Interesting Facts

• We eat about 500kg of food per year.

• We make approximately 1.7 liters of saliva every day.

• Every day 11.5 liters of digested food, liquids and digestive juices flow through the digestive system, but only 100 mL is lost in feces.

• Digestive problems cost Americans $50 billion each year in both direct costs and absence from work.

• By age 50, many people will produce only 15% of the Hydrochloric Acid (stomach acid) they released at age 25.

• Most of us pass somewhere between 200 and 2,000 ml of gas per day (average, about 600 ml) in roughly 13-14 passages.
• **How big is your stomach?**

An adult’s stomach holds about 1 liter of food. A child’s stomach holds a little bit less. Your stomach gets bigger the more you eat. A large adult can eat and drink up to 4 liters of food and liquid at one meal!

• **How long are the intestines?**

The small intestine is more than three times as long as the whole body! In an adult, this is about 21 feet long. The large intestine is another 5 feet long. The whole tube from the mouth to the anus is about 30 feet long. Wow!

• As a group, vegetarians produce more gas than meat-eaters because the intestinal enzymes can't digest the cellulose in vegetables' cell walls.
I1. Identify and give a function for each of the following:
   - Mouth, Tongue, Teeth, Salivary glands, Pharynx, Epiglottis, Esophagus, Cardiac Sphincter, Stomach, Pyloric sphincter, Duodenum, Liver, Gall bladder, Pancreas, Small intestine, Appendix, Large intestine (colon), Rectum, Anus.
I2. Relate the following digestive enzymes to their glandular sources and describe the digestive reaction they promote:
   - Salivary amylase, pancreatic amylase, proteases (pepsin, trypsin), lipase, peptidase, maltase, nuclease.
I3. Describe swallowing and peristalsis.
I4. Identify the components and describe the digestive actions of gastric, pancreatic, and intestinal juices.
I5. Identify the source gland for and describe the function of insulin.
I6. Explain the role of bile in the emulsification of fats.
I7. List six major functions of the liver.
I9. Examine the small intestine and describe how it is specialized for digestion and absorption.
I10. Describe the functions of E. coli in the colon.
| Absorption | Endocrine gland | Nuclease |
| Acetic chyme | Epiglottis | Pancreas |
| Albumin | Esophagus | Pancreatic amylase |
| Alkaline | Exocrine gland | Pancreatic juice |
| Amylase | Fatty acids | Pepsin |
| Anal sphincter | Gall bladder | Pepsinogen |
| Appendix | Gastric juice | Peptidase |
| Bicarbonate ions | Gastrin | Peptides |
| Bile | Glucagon | Peristalsis |
| Bilirubin | Glycerol | Pharynx |
| Biliverdin | Glycogen | Protease |
| Bolus | HCl | Pyloric sphincter |
| Cardiac sphincter | Hemoglobin | Rectum |
| Chemical digestion | Ileo-caecal valve | Saliva |
| Cholecystokinin (CCK) | Insulin | Salivary amylase |
| Chyme | Islets of Langerhans | Salivary glands |
| Cirrhosis | Lacteals | Secretin |
| Deaminate | Large intestine (colon) | Sodium bicarbonate |
| Defecation | Lipase | Sphincter |
| Disaccharide | Maltase | Starch |
| Duodenum | Maltose | Stomach |
| E. Coli | Mechanical Digestion | Trypsin |
| Emulsifier | Mitochondria | Urea |
| | | Villi |
Anatomy is the study of structures.

