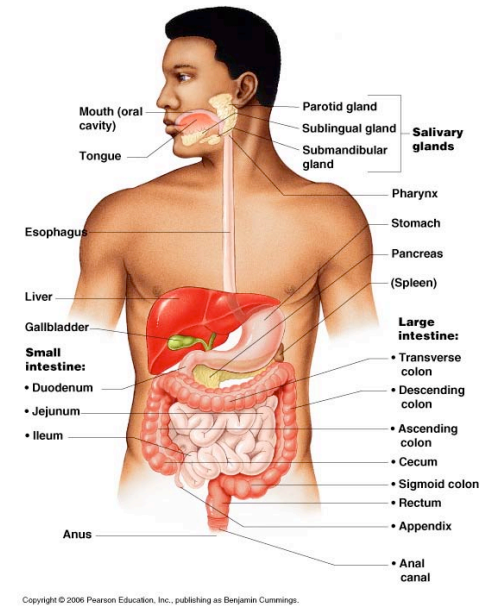




Anatomy
Can be (tract) and

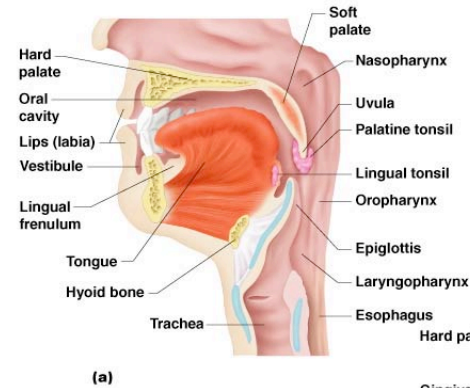


System
al (GI)

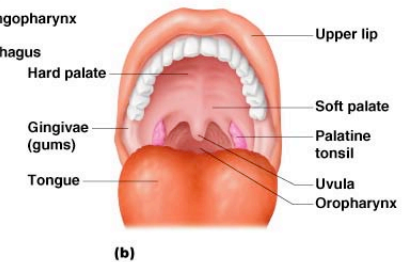
Alimentary canal

Mouth

The mouth



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



Alimentary canal

Mouth
Pharynx

The pharynx

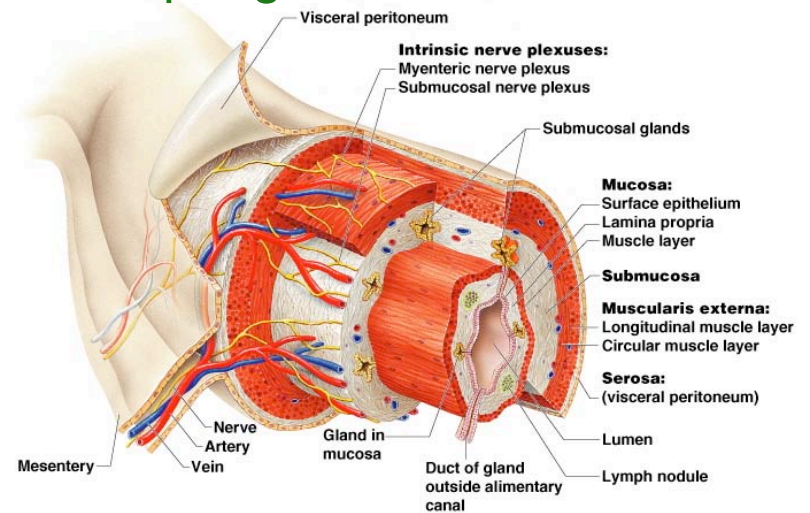
Divided into *nasopharynx*, *oropharynx*,
laryngopharynx

