Anatomy of the digestive system

Can be divided into the **alimentary canal** (GI tract) and **accessory organs**

**Digestion** is the process of **food breakdown**

Thus, each of these “parts” works in some way to break down food

All digestion takes place **outside of the body** (think about it…it’s true!)

We will review the anatomy of the system, then look at how food is broken down

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The mouth

Food breakdown begins in the mouth by being chewed and mixed with saliva
Alimentary canal

Mouth
Pharynx

The pharynx

Divided into nasopharynx, oropharynx, laryngopharynx

Walls contain one circular and one longitudinal layer of smooth muscle--this assists with peristalsis

Alimentary canal

Mouth
Pharynx
Esophagus

The esophagus
Alimentary canal

Mouth
Pharynx
Esophagus
Stomach

What it does

After food is processed in the stomach, it resembles a heavy cream, called *chyme*, which enters the small intestine

Alimentary canal

Mouth
Pharynx
Esophagus
Stomach
Small intestine
The small intestine

3 subdivisions: *duodenum* (5%), *jejenum* (40%), *ileum* (55%)

*Pyloric sphincter* controls entry of food into small intestine

Duodenum contains *pancreatic and bile ducts*

Small intestine is the site of almost all nutrient absorption

*Villi/microvilli* increase surface area dramatically

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Alimentary canal

Mouth
Pharynx
Esophagus
Stomach
Small intestine
Large intestine

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The large intestine

Villi/microvilli
**Holding it all in place**

**Alimentary canal**
- Mouth
- Pharynx
- Esophagus
- Stomach
- Small intestine
- Large intestine
- Anus

**Accessory organs**
- Salivary glands

**Salivary glands**
- Two main sets: *parotid* glands, *submandibular* glands
- Saliva has several main functions:
  - moisten food and bind it together into a *bolus* (lubricates food)
  - start process of digestion with *salivary amylase*
  - contains *lysozyme and antibodies*
  - assists with taste by dissolving food chemicals
Accessory organs
Salivary glands
Teeth

Pancreas
Secretes enzymes to break down all types of macromolecules in your food

What are the 4 types of macromolecules?

What is the other role of the pancreas?

Teeth
Mechanical breakdown of food
Two sets of teeth: deciduous (= baby, milk) and permanent

Pancreas
Secretes enzymes to break down all types of macromolecules in your food
Accessory organs

Salivary glands
Teeth
Pancreas
Liver and gallbladder

Liver and gallbladder

The liver produces bile, which enters the duodenum and emulsifies fats—breaks down large fat globules into small ones. The gall bladder stores bile when digestion is not taking place.

Ingestion and breakdown in the mouth

Mechanical/chemical breakdown
Simply having food in the mouth can trigger saliva release
Emotions can trigger saliva release
No nutrient absorption occurs in the mouth, pharynx, or esophagus

Swallowing and peristalsis
### Food breakdown in the stomach

*Gastric juice* secretion is regulated by nervous and hormonal factors. *Gastrin* is the hormone that triggers secretion of *pepsinogens*, mucus, and HCl. Pepsinogen is converted to *pepsin* in the acid, and *rennin* also digests milk protein. Finally, the *chyme* is ejected into the small intestine in small amounts.

### Breakdown and absorption in the small intestine

The *microvilli* of the small intestine secrete *brush border enzymes* that break down sugars and complete protein digestion. *Pancreatic enzymes* contribute to starch digestion, protein digestion, and all of fat digestion (*lipases*); they also digest nucleic acids. Mucosa cells secrete *secretin* and *cholecystokinin*.

### Large intestine

No enzymes are present, but *bacteria* further break down food for more nutrient absorption. Water and vitamins are absorbed here. Feces contain undigested food, mucus, bacteria and a small amount of water are moved to the rectum.

