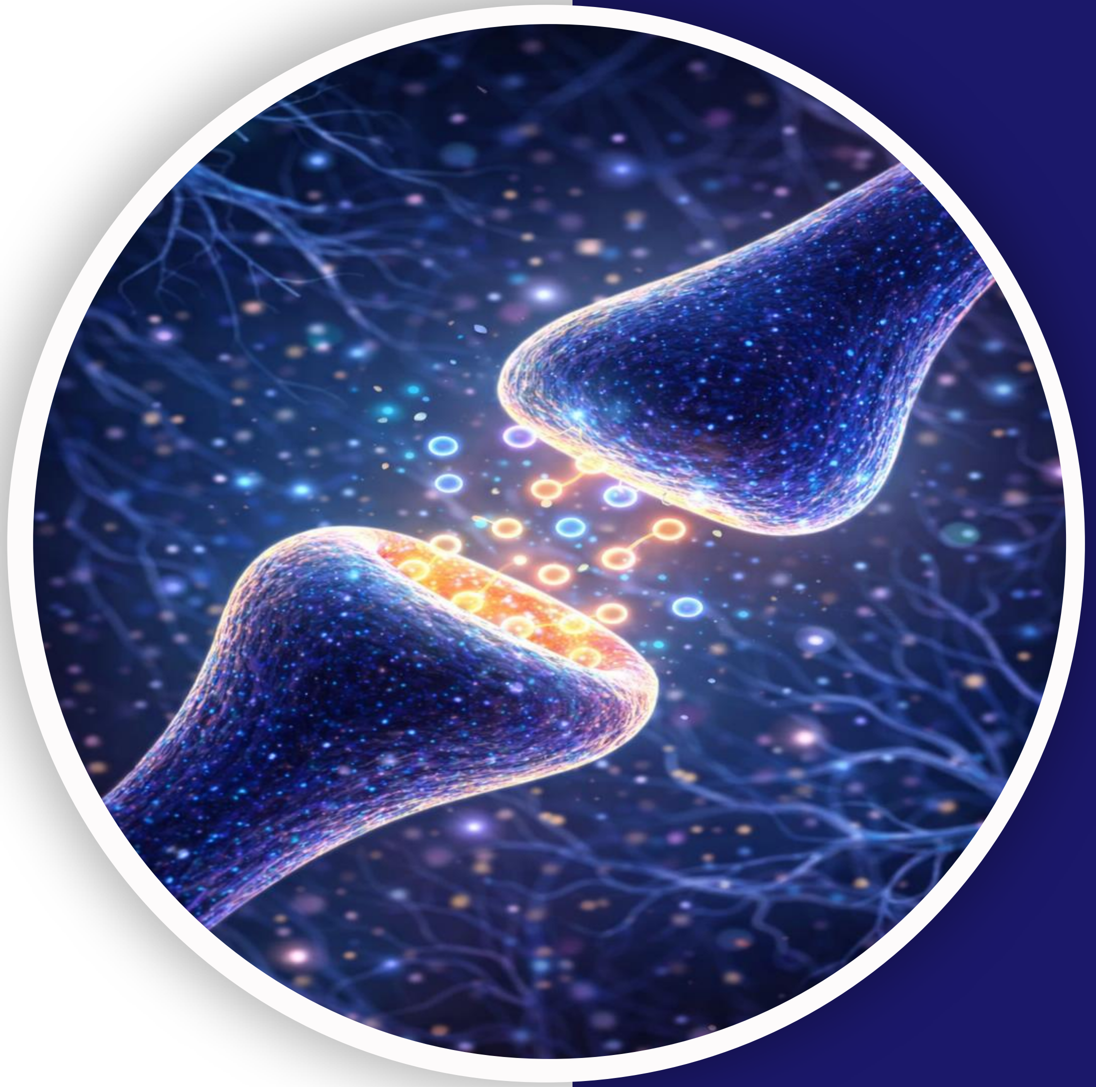
بسم الله الرحمٰن الرحيم

(وَفَوْقَ كُلِّ ذِي عِلْمٍ عَلِيمٌ)

MSS Physiology | MID 3

GI Secretions



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Motility of the Colon

رَبِّ اشْـــــرَحْ
لِي صَـــــدْرِي
وَيَسِّرْ لِي أَمْرِي

We have 2 types of movement along the colon :

- Haustration contractions:

  effect: propulsive

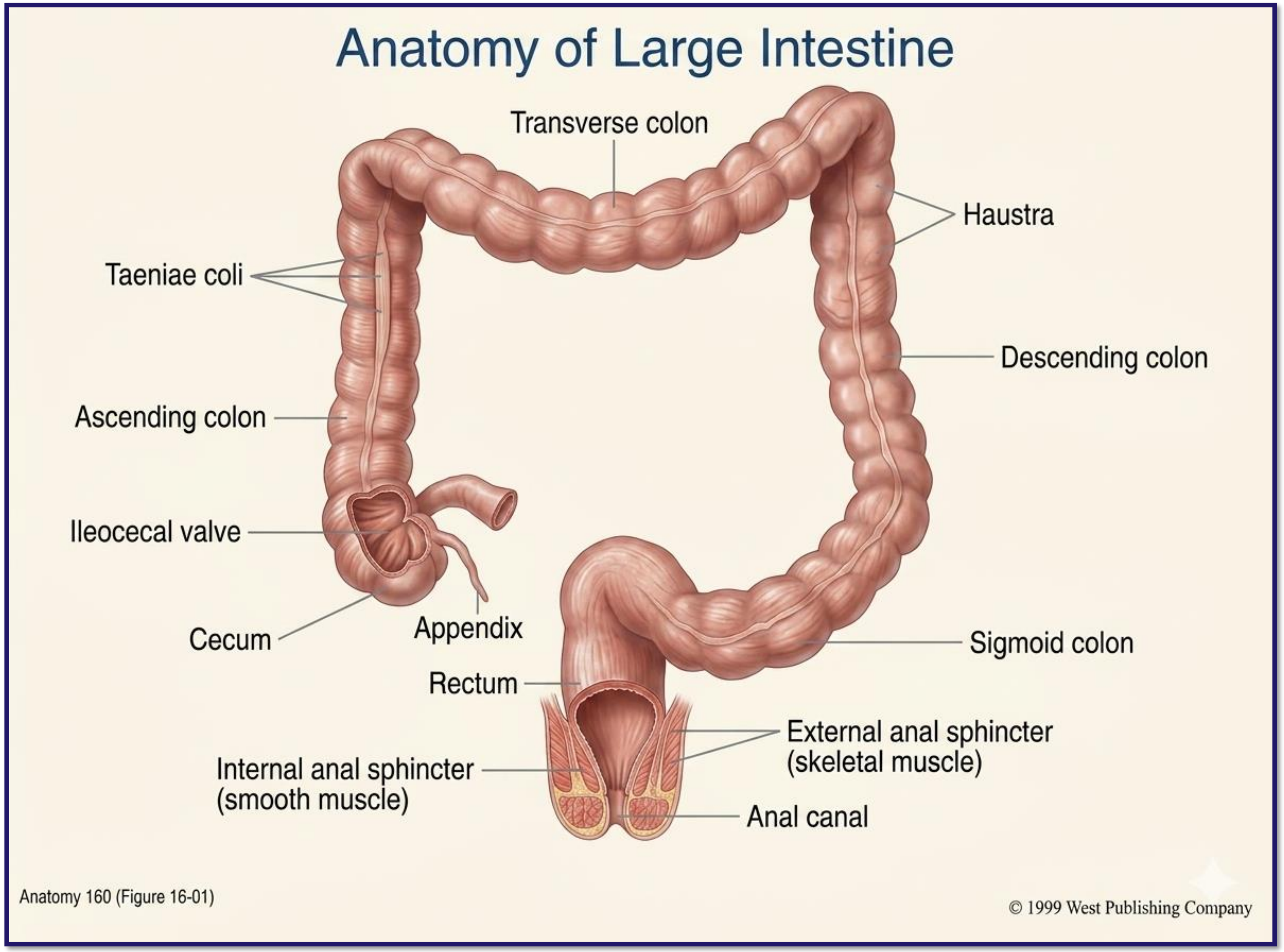
- Mass contractions: -

✓ acilitated by: gastrocolic and duodenocolic reflexes

✓ **effect: propulsive**

Motility of colon

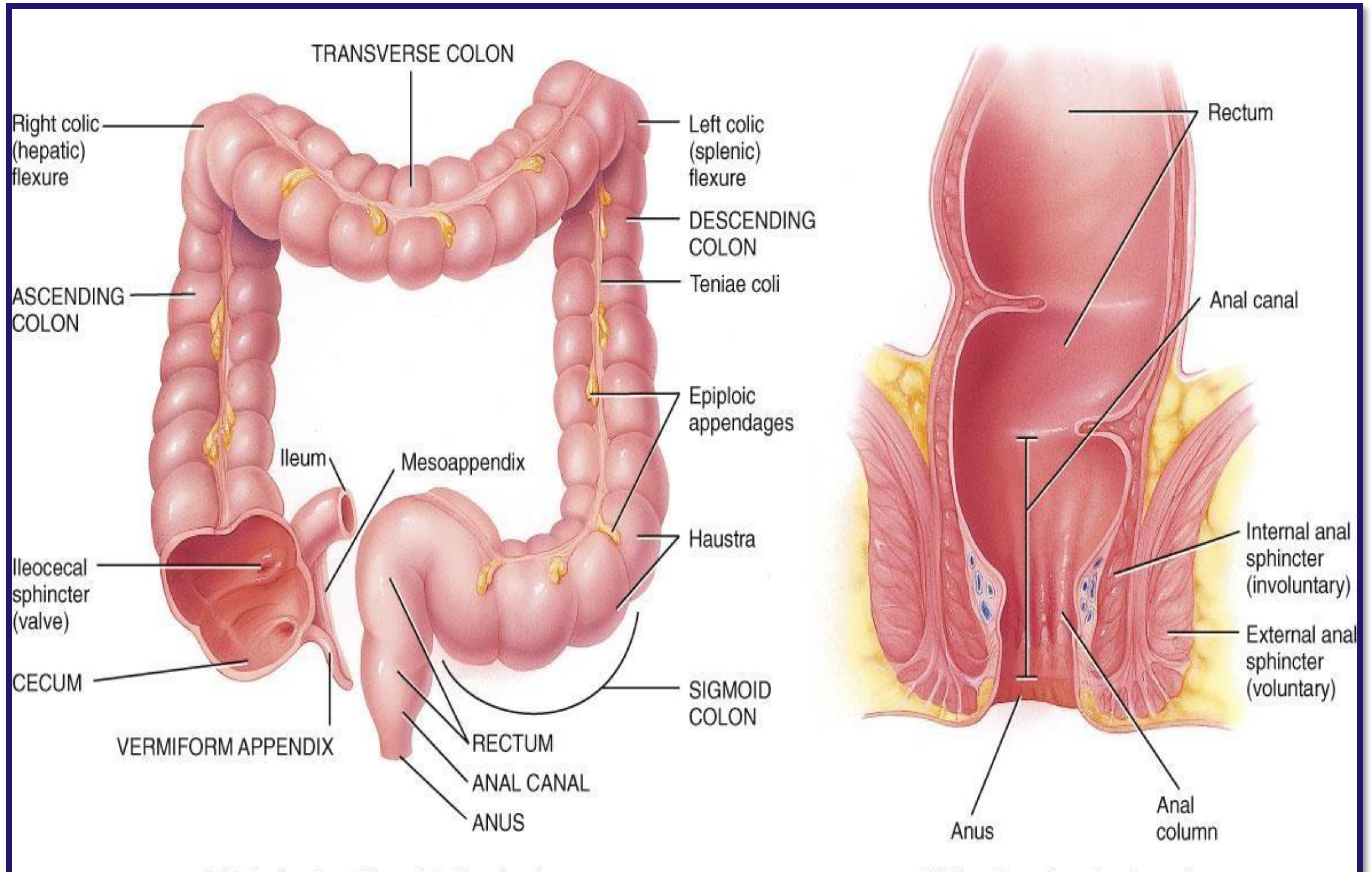
- **The colon lacks the segmentation contractions** that are present in the small intestine.
- The **haustra** are the **bulges of the colon**. Because of this characteristic appearance, the type of movement observed in the colon is referred to as **haustration contractions**, which occur along the colon.



Motility of colon

- The presence of **haustra in the colon** is primarily due to structural variations in the arrangement of the **longitudinal muscle layer**. Unlike the small intestine, where the longitudinal layer **is distributed relatively uniformly**, the colon exhibits a distinct organization in which the longitudinal muscle is concentrated into **three separate bands** known as the **taeniae coli**.

- These bands contain a **higher proportion of smooth muscle cells** and maintain a certain degree of **basal tone**. As a result of this tone, combined with the activity of the **circular muscle layer**, the colon develops **segmented bulges**. These bulges are referred to as **haustra**, and they give the colon its characteristic sacculated appearance. Anatomists have described this pattern as a form of **haustral segmentation**, and the associated motor activity is termed **haustral contractions**.



(a) Anterior view of large intestine showing major regions

(b) Frontal section of anal canal

- Regarding the **functional significance of haustral contractions**, their primary role is **not mixing**, but rather **propulsion of colonic contents**. These contractions contribute to the **gradual movement of intestinal contents from the cecum and ascending colon toward the transverse colon**. However, this propulsive effect is **relatively weak.** Consequently, the transit of contents through **this segment of the colon occurs slowly, often taking several hours (approximately 9 hours).**

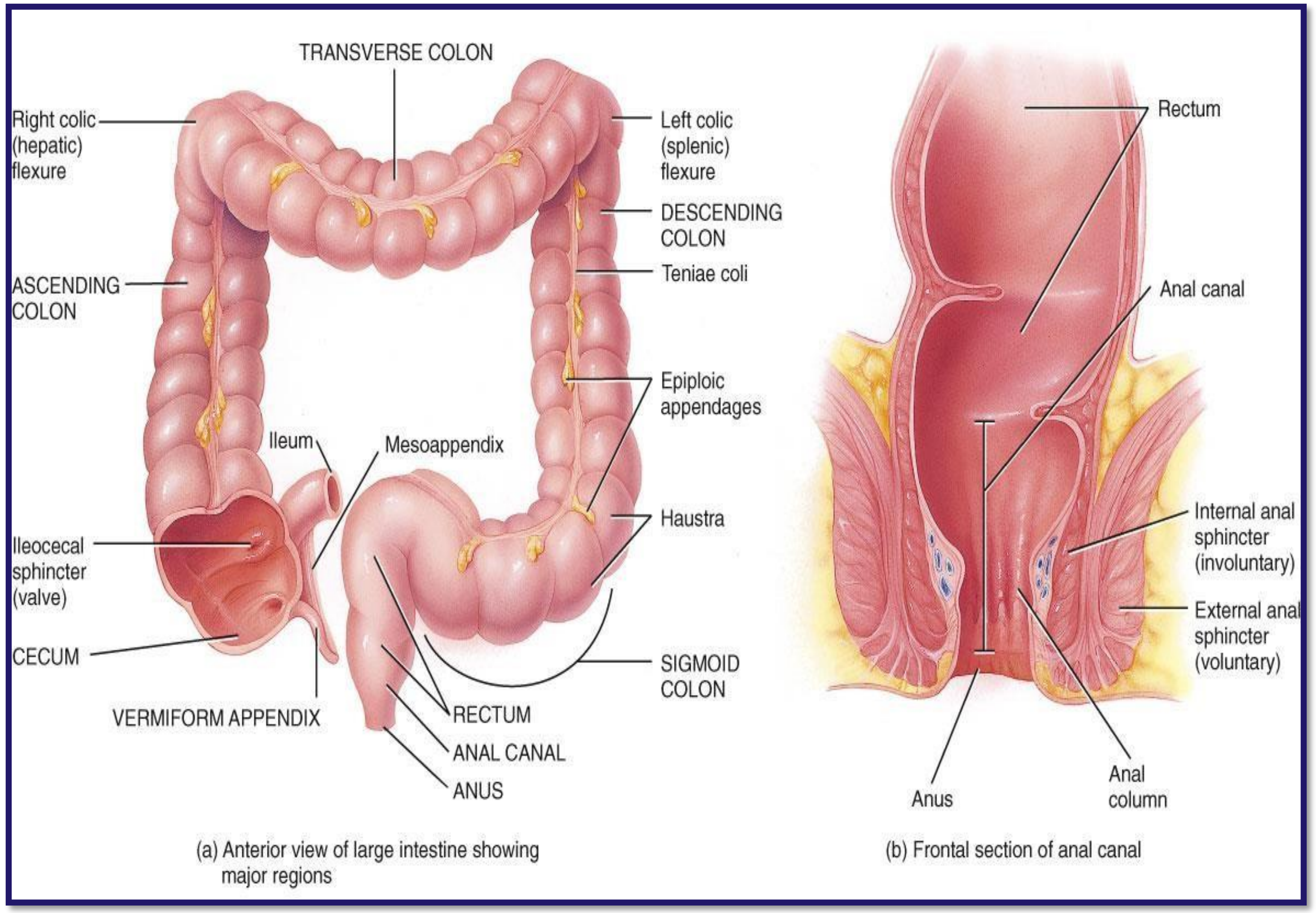
- This prolonged transit time is physiologically important, as it allows for **increased absorption of water and electrolytes**, which is a key function of the colon.

Motility of colon

- Once the intestinal contents reach the transverse colon, **they become less fluid and more solid in consistency.**

- At this stage, **more powerful motor activity is required to propel the contents toward the distal parts of the colon.** This is achieved through a different type of motility known as ***mass contractions***.

- Mass contractions are **functionally similar to peristaltic movements. They involve coordinated contraction of the proximal segment, relaxation of the distal segment, and shortening of the colonic segment in between.** This coordinated activity generates a strong propulsive force that effectively **moves the contents toward the lower parts of the colon.**



(a) Anterior view of large intestine showing major regions
(b) Frontal section of anal canal

- Compared to ordinary peristaltic contractions, mass contractions are **significantly more powerful** and are primarily **responsible for large-scale movement of colonic contents over longer distances.**

- However, mass contractions do not occur continuously throughout the day. Instead, they occur intermittently in episodes, typically **taking place once, twice, or up to three times per day**. Each episode consists of a series of contractions lasting **approximately 10-20 minutes**, followed by a **prolonged resting period of about 8 hours** before another series is initiated.

Gastrocolic Reflex and Defecation Mechanism

- The initiator of the mass contractions s the **gastrocolic reflex.**

- **gastrocolic reflex** refers to a physiological response triggered by **distention of the stomach after a meal**, particularly noticeable in the **morning following food intake.** This gastric distention **activates the reflex**, which in turn initiates **mass contractions along the colon**, leading to **propulsion** of contents from the **transverse colon toward the descending and sigmoid colon**.

- As the contents move distally, what happens to these colonic segments? They undergo **distention**, and this distention activates the ***intrinsic defecation reflexes***.

- Consequently, **colonic motor activity becomes more powerful, enhancing the propulsive movement** and driving the contents further toward the **rectum.**

- Once the fecal material reaches the rectum, what is the next step? The resulting **rectal distention** activates the ***extrinsic defecation reflexes***, which further **strengthen and reinforce the motor activity, facilitating movement of fecal matter toward evacuation.**

- Now, what is meant by ***intrinsic defecation reflexes,*** and which nervous system is involved? These reflexes are mediated by the **enteric nervous system (ENS)** and **originate locally within the gastrointestinal tract**, contributing to the initiation and coordination of colonic motility.

Gastrocolic Reflex and Defecation Mechanism

- In contrast, what are ***extrinsic defecation reflexes***, and which mediated by **autonomic nervous system**, predominantly the **parasympathetic fibers** **arising from the sacral spinal cord (S2–S4)**. These fibers **augment and intensify colonic contractions**, thereby **reinforcing the propulsive activity required for defecation.**

- However, is activation of these reflexes alone sufficient for defecation? Defecation can only occur if there is appropriate relaxation of the **anal sphincters**. What types of sphincters are present? There are two: the **internal anal sphincter** and the **external anal sphincter**.

- The internal anal sphincter, composed of smooth muscle, relaxes involuntarily during both intrinsic and extrinsic reflexes. In contrast, the external anal sphincter consists of skeletal muscle and is under **voluntary (somatic) control**, allowing the individual to regulate the timing of defecation.

