Gastrointestinal Physiology
Lecture 2

Physiology of Salivary gland
(Chapter 664; page 773-777)

Dr. Hayam Gad

Associate Professor Of Physiology

Learning objectives

- Mastication and Chewing reflex
- Salivary glands
  - Secretory unit (salivon)
  - Secretion of saliva and its characteristics
  - Composition of saliva
  - Secretion of water & electrolytes by salivary glands
  - Saliva and its flow rate
  - Functions of saliva
  - Control of secretion by sympathetic and parasympathetic nervous systems
  - Unconditioned and conditioned reflexes

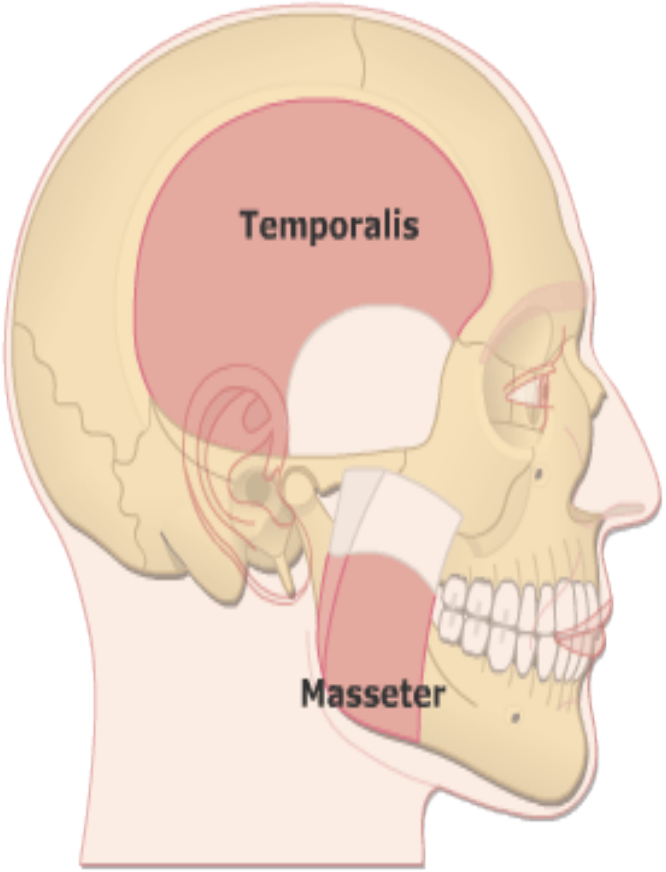
Mastication (Chewing)

Functions:

1. To lubricate the bolus with salivary secretion
2. To breakdown the bolus to small particles
3. To begin digestion of carbohydrate (amylase)

- Teeth organization
  - Anterior teeth (incisors) for cutting
  - Posterior teeth (molars) for grinding
- Chewing muscles are innervated by cranial nerve V:
  - Masseter
  - Temporalis
  - Lateral Pterygoid
  - Medial Pterygoid
- Taste center (Hypothalamus) ⟶ rhythmical chewing movements

