"The Digestive System"

an excerpt from
Cliffs AP Biology,
2nd Ed.

vs.

"Goodwork"

by Julia Tsao
Ms. T was my eleventh grade Biology teacher. She remains to this day one of the greatest influences I’ve ever met.

When I was in my junior year of high school, Ms. T graciously accepted the absurd task of teaching Advanced Placement Biology to my overly anxious and rightly neurotic class of over-achievers. I was decidedly out of place. Hardly an overachiever in any sense of the word, I was a lonely drifter in the midst of a sea of would-be doctors and surgeons. To make matters worse, I hated science.
The Digestive System

Digestion is the chemical breakdown of food into smaller molecules. In an individual cell, digestion is accomplished by intracellular digestion when a lyosome containing digestive enzymes merges with a food vacuole. In most animals, however, the food ingested is too large to be engulfed by individual cells. Thus, food is first digested in a cavity by extracellular digestion and then absorbed by individual cells.

During digestion, four different groups of molecules are commonly encountered. Each is broken down into its molecular components by specific enzymes and follows:

1. Starches are broken down into glucose molecules.
2. Proteins are broken down into amino acids.
3. Fats (or lipids) are broken down down into glycerol and fatty acids.
4. Nucleic acids are broken down into their nucleotides.

In humans and other mammals, digestion follows the following sequence of events. In particular, enzymes are specific for different bonds, only a representative few of the numerous enzymes are given.

1. Mouth. Salivary amylase, secreted into the mouth by the salivary glands, begins the breakdown of starch into maltose (a disaccharide). Chewing reduces the size and consistency of the food particles, thereby increasing the surface area upon which amylase and other salivary enzymes can operate. Food is shaped into a bolus by the cheeks, the tongue, and the teeth.

2. Pharynx. The pharynx produces saliva, including salivary amylase (digestion of starch). These and other enzymes, packaged in an alkaline solution that serves to neutralize the HCl in the chyme, enter the duodenum through the pancreatic duct.

3. Esophagus. Food moves through the esophagus, a tube leading to the stomach, by peristalsis and the process of emulsification. Food is stored in the esophagus for a short time and then swallowed.

4. Stomach. The stomach secretes gastric juice, a mixture of digestive enzymes and hydrochloric acid (HCl), and secretes a variety of factors, as follows:

- Hydrochloric acid: because of its acidic nature, the pH of the stomach contents is kept below 2, which kills or denatures bacterial proteins. HCl also denatures proteins and other substances present in the food.
- Digestive enzymes: pepsinogen, activated into pepsin by an activating agent called pepsin, digests proteins.
- Gastrin: produced by the cells lining the stomach lining, stimulating the production of hydrochloric acid.
- Histamine: produced by cells lining the stomach lining, stimulating the production of hydrochloric acid.
- Intrinsic factor: produced by parietal cells of the stomach lining, which is necessary for vitamin B12 absorption.

5. Small intestine. The small intestine is divided into three segments: the duodenum, jejunum, and ileum. The first twenty cm of the small intestine, the duodenum, contains the digestion of starches and proteins (which begin in the mouth and stomach, respectively) as well as all remaining food types (including food that enters from the stomach). Secretin is produced by the cells lining the small intestine lining when food enters. Secretin stimulates the pancreas to produce bicarbonate which, when deflected into the small intestine, neutralizes the acidity of the chyme. Food leaves the duodenum and enters the jejunum and then the ileum (the last part of the small intestine). Enzymes for these various processes originate from the following sources.

- Pancreas. The pancreas produces various enzymes, including trypsin, lipase (digestion of fats), and pancreatic phosphatase.

6. Liver. The liver produces bile, which functions to modify fats. Emulsification is the breaking up of fat globules into smaller fat droplets, increasing the surface area upon which fat-digesting enzymes (lipase, for example) can operate. Since bile does not chemically change anything, it is not an enzyme.
zyme. Bile is also alkaline, serving to help neutralize the HCl in the chyme. The bile is stored adjacent to the liver in the gallbladder and flows through the bile duct where it merges with the pancreatic duct. The remainder of the small intestine (nearly six meters) absorbs the breakdown products of food. It is characterized by villi and microvilli, fingerlike projections of the intestinal wall that increase its total absorptive surface area. Amino acids and sugars are absorbed into blood capillaries, while most of the fatty acids and glycerol are absorbed into the lymphatic system.

6. **Large intestine.** The main function of the large intestine, or colon, is the reabsorption of water to form solid waste, or feces. Various harmless bacteria live in the large intestine, including some that produce vitamin K, which is absorbed through the intestinal wall. At the beginning of the large intestine, there is a short branch to a dead-end pouch which bears a fingerlike projection called the appendix. Other than a possible role in the immune response, the appendix is significant only when it becomes inflamed, causing appendicitis. Food then travels upward in the ascending colon. The food travels across the abdomen in the transverse colon, goes back down the other side of the body in the descending colon, and then through the sigmoid colon.