- **Finally, what happens when fecal material is hard due to increased absorption of water and electrolytes?**

✓ In such cases, defecation may require an increase in **intra-abdominal pressure**. This is achieved **through contraction of the abdominal muscles**, which enhances the expulsive force necessary to evacuate the fecal material and complete the process of defecation.

Defication

- Intrinsic reflexes

  This is a local reflex mediated entirely by the enteric nervous system within the rectal wall.

- Extrinsic reflexes -

  This is a spinal cord reflex that "fortifies" the intrinsic reflex, making it much more powerful.

Defecation Reflexes

Intrinsic Myenteric vs. Parasympathetic (Extrinsic) Reflex

FEATURE	INTRINSIC MYENTERIC REFLEX	PARASYMPATHETIC (EXTRINSIC) REFLEX
Control Center	Local (Enteric Nervous System)	Central (Sacral Spinal Cord)
Mediating Nerves	Myenteric Plexus	Pelvic Nerves (Parasympathetic)
Trigger	Distention of the rectal wall	Distention of the rectal wall
Relative Strength	Weak; usually ineffective alone	Strong; provides the "power" for emptying
Scope of Action	Localized to the distal rectum/anus	Extends from the splenic flexure to the anus
Effect on Sphincter	Relaxes internal anal sphincter	Strongly relaxes internal anal sphincter

Defication

❖ **Intrinsic Myenteric Defecation Reflex.**

- This is a local reflex mediated entirely by the **enteric nervous system** within the rectal wall.
- **Mechanism:** When feces enter the rectum, the distention of the rectal wall sends afferent signals through the **myenteric plexus**.
- **Action:** This initiates peristaltic waves in the descending colon, sigmoid colon, and rectum. As the wave approaches the anus, the **internal anal sphincter** is inhibited (relaxed) by inhibitory signals from the myenteric plexus.
- **Limitation:** On its own, this reflex is relatively weak and often insufficient to cause effective defecation without external reinforcement.

❖ **Parasympathetic (Extrinsic) Defecation Reflex**

- This is a spinal cord reflex that "fortifies" the intrinsic reflex, making it much more powerful.
- **Mechanism:** When the nerve endings in the rectum are stimulated by distention, signals travel via **afferent nerve fibers** to the sacral segments of the spinal cord (S2–S4).
- **Action:** The signals are reflexively sent back to the descending colon, sigmoid, rectum, and anus via **parasympathetic nerve fibers** in the **pelvic nerves**.

Pathophysiology and Control of Colonic Motility

- There are several **physiological and pathological conditions** associated with colonic motility.

- For instance, what happens in cases of **hypermotility**?

  - ✓ Hypermotility of the colon results in ***constipation***, due to **ineffective coordination of propulsive movements**. In contrast, **excessive irritation of the colon** leads to ***diarrhea***; however, what type of diarrhea is observed in this case? It is specifically **mucus diarrhea rather than watery diarrhea**.

- Why does mucus diarrhea occur?

  - ✓ This is explained by the fact that **the colon normally secretes a large amount of mucus (later in the lecture of secretions)**. When the colon is **highly irritated, there is an increased urge for defecation**, but instead of expelling fecal material, the individual passes **small amounts of mucus** due to **normal excessive mucosal secretion and irritation.**

- Next, what controls the activity of the **circular muscle layer**?

  - ✓ The circular layer exhibits **rhythmic electrical activity**, resulting in coordinated contractions and relaxations. When one segment undergoes contraction, the adjacent segment undergoes relaxation; this pattern is referred to as a **rhythmic, segmental (static) contraction**, which is characteristic of haustral activity.

  - ✓ In addition to these rhythmic contractions, **mass contractions** follow a different pattern characterized by **contraction proximally and relaxation distally**, producing effective propulsion of colonic contents.

  - What controls this coordinated pattern?
    - ✓ This process is regulated by the **enteric nervous system (ENS)**, which also mediates the **intrinsic defecation reflexes**.

Pathophysiology and Control of Colonic Motility

- What would happen if there is a decreased representation of the enteric nervous system in the colon?

  - ✓ This would lead to **reduced motility**, resulting in accumulation of intestinal contents over time. Consequently, the colon becomes **distended and enlarged**, leading to a condition known as **Hirschsprung's disease (congenital megacolon)**. This disorder arises due to the absence or deficiency of enteric neurons in segments of the colon.

- A similar mechanism can be observed in the esophagus. What happens when there is decreased enteric innervation in the esophagus?

  - ✓ This results in **achalasia**, characterized by impaired motility and dilation of the esophagus due to failure of proper relaxation and coordination.

- In summary, colonic motility follows a coordinated sequence: it begins with **haustral contractions**, progresses to **mass contractions**, and subsequently activates the **intrinsic defecation reflexes**, followed by the **extrinsic defecation reflexes**, ultimately leading to the act of **defecation**.

Gastrointestinal Physiology

Secretion

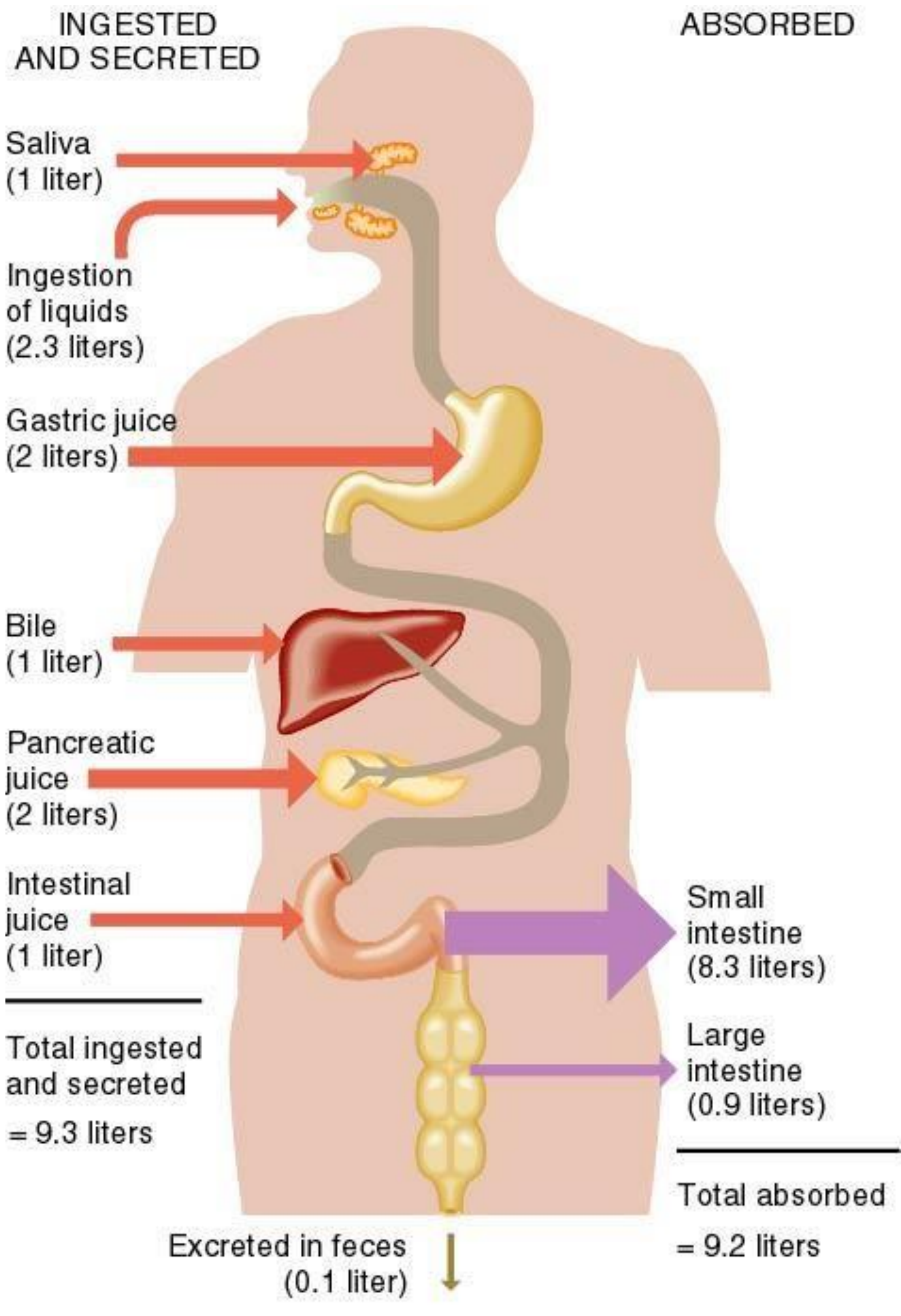
Secretion

- The gastrointestinal tract is not only involved in digestion and absorption but also in the **secretion of large volumes of fluids** into its lumen. These secretions originate from multiple organs and contribute significantly to the overall fluid dynamics within the body.

- For example, what is the daily amount of salivary secretion?
  - ✓ The salivary glands produce approximately **1.5 liters per day**. In addition, there are **esophageal secretions**, which are primarily **mucus in nature**, serving a lubricative and protective function. The stomach also contributes significantly by secreting about **2 liters of gastric juice per day**.

- When considering total fluid input into the gastrointestinal tract, what are the main contributors?
  - ✓ Ingested fluids account for approximately **2 liters per day**, which, when combined with salivary and gastric secretions, significantly increases the luminal fluid volume. Furthermore, the **liver secretes about 1 liter of bile per day**, while the **pancreas releases approximately 2 liters of pancreatic juice**. The **small intestine itself contributes around 1 liter of intestinal secretions**.