  Chewing reflex & stretch reflex



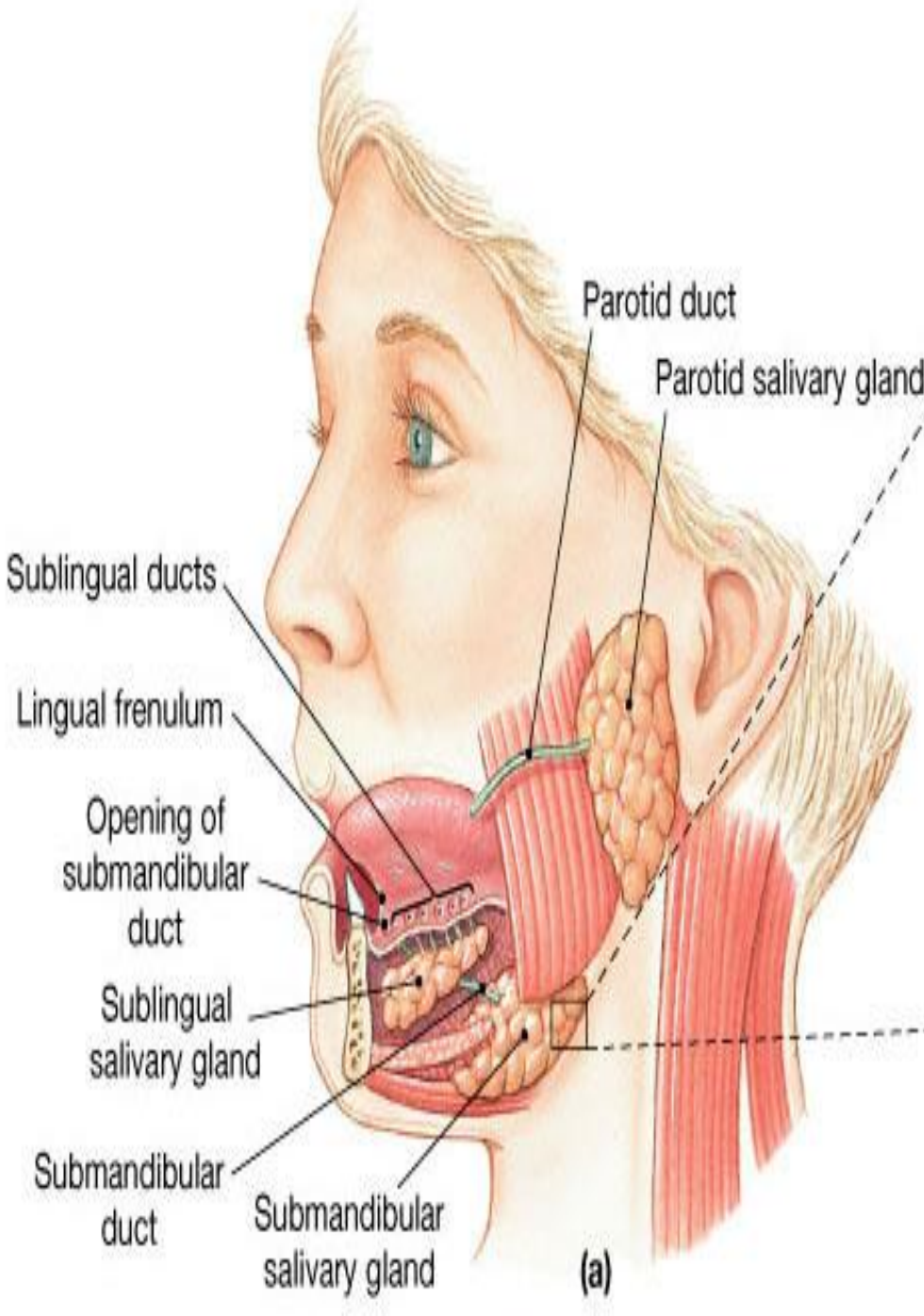
Chewing reflex & stretch reflex

- The presence of a bolus of food in the mouth initiates reflex inhibition of the muscles of mastication, which allows the lower jaw to drop.
- The drop in turn initiates a stretch reflex of the jaw muscles that leads to *rebound contraction.*
- *This automatically raises the jaw to cause closure of the* teeth, but it also compresses the bolus again against the linings of the mouth, which inhibits the jaw muscles once again, allowing the jaw to drop and rebound another time; this is repeated again and again.

Salivary Glands

The principal glands of salivation are:

1. Parotid glands
2. Submandibular (Submaxillary) glands
3. Sublingual glands
4. Smaller glands in mucosa of tongue, palate, etc.



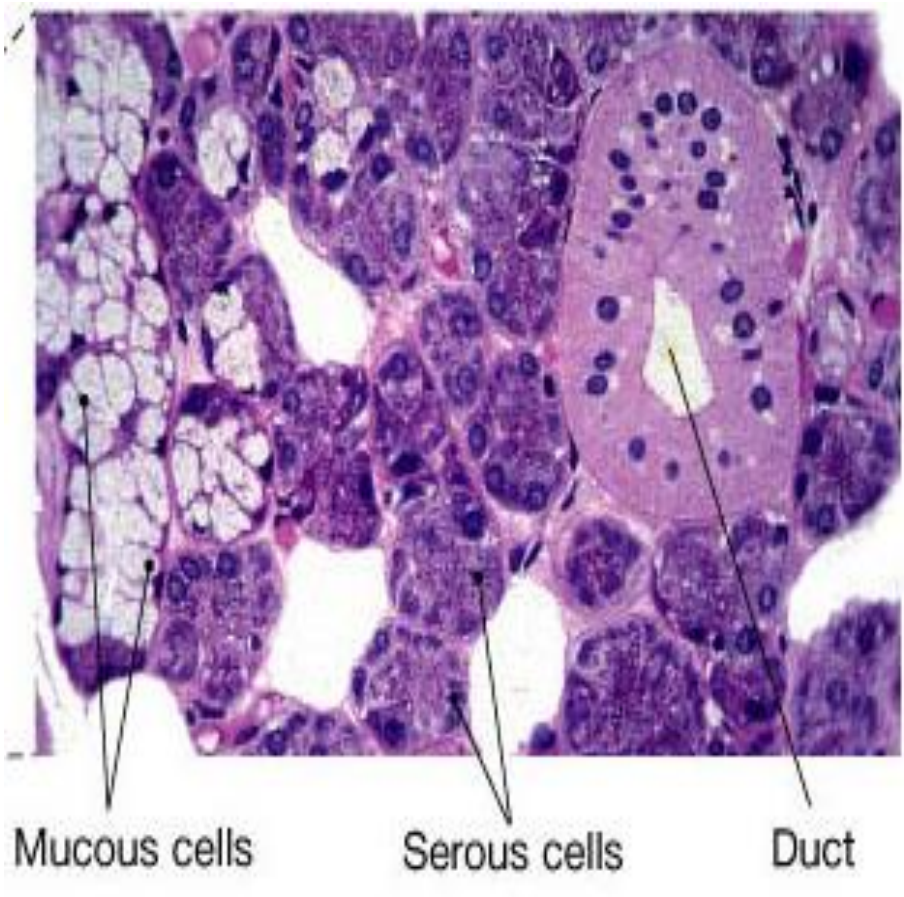
Secretory Unit (Salivon)

- Salivary glands are typical exocrine glands.
- The basic unit “salivon” consists of:
  - Acinus -initial secretory process, has 2 types of cells: serous & larger mucous cells
  - Intercalated duct -initial portion of duct
  - Striated duct -modification of secretory product
  - Myoepithelial cells:
    - Surround acinus and intercalated duct
    - Contraction moves saliva, prevents development of back pressure

Secretion of Saliva

Saliva contains two major types of secretion:

1. Aqueous fluids (a *serous secretion)*
   - ✓ Water, ions and enzymes such as *ptyalin (an* α-amylase)
   - ✓ Parotid, Submandibular and Sublingual glands
2. Mucus secretion (mucin)
   - ✓ Submandibular and Sublingual glands



Characteristics of saliva

- Daily secretion of saliva = 800-1500 mL
- Specific gravity: 1002-1010
- It is hypotonic.
- pH: 6-7
- Composition: Water (99.5%) and solids (0.5%) which include organic and inorganic constituents.

