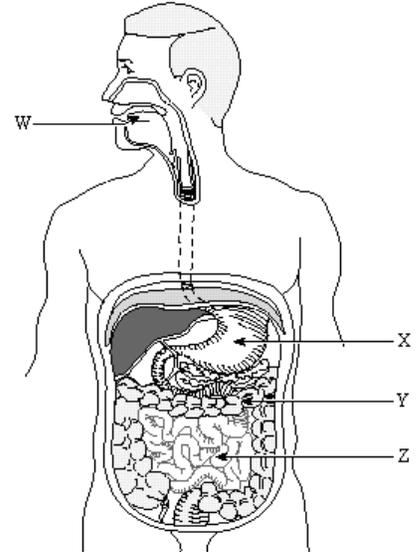


**In a nutshell...**

- The body uses a variety of **small molecules** (amino acids, fatty acids, glucose) for its metabolic needs. Food is mechanically and chemically broken down into these molecules during \_\_\_\_\_, after which they can be taken up by body cells through the separate process of \_\_\_\_\_.
- Food travels in a \_\_\_\_\_ from mouth to esophagus to stomach to small intestine to large intestine to anus.
- Organs and structures in the digestive system are **specialized** for specific functions in digestion.
- **Digestive** \_\_\_\_\_ are specific hydrolytic enzymes that have a preferred temperature and pH.
- Proper \_\_\_\_\_ is necessary to health.



- **DIGESTION:** the \_\_\_\_\_ and \_\_\_\_\_ breaking down of ingested food into particles, then into **molecules small enough** to move through epithelial cells and into the internal environment.
- **ABSORPTION:** the passage of \_\_\_\_\_ from the gut lumen into the blood or lymph, which distributes them through the body.
- **ELIMINATION:** the expulsion of \_\_\_\_\_ residues from the body.

We will look at **DIGESTION** first.

- During digestion, \_\_\_\_\_ are broken down into \_\_\_\_\_, **carbohydrates** into \_\_\_\_\_, fat to \_\_\_\_\_ and \_\_\_\_\_, \_\_\_\_\_ to \_\_\_\_\_
- Digestion is an \_\_\_\_\_ **process**. It occurs within the \_\_\_\_\_ (a tube that runs from \_\_\_\_\_ to \_\_\_\_\_).
- Digestion is achieved through the **cooperation of a number of body parts** and **organ systems**, and its \_\_\_\_\_ depends on the actions of several key \_\_\_\_\_. Let's first look at the parts of the digestive system:

**Mouth**

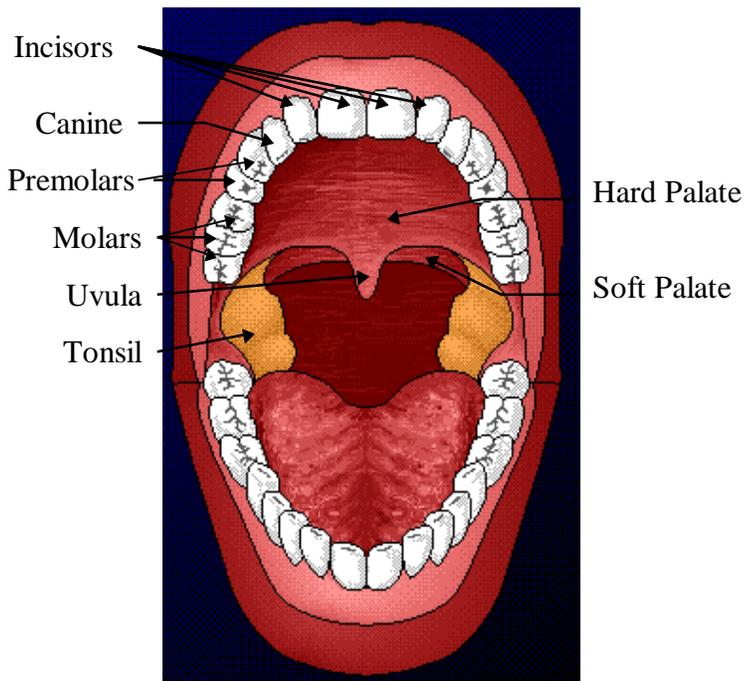
- besides emitting pearls of wisdom, your mouth is **where** \_\_\_\_\_.
- the mouth receives food, chews it up, moistens it, and starts to digest any starch in the food.