Physiology is the study of functions.
Functions of the Digestive System

- **Ingest** (eat) our food
- **Secretes** (enzymes, bile, HCl) to assist in digestion
- **Digest** (breaks down) food
- **Absorbs** our food
  - Used to make **energy**
  - Used to help us **grow and repair** ourselves
- **Eliminates** our food (rids us of undigestable waste)
Steps of Digestion

1. Ingestion
2. Digestion
3. Absorption
4. Elimination

Food -> Mechanical breakdown -> Pieces of food -> Enzymatic hydrolysis -> Small molecules -> Nutrient molecules enter body cells -> Undigested material
Salivary Glands
The Digestive System

1. Epiglottis
2. Salivary Glands
3. Esophagus
4. Liver
5. Stomach
6. Small Intestine
7. Ascending Colon
8. Descending Colon
9. Sigmoid Colon
10. Rectum
The Digestive System

1. Epiglottis
2. Salivary Glands
3. Esophagus
4. Stomach
5. 
6. 
7. 
8. Large Intestine
9. Small Intestine
10. 

Human Digestion
The Digestive System

Epiglottis

1. Salivary Glands
2. Esophagus
3. Stomach
4. Liver
5. Gall bladder
6. Large Intestine
7. Small Intestine
8. Gall bladder
9. Large Intestine
10. Small Intestine
The Digestive System

1. Epiglottis
2. Salivary Glands
3. Esophagus
4. Liver
5. Stomach
6. Gall bladder
7. Pancreas
8. Large Intestine
9. Small Intestine
10. Rectum
1. **Ingestion**

2. To begin **digestion**:
   a) mechanical
   b) chemical
THE MOUTH: structures

- Teeth
- Salivary Glands
- Tongue
• Teeth

• Takes in the food

• Begins **mechanical digestion** by breaking the food into smaller pieces.
YOU ANIMAL!
• **Salivary Glands:** ducted glands that produce saliva, which:

1) **Liquifies** food
2) **Contains** amylase and begins chemical digestion
3) **Lubricates** and softens the **BOLUS** of food.
4) Enzymes in saliva **kill bacteria**

![Diagram](image)
**THE MOUTH: structures**

- **Tongue:** 3 functions

  1. Contains **taste buds**, at the back of the tongue. This protects us against poisons as they most often taste bitter.

  2. **Moves the food** around in the mouth and towards the teeth to mix the food and the saliva.

  3. Pushes the **BOLUS** of the food to the back of the throat to the ‘**swallow reflex center**’.
**PHARYNX**

**Structure:** the back of the throat. Opens to the respiratory and digestive systems.

**Function:** When food is placed on the ‘reflex center’ by the tongue, the following things happen:

a) the soft palate covers the opening to the nose

b) the epiglottis covers the trachea

c) peristalsis of the esophagus begins
Covers the **trachea** (lungs) when we swallow food
ESOPHAGUS: structure

- **30cm** long tube
- Connects the pharynx to the stomach.
- **No digestion** occurs.
- At the beginning of the stomach, there is a ring of muscle called the **cardiac sphincter** which stops food from re-entering the esophagus.
The esophagogastric junction cannot be assessed by endoscopy, but requires histopathology.

- Rise of endoscopic gastric folds
- Histologic "Junction": transition from CLE to oxyntic mucosa!
Food moves through the esophagus by a process called **PERISTALSIS**.

This is a slow, rhythmic contraction that pushes the BOLUS along.

*Peristalsis continues down the entire digestive tract.*
Fig. 21.7. Peristalsis pushes food down the esophagus to the stomach.
• It is a ‘J’ shaped organ.
• It can hold **2.3 Litres** of food.
• It has **3 layers of muscle**
  • Circular
  • Longitudinal
  • Transverse
STOMACH: function

Churns food and liquifies it (mechanical digestion).

This process is aided by the ridges in the mucosa layer of the stomach.
Begins the chemical digestion of proteins with 3 cell types

1. One type makes the inactive enzyme **PEPSINOGEN**. These cells have lots of mitochondria for active transport.

2. Chief Cells produce **3M Hydrochloric Acid** (HCl).

3. Mucous cells produce **mucous** to protect the mucosa cells (inner stomach lining) from the HCl.
Gastric Juices contain:

1. Pepsinogen
2. Hydrochloric Acid
3. Mucous
Hydrochloric acid (HCl) is released when proteins enter the stomach. This creates a pH of 2.5.