The organic constituents include:-

1- Enzymes as:

- α-amylase (from parotid glands)
- Lingual lipase
- Kallikrin (protease, from acinar cells)
  - Catalyzes production of bradykinin (vasodilator) from α-globulin
  - Increases local blood flow
- Muramidase (lyses muramic acid of Staphylococcus)
- Lactoferrin, lysozymes

2- IgA and epithelial growth factor (EGF)

3- Mucus

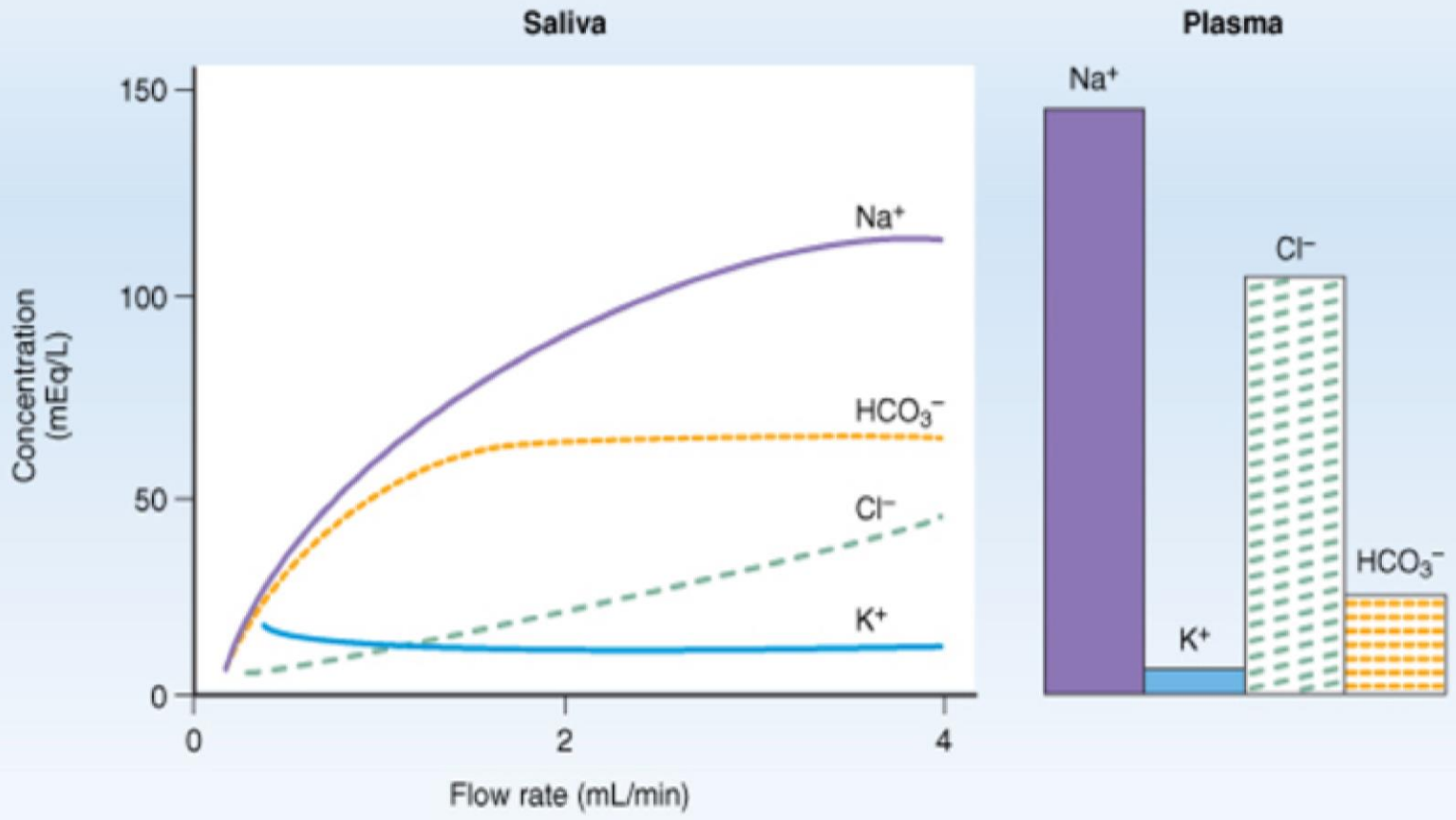
- Mucus is a thick secretion composed mainly of water, electrolytes, and glycoproteins
- It is an excellent lubricant and a protectant for the wall of the gut because of the following:

1. It has adherent qualities that make it adhere tightly to the food.
2. It causes food particles to adhere to one another.
3. It coats the wall of the gut and prevents actual contact of most food particles with the mucosa.
4. It has a low resistance for slippage.
5. It is strongly resistant to digestion by the GI enzymes.
6. The glycoproteins of mucus have amphoteric properties, (buffering small amounts of either acids or alkalies).