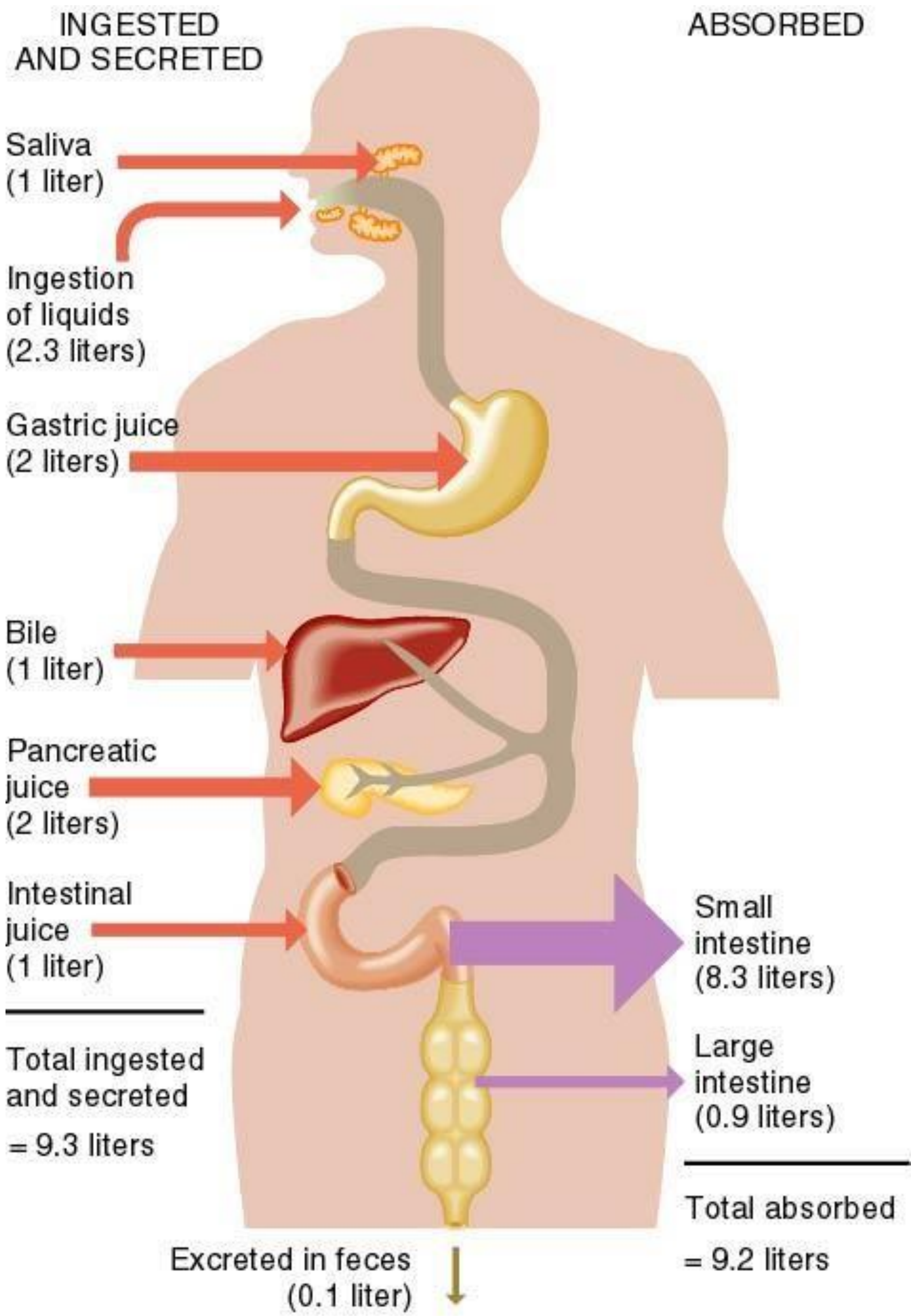
- If all these sources are combined, **the total volume of gastrointestinal secretions will reaches approximately 9.3 liters per day**, representing a substantial fluid load within the intestinal lumen.



Fluid balance in GI tract

Secretion

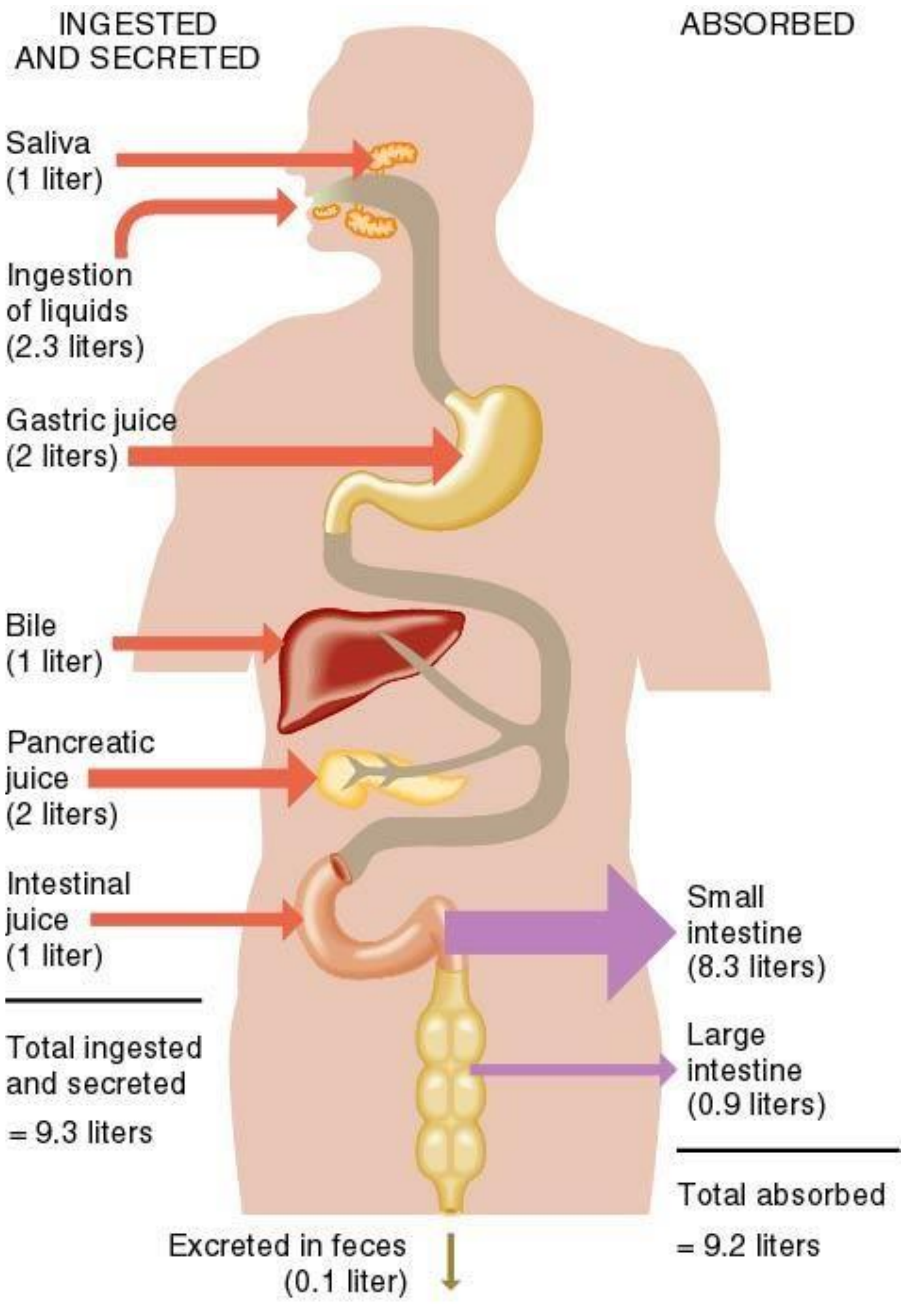
- What happens to this large volume of fluid?
  - ✓ Most of it is **reabsorbed along the gastrointestinal tract**, particularly in the **distal small intestine (ileum)**, where about **85% of the fluid is recovered**. The remaining fluid passes into the colon, which is responsible for the **final absorption of water and electrolytes** from the chyme.
- What is the overall balance between secretion and absorption?
  - ✓ Approximately **9.2 liters are reabsorbed**, leaving only about **100 mL of water lost in feces per day**, which reflects an efficient balance between secretion and reabsorption.
- What occurs in pathological conditions such as cholera?
  - ✓ In such conditions, there is **increased intestinal motility and secretion**, particularly in the small intestine, leading to **impaired reabsorption of fluids**. Consequently, there is a massive loss of water and electrolytes, resulting in **severe dehydration**.
- How should such conditions be managed?
  - ✓ The first-line management is **fluid and electrolyte replacement**, typically using **oral rehydration solutions (ORS)** available in pharmacies. These solutions help restore the lost fluids and maintain electrolyte balance. Why are anti-diarrheal medications not recommended as first-line therapy? Because it is important to allow the intestine to **eliminate pathogens or toxins naturally**, rather than suppressing motility prematurely.



Fluid balance in GI tract

Secretion

In summary,
Gastrointestinal physiology maintains a delicate balance between **large volumes of secretion and efficient reabsorption**, and disruption of this balance—especially due to increased motility—can lead to significant clinical consequences such as dehydration.



Fluid balance in GI tract

Functions

Provided by secretory glands which serve 2 functions:

- Digestive enzymes, essential for the process of digestion.
- Lubrication and protection of the mucosa.

Once food is ingested, it needs to be lubricated; therefore, **saliva is secreted**, which is important for lubricating the food and facilitating the **process of swallowing**.

Types of secretory structures

- The types of secretory glands:
  - Single-cell secretory glands (goblet cells).
  - Pits (within mucosa): that represent invaginations of the epithelium in the submucosa in small intestine are known as crypts of Lieberkühn.
  - Complex glands (within submucosa) : in stomach and duodenum.
  - Organs: salivary, pancreas and liver. Located outside the tubular structure of the GI.

Control of secretion

Neural Control

ENS:

ANS:

Parasympathetic: generally **increases secretory activity.**

Sympathetic:

- **moderate increase →**
- **it reduces secretion by reducing blood →flow.**

- The **sympathetic** component has a more complex but overall **inhibitory effect** on secretions. Its main action is through **vasoconstriction**, which reduces blood flow to the secretory structures. As a result, there is a **decrease in the availability of water and electrolytes**, leading to reduced secretion.

- However, the sympathetic system can also act on **mucus-secreting structures**, where it may **increase vesicular transport and mucus formation**, resulting in a slight increase in mucus secretion. Because of this, some literature may describe a moderate increase in secretion under sympathetic stimulation.

- Despite this localized effect on mucus, the **dominant effect of sympathetic stimulation** remains **inhibition of water and electrolyte secretion** due to reduced blood supply to the secretory tissues.