This transforms pepsinogen into an active hydrolytic enzyme PEPSIN, which begins the digestion of the proteins into smaller amino acid chains.
HCl will also be released, however, when you are **stressed** and there is chronic stimulation of your autonomic nervous system.

This dissolves the mucosa layer of the stomach lining, and results in an **ULCER**.
The stomach empties within **4 hours**. What leaves the stomach is an acidic liquid called **CHYME**.

The **pyloric sphincter** at the base of the stomach will meter out the chyme into the duodenum at a **slow, controlled rate**.
Almost all cases of pyloric stenosis happen in very young babies (usually 3-12 weeks old). This problem happens about 2-4 times out of every 1,000 births. It is much more common in males than in females.
1. Half of it is an **ENDOCRINE GLAND** which makes hormones **insulin and glucagon**.

2. Half of it is an **EXOCRINE GLAND** which make the **enzymes** to digest carbs, fats, proteins and nucleic acids.

The pancreas is a dual organ.
Insulin and Glucagon are made by specialized cells of the pancreas called ‘the islets of Langerhans.’

If there is high blood sugar (more than 0.1% glucose), the pancreas will release insulin. Insulin removes glucose from the blood by:
1. causes the liver to store it as glycogen
2. promotes formation of fats
3. causes cells to absorb glucose

If there is low blood sugar (less than 0.1% glucose), the pancreas will release glucagon. Glucagon adds glucose back into the blood by:
causes the liver to break down glycogen and release glucose
Pancreatic Juices contain (SALT + N):

1. Sodium Bicarbonate
2. Pancreatic Amylase
3. Lipase
4. Trypsin
5. Nucleases
The pancreatic juices include SALT + N:

1. Sodium Bicarbonate (NaHCO₃) is a base and is released to neutralize the stomach acid.

Chyme pH 2.5 → SODIUM BICARBONATE → pH 8.5
The pancreatic juices include SALT + N:

2. **Amylase** is an enzyme that converts uncooked carbohydrates to **maltose**.

Uncoooked Starch \[\xrightarrow{\text{PANCREATIC AMYLASE}}\] Maltose
PANCREAS: exocrine gland

The pancreatic juices include SALT + N:

3. Lipase is an enzyme that converts lipids into fatty acids and glycerol

\[ \text{Lipids} \rightarrow \text{LIPASE} \rightarrow \text{Fatty Acids & Glycerol} \]

- **Lipase**: Enzyme that converts lipids into fatty acids and glycerol.
- **Fatty Acids & Glycerol**: Products of lipase action.

**Diagram**:
- **Triglyceride**: Structure showing the long chains of fatty acids attached to glycerol.
- **Glycerol**: Alternative structure of glycerol.
- **Fatty Acid**: Structure of a fatty acid with a carboxyl group.
- **"Free" Fatty Acid**: Representation of a fatty acid without its glycerol linkage.
PANCREAS: exocrine gland

The pancreatic juices include SALT + N:

4. Trypsin is an enzyme that converts small protein chains into dipeptides and tripeptides.
PANCREAS: exocrine gland

The pancreatic juices include SALT + N:

5. **Nucleases** are enzymes that convert nucleic acids (DNA and RNA) into **nucleotides**.
There are 3 regions:

1. **Duodenum**: completes the chemical digestion

2. **Jejunum**: finishes digestion and begins absorption

3. **Ileum**: this is the longest section and its function is to absorb all of the nutrients into the circulatory and lymphatic systems.
SMALL INTESTINE: structures

The small intestine has an increased rate of absorption (speeds up diffusion) due to its highly convoluted walls with a very large surface area.

There are folds in the mucosa layer of the small intestine called VILLI.

These villi also have smaller folds called MICROVILLI.
WALL OF SMALL INTESTINE

**Fig. 21.10B. Structure of the Small Intestine**

- $2.5 \text{ cm (diameter)} \times 6.4 \text{ m (length)} = 0.5 \text{ sq. m. (area)}$

- $x \times 3 = 1.5 \text{ sq. m.}$
- Circular folds
- Villi

- $x \times 10 = 15 \text{ sq. m.}$
- Villus
- Capillaries
- Lymph vessel

- $x \times 40 = 600 \text{ sq. m.}$
- Nutrient absorption
- Microvilli

(x25,000)
increased surface area

Villi
The absorption takes place through the columnar cells of the microvilli.