The inorganic constituents include:-

- ✓ Na^{+}, Cl^{-}. Their concentration is less than those of plasma.
- ✓ K^{+}, HCO_3^{-} are found at higher concentration than that in plasma.
- ✓ Ca^{++} and Ph^{+3}.
- ✓ The concentration of these ions depends on the rate of salivary flow.
- ✓ At low flow rate, salivary secretions have:
  - High K^{+} and HCO_3^{-}
  - Low Na^{+} and CI^{-}

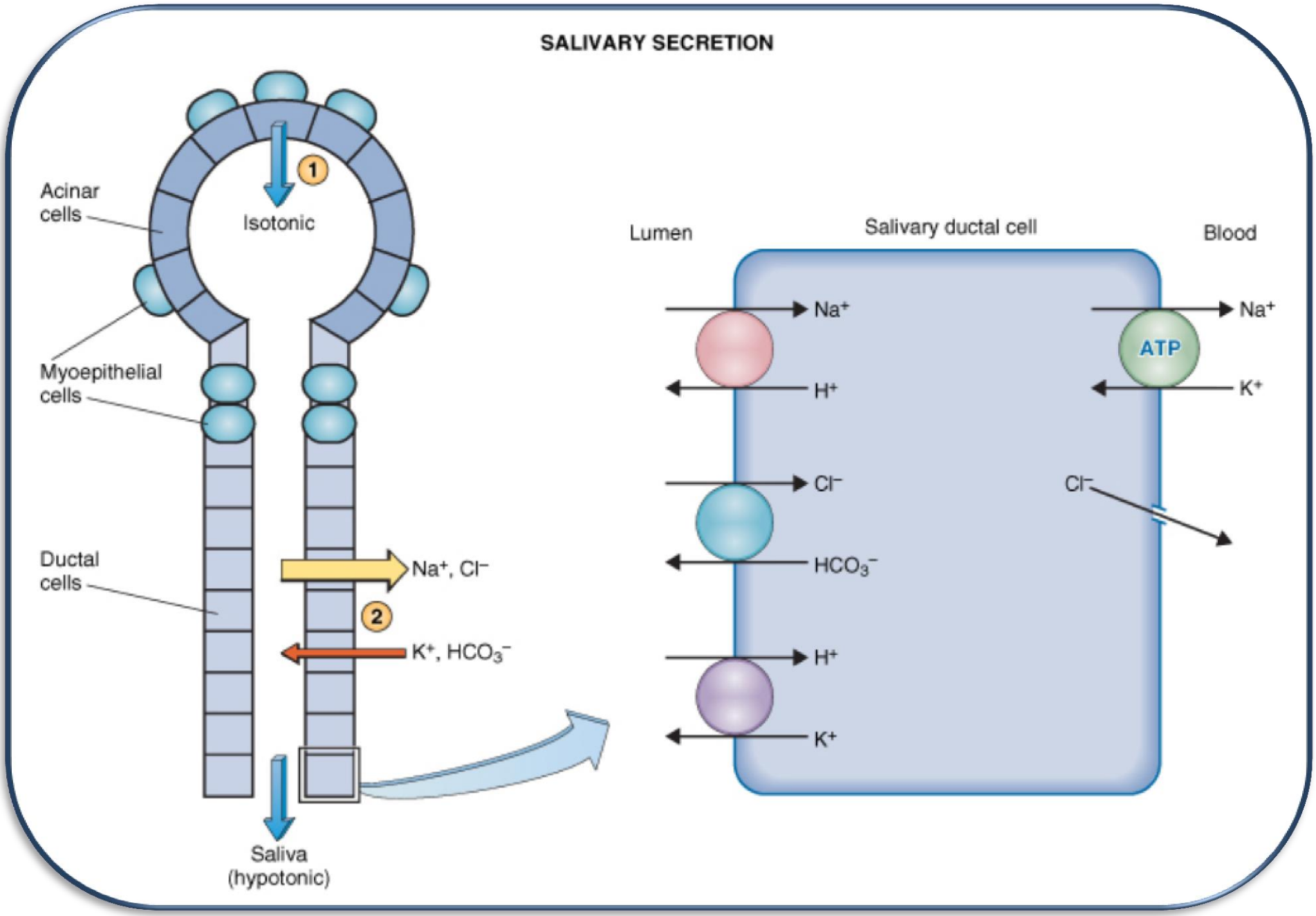
Characteristics of Saliva and Flow Rate



Secretion of water and electrolytes by salivary glands

The secretion of H_2O & electrolytes occurs in two stages. First, a primary secretion in the acini; which is secondarily modified at the level of the striated ducts.

1- The primary acinar secretion is isotonic to plasma. The amylase concentration and the rate of its secretion vary with the level and type of stimulation. The electrolyte composition is similar to that of plasma.


SALIVARY SECRETION
Acinar cells
Myoepithelial cells
Ductal cells
1
Isotonic
Na+, Cl−
2
K+, HCO3−
Saliva (hypotonic)
Lumen
Salivary ductal cell
Blood
Na+
H+
Cl−
HCO3−
H+
K+
ATP
Na+
K+
Cl−

2- The striated ducts modify the primary secretion by extracting Na^+ & CL^- from, and adding K^+ & HCO_3^- to the saliva. Na^+ is actively reabsorbed unaccompanied by H_2O, and K^+ is secreted while HCO_3^- is actively secreted. This process is influenced by aldosterone.

- Because the ducts remove more Na^+ & Cl^- ions from saliva than they add K^+ and HCO_3^-, saliva becomes progressively more hypotonic as it flows through the ducts.

The concentration of electrolytes depends on the flow rate as follows

Under resting conditions

- The concentration of Na^+ and Cl^- in saliva are 1/7 their concentration in plasma.
- The concentration of K^+ is 7 times greater than in plasma.
- The concentration of HCO_3^- is 2-3 times that of plasma.