Hormonal regulation

- **Some hormones are secreted by the presence of food or other local changes in the digestive organs.**

- There are also many **hormones involved in the regulation of gastrointestinal functions**. The specific aspects of hormonal control will be addressed in detail when discussing regulation at the level of individual organs, such as the **stomach**, **gallbladder**, and **pancreas**.

Salivary Secretions

Salivary Secretions

- Anatomically, there are several types of salivary glands.

- The **submandibular glands** produce a **mixed secretion (mucous and serous)** and contribute approximately **70% of total saliva**. The **parotid gland** primarily produces **serous secretion**, contributing about **25% of saliva.** In contrast, the **sublingual glands** mainly release **mucous secretions**, accounting for approximately **5% of total salivary secretion**.

Salivary Glands

Name of Gland	Type of Saliva	% of Total Saliva Secreted
Submandibular	Mucous-serous	70
Parotid	Serous	25
Sublingual	Mucous	5

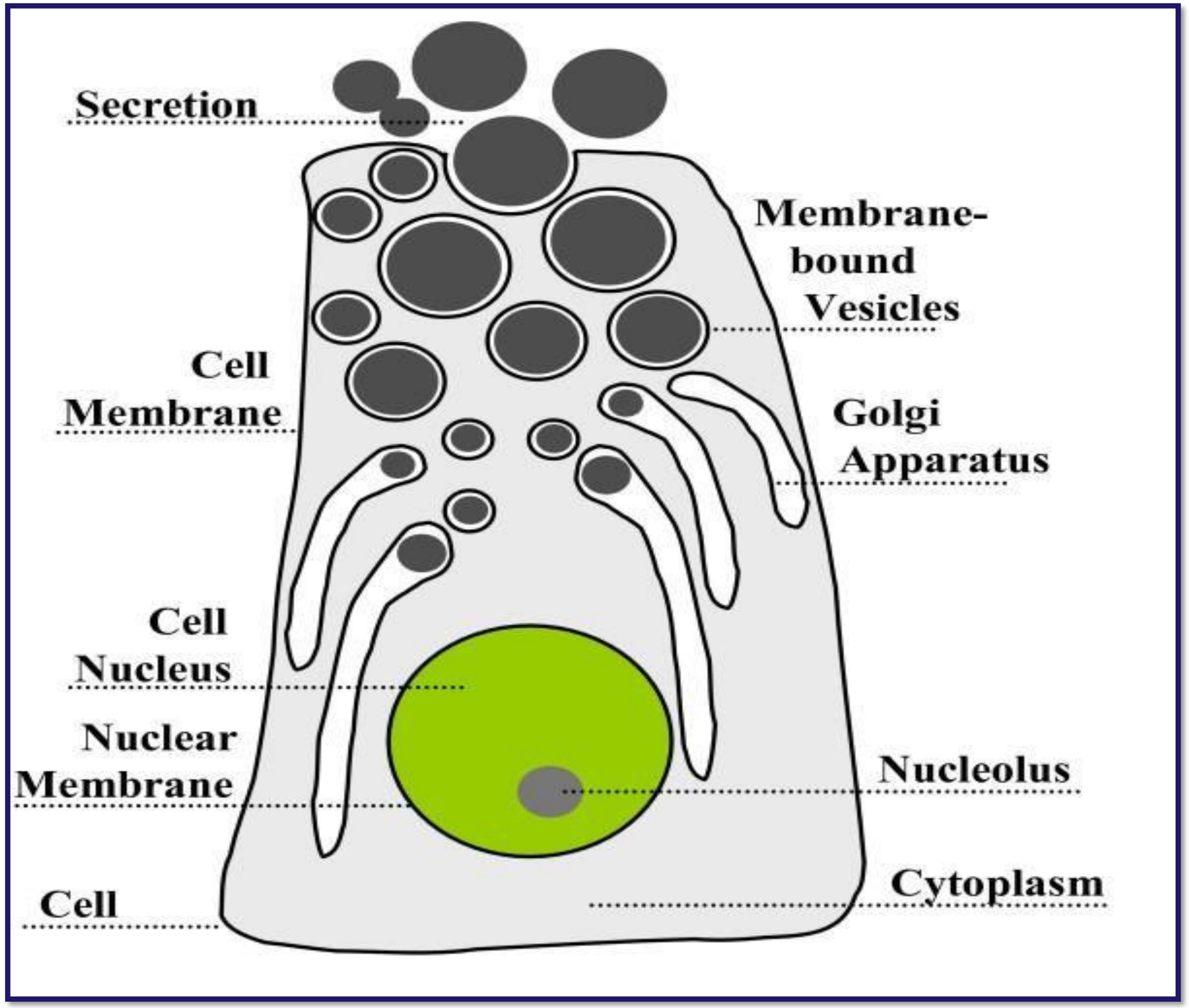
Mucus (Mucin) Secretion

- Mucus secretion involves the release of **mucin**, which is a **glycoprotein**. The cells responsible for mucus secretion function similarly to other **protein-secreting cells**.

- How does this secretion occur?

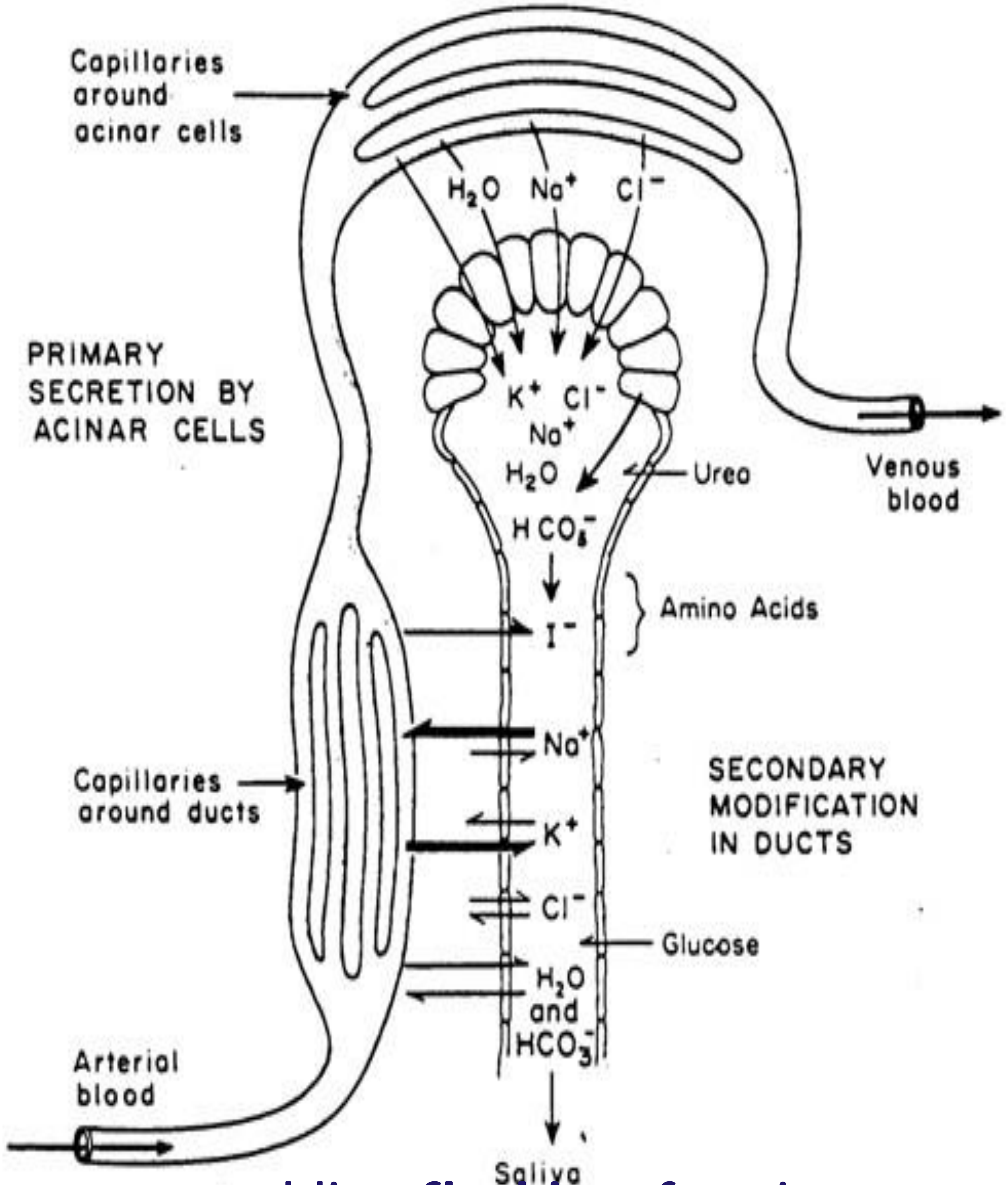
  - ✓ It is carried out by **vesicular transport**, where mucin is packaged into vesicles and released from the cell. This mechanism is characteristic of protein secretion and is **different from the mechanism involved in water and electrolyte secretion**.

- ❖ In histology, these mucus-secreting cells are identifiable as cells specialized in **protein production and secretion**.



Water and Electrolyte Secretion

- Water and electrolyte secretion in the salivary glands involves two main types of cells:
  - **Acinar cells.**
  - **Duct cells.**



- What is the role of acinar cells?
  - ✓ The **acinar cells** are responsible for secreting **water and electrolytes** into the duct system.

- How does this process occur?
  - ✓ At the **basolateral membrane**, there is **active transport of chloride ions (Cl^-)** from the interstitial fluid into the cell. This increases the **negative charge** داخل الخلية, which attracts **positively charged sodium ions (Na^+)** from the interstitial fluid.

- What happens to osmolarity?
  - The osmolarity داخل المنطقة increases, leading to **osmotic movement of water toward the lumen**.
  - As a result, water and electrolytes are secreted into the duct system by a process resembling **flushing**, forming what is known as **primary saliva**.