This involves active transport and requires much energy.

The total surface area of the small intestine is 180m² (this is the size of a tennis court).
To complete the digestion of all of the nutrient types:

a) Proteins
b) Carbohydrates
c) Nucleic Acids
d) Lipids

To begin the absorption of nutrients:

a) Amino acids (into the blood stream)
b) Glucose and other monomers of carbs (into the blood stream)
c) Nucleotides (into the blood stream)
d) Fatty acids and Glycerol (into the lactael -- lymphatic system)
The Walls of the Duodenum: The glands in the duodenum produce and release intestinal juices.

What is in the intestinal juices? All of the enzymes that are required to complete the digestion of all of the food types.
Intestinal Juices contain:

1. Peptidases
2. Nucleases
3. Maltase
4. Sucrase
5. Lactase
Fig. 1-11  Unbranched Simple Tubular Exocrine Glands: Intestinal Glands. (A) Diagram of gland. (B) Transverse section. Stain: hematoxylin-eosin. Medium magnification.
1. **Peptidases** digest the tri and di-peptides into **amino acids**.
2. **Nucleases** digest the rest of the nucleic acids into nucleotides.
3. **Maltase** digests the maltose into **2 glucose** molecules.

**Diagram:**
- **Maltose** (a disaccharide) is converted by **MALTASE** into **Glucose + Glucose**.
Basic Enzyme

1. Maltose
2. Active Site
3. Glucose

maltase
4. **Sucrase** digests sucrose into its **monomers**.

```
Sucrose  SUCRASE  glucose + fructose
```

![Chemical structures of sucrose, glucose, and fructose](image)
5. **Lactase** digests lactose into its **monomers**.

Lactose $\xrightarrow{\text{LACTASE}}$ glucose + galactose

\[
\text{C}_{12}\text{H}_{22}\text{O}_{11} + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + \text{C}_6\text{H}_{12}\text{O}_6
\]
Sugars, amino acids, & nucleotides are absorbed by the capillaries in the villi.

Glycerol & fatty acids are absorbed by the lymph lacteals in the villi.
The water, juices, and indigestible food continues on to the large intestine through the ileoceleal sphincter.

Fig. 21.11. Large intestine - absorbs water from indigestible waste and compacts faeces
The large intestine is large in diameter, but is shorter than the small intestine.

It consists of 5 parts:

1. **Ascending** Colon
2. **Transverse** Colon
3. **Descending** Colon
4. **Sigmoid** Colon
5. **Rectum**
Main Job: **Absorption of the water and salts** that were used in the digestive process.

The **E.Coli** bacteria in the large intestine do 4 things:
1. They **slow the movement** of waste through the colon, which allows time for the water to be re-absorbed.
2. They eat the wastes and produce useful things that we need to survive. (ie: **vitamin K** and amino acids)
3. They produce **growth factors** (proteins that stimulate cell growth)
4. Produce waste of their own (**methane** gas) Phew!
Fig. 21.12A. Digestive tracts of carnivores & herbivores
Birds eat stones to grind their food.
By the end of the large intestine wastes are transformed into pasty ‘feces’.

The entire process of digestion from the mouth to the anus lasts 24 hours.
If these wastes moves through the large intestine **too quickly**.

The intestines don’t have time to absorb enough water.

Your feces are liquified, and you have **diarrhea**.
Sometimes the feces move through the large intestine too slowly.

Too much water is absorbed.

The feces become hard and then you are constipated.
Fiber

Food sources of fiber include whole wheat, bran, fresh or dried fruits, and vegetables.
YOU TUBE OVERVIEW OF THE WHOLE DIGESTIVE SYSTEM: excellent!
http://www.youtube.com/watch?v=pXIO3J-hOqg
• Liver

• Gall Bladder
• This is the **largest** internal organ.