Under maximum secretion

- The concentration of Na^+ and Cl^- in saliva rises to 1/2-2/3 their concentration in plasma.
- The concentration of K^+ falls to only 4 times that of plasma.

In presence of excess aldosterone secretion

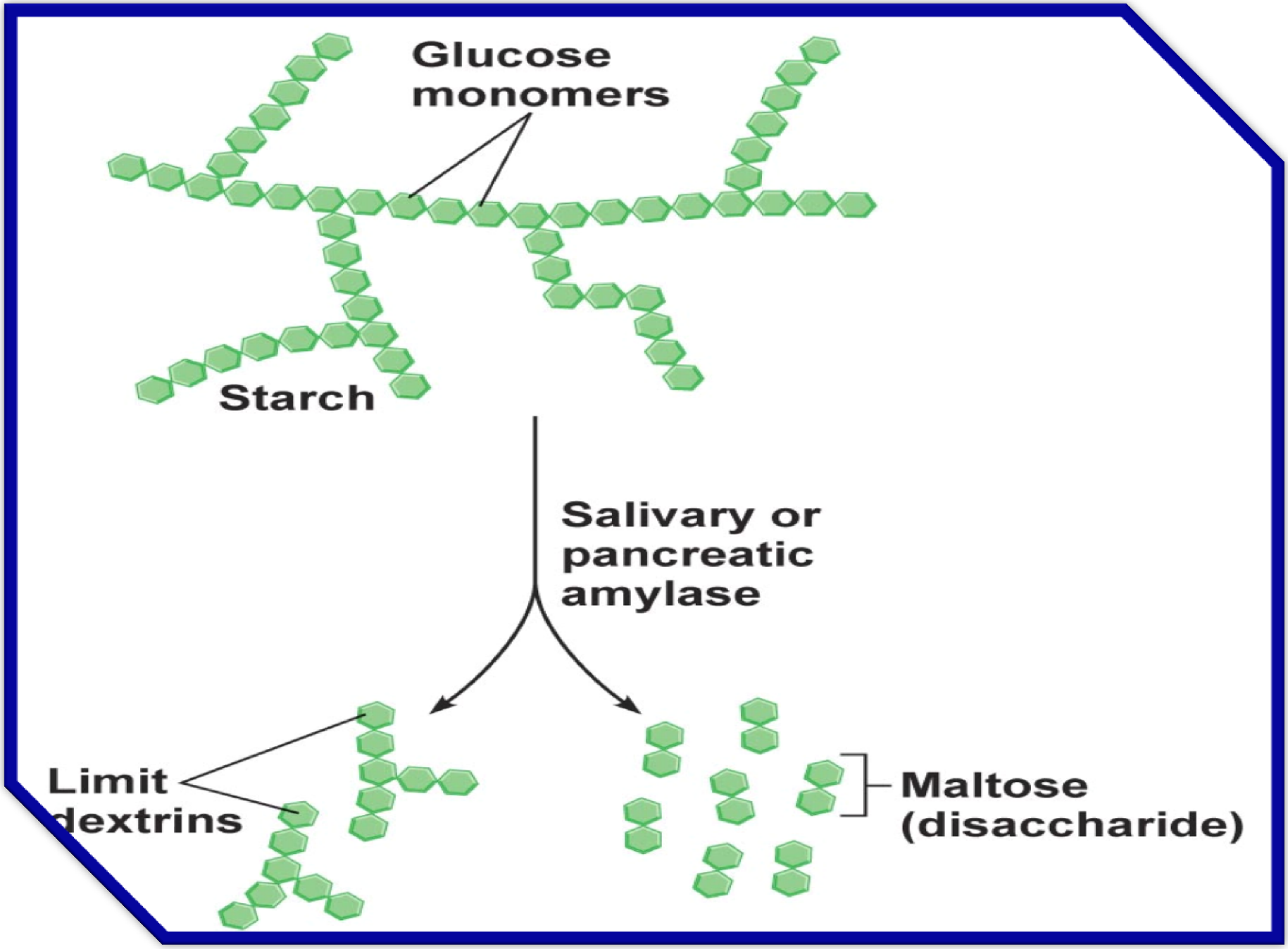
- NaCl reabsorption and K^+ secretion increase so that NaCl concentration in saliva decreases to almost zero, while K^+ concentration increases.

Functions of saliva

1. *Saliva moistens and lubricates food and thus facilitates swallowing.*
2. *Saliva keeps the oral mucosa moist and so helps movement of tongue and lips in speech.*
3. *Saliva has a digestive function:-*
   - *α-amylase*
   - *Lingual lipase*

Ptyalin (salivary α-amylase)

- It is secreted mainly from parotid gland.
- It cleaves α -1 ,4-glycosidic bonds and breaks down starch to maltose, dextrins and maltotriose.
- Its optimum pH = 6.8.
- Inactivated at pH 4 but continues to work for sometime in unmixed food in Orad portion of stomach for about half an hour and is arrested only when gastric acid penetrates the food mass.


Glucose monomers
Starch
Salivary or pancreatic amylase
Limit dextrins
Maltose (disaccharide)

Lingual lipase

- *It is secreted from serous salivary glands on the tongue; it breaks down triglycerides into monoglycerides and fatty acids. Its action may continue in the stomach after food is swallowed.*

4. *By acting as a solvent, saliva is important for the sense of taste. Any substance must first dissolve in saliva before it can be sensed by the taste buds.*

5. Saliva prevents the deteriorative process of oral mucosa in several ways:-

   a. The flow of saliva helps wash away the pathogenic bacteria as well as the food particle that provide their metabolic support.

   b. Saliva contains several factors that destroy bacteria as thiocyanate ions, lysozyme and proteolytic enzymes. Lactoferrin can deprive bacteria of iron.

   c. Saliva contains significant amount of protein antibodies (IgA) that can destroy the oral bacteria.