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

Alimentary canal

Mouth
Pharynx
Esophagus

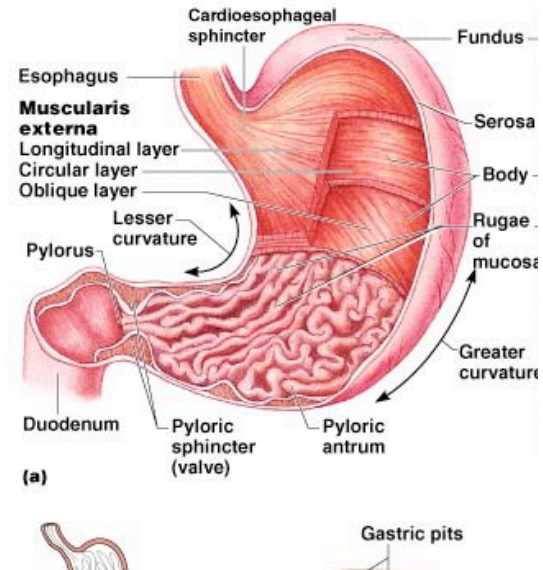
The esophagus



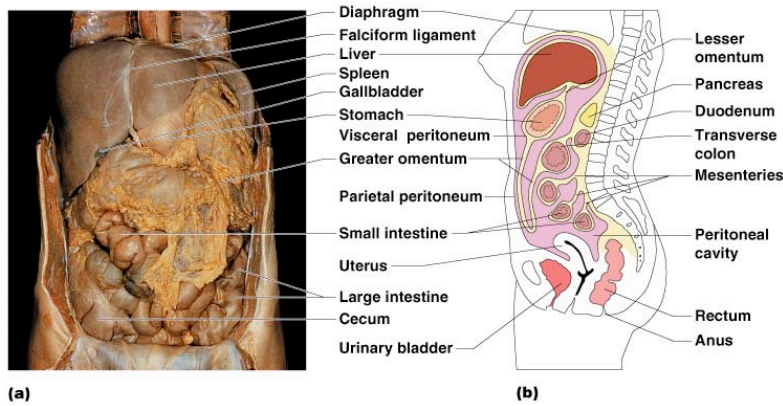
Alimentary canal

- Mouth
- Pharynx
- Esophagus
- Stomach

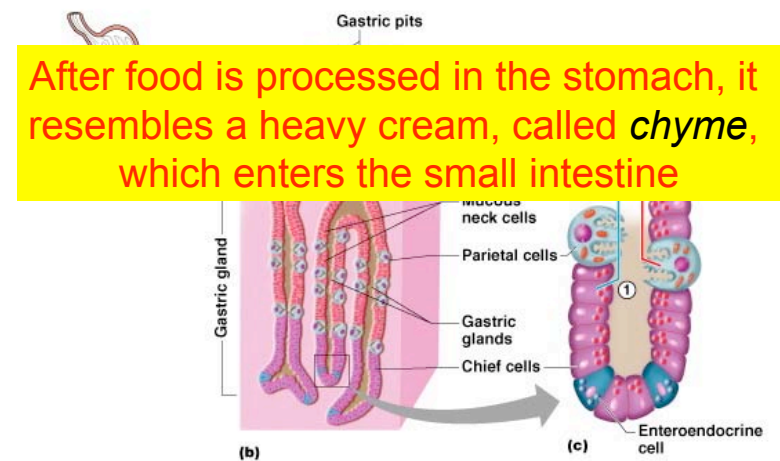
The stomach



Holding it all in place



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%), *jejunum* (40%), *ileum* (60%)

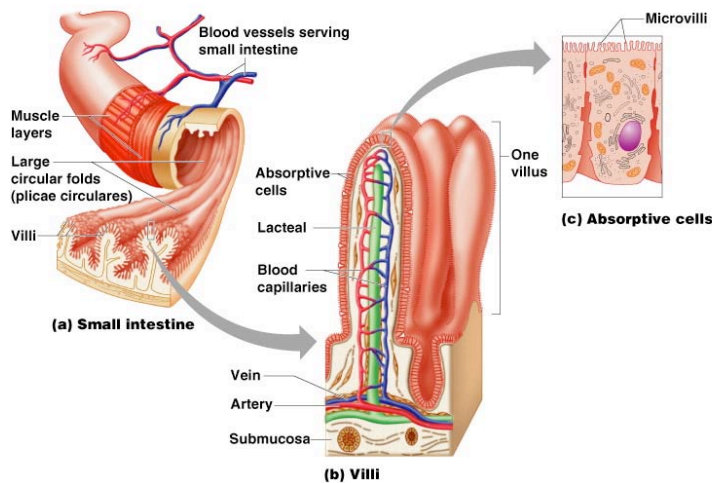
Pyloric sphincter controls entry of food into small intestine