• It has over **500 jobs**.

• All of the blood from the villi of the small intestines travels via the **hepatic portal vein** to the liver.

• The liver acts as a **‘gatekeeper’** to the blood by keeping levels of various nutrients in the blood constant.
1. **Detoxifies any poisons** or harmful substances that were absorbed by the digestive tract.

The liver turns alcohol into **fatty acids**.

Over time this can cause scarring of the liver tissue which gives rise to **cirrhosis**.
2. Regulates the blood glucose level at ~0.1% of plasma.

High blood sugar

Glucose $\xrightarrow{INSULIN}$ Glycogen

Low blood sugar

Glycogen $\xrightarrow{GLUCAGON}$ Glucose
3. **DEAMINATION** of amino acids.

If necessary the liver can **convert amino acids into glucose** to maintain glucose concentration of plasma. This is called **GLUCONEOGENESIS**.

This process releases the amino acids groups which the liver converts into **urea**.

The urea is released into the blood, where it is removed by the **kidneys** in the production of **urine**.
4. **Destroys old red blood cells** (after ~ 4 months) and recycles **Hemoglobin**.

Most of the Hemoglobin is reused by the bone to make new RBC, the rest is ‘worn out’ and is converted into **bilirubin** and **biliverdin** (the components of **bile**).
Excessive bilirubin in the blood leads to **JAUNDICE**.
Jaundice

Before phototherapy

After phototherapy

Fluorescent light

Baby with mild jaundice
5. **Produces bile emulsifies** which fats by breaking fats into smaller pieces.

This increases the **surface area of fats** for digestion.

This makes the enzyme lipase much more **efficient**.
WHAT HAPPENS TO THE BLOOD IN THE LIVER?

6. Makes **blood clotting proteins** (fibrinogen and prothrombin) and another protein called **albumin** which helps to maintain the osmotic pressure of the blood.
• **Stores Bile**

• When we eat fat, the gall bladder sends bile to the small intestine through the **common bile duct**.

• The bile breaks fat blobs into **smaller pieces** (micelles) so they are easier to digest.
Gall Stones
Gallstone lodges in duct blocking lumen and aggravating pancreas

Gallstone in duct

Inflamed pancreas

Duodenum
Enzymes are \textit{energetically expensive} to make, so we only want enzymes in the gut when \textit{food} is present.

This is controlled by \textit{3 hormones}.

1. \textbf{Gastrin}
2. \textbf{Secretin}
3. \textbf{CCK} (Cholecystokinin)

\textit{A hormone is a chemical messenger that is produced in the glandular tissue. It travels to some other target location in the body via the blood stream, where it has a desired effect.}
GASTRIN is released by glands in the stomach when food (especially proteins) enters the stomach.

It stimulates the cells of the stomach to secrete gastric juice, a mixture of hydrochloric acid and the enzyme pepsin.

Pepsin will begin the digestion of proteins.
SECRETIN is released by cells in the duodenum when they are exposed to the acidic chyme entering from the stomach.

- Secretin stimulates the pancreas to release its pancreatic juices.
- This includes sodium bicarbonate (NaHCO₃), which neutralizes the acid from the stomach => pH 8.5.
- Without this, the enzymes would all denature as they need an optimum pH of 8.5 to work properly.
• **Cholecystokinin (CCK)** is released by cells in the duodenum when they are exposed to the **fats and proteins** coming from the stomach.

• It ‘tells’ the **gall bladder** to contract and force its **bile** into the intestine and ‘tells’ the **pancreas** to release its **pancreatic juices** (SALT + N). These enzymes, with the help of bile, will help to **digest** the **fats and proteins**.