**Structure**

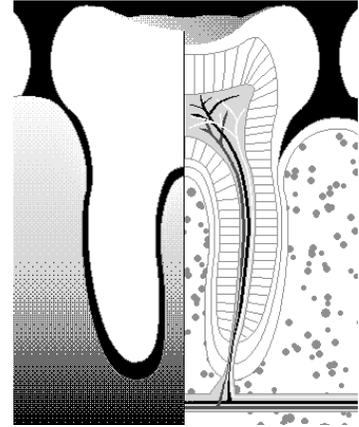
- divided into an anterior \_\_\_\_\_ (contains several bones) and a posterior \_\_\_\_\_, which is composed of muscle tissue. That *thing* that hangs down in the back of your throat people think is their tonsils is really the \_\_\_\_\_, and is the end part of soft palate. (*the tonsils lie on the sides of the throat*).
- *sense of hunger* is due to the combined sensations of **smelling** and **tasting** of food. \_\_\_\_\_ (scent) \_\_\_\_\_ in the nose, **and** \_\_\_\_\_ on the tongue, remind you that you're hungry.

**Teeth**

- a normal adult mouth has \_\_\_\_\_. The purpose of teeth is to chew food into pieces that can be swallowed easily.
- \_\_\_\_\_ aid this: **8** \_\_\_\_\_ for \_\_\_\_\_, **4** \_\_\_\_\_ for \_\_\_\_\_, **8** flat \_\_\_\_\_ for \_\_\_\_\_, and **12** \_\_\_\_\_ for \_\_\_\_\_. (*wisdom teeth* are final molars which may or may not *erupt* properly) -- if not, they must be removed surgically).



- each tooth is shrouded by a tough, extremely hard layer of \_\_\_\_\_ (composed largely of **calcium salts**), \_\_\_\_\_ (a thicker, brownish bone-like material) and an inner layer of **nerves and blood vessels** called the \_\_\_\_\_.



- “\_\_\_\_\_” (proper name for cavities is “**caries**”) are caused by **bacteria** in the mouth feeding on foods (like sugars) and giving off acids that corrode the tooth. “\_\_\_\_\_” is actually the living and *dead bodies of millions of bacteria*. **Fluoride** makes the tooth enamel stronger and more resistant to decay.

- Gum disease (inflammation of the gums = “\_\_\_\_\_” is the *most common disease in the world!* If it spreads to the **periodontal membrane** (the lining of the tooth socket), it can cause **bone loss** in the socket and loosening of the teeth (= \_\_\_\_\_).

- There are three sets of \_\_\_\_\_ that produce \_\_\_\_\_
  - \_\_\_\_\_ (below ears)
  - \_\_\_\_\_ (below tongue)
  - \_\_\_\_\_ (under lower jaw).

- You can locate the duct opening of these with your tongue (\_\_\_\_\_ - *by second upper molar*, \_\_\_\_\_ and **submandibular flaps** are under the tongue).

- When you chew food, you moisten and lubricate it with **saliva**. Saliva contains \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_

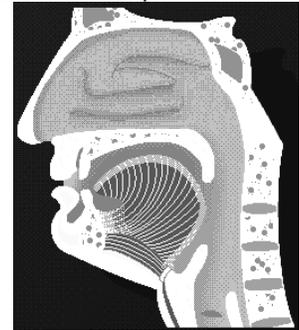
- \_\_\_\_\_, a \_\_\_\_\_ enzyme that breaks down starch in the presence of water. \_\_\_\_\_ **is broken down to** \_\_\_\_\_ (a disaccharide of glucose), which is later broken down to glucose in the intestine.

- Thus, digestion \_\_\_\_\_, even before the food is swallowed. Once food has been chewed, it is called a \_\_\_\_\_.

- Food is then passed through the back of the mouth when you swallow. The first region that it enters is called the \_\_\_\_\_, which is simply **the region between mouth and esophagus** where \_\_\_\_\_ takes place.

- Swallowing is a \_\_\_\_\_ (requires no conscious thought).

