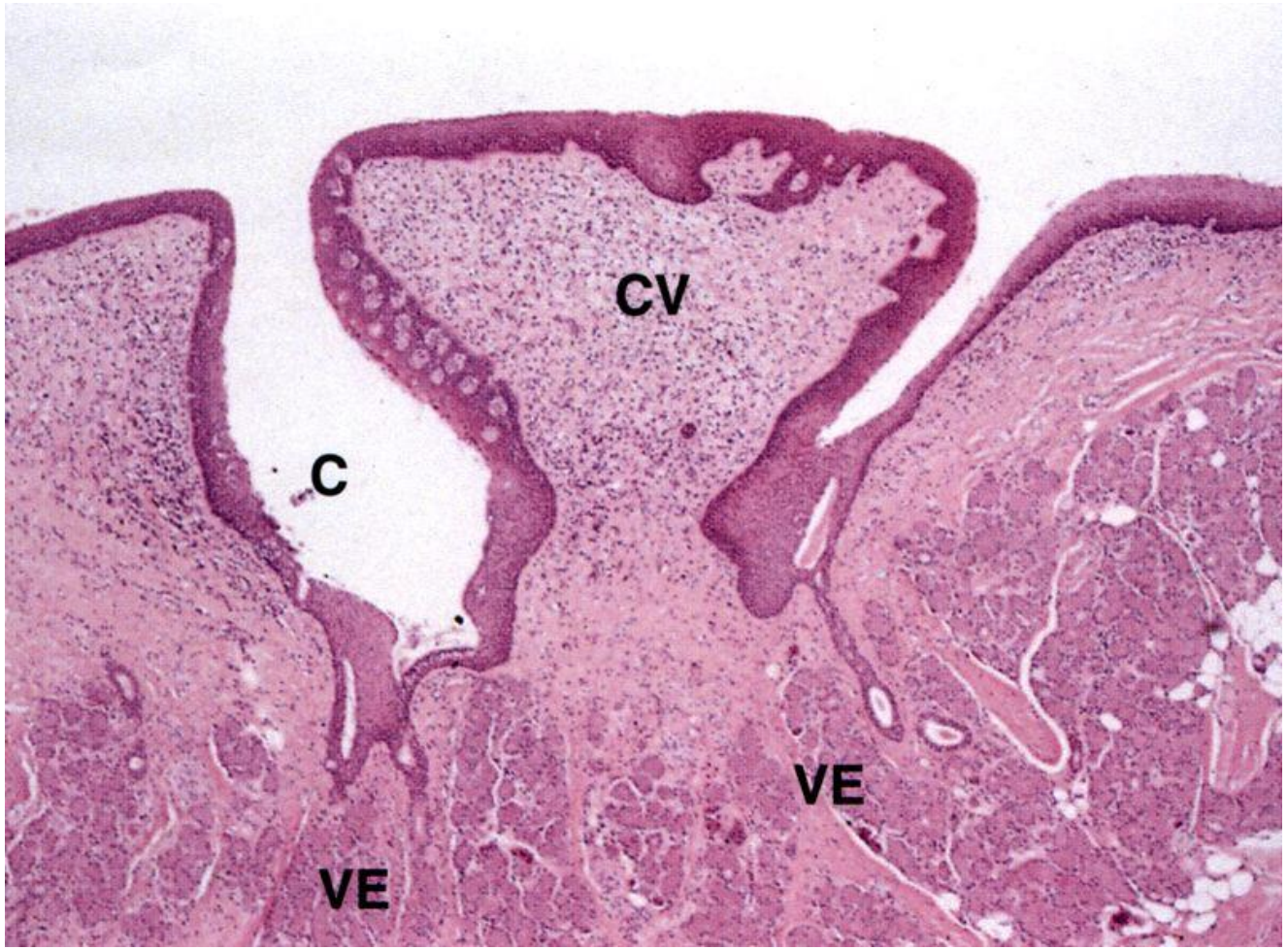
- Count: 3 - 8
- Vertically-oriented
- Rudimental
- Laterally on the edge of the main body and root of tongue
- Taste buds