• *There is some evidence that CCK acts on the brain as a satiety signal (i.e., "that’s enough food for now").*
Put It All Together...
CHARTS!
Let's Put It All Together

1. Eat carbohydrates and chew them with our mouth.
2. Saliva is released with salivary amylase and mucous.
3. The salivary amylase digests the cooked starch into maltose.
4. The bolus goes to the back of the throat and we swallow it.
5. The esophagus takes the bolus to the stomach via peristalsis.
6. When food reaches the stomach, GASTRIN is released.
7. Gastrin causes the release of the gastric juices (HCl, mucous, pepsinogen).
8. HCl kills the bacteria in the food and creates a pH of 2.5.
9. The stomach mixes the food around.
10. The acid chyme is slowly released into the duodenum through the pyloric sphincter.
11. When the CARBS enter the duodenum, the hormone SECRETIN is released.
12. SECRETIN causes the release of the pancreatic juices.
13. Sodium bicarbonate neutralizes the pH to 8.5 so all the enzymes can work at their optimum pH.
14. Pancreatic Amylase digests the uncooked starch into maltose.
15. The maltose moves further down into the smaller intestines.
16. The intestinal glands release the enzymes: peptidases, nuclease, maltase, sucrase, and lactase.
17. The maltase digests the maltose into 2 glucose molecules.
18. The sucrase digests the sucrose into glucose and fructose.
19. The lactase digests the lactose into glucose and galactose.
20. The glucose, fructose, and galactose move into the capillaries of the villi.
21. The capillaries are attached to the hepatic portal vein which takes the monosaccharides to the liver.
22. If the blood sugar is high the pancreas will release insulin.
Let's Put It All Together

23. Insulin will cause the liver to store the glucose as glycogen.
24. When blood sugar drops again, the pancreas will release glucagon.
25. Glucagon will cause the liver to release the glucose into the blood stream.
26. The blood will go to the heart where it will be pumped to the body cells.
27. The glucose will enter the cells and go into the mitochondria.
28. The mitochondria turns the glucose into ATP via cellular respiration.
29. The indigestible wastes continue into the large intestines, where water is reabsorbed and the feces are released from the body when the anal sphincter relaxes.
Let's Put It All Together

**CARBOHYDRATES**

**Step 1:** eat carbs & chew with teeth.
Step 2: saliva is released with salivary amylase and mucous.
Let's Put It All Together
CARBOHYDRATES

Salivary amylase
Let's Put It All Together
CARBOHYDRATES

Salivary amylase
Let's Put It All Together

**CARBOHYDRATES**

Step 3: salivary amylase breaks cooked starch down into maltose.

Salivary amylase

MALTOSE
Step 4: tongue pushes food to back of throat and we swallow.
Step 5: peristalsis pushes the BOLUS down to the stomach.
Step 6: when food reaches the stomach, GASTRIN is released.
Step 6: GASTRIN causes the release of all of the gastric juices.
Gastric Juices

Step 7: HCl kills bacteria in food and creates a pH of 2.5.
Gastric Juices
HCl
Pepsinogen

Gastrin

Esophagus

Stomach
Gastric Juices
- HCl
- Pepsinogen
- Mucous

Esophagus

Gastrin

Stomach
Step 8: the stomach mashes the food around.
Step 9: the food slowly leaves the stomach through the PYLORIC valve.
Step 10: when the acid chyme reaches the duodenum, the hormone SECRETIN is released.
Step 10: Secretin causes the release of all of the pancreatic juices.
Pancreatic Juices
Sodium Bicarbonate

Step 10: sodium bicarbonate increases the pH to 8.5.
Pancreatic Juices

Sodium Bicarbonate

secretin
Pancreatic Juices

pH = 8.5

secretin
Step 11: the enzyme amylase digests the uncooked starch to maltose.
Pancreatic juices include:
- Sodium Bicarbonate
- Amylase
- Secretin
Pancreatic Juices
Sodium Bicarbonate

secretin

Pancreatic juice

Amylase

Duodenum of small intestine

Intestinal juice

Bile

Acid chyme

Liver

Gall bladder

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Pancreatic Juices

Sodium Bicarbonate

Amylase

secretin

Pancreatic Juices

Sodium Bicarbonate
Pancreatic Juices
Sodium Bicarbonate

secretin

Pancreatic juice

Duodenum of small intestine

Intestinal juice

Liver

Bile

Gall bladder

Acid chyme

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MALTOSE
Step 12: the other enzymes have no effect on carbohydrates.
Pancreatic Juices