6. *Buffering action, saliva neutralizes any acids that may result from bacterial action, also swallowed saliva may help to neutralize gastric HCl in empty stomach.*
7. *The epidermal growth factor in salivary secretion is responsible for healing of ulcers in the mucous membrane of oral cavity.*

Control of Salivary Secretion

- **Unique aspect of control of salivary secretion**

- Secretion rate depends entirely on neural control –autonomic nervous system (ANS)
- Both Parasympathetic and Sympathetic lead to increase secretion
- Composition is modified by Aldosterone:
  i. Increases Na^+ , Cl^- reabsoption
  ii. Increases K^+ secretion

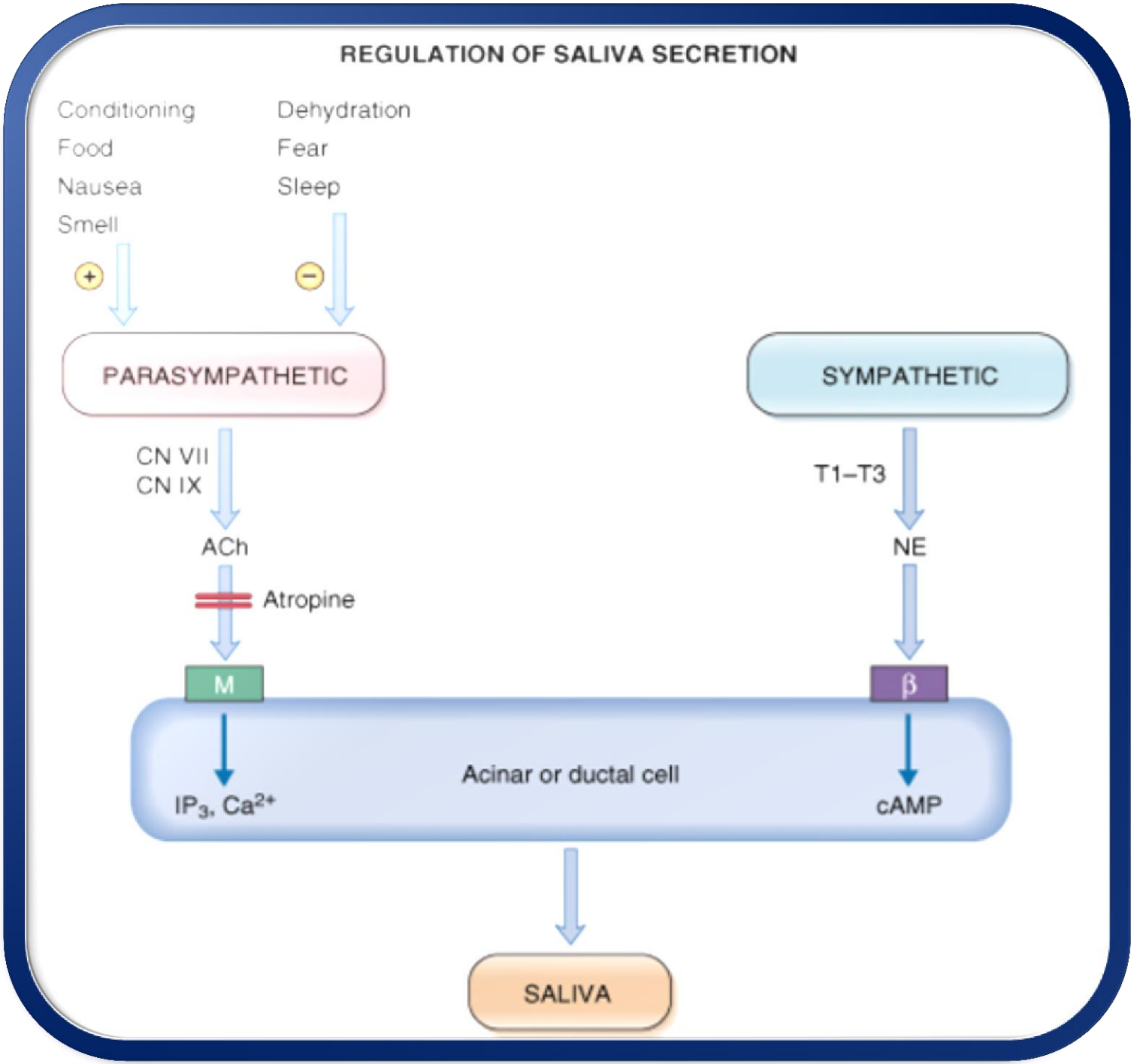
Parasympathetic

- Origin
  - Salivary nucleus in medulla
- Outflow
  - CN VII & IX
- Transmitter
  - Ach
- Increases stimulation in response to
  - Conditioned reflexes (taste, smell)
- Decreases stimulation due to
  - Sleep, fear, dehydration

- Stimulates
  - The secretion (protein poor, high k^+ and HCO_3^-)
  - The contraction of myoepithelial cell
  - The metabolic rate
  - The blood flow due to marked vasodilatation. This occurs due to the release of kallikrin enzyme from active gland tissues which cause conversion of α2 globulin into bradykinine, a potent vasodilator.
  - The growth and development of different cells
- Sectioning of parasympathetic markedly decreases flow & leads to atrophy