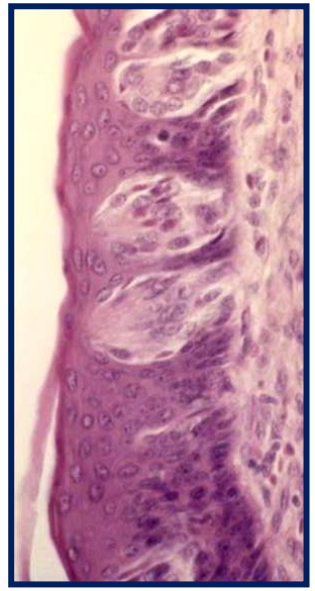


Papillae vallatae

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







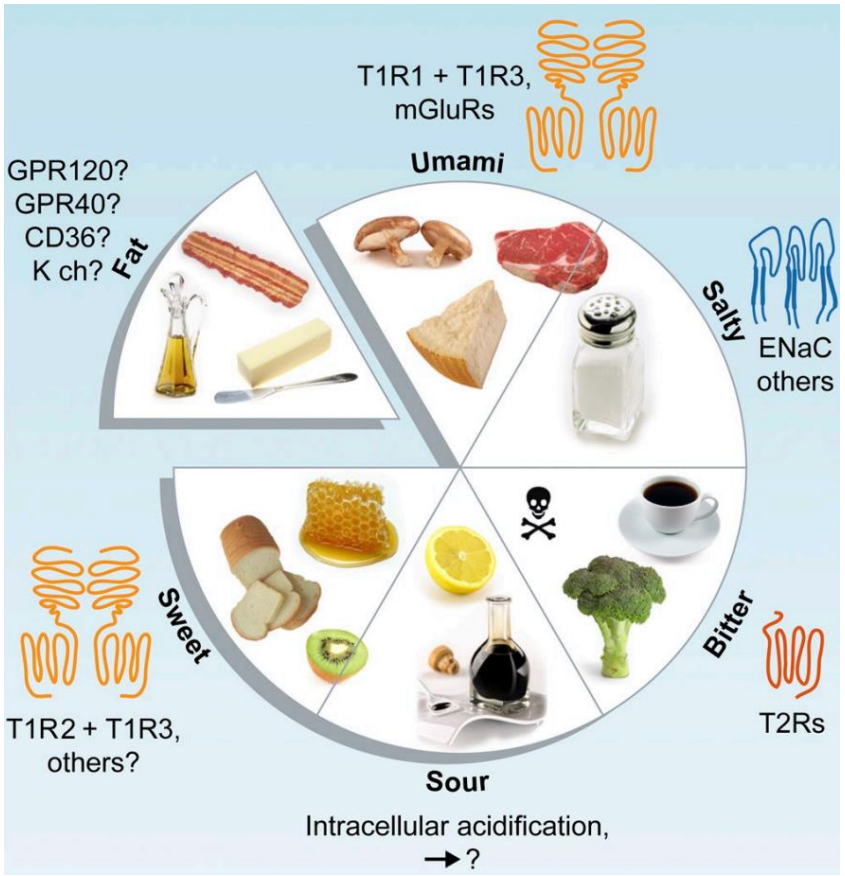
Papilla vallata

Taste

Basic tastes:
Sweet
Salty
Sour
Bitter
Umami

Suggested (still discussed):
Fatty
Metalic

Why do we perceive tastes?



(Chaudhari et Roper, JCB, 2010)

?

Taste buds

(caliculi gustatorii)

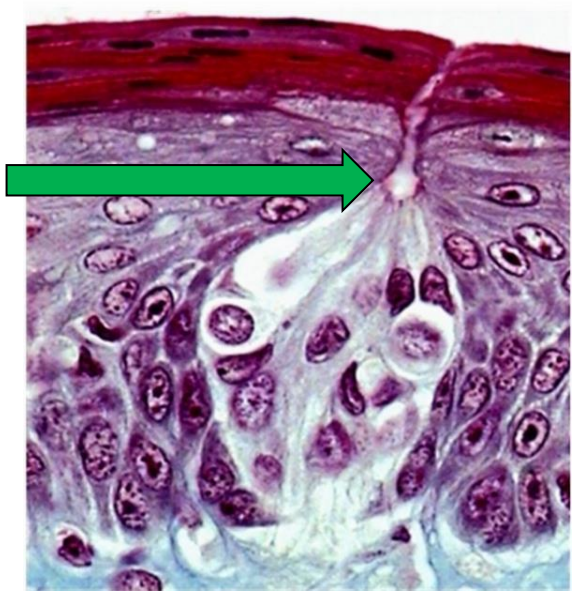
Intraepithelial structures

Localization:

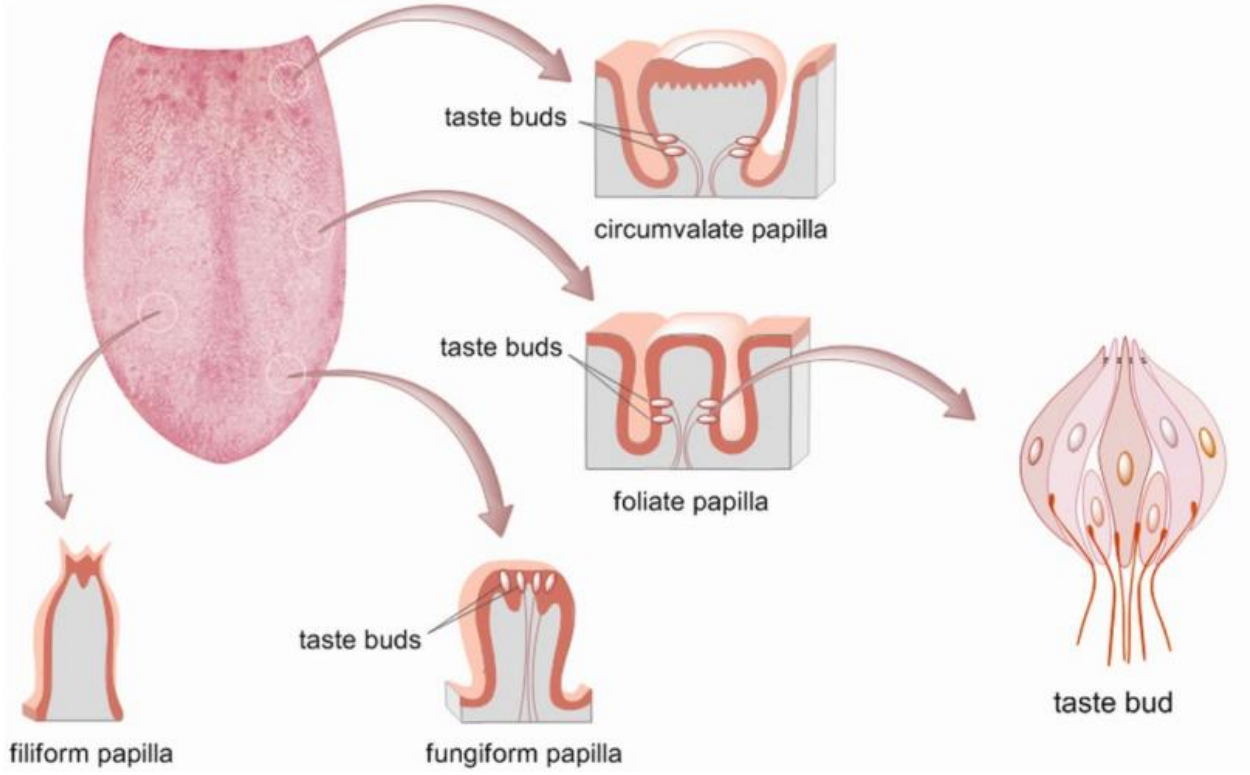
- In epithelium of vallate papillae + circumpapillar furrows
- In epithelium of fungiform papillae and foliate papillae
- Rarely in other places

The number is reported to be between 2,000 - 10,000 (their amount decreases with age)

Porus gustatorius



(Kikut-Ligaj, et al., 2015)



Taste buds

(caliculi gustatorii)

Cellular organization:

- Each taste bud consits of about 30-80 spindle-shaped neuroepithelial cells
- There are 3 (+1) cell types in the taste buds distinguishable by electron microscopy and immunohistochemical staining:

Type I

Most abundant (about half of the cells)