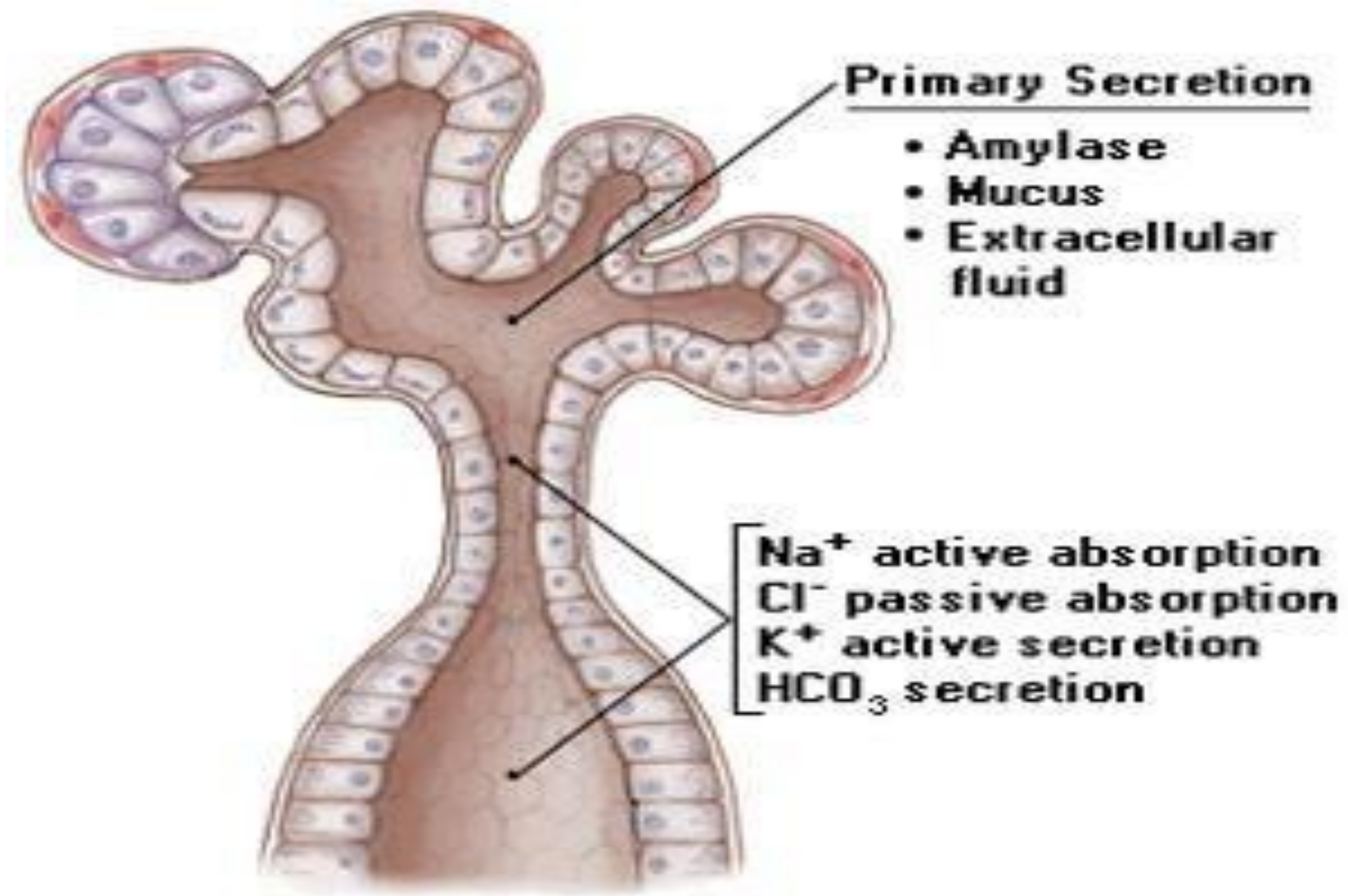
What is the composition of primary saliva? It is initially **similar to interstitial fluid**, meaning it is:

·Rich in **sodium (Na^+).**
·Rich in **chloride (Cl^-).**
·Low in **potassium (K^+).**

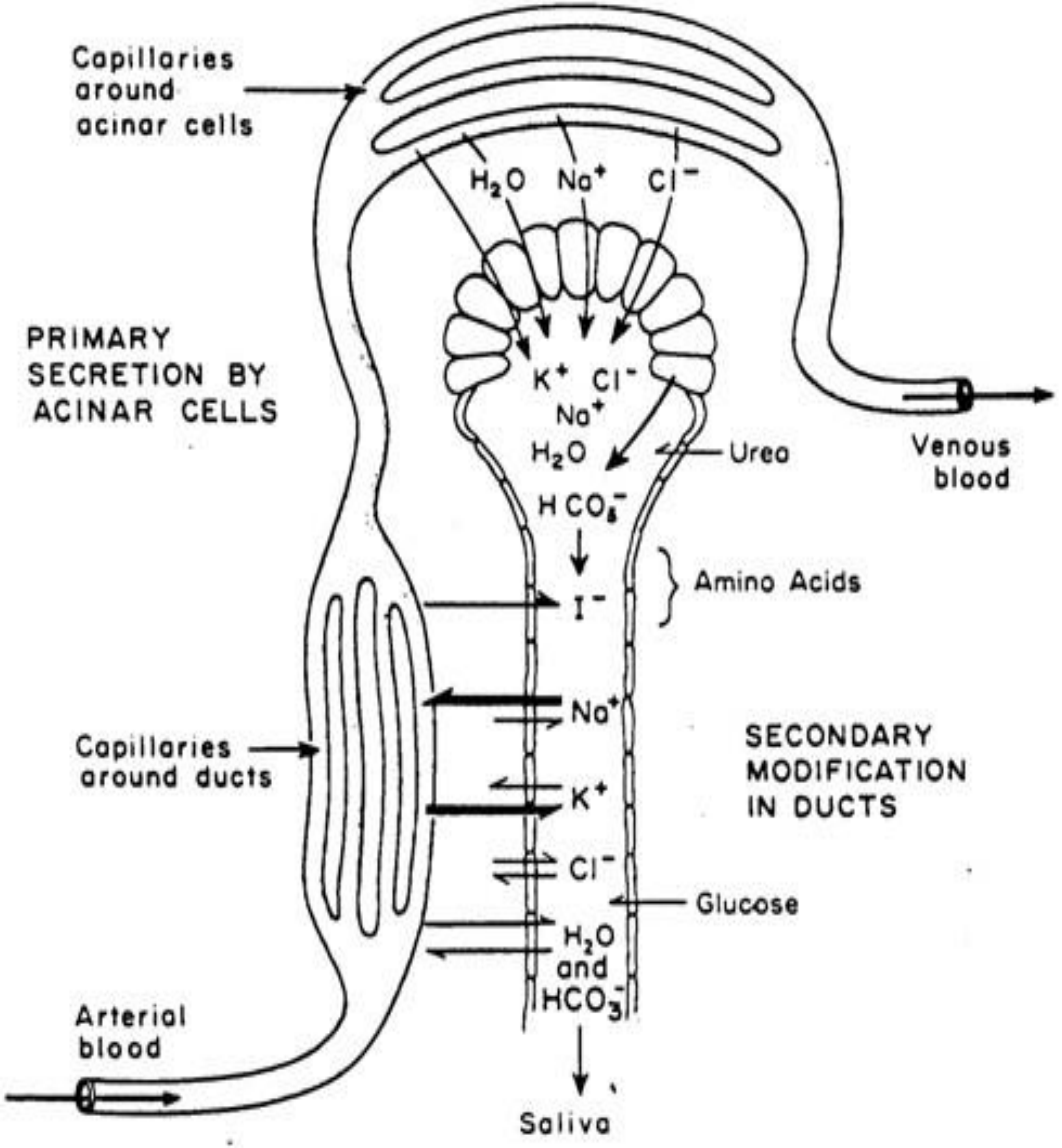
What happens next? As this primary saliva passes through the ducts, it undergoes **modification by duct cells**, leading to changes in its final composition.

Mechanism of Secretion

- **Active transport of Cl-** at the basal portion of the membrane.
- Increase in negativity of membrane potential which **attract the positive ion (Na+).**
- Increase osmotic pressure inside the cell >> **pull water inside** >> increase hydrostatic pressure.
- This increase results in **minute ruptures at the lumenal part** of the membrane which causes flushing of water,



Primary Secretion
• Amylase
• Mucus
• Extracellular fluid
Na+ active absorption
Cl- passive absorption
K+ active secretion
HCO3 secretion


Capillaries
around
acinar cells
H_2O Na^+ Cl^-
PRIMARY
SECRETION BY
ACINAR CELLS
K^+ Cl^-
Na^+
H_2O
HCO_3^-
Urea
Venous
blood
Amino Acids
I^-
Na^+
Capillaries
around ducts
K^+
SECONDARY
MODIFICATION
IN DUCTS
Cl^-
Glucose
H_2O
and
HCO_3^-
Arterial
blood
Saliva

Changes in Composition in Final Saliva

↓ the Na+ and Cl- concentration to the 1/10 of their plasma concentration

↑ 7 folds increase in K+ concentration.

↑ HCO_3^- concentration also increases 2-3 times.

- Now, an important question arises: can the **composition of final saliva** remain the same under basal conditions and during stimulation? The answer is **no**.

- Under **basal conditions**, the rate of salivation is low, and the **pH is approximately around 7**, being nearly neutral. However, upon stimulation, the rate of salivation can increase significantly, reaching up to **20-fold**.

- With such a high flow rate, is there sufficient time for full modification of saliva within the ducts? The answer is **no**, and this leads to changes in the final composition.

- What happens to the pH during stimulation? The **pH increases**, which indicates **increased formation and secretion of bicarbonate by the duct cells**. As a result, the saliva becomes **more alkaline** compared to basal conditions.

Rate of Secretion

- The amount of salivary secretion is about 1500ml/day.

- Resting secretion rate 0.025-0.5ml/min (during basal conditions).