- Sodium Bicarbonate
- Amylase
- Lipase
- Trypsin

secretin
Pancreatic Juices
- Sodium Bicarbonate
- Amylase
- Lipase
- Trypsin
- Nucleases
Step 13: maltose, sucrose, and lactose travel further down in the duodenum.
Step 14: the intestinal juices are released.
INTESTINAL JUICES
1. Peptidases
2. Nucleases
INTESTINAL JUICES
1. Peptidases
2. Nucleases
3. Maltase

Step 15: maltase digests maltose into glucose.
INTESTINAL JUICES
1. Peptidases
2. Nucleases
3. Maltase
INTESTINAL JUICES
1. Peptidases
2. Nucleases
3. Maltase
INTESTINAL JUICES

1. Peptidases
2. Nucleases
3. Maltase
INTESTINAL JUICES
1. Peptidases
2. Nucleases
3. Maltase
INTESTINAL JUICES

1. Peptidases
2. Nucleases
3. Maltase
4. Sucrase

Step 16: sucrase digests sucrose into glucose and fructose.
INTESTINAL JUICES

1. Peptidases
2. Nucleases
3. Maltase
4. Sucrase

Duodenum —  Jejunum

GLUCOSE
FRUCTOSE

GLUCOSE
INTESTINAL JUICES

1. Peptidases
2. Nucleases
3. Maltase
4. Sucrase
5. Lactase
INTESTINAL JUICES

1. Peptidases
2. Nucleases
3. Maltase
4. Sucrase
5. Lactase

Step 17: lactase digests lactose into glucose and galactose.
INTESTINAL JUICES

1. Peptidases
2. Nucleases
3. Maltase
4. Sucrase
5. Lactase

GLUCOSE

GALACTOSE
Step 18: the glucose, galactose and fructose travel further down in the intestines.
Step 19: the glucose, galactose and fructose move into the blood capillaries inside the villi.
Step 20: the glucose, galactose and fructose go into the hepatic portal vein on their way to the liver.
Step 20: the glucose, galactose and fructose go into the hepatic portal vein on their way to the liver.
Step 21: because it was a big meal, the pancreas releases INSULIN and the liver turns the glucose into glycogen for storage.
insulin
Step 22: When the body needs energy, the pancreas releases GLUTAGON and the glycogen is turned back into glucose.
Step 23: glucose enters the blood stream, and the heart pumps it to the body cells.
Step 23: glucose enters the body cells and goes into the mitochondria.
Step 23: the mitochondria turns the glucose into ATP via cellular respiration.
Step 24: the indigestible wastes move into the large intestines.
Step 25: water is reabsorbed from the feces.
Step 26: the feces continue until the sphincter relaxes and they are released from the body.
Let's Put It All Together

1. Eat lipids and chew them with our mouth.
2. Saliva is released with salivary amylase and mucous.
3. The bolus goes the to back of the throat and we swallow it.
4. The esophagus takes the bolus to the stomach via peristalsis.
5. When food reaches the stomach, GASTRIN is released.
6. Gastrin causes the release of the gastric juices (HCl, mucous, pepsinogen)
7. HCl kills the bacteria in the food and creates a pH of 2.5.
8. The stomach mixes the food around.
9. The acid chyme is slowly released into the duodenum through the pyloric sphincter.
10. When the FATS reach the duodenum two hormones are released.
Let's Put It All Together

LIPIDS

11. SECRETIN causes the release of the pancreatic juices.

12. CCK causes the release of bile from the gall bladder and an additional release of the pancreatic juices.

13. Sodium bicarbonate neutralizes the pH to 8.5 so all the enzymes can work at their optimum pH.

14. Bile emulsifies the fats into small droplets.

15. Lipase breaks the small fat droplets into fatty acids and glycerol.

16. Fatty acids and glycerol move into the lactaels of the villi.

17. The lactaels are connected to the lymphatic system and take the fatty acids and glycerol to the subclavien vein (in the shoulder).