Support function, possible contribution to taste perception

Type II

Adjacent to intraepithelial nerves

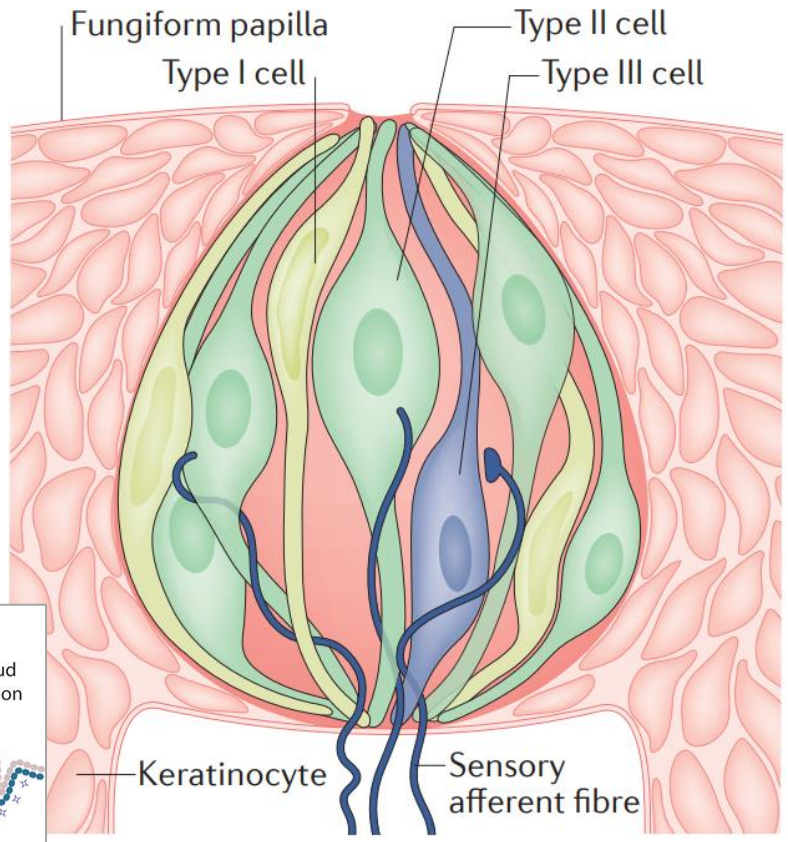
No synapses, signal transmission by purinergic signaling

Typ III

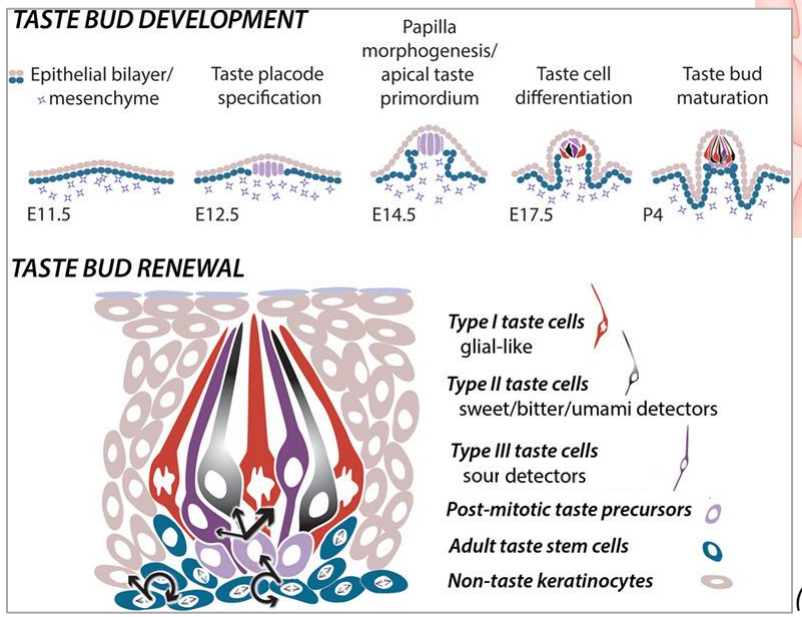
They are the only ones with identifiable synapses

Basal cells (Type IV)