Sympathetic

- Origin
  - Intermediolateral gray T1-T3
- Transmitter
  - Norepinephrine
- Stimulates
  - Secretion (mostly enzymes)
  - Contraction of myoepithelial cell
  - Metabolic rate
  - Growth and development of different cells
- Sectioning of sympathetic nerves has minimal impact on secretion


REGULATION OF SALIVA SECRETION
Conditioning
Food
Nausea
Smell
Dehydration
Fear
Sleep
+
−
PARASYMPATHETIC
SYMPATHETIC
CN VII
CN IX
ACh
Atropine
T1–T3
NE
M
β
Acinar or ductal cell
IP3, Ca2+
cAMP
SALIVA

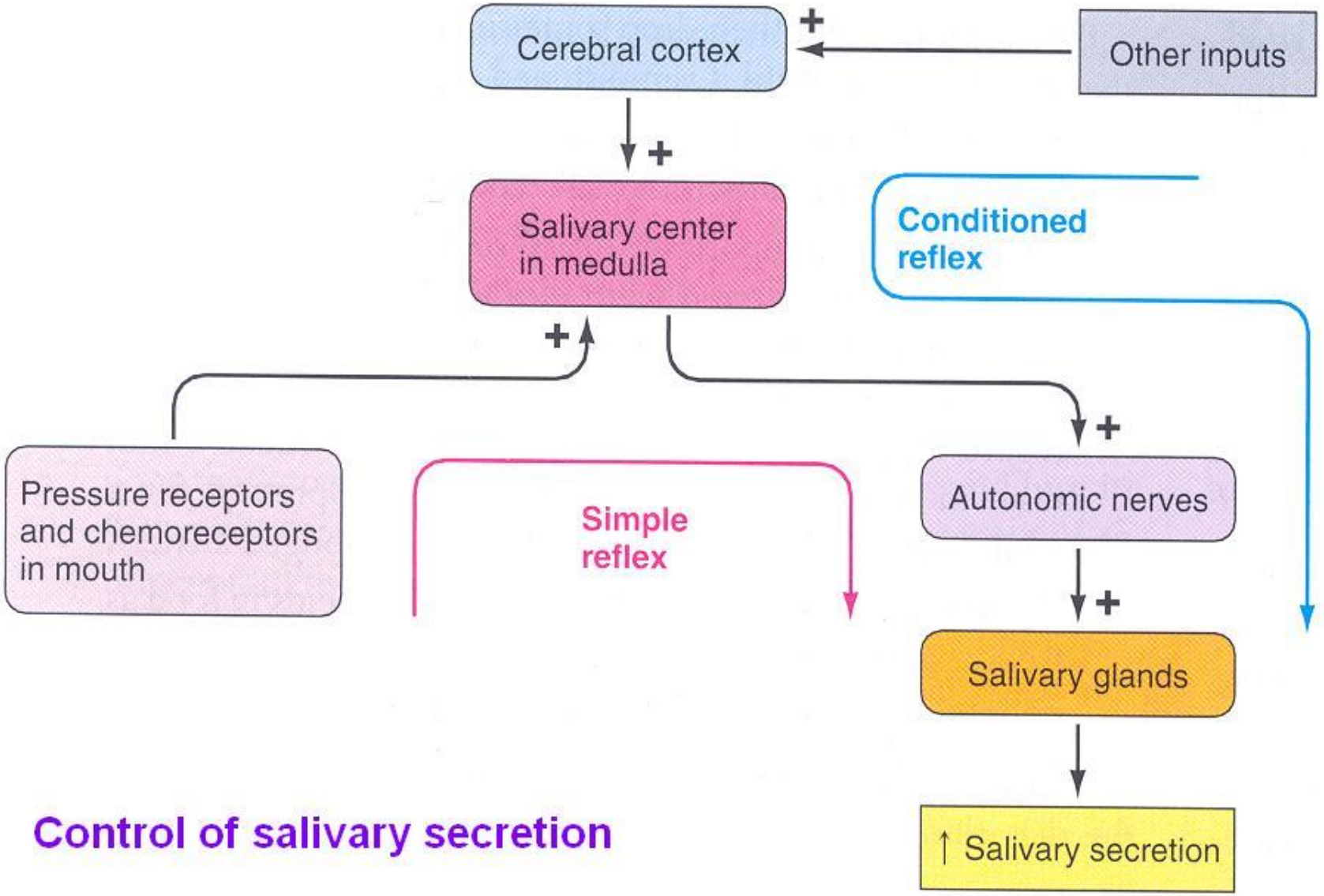
Unconditioned and conditioned reflexes

Salivary secretion is controlled exclusively by nervous mechanism through:

- Unconditioned reflex
- Conditioned reflex

1- Unconditioned reflex

- ✓ The presence of food in the mouth stimulates general receptors and especially taste receptors.
- ✓ Impulses travel along afferent nerves to the salivary nuclei in brain stem.
- ✓ Efferent impulses travel along autonomic nerves to salivary glands to stimulate salivary secretion.
- ✓ This reflex is innate and is not acquired by learning.



Control of salivary secretion

2- Conditioned reflex

- ✓ Seeing, smelling, hearing or even thinking about appetizing food can result in secretion of saliva.
- ✓ Iinitial impulses arise in the parts of the brain concerned with these special sensations and stimulates the salivary centers.
- ✓ In human, mouth watering on seeing or thinking of food provides evidence of this psychic reflex.