18. The fatty acids and glycerol move through the subclavien vein, into the vena cava, and into the heart.
19. The heart pumps the fatty acids around the body to be used for…
   Insulation
   Protection of the organs
   Energy storage in fat cells
20. The remainder of the indigestible food continues into the large intestines.
21. Water is reabsorbed from the feces.
22. The feces continue on until the anal sphincter is relaxed and the feces leave the body.
Let's Put It All Together

PROTEINS

1. Eat proteins and chew them with our mouth.
2. Saliva is released with salivary amylase and mucous.
3. The bolus goes to the back of the throat and we swallow it.
4. The esophagus takes the bolus to the stomach via peristalsis.
5. When food reaches the stomach, GASTRIN is released.
6. Gastrin causes the release of the gastric juices (HCl, mucous, pepsinogen)
7. HCl kills the bacteria in the food and creates a pH of 2.5.
8. HCl also activates the pepsinogen and turns it into the active form PEPSIN.
9. Pepsin digests proteins into smaller polypeptides.
10. The stomach mixes the food around.
11. The acid chyme is slowly released into the duodenum through the pyloric sphincter.
12. When the PROTEINS reach the duodenum two hormones are released.
13. SECRETIN causes the release of the pancreatic juices.
14. CCK causes the release of bile from the gall bladder and an additional release of the pancreatic juices.
15. Sodium bicarbonate neutralizes the pH to 8.5 so all the enzymes can work at their optimum pH.
16. Trypsin digests the smaller polypeptides into di and tri-peptides.
17. The di and tri-peptides move further down into the small intestines.
18. The glands in the small intestine release intestinal juices: peptidases, nuclease, maltase, sucrase and lactase.
19. The peptidases digest the di and tri-peptides into amino acids.
20. The amino acids move into the capillaries of the villi.
21. The capillaries are attached to the hepatic portal vein which takes the amino acids to the liver.
22. The liver may turn the amino acids into glucose if the body needs energy.
23. Otherwise, the liver sends the amino acids to the heart where they are pumped to the body cells.
24. The body cells use proteins to:
   build new cells and grow and repair
25. The indigestible wastes continue into the large intestines, where water is reabsorbed and the feces are released from the body when the anal sphincter relaxes.
Let's Put It All Together

NUCLEIC ACIDS

1. Eat nucleic acids (DNA and RNA) and chew them with our mouth.
2. Saliva is released with salivary amylase and mucous.
3. The bolus goes to the back of the throat and we swallow it.
4. The esophagus takes the bolus to the stomach via peristalsis.
5. When food reaches the stomach, GASTRIN is released.
6. Gastrin causes the release of the gastric juices (HCl, mucous, pepsinogen)
7. HCl kills the bacteria in the food and creates a pH of 2.5.
8. The stomach mixes the food around.
9. The acid chyme is slowly released into the duodenum through the pyloric sphincter.
10. When the NUCLEIC ACIDS reach the duodenum, SECRETIN is released.
11. Sodium bicarbonate neutralizes the pH to 8.5 so all the enzymes can work at their optimum pH.
12. Nucleases digest the nucleic acids into nucleotides.
13. The nucleotides move further down into the small intestines.
15. The nucleases further digest the nucleic acids into nucleotides.
16. The nucleotides move into the capillaries of the villi.
17. The capillaries are attached to the hepatic portal vein which takes the nucleotides to the liver.
18. The liver will send the nucleotides to the heart where they are pumped to the body cells.
19. The body cells use nucleotides to make new DNA during DNA replication, and RNA during transcription.
20. The indigestible wastes continue into the large intestines, where water is reabsorbed and the feces are released from the body when the anal sphincter relaxes.
VIRTUAL BODY GUIDED TOUR

http://www.kitses.com/animindex.html

http://mediaspace.evergreen.edu/Egallery/animationgallery/gallery/animation/Digestion.html