Non-differentiated cesll, stem function

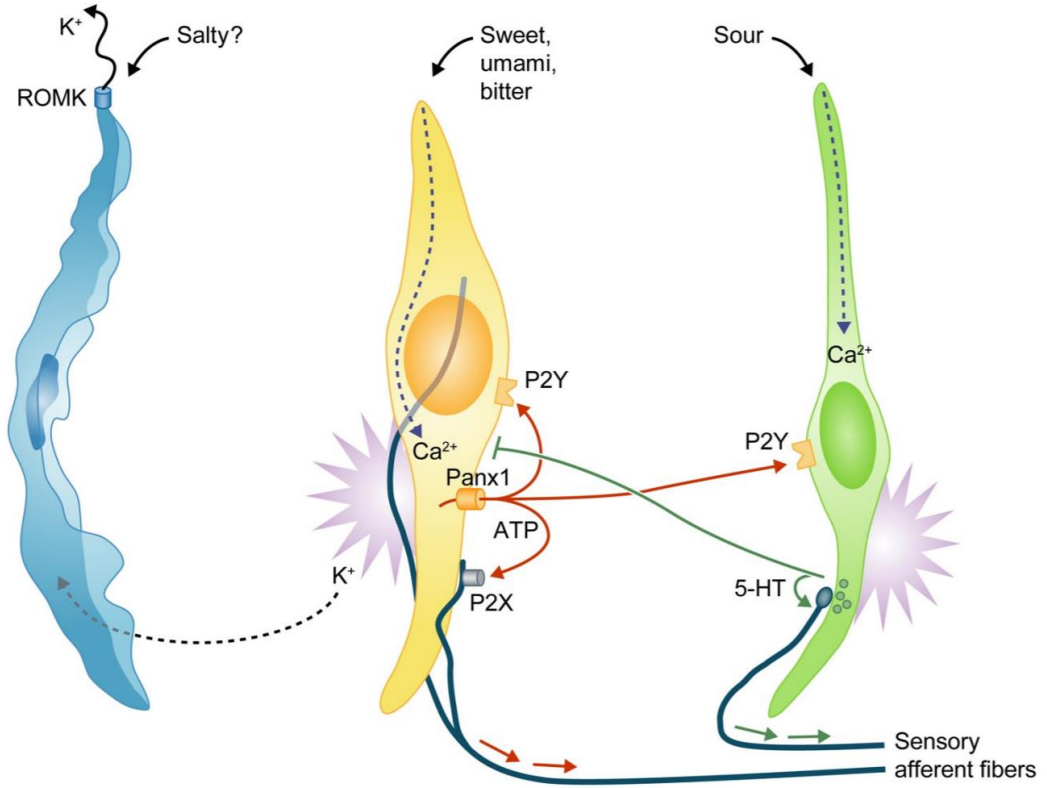


(Roper, et al., 2017)



(Barlow, 2021)