Duodenum contains *pancreatic and bile ducts*

Small intestine is the site of almost all nutrient absorption

Villi/microvilli increase surface area massively

Villi/microvilli

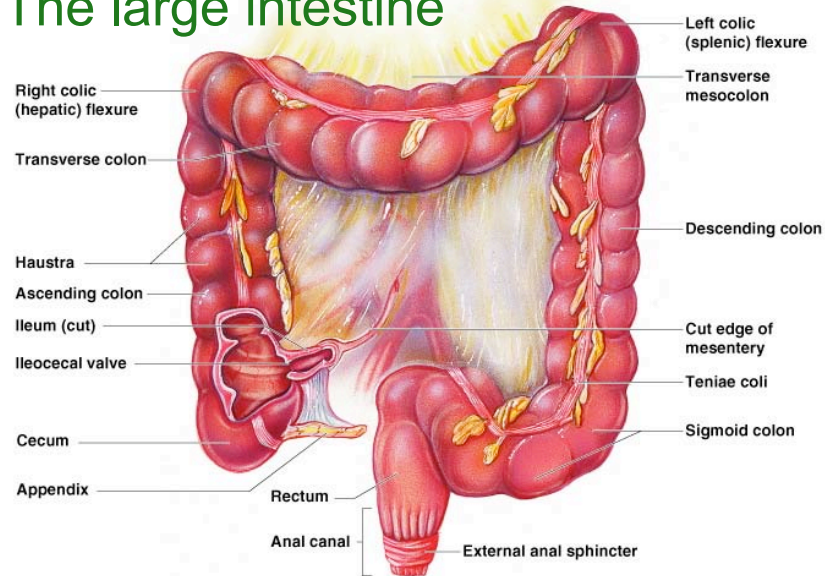


Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

Alimentary canal

Mouth
Pharynx
Esophagus
Stomach
Small intestine
Large intestine

The large intestine



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

Accessory organs

Salivary glands

Alimentary canal

Mouth
Pharynx
Esophagus
Stomach
Small intestine
Large intestine
Anus

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*

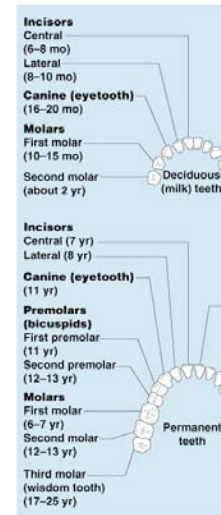
assists with taste by dissolving food chemicals