7. Feces are stored at the end of the large intestine, in the rectum, and excreted through the anus.
The next month at school was hell.

Ms. Ti’s weekly exams had me teetering on the edge of disaster—disaster being C-minus, a mere 2% away from the dreaded D.

And I wasn’t alone. More than half of my classmates were struggling right there with me, some faring even worse than my shameful C-minus. Something had to be done. I swore to myself that I would bring up my grade before the midsemester grading period.

And so I finally unearthed the neglected eight-pound textbook and dragged it back home with me. I flipped it open, optimistic and ready to read, before
slamming it shut after a mere 15 minutes of effort. The textbook, an aged, decrepit thing, was a nightmare; a glittering symbo of everything I hated about biology and science in general. It lacked any distinguishable clarity, and was filled with page after page of boring science-text and complicated cia-grams. I felt cheated, and royally screwed. How was I supposed to dig myself out of my hole with such a shit textbook?

I went to school the next day, irritated and on the offensive. I needed to know what I was supposed to do; given my scores in the class and lacking the resources I needed to study on my own. When Ms. T walked into our sixth period Biology class, for the first time, I sat up a little straighter. I had a purpose that day. Ms. T collected her notes and made her way up to the overhead projector flipped the switch, and began that day’s lecture on the human digestive system. She began the lesson, and I watched, she mapped out intricate dia-grams with clarity and ease and complex structures and sys-tems with surprising candor.

I went home that night and read over my lecture not a few un-answered questions I needed answered, so I found myself getting lost in the book. Images of zymes danced through my head, painting a clear-tonality, fluidity, and illustriousness of the human-ed at the power of Ms. T’s lecture, its visual clari-ty, and how it had been able to act as such a strong complement or, digest-amazed, as

or,

es several times. I had flipped through my notes. To my surprise, I intestines and en-picture of the func-body. I was amaz-ty, and how it had to the verbose
and one-dimesional textbook. Her teaching absurdly simple: she took the facts laid out in the book and presented them in a straightfor compelling way. I had never seen science in and I was intrigued and excited. Ms. T’s methods learned, invaluable to my success in the course, inspired. I wanted to learn everything I could about Later that year, after Ms. T’s class, I sent out tions with a major in Biology. Ms. T’s teaching of passion for the sciences that I had never Biology AP with Ms. T taught me to look for places, to take rigid and structured experienc of wonder and adventure. Great design when encountered, can be life changing, with the slightest alter inspiring and in modes of thin later, I’m no biologist. I’m an aspiring fully, can do what Ms. T was ab method was so impossible text ward, visually this kind of light, were, I quickly and in life. I was out the life sciences. my university applica had stirred in me a sense before known existed. design in the most unexpected of es and ideas, and imbue in them a sense ign is rare, can be unexpected, and nging. Simple, repetitive systems ation, be transformed into novative new king. Looking back, years iring designer, one who, hope- le to do all those years ago:
The Digestive System

Digestion is the chemical breakdown of food into smaller molecules. In an individual cell, digestion is accomplished by intracellular digestion when a lysosome containing digestive enzymes merges with a food vacuole. In most animals, however, the food ingested is too large to be engulfed by individual cells. Thus, food is first digested in a gastrovascular cavity by extracellular digestion and then absorbed by individual cells.

During digestion, four different groups of molecules are commonly encountered. Each is broken down into its molecular components by specific enzymes, and follows:

1. Starches are broken down into glucose monomers, thereby increasing the surface area upon which amylase and subtilisin enzymes can operate. Food is shaped into small balls, and then eaten.

2. Proteins. In the mouth by the salivary amylase, secreted into the mouth by the salivary glands, begins the breakdown of starch into maltose (a disaccharide). Chewing reduces the size of food particles, thereby increasing the surface area upon which amylase and subtilisin enzymes can operate. Food is shaped into small balls, and then swallowed.

3. Nucleic acids are broken down to the simplest elements by digestive enzymes.

4. Fats are broken down into glycerol and fatty acids. In mammals, digestion follows the following sequence of events. In particular, each of the following events is digested (broken down) and by which enzymes. Since enzymes are secreted into different body areas, only a representative few of the numerous enzymes are given.

Flavour. Salivary amylase, secreted into the mouth by the salivary glands, begins the breakdown of starch into maltose (a disaccharide). Chewing reduces the size of food particles, thereby increasing the surface area upon which amylase and subtilisin enzymes can operate. Food is shaped into small balls, and then swallowed.