Taste detection

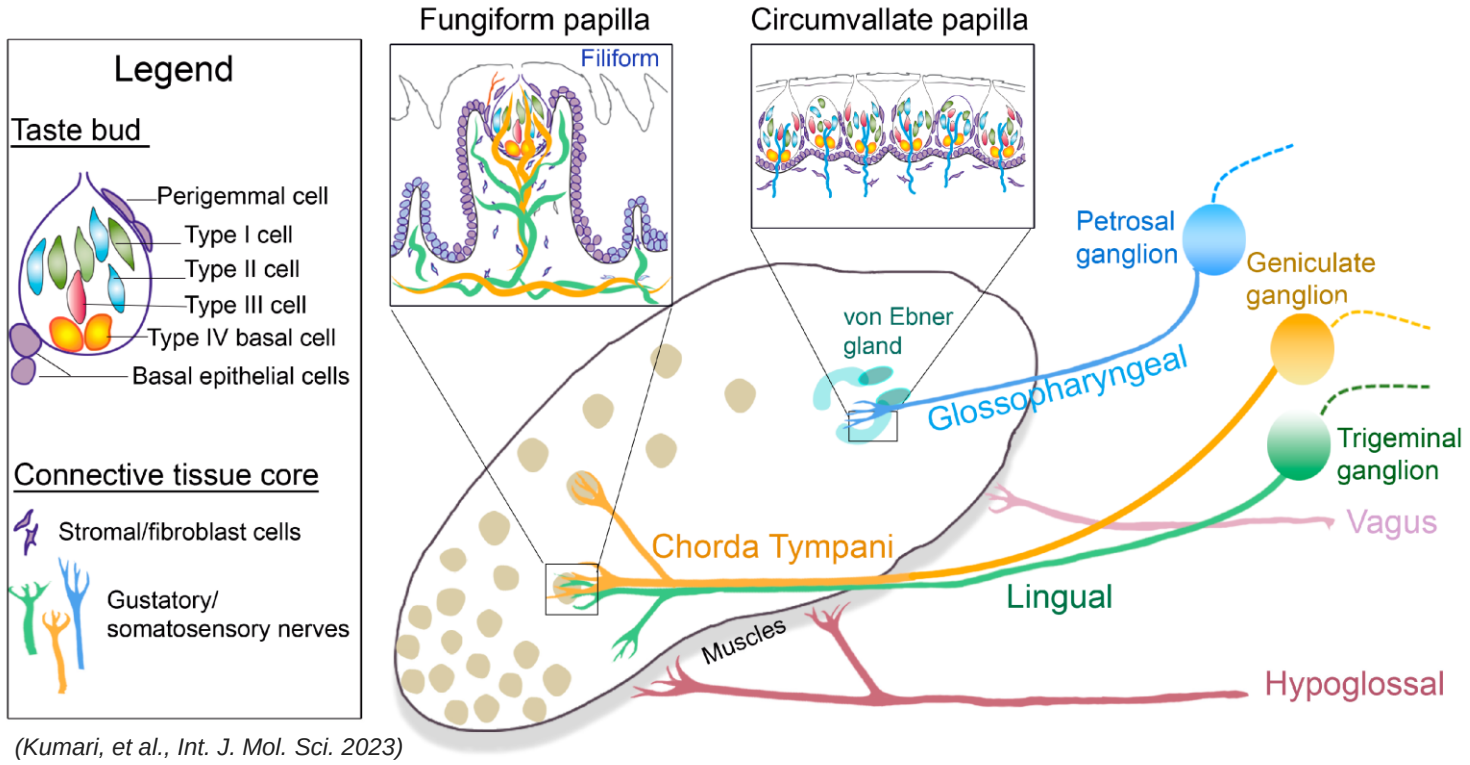


Type I glial-like cell	
Neurotransmitter clearance	
GLAST	Glutamate reuptake
NTPDase2	Ecto-ATPase
NET	Norepinephrine uptake
Ion redistribution and transport	
ROMK	K^+ homeostasis
Other	
OXTR	Oxytocin signaling?

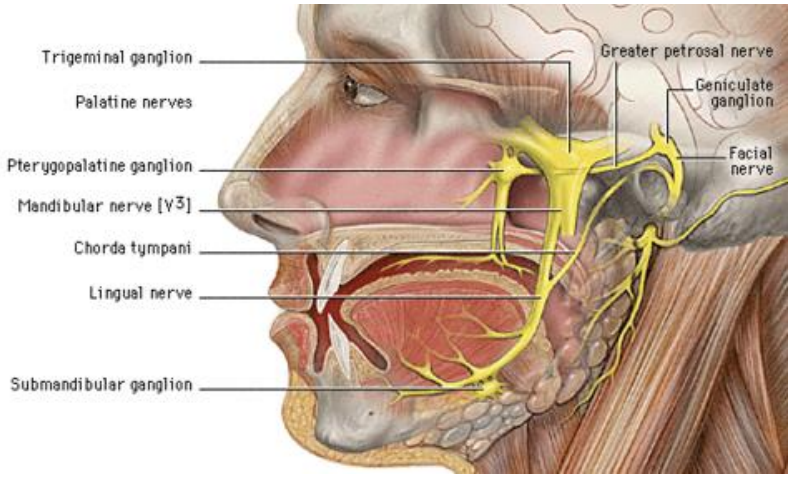
Type II receptor cell	
Taste transduction	
T1Rs, T2Rs	Taste GPCRs
mGluRs	Taste GPCRs
Gα-gus, Gγ13	G protein subunits
PLCβ2	Synthesis of IP3
TRPM5	Depolarizing cation current
Excitation and transmitter release	
$Na_v1.7$, $Na_v1.3$	Action potential generation
Panx1	ATP release channel

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

Transmission of taste signals



(Kumari, et al., Int. J. Mol. Sci. 2023)



Inervation of taste buds

- Taste buds on *fungigorm papillae* – ***n. facialis*** - 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***