Accessory organs

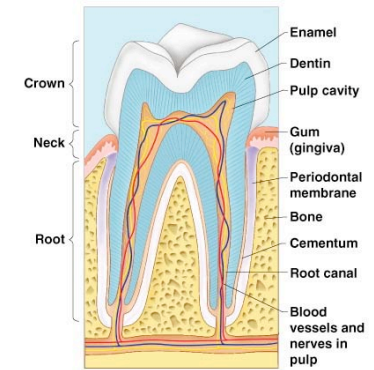
Salivary glands

Teeth

Teeth



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

Accessory organs

Salivary glands

Teeth

Pancreas

Pancreas

Secretes enzymes to break down all of your food

Accessory organs

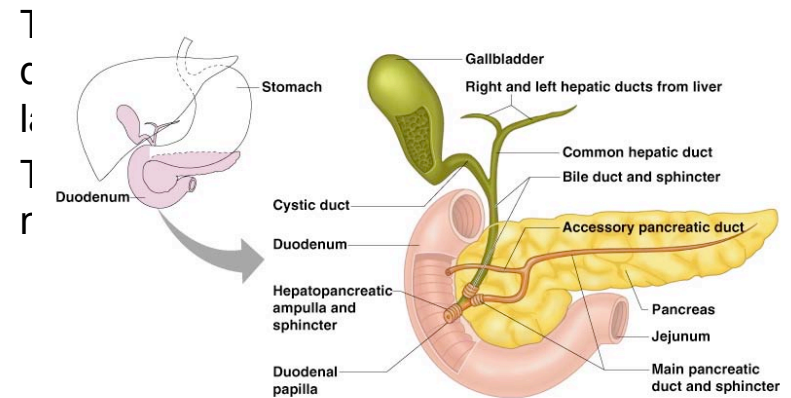
Salivary glands

Teeth

Pancreas

Liver and gallbladder

Liver and gallbladder



Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

Ingestion and breakdown in the mouth

Mechanical/chemical breakdown

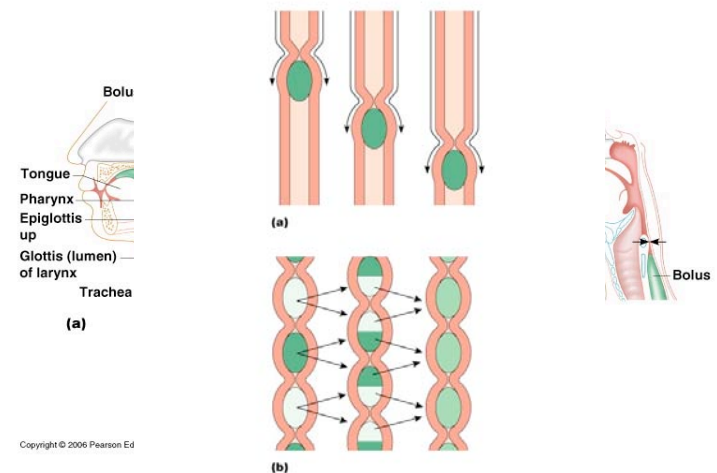
Saliva can be triggered by anything in the mouth

Emotions can trigger saliva release

No food absorption occurs in the mouth, pharynx, or esophagus

Swallowing and peristalsis

Sv
bc
ph
ph
Or
es
tra
st



Copyright © 2006 Pearson Ed

Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

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

Large intestine

No enzymes are present, but bacteria further break down food for absorption

Water and vitamins are absorbed here

Feces contain undigested food, mucus, bacteria and a small amount of water are moved to the rectum

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*

Cell physiology and metabolism

Cell physiology and energy budgets

Cells make up organisms, which are incredibly complex

Cell physiology and energy budgets

Cells make up organisms, which are incredibly complex

Remember: all living organisms are **thermodynamically open systems**:

They must **exchange energy** and materials with their environments (no exchange = no life)

Cell physiology and energy budgets

Cells make up organisms, which are incredibly complex

Remember: all living organisms are **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 ***ALL must be carefully balanced***

Cell physiology and energy budgets

Cells make up organisms, which are incredibly complex

Remember: all living organisms are **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 ***ALL must be carefully balanced***

This is what we call **homeostasis**--cell physiology largely focuses on how homeostasis is maintained

An example of a young woman's energy budget



An example of a young woman's energy budget



Partial 'bookkeeping' a young adult woman (.05 tons) over 10 years:

Food eaten: 2-3 tons

Oxygen used: 2 tons

Water intake: 6-10 tons

Heat produced: 7 million kilocalories (enough to heat 90 tons of water from room temperature to boiling)

An example of a young woman's energy budget



Partial 'bookkeeping' a young adult woman (.05 tons) over 10 years:

Food eaten: 2-3 tons

Oxygen used: 2 tons

Heat produced: 7 million kilocalories (enough to heat 90 tons of water from room temperature to boiling)

Clearly, a balanced budget is critical!

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

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.

Activity	Kcal Consumed per Hour by a 67.5-kg (150-lb) Person*
Bicycling (racing)	514
Bicycling (slowly)	170
Dancing (slow)	202
Dancing (fast)	599
Eating	28
Gymnastics	186
Laboratory work	73
Running (7 min/mi)	865
Sitting (writing)	28
Sleeping or lying still	0
Standing (relaxed)	32
Swimming (2 mph)	535
Walking (3 mph)	158
Walking (4 mph)	231

* Not including kcal needed for body maintenance

Activity	Kcal Consumed per Hour by a 67.5-kg (150-lb) Person*
Bicycling (racing)	514
Bicycling (slowly)	170
Dancing (slow)	202
Dancing (fast)	599
Eating	28
Gymnastics	186
Laboratory work	73
Running (7 min/mi)	865
Sitting (writing)	28
Sleeping or lying still	0
Standing (relaxed)	32
Swimming (2 mph)	535
Walking (3 mph)	158
Walking (4 mph)	231