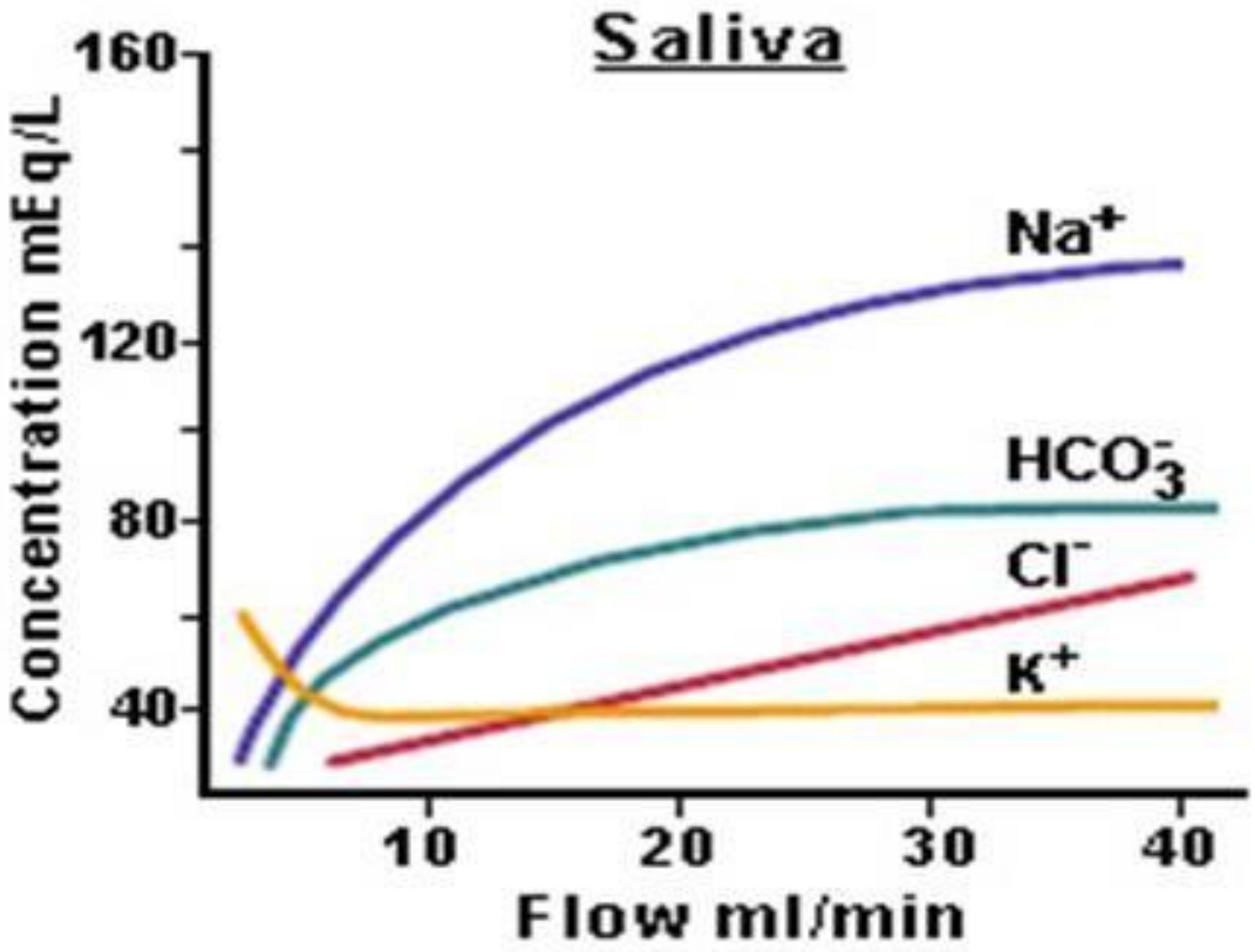
- The pH = 7.0

DURING MAXIMAL STIMULATION

- The primary saliva increasing **20** folds.
- Flow rate of saliva is increased **PH=8.**

At a **low rate of salivation**, there is sufficient time for ductal modification. Therefore, there is **increased secretion of potassium**, along with **greater reabsorption of sodium and reabsorption of chloride**.
In contrast, what happens at a **high rate of salivation?** Due to the reduced time available for modification, the **potassium concentration becomes lower** compared to the low rate, while the **sodium and chloride concentrations become higher**.

What about bicarbonate? It is important to note that the **bicarbonate concentration is also higher at high flow rates**. This indicates that there is **increased formation and secretion of bicarbonate during stimulation**, resulting in its higher concentration in saliva.



Control of salivary Secretion

How is the salivation process controlled? It is important to clarify that salivary secretion is **not regulated by the enteric nervous system**, as no enteric fibers reach this region.
Instead, the primary control of salivation is achieved through the **autonomic nervous system**.

Autonomic nervous system.

- Both sympathetic and parasympathetic increase salivation but by different mechanisms.

- **parasympathetic** **increase water and electrolyte secretion.**

- **Sympathetic** **increase mucin synthesis** An increase in the sympathetic activity → **reduces salivation.**

Control of salivary Secretion

Aldosterone:

> **Aldosterone can affect ion transport**, leading to **increased sodium absorption and potassium secretion**, this represents a **general systemic effect.** It is **not a primary controller of the salivation process** or the activity of duct cells.

Salivation is increased by:

- **Unconditioned** salivary reflex (dental procedures).
- **Conditioned** salivary reflex (learned – response).

- Salivation can be increased through **parasympathetic stimulation**, which operates via both **unconditioned and conditioned reflexes**.

- What is the difference between unconditioned and conditioned reflexes? **Unconditioned reflexes** are **innate, general responses**, whereas **conditioned reflexes** are **learned responses** acquired through experience.

- In the case of **unconditioned reflexes**, salivation increases in response to direct stimuli. For example, during **dental manipulation** or while **eating food**, salivary secretion is naturally stimulated and increases.

- In contrast, **conditioned reflexes** depend on prior experience. For instance, if an individual becomes accustomed to eating from a particular plate, the mere presentation of that plate—even if empty—can lead to **increased salivation**. Similarly, exposure to the **smell or thought of delicious food** can stimulate salivation, provided there has been a previous association with that stimulus.
- Thus, salivary secretion is enhanced through both **innate reflex mechanisms** and **learned (conditioned) responses** mediated by parasympathetic activity.

Functions of Saliva

- Saliva begins **digestion** of carbohydrates in the Saliva begins digestion of carbohydrates in the mouth:

- **Amylase** that breaks polysaccharide into maltose (disaccharide consists of 2 glucose).

- **Facilitate swallowing** by:

Moistening the food particles.

Lubrication BY mucous secretion

NOTE: The optimal activity of the **amylase enzyme** occurs at an **alkaline pH**. Once food is ingested and reaches the **stomach**, the environment becomes **acidic**, which is not optimal for the activity of amylase.

Functions of Saliva

- Antibacterial actions:

A lot of Lysozyme: an enzyme that lyses or destroys certain bacteria,contain **sugars as part of their structure**, including bacterial antigens. By **digesting these components**, lysozymes can **alter the integrity of the bacteria and lead to their destruction**..

- Oral hygiene :

keeping mouth and teeth clean (continuously rinsing your mouth) by the constant flow and secretion of IgA which helps in the destruction of bacteria, .

Functions of Saliva

- **Solvent** for molecules that stimulate taste buds, When studying the nervous system and taste buds, the substances being tasted must first dissolve in saliva to activate the receptors..

- **Aids speech,** Imagine having no salivation—can you continue speaking? In reality, speech becomes difficult very quickly and may stop after only a few minutes..

- Bicharbonate **neutralizes acids** →

→preventing cari (tooth decay)

These acids are produced as **metabolic products of bacteria**, particularly **saprophytic bacteria in the mouth**.
Example: These bacterial acids can damage teeth, leading to **dental caries (tooth decay)**. Therefore, a higher bicarbonate concentration is essential to **neutralize these acids** and help prevent the development of cari.

Esophageal secretion

- **Simple mucus glands** and solitary cells (mucoid character) help in lubrication and protection.

- **Compound mucus glands** near the esophago-gasrtic junction and protect the esophagus from reflux.

Esophageal Secretions further explanation

What about **esophageal secretions?** The esophagus primarily secretes **mucus**, which plays a key role in **lubrication and protection** of the mucosa.

Anatomically, the distribution of mucus-secreting glands varies along the esophagus. In the **upper part**, there are mainly **simple mucous glands within the mucosa**. In contrast, the **lower part of the esophagus** contains **more abundant mucous glands (including compound mucous glands)**, resulting in **greater mucus secretion**.

Why is more mucus needed in the lower part? This is related to the risk of **gastroesophageal reflux**, where **acidic gastric contents** may move back into the esophagus due to dysfunction of the **lower esophageal sphincter (LES)**.

What is the consequence of this reflux? The acidic content can **damage the esophageal mucosa**, as the esophagus is not well adapted to withstand low pH.

Some people experience **heartburn** حرقة, a burning sensation in the chest, due to the reflux of acidic gastric contents into the esophagus.

Therefore, the increased mucus secretion in the **lower esophagus** provides an important **protective barrier**, helping to reduce mucosal damage caused by gastric acid.

Gastric Secretions

At the structural level, the stomach contains a **mucosal layer**, within which there are numerous **glands**. These glands open into structures known as **gastric pits**, which are abundant throughout the gastric mucosa.
What are these gastric pits composed of? They are formed by different types of **secretory cells**, which together constitute the **gastric glands (gastric pits)** responsible for secretion.

Further details regarding the types of these secretory cells and their specific functions will be discussed later.