Pharynx. When food is swallowed and passed into the throat, or pharynx, a flap of tissue, the epiglottis, blocks the trachea so that solid and liquid material enter only the esophagus.

Eosophagus. Food moves through the esophagus, a tube leading to the stomach, by muscular contractions called peristalsis.

Stomach. The stomach secretes gastric juice, a mixture of digestive enzyme and hydrochloric acid (HCl), and serves a variety of functions, as follows:

- Storage. Because of its accordion-like folds, the wall of the stomach can expand to store two to four liters of material.
- Mixing. The stomach mixes the food with water and gastric juice to produce a creamy medium called chyme.

- Physical breakdown. Muscles churn the contents of the stomach, physically breaking food down into smaller particles. In addition, HCl from the gastric juice denatures (or unfolds) proteins and loosens the cementing substances between cells of the food. Also, the HCl kills most bacteria that may exist in the food. The stomach secretes gastric juice, a mixture of digestive enzyme and hydrochloric acid (HCl), and serves a variety of functions, as follows:

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highlight, and you will succeed.

cornell style notes: fold the page into two columns. vocabulary words go on the left, definitions go on the right.

flash cards are the best way to memorize anything.

if you write it enough times, you'll remember it.

different letters will cue you in. take all different letters and make a sentence out of them. you'll remember it forever.
### Digestion

#### Intracellular digestion
- Individual cell
- Food must be broken down

#### Extracellular digestion
- Most animals
- Food is first taken into gastrovascular cavity then digested and absorbed

### 4 groups of molecules in digestion
- Starches: Broken down into glucose molecules.
- Proteins: Broken down into amino acids.
- Fats (Lipids): Broken down into glycerol and fatty acids.
- Nucleic Acids: Broken down into nucleotides.

### Chemical Breakdown of Food into Smaller Molecules

- **Digestion**
  - Chemical breakdown of food into smaller molecules
- **Intracellular digestion**
  - Lysosome merges with a food vacuole
- **Extracellular digestion**
  - Food must be broken down
- **4 groups of molecules in digestion**
  - Each is broken down into its molecular components by specific enzymes
- **Starches**
  - Broken down into glucose molecules.
- **Proteins**
  - Broken down into amino acids.
- **Fats**
  - Broken down into glycerol and fatty acids.
- **Nucleic Acids**
  - Broken down into nucleotides.

### Enzymes and Their Roles
- **Salivary amylase**
- **Pepsin**
- **Chyme**
- **Hydrochloric acid**
- **Peristalsis**

- **Digestion**
- **Intracellular digestion**
- **Extracellular digestion**
- **Chyme**
In an individual cell, digestion is accomplished by intracellular digestion when a lysosome containing digestive enzymes merges with a food vacuole.

The chemical breakdown of food into smaller molecules.

In most animals, however, the food ingested is too large to be engulfed by individual cells. Thus, food is first digested in a gastrointestinal cavity by extracellular digestion and then absorbed by individual cells.

The stomach secretes gastric juice, a mixture of digestive enzyme and hydrochloric acid (HCl), and serves a variety of functions.

Muscular contractions

The chemical breakdown of food into smaller molecules.

Proteins are chemically broken down (digested) by the enzyme pepsin.

The chemical breakdown of food into smaller molecules

Muscular contractions

Bicarbonate neutralizes the acidity of the chyme

Secretin stimulates the pancreas to produce bicarbonate

Secretin: produced by the cells lining the duodenum when food enters

Duodenum continues the digestion of starches, proteins, fats, nucleotides.

Pancreas produces various enzymes, including trypsin and chymotrypsin, lipase, and pancreatic amylase

Small Intestine

Duodenum continues the digestion of starches, proteins, fats, nucleotides.

Pancreas produces various enzymes, including trypsin and chymotrypsin, lipase, and pancreatic amylase.

Wall of the small intestine: source of various enzymes to digest proteins.

Bicarbonate neutralizes the acidity of the chyme.

Secretin produced by the cells lining the duodenum when food enters

Duodenum continues the digestion of starches, proteins, fats, nucleotides
Salivary amylase: begins the breakdown of starch into maltose
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Mouth
Chewing!
Starch → Maltose
Food becomes Bolus, and Swallowed.

Pharynx
Epiglottis
Blocks the trachea so material enters only the Esophagus.

Esophagus
Tube leading to the stomach.
Moves by Peristalsis (muscular contractions)

Stomach
Gastric Juice
mixture of digestive enzyme and hydrochloric acid.

Small Intestine
Digestion of starches and proteins.
Secretin - to neutralize acid.

Large Intestine
Colon
Reabsorption of water to form solid waste, or feces.

OUT
Rectum
Feces are stored at the end of the large intestine, in the rectum, and excreted through the anus.