* Not including kcal needed for body maintenance

You need ~2,200 calories/day

Carl's Jr. Steak and egg breakfast burrito



You need ~2,200 calories/day

Carl's Jr. Steak and egg breakfast burrito



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

You need ~2,200 calories/day

Carl's Jr. breakfast burrito

600 calories








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

1,760 calories

You need ~2,200 calories/day



TABLE 14.2 Five Basic Food Groups and Some of Their Major Nutrients

Group	Example foods	Major nutrients supplied in significant amounts:	
		By all in group	By only some in group
 <p>Fruits</p>	Apples, bananas, dates, oranges, tomatoes	Carbohydrate Water	Vitamins: A, C, folic acid Minerals: iron, potassium Fiber
 <p>Vegetables</p>	Broccoli, cabbage, green beans, lettuce, potatoes	Carbohydrate Water	Vitamins: A, C, E, K, and B vitamins except B ₁₂ Minerals: calcium, magnesium, iodine, manganese, phosphorus Fiber
 <p>Grain products (preferably whole grain; otherwise, enriched or fortified)</p>	Breads, rolls, bagels; cereals, dry and cooked; pasta; rice, other grains; tortillas, pancakes, waffles; crackers; popcorn	Carbohydrate Protein Vitamins: thiamin (B ₁), niacin	Water Fiber Minerals: iron, magnesium, selenium
 <p>Milk products</p>	Milk, yogurt; cheese; ice cream, ice milk, frozen yogurt	Protein Fat Vitamins: riboflavin, B ₁₂ Minerals: calcium, phosphorus Water	Carbohydrate Vitamins: A, D
 <p>Meats and meat alternates</p>	Meat, fish, poultry; eggs; seeds, nuts, nut butters; soybeans, tofu; other legumes (peas and beans)	Protein Vitamins: niacin, B ₆ Minerals: iron, zinc	Carbohydrate Fat Vitamins: B ₁₂ , thiamin (B ₁) Water Fiber

Source: Christian, Janet, and Janet Greger. *Nutrition for Living*, 3rd ed. San Francisco, CA: Benjamin Cummings, 1991.

Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.

'Respiration' has two meanings

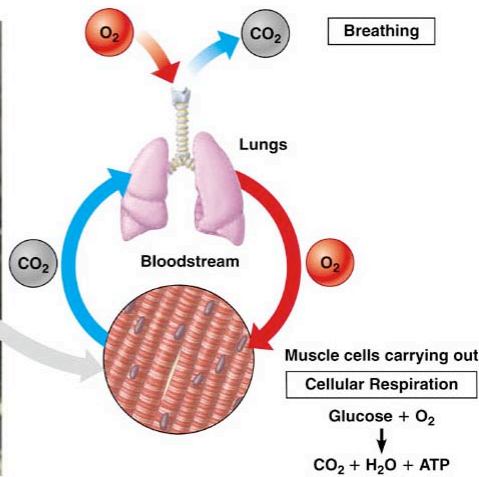
- 'Breathing' and respiration are often used synonymously
= the exchange of gases

'Respiration' has two meanings

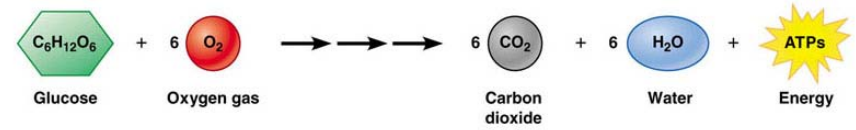
- 'Breathing' and respiration are often used synonymously
= the exchange of gases
- **Cellular respiration** refers to the harvesting of energy from food molecules