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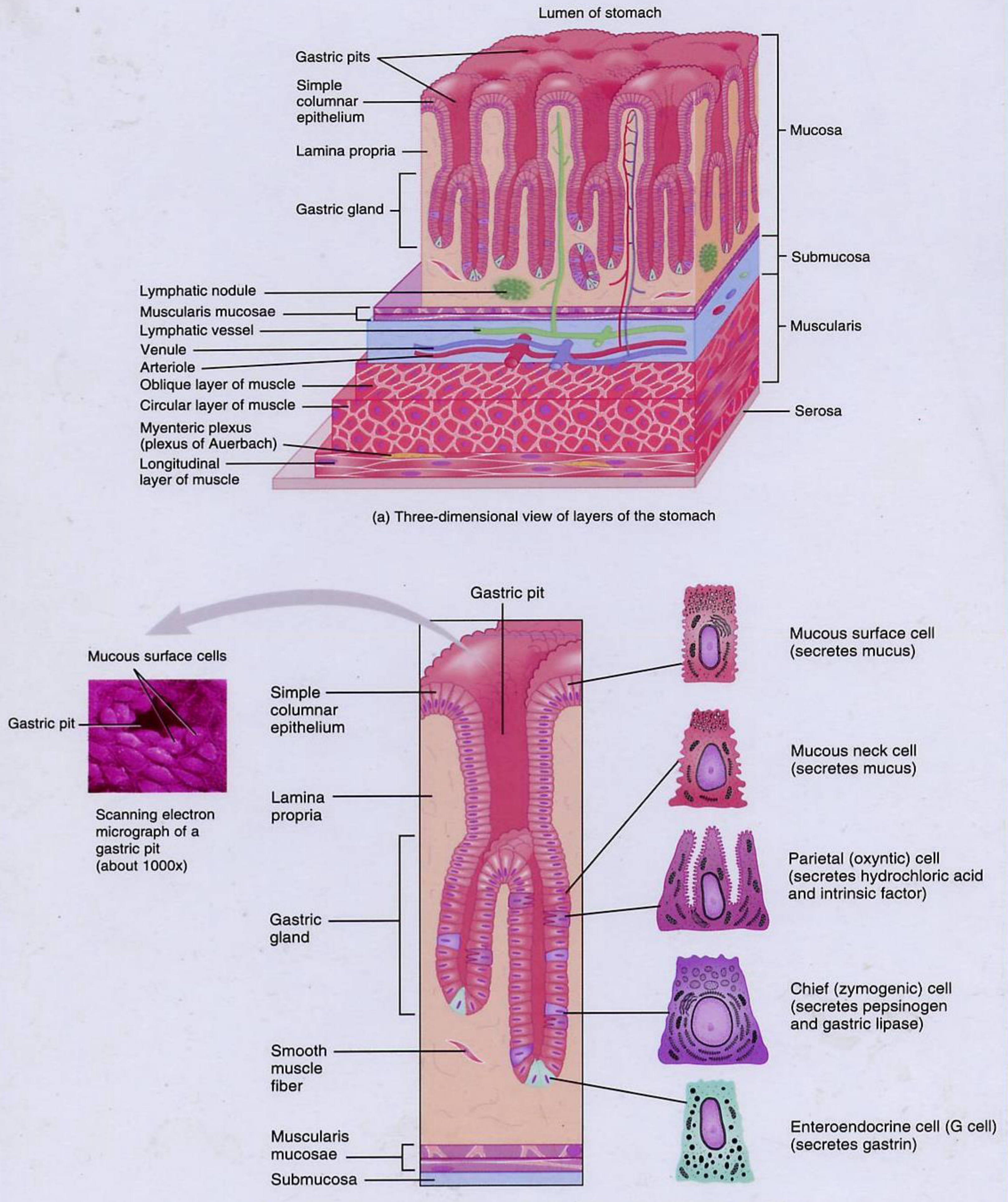

(a) Three-dimensional view of layers of the stomach

(b) Sectional view of the stomach mucosa showing gastric glands

Histology of the Stomach: Layers of the Stomach and the Stomach Mucosa, Fig# 24.12a-b

DR.'S HANDOUT

University of Jordan Faculty of Medicine
Department of Physiology and Biochemistry
Medical students. Academic year 2023/2024.
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Gastrointestinal Physiology: Part II.

GASTROINTESTINAL SECRETION:

Secretions along digestive system appear as a response to the presence of food in GI tract. The composition of secretions (enzymes and other constituents) varies according to the type of food, and serves to:

- Digest food.
- Lubricate and protect the mucosa.

The composition of secretion includes:

- Organic materials that secretory cells synthesize are stored in vesicles, and then secreted upon stimulation.
- Water and electrolytes are taken from blood vessels, and then secreted by secretory cells.

Many types of secretory glands are found along the GI tract, these include:

- Single-cell secretory glands (goblet cells).
- Pits that represent invaginations of the epithelium in the submucosa in small intestine are known as "Crypts of Lieberkühn" and in the stomach "Tubular glands".
- Complex glands: like mucus glands at lower part of esophagus.
- Organs: like Salivary glands, Pancreas and Liver.

Located outside the tubular structure of the GI.

Regulation of glandular secretion: <u>The role of ENS</u>:

The presence of food in certain segments usually stimulates glandular secretions. This appears as a response to mechanical or chemical stimulation, which induces activation of secretory reflexes that are responsible for the increased secretions by gland.

The role of Autonomic nervous system:

- Parasympathetic stimuli increase the rate of glandular secretions.
- Sympathetic stimuli can cause moderate increase in glandular secretion by increasing vesicular transport (increases secretion of organic materials).
  On the other hand it can reduce secretion of water and electrolytes by its effect on vessels (reduces blood flow).

Hormonal regulation:

- Some hormones are secreted by the presence of food in digestive organs which affect the glands where they stimulate secretions.

SALIVARY GLANDS SECRETION:

General consideration:

Secretion: is a net movement of water, electrolytes and proteins (starch splitting enzyme (amylase) and glycolproteins) into the lumen of salivary duct.

The role of acinar cells:

- Secretion of water and electrolytes:

Origin of water and electrolytes is extracellular fluid. The acinar cells are surrounded by capillary plexus which plays an important role in glandular secretion.

Proposed steps of secretion:

1.Active transport of Cl- at the basal portion of the membrane causes more negative membrane potential.
2.Increased negativity of membrane potential attracts the positive ion (Na+).
3.Increase osmotic pressure inside the cell causes water to move inside, which in turn increase hydrostatic pressure inside acinar cells.

4. This increase results in minute ruptures at the apical membrane of secretory cells which cause flushing of water, electrolytes and organic materials out of the cell into the lumen.

- Synthesis and secretion of protein components:

Protein secretion: Proteins (ptyalin, lingual lipase and mucin) are synthesized at ER (endoplasmic reticulum) of acinar cells, then transported by a mean of vesicular transport toward the apical (luminal part) membrane where they are secreted by exocytosis.

The secretory cells are rich in ER and mitochondria. Mitochondria provide sufficient energy supply for transport of nutrients that enter in the
constitution of synthesized materials and for the process of synthesis.

The acinar cells secrete primary secretion that contains ptyalin and mucin in a solution of electrolytes. The water and electrolyte concentration in primary secretion is not far from that in extracellular fluid.

The role of duct cells:

During the flow of saliva through the ducts, two major transport processes are taking place to finalize the ionic composition of saliva:

- Na+ reabsorption and K+ secretion: by the activity of Na+ / K+ pump. This will result in a negative trans-cellular potential which induces reabsorption of Cl- ions.

- HCO3- secretion into the duct, partly by exchange of HCO3- for Cl- and may result also by an active transport of HCO3-.

The final saliva is a hypotonic solution because there is a higher absorption rate of Na+ and Cl- than secretion of K+ and HCO3- by tubular cells.

Note: The NET result is a change in the ionic composition of saliva by decreasing Na+ and Cl- concentration to the 1/10 of their plasma concentration and increasing K+ concentration by 7 folds and HCO3- concentration by 2-3 folds.

The amount of secretion by saliva is about 1500ml/day. The rate of secretion is less than 0.025 (during sleep) to about 0.5ml/min (during the basal conditions). The spontaneous secretion of saliva is maintained by a constant low level of parasympathetic stimulation.

The amount of saliva secreted by salivary glands is not the same in all glands. And the type of saliva is different also. The parotid glands secrete about 25% of secretion and the type of secretion is *serous*. Submandibular (submaxillary) glands secrete about 70% of the saliva and the type is *mixed*. Sublingual glands secrete about 5% of saliva and the type is *mucus*.

The pH of saliva during resting secretion is around 7.0 and approaches 8.0 during active secretion.

During maximal stimulation, the formation of primary saliva increased as much as 20 folds by increasing the secretory activity of acinar cells. As a result the flow rate of saliva through the ducts is increased, which may result in relative reduction of the reabsorptive and secretory activity of the duct cells. This will change the composition of secondary (final) saliva (more Na^+ and Cl^-, and less K^+ are found in secondary saliva during high stimulation than their concentration at low rate of flow).

Stimulation of salivation can be induced by:

-Unconditioned salivary reflex:

Occurs by stimulation of chemo-receptors and pressure-receptors in oral cavity to the presence of food.

For ex. dental procedures induce activation of pressure receptors.

These transmit signals through afferent fibers to salivary centers in the medulla, which transmit stimulatory signals through efferent fibers via extrinsic autonomic nerve fibers to increase salivation.

-Conditioned salivary reflex:

Stimulation of salivation by thinking about, seeing, smelling, or hearing about pleasant food. This is known as (Mouth watering) in anticipation of something delicious to eat.

The conditioned response is learned and based on previous experience.

-Nervous regulation:

Both sympathetic and parasympathetic increase salivation, but by different mechanisms. More increase in the sympathetic activity can reduce salivation by its effects on blood vessel supply.

The functions of saliva:

1.Saliva begins digestion of carbohydrates in the mouth:
Amylase that breaks polysaccharide into maltose (disaccharide consists of 2 glucose).

2.Facilitate swallowing by:
- Moistening the food particles.
- Lubrication by mucus which protects the mucosa during swallowing and allowing easy slippage of solid food, which prevents physical damage to the mucosa.

3.Antibacterial actions:
- Lysozyme: an enzyme that lyses or destroys certain bacteria.
- The constant flow of saliva rinsing away materials (food residues, shed epithelial cells, and foreign particles) that may play an important role in oral hygiene and keeping mouth and teeth clean.
- IgA helping in the destruction of bacteria

2.Solvent for molecules that stimulate taste buds.

3.Facilitate movements of lips and tongue → aids in speech.

4.Bicarbonate neutralizes acids in food and that produced by bacteria → preventing caries.

ESOPHAGEAL SECRETION:

- Mainly **simple mucus glands** and that have secretion with mucoid character, which help in lubrication and protection of esophageal mucosa from excoriation during swallowing process.
- **Compound mucus glands** near the esophago-gasrtic junction with alkaline secretion that protect esophageal wall from the gastric reflux into the esophagus.

GASTRIC SECRETION:

- **Mucus secreting cells**: line all the stomach surface. These cells secret viscid mucus which may have the following functions:

رسالة من الفريق العلمي:

For any feedback, scan the code or click on it.

Corrections from previous versions:

Versions	Slide # and Place of Error	Before Correction	After Correction
V0 → V1			
V1 → V2			