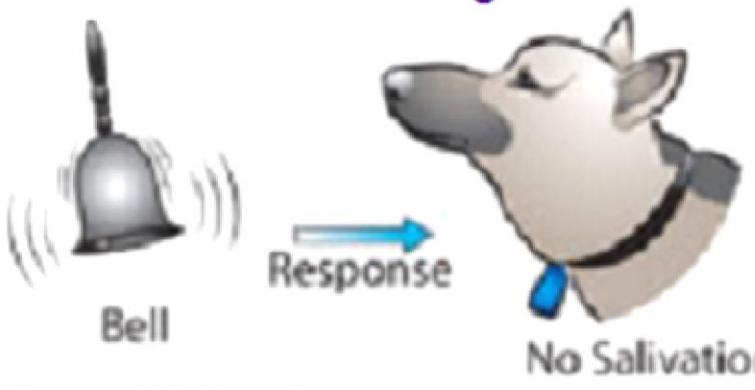
How Dog Training Works

1. Before conditioning

Unconditioned Stimulus

Unconditioned Response

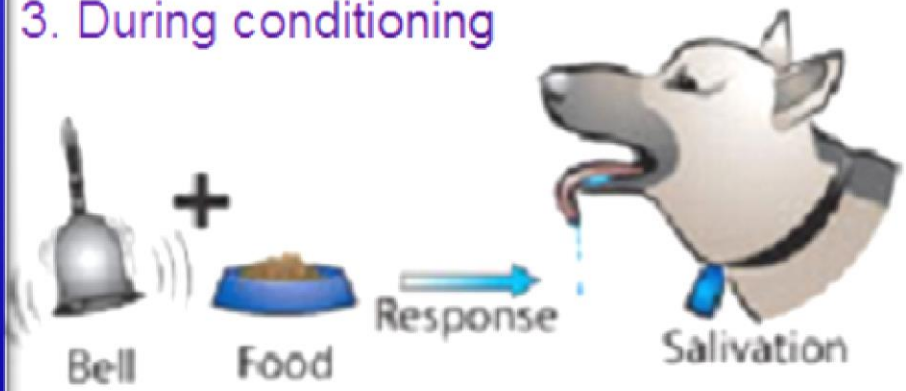
2. Before conditioning



Neutral Stimulus

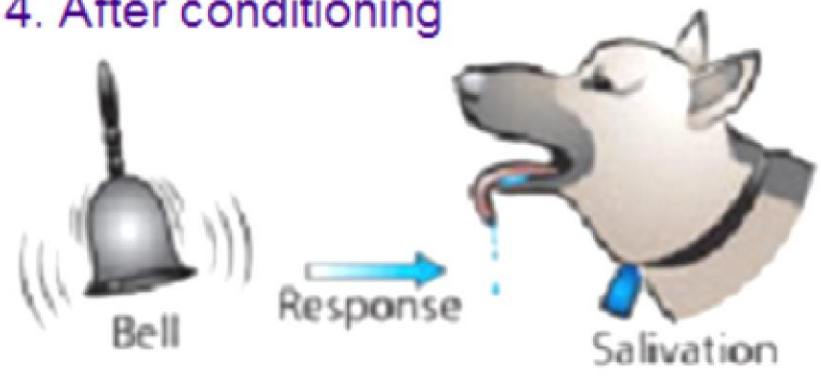
No Conditioned Response

3. During conditioning



Unconditioned Response

4. After conditioning



Conditioned Stimulus

Conditioned Response

Xerostomia(dry mouth)

- Xerostomia is defined as dry mouth resulting from reduced or absent saliva flow.
- It may or may not be associated with decreased salivary gland function.

Common causes of xerostomia

- Medications as antihistamines, antidepressants.
- Diseases as HIV, rheumatoid arthritis, systemic lupus erythematosus, diabetes mellitus, hypertension, endocrine disorders, nutritional deficiencies, nephritis and thyroid dysfunction.
- Radiation to the head and neck in cancer therapy.

Signs and symptoms of xerostomia

- Difficulty of eating, speaking, swallowing.
- Burning sensation
- Taste disorders (dysgeusia)
- A painful tongue (glossodynia)
- Thirst, especially at night.
- Increased dental caries
- Inflammation and fissuring of the lips (cheilitis)

Diagnosis of xerostomia

- The patient's history
- Examination of the oral cavity: dry, erythematous or sticky oral mucosa due to an overgrowth of Candida albicans. Little or no pooled saliva in the floor of the mouth, and the tongue may appear dry with decreased numbers of papillae. The saliva may appear stringy, ropy or foamy.
- Sialometry, that measures the flow rate of saliva. The normal resting flow rate is 0.3 to 0.5 mL/min; for stimulated saliva, 1 to 2 mL/min. Values less than 0.1 mL/min are considered xerostomic.
- Sialography involves the injection of radio-opaque media into the salivary glands.
- Biopsy of major salivary glands when malignancy is suspected.

Management of xerostomia

- Identification of the underlying cause.
- Self-care: Patients should be encouraged to conduct a daily mouth examination, checking for red, white or dark patches, ulcers or tooth decay, plaque removal.
- Increasing existing saliva flow using saliva stimulants or sialagogues, such as chewing gum.
- Replacement therapy using Saliva substitutes
- Treatment of dental caries
- Specific measures such as treatment of infections.

Complications associated with xerostomia

- Decreases the oral pH and significantly increases the development of plaque and dental caries and tooth loss
- Gum disease as oral candidiasis.
- Inflammation or ulcers of the tongue and buccal mucosa, oral candidiasis, salivary gland infection (sialadenitis).


Thank You