'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

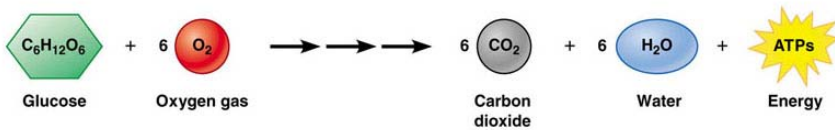


Cellular respiration: efficiency



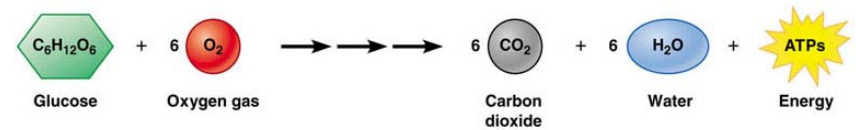
Breaking down glucose is a multi-step process

Cellular respiration: efficiency



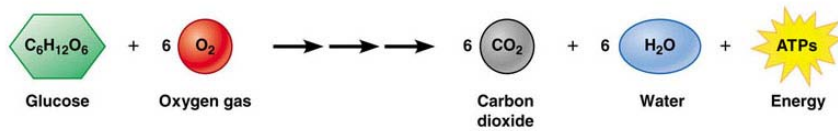
Second law of thermodynamics: energy transfer or transformation is not 100% efficient

Cellular respiration: efficiency



How efficient is cellular respiration?

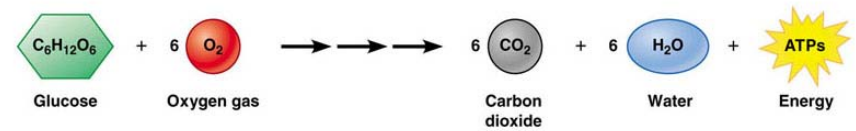
Cellular respiration: efficiency



▲ 1 glucose = 38 ATP molecules ▲

How efficient is cellular respiration?

Cellular respiration: efficiency

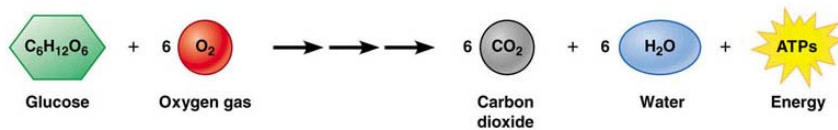


▲ 1 glucose = 38 ATP molecules ▲

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

How efficient is cellular respiration?

Cellular respiration: efficiency



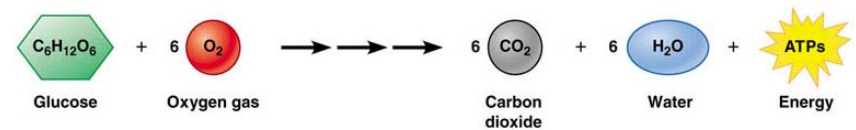
▲ 1 glucose = 38 ATP molecules ▲

How efficient is cellular respiration?

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

Therefore, 60% is released as heat

Cellular respiration: efficiency



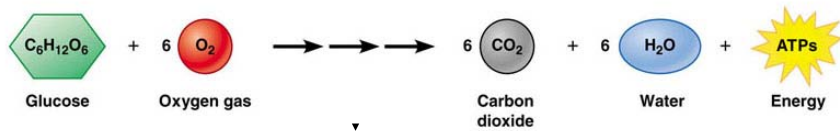
▲ 1 glucose = 38 ATP molecules ▲

How efficient is cellular respiration?



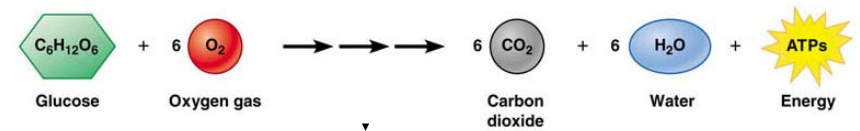
25% of gasoline energy is converted to kinetic energy

(i.e. 15% less efficient than cellular respiration)



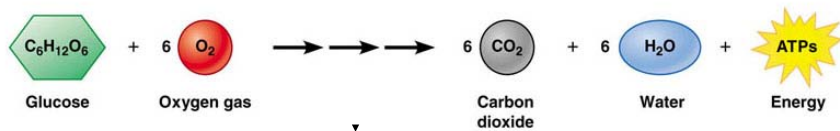
How is energy released, then stored?