### Cell physiology and metabolism
Cell physiology and energy budgets

Cells make up organisms, which are incredibly complex

Remember: all living organisms are \textit{thermodynamically open systems}:
- They must exchange energy and materials with their environments (no exchange = no life)

Some exchanges are fast and some are slow, but \textit{ALL must be carefully balanced}

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Metabolic rate

An organism’s \textit{metabolic rate} is the sum total of all of all biochemical energy transactions occurring at one time…

\textit{ = the rate of production and utilization of ATP}
Metabolic rate

An organism’s **metabolic rate** is the sum total of all of all biochemical energy transactions occurring at one time…

= *the rate of production and utilization of ATP*

**Remember:**

An average human contains only ~1.75 ounces of ATP at a given time…but makes and uses about **16 pounds of ATP per day!** About 0.003 ounces per second.

Metabolic rate

An organism’s **metabolic rate** is the sum total of all of all biochemical energy transactions occurring at one time…

= *the rate of production and utilization of ATP*

Cellular respiration is the source of ATP for animals & plants.

‘Respiration’ has two meanings

- ‘Breathing’ and respiration are often used synonymously
  
  = the exchange of gases

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- **Cellular respiration** refers to the harvesting of energy from food molecules
‘Respiration’ has two meanings

- ‘Breathing’ and respiration are often used synonymously = the exchange of gases
- *Cellular respiration* refers to the harvesting of energy from food molecules
- These are closely related

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**Cellular respiration: efficiency**

Breaking down glucose is a multi-step process

**Second law of thermodynamics**: energy transfer or transformation is not 100% efficient
How efficient is cellular respiration?

1 glucose = 38 ATP molecules

(remember: a working cell may need 10,000,000 per second)

38 ATP molecules = 40% of the energy content in glucose

Therefore, 60% is released as heat.
Cellular respiration: efficiency

1 glucose = 38 ATP molecules

How efficient is cellular respiration?

25% of gasoline energy is converted to kinetic energy
(i.e. 15% less efficient than cellular respiration)

3 stages of cellular respiration

Glucose isn’t the only available substrate for ATP production

<table>
<thead>
<tr>
<th>Activity</th>
<th>Heat Consumed per Hour by a 157.5 kg (340 lb) Person*</th>
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</thead>
<tbody>
<tr>
<td>Cycling (slow)</td>
<td>1.70</td>
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<tr>
<td>Cycling (fast)</td>
<td>2.02</td>
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<tr>
<td>Dancing (slow)</td>
<td>0.66</td>
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<tr>
<td>Dancing (fast)</td>
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<tr>
<td>Eating</td>
<td>0.38</td>
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<tr>
<td>Gardening</td>
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<tr>
<td>Laboratory work</td>
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<tr>
<td>Running (7 min/mile)</td>
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<td>Swimming</td>
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<tr>
<td>Walking (4 mph)</td>
<td>1.08</td>
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<tr>
<td>Walking (4 mph)</td>
<td>2.51</td>
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</table>

*Heat including heat needed for body maintenance
You need ~2,200 calories/day

Carl’s Jr. Steak and egg breakfast burrito

<table>
<thead>
<tr>
<th>Activity</th>
<th>Calories per hour for a 67.5-kg (150-lb) person</th>
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<tbody>
<tr>
<td>Bicycling (fast)</td>
<td>514</td>
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<tr>
<td>Bicycling (slow)</td>
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<tr>
<td>Dancing (slow)</td>
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<tr>
<td>Dancing (fast)</td>
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<td>Eating</td>
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<td>Gymnastics</td>
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<td>Laboratory work</td>
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<tr>
<td>Running (7 mph)</td>
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<td>Sitting (sitting)</td>
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<td>Standing (vertical)</td>
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<td>Standing (tall)</td>
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<tr>
<td>Swimming (2 miles/hr)</td>
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<tr>
<td>Walking (3 mph)</td>
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<tr>
<td>Walking (4 mph)</td>
<td>231</td>
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</table>

*Not including cost needed for body maintenance

In-N-Out Double-Double with fries and a chocolate shake

You need ~2,200 calories/day

Carl’s Jr. Steak and egg breakfast burrito

600 calories

In-N-Out Double-Double with fries and a chocolate shake

1,760 calories
You need ~2,200 calories/day