1. Two hydrogen atoms are removed from organic molecules by an enzyme (dehydrogenase)



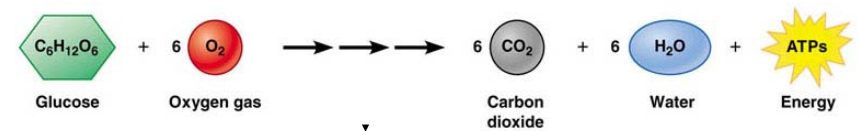
How is energy released, then stored?

1. Two hydrogen atoms are removed from organic molecules by an enzyme (dehydrogenase)
3. A coenzyme (NAD^+) captures two electrons, turning into NADH and then releasing a H^+



How is energy released, then stored?

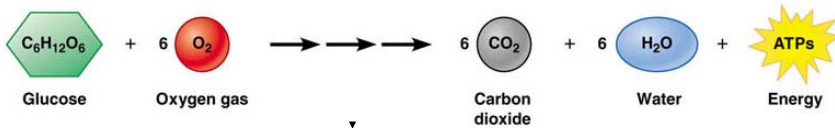
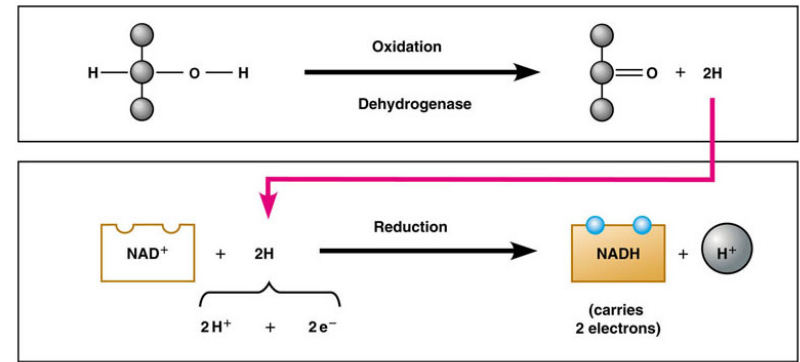
1. Two hydrogen atoms are removed from organic molecules by an enzyme (dehydrogenase)
3. A coenzyme (NAD^+) captures two electrons, turning into NADH and then releasing a H^+
3. This process – called a **redox reaction** – is repeated several times



How is energy released, then stored?

1. Two hydrogen atoms are removed from organic molecules by an enzyme (dehydrogenase)
3. A coenzyme (NAD^+) captures two electrons, turning into NADH and then releasing a H^+
3. This process – called a redox reaction – is repeated several times
4. Each reaction releases some energy, stored as ATP

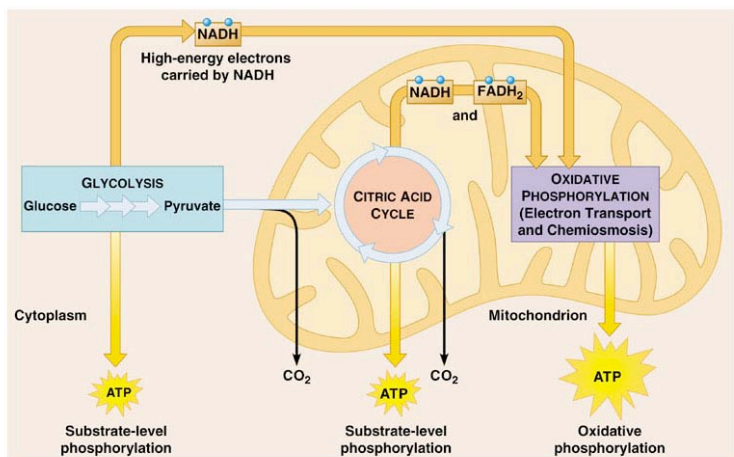
Redox reactions



How is energy released, then stored?

1. Two hydrogen atoms are removed from organic molecules by an enzyme (dehydrogenase)
3. A coenzyme (NAD⁺) captures two electrons, turning into NADH and then releasing a H⁺
3. This process – called a redox reaction – is repeated several times
4. Each reaction releases some energy, stored as ATP
5. NADH molecules are used in the last step of cellular respiration, transferring electrons to other molecules and producing more ATP

3 stages of cellular respiration



Glucose isn't the *only* available substrate for ATP production