- To prevent food from going down your air passages**, some clever maneuvering is necessary. Note that it is **impossible** to breath and swallow at the same time. *What is happening?*



- when you swallow, the following happens in order to block air passages:

- the \_\_\_\_\_ to cover openings to nose (nasopharyngeal openings).

- \_\_\_\_\_ under a flap of tissue called the epiglottis, blocking its opening. When food goes down the “wrong way” it goes into the trachea, and is then coughed back up.

- opening to** \_\_\_\_\_ (larynx = “voice box”) is called the “\_\_\_\_\_.” This opening is **COVERED** when the \_\_\_\_\_ (you can see this by observing the movement of the **Adam's Apple** (part of the larynx) when swallowing). It gets covered by a flap of tissue called the \_\_\_\_\_.

- food then has **one route** to go ---> \_\_\_\_\_.

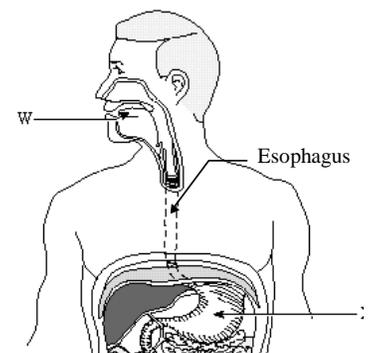
- \_\_\_\_\_: a **long muscular tube** that extends from pharynx to stomach. Made of several types of tissue.

- The inner surface lined with **mucus membranes**. This layer is attached by connective tissue to a layer of **smooth muscle** containing both \_\_\_\_\_ and \_\_\_\_\_ muscle.

- food moves down the esophagus through **PERISTALSIS** (**rhythmical contractions of the esophageal muscles**). If peristalsis occurs when there is no food in the esophagus, you will feel that there is a “*lump*” in your throat.

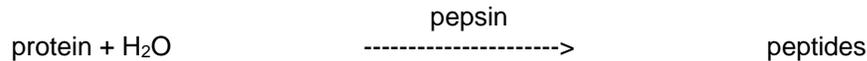
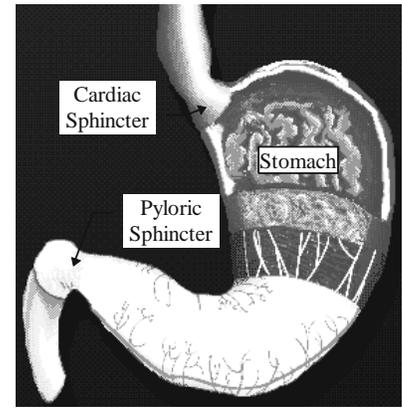
- Food bolus reaches the end of the esophagus and arrives at the \_\_\_\_\_ connecting to the stomach. (sphincters function like **valves**. Made of muscles that encircle tubes, open them when they relax, close them when they contract).

- Normally, this sphincter prevents food from moving up out of stomach, but when **vomiting** occurs, a *reverse peristaltic wave* causes the sphincter to relax and the contents of the stomach are propelled outward.



## Stomach

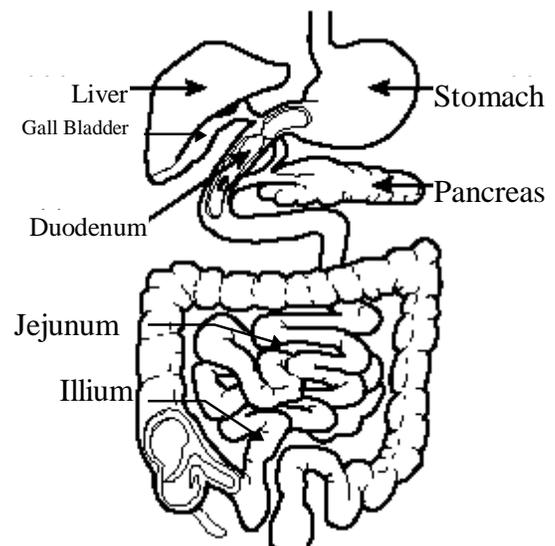
- is a **thick-walled, J-shaped organ** that lies on left side of the body beneath the diaphragm.
- can stretch to hold about half a gallon (~\_\_\_\_\_) of solids and/or liquids in an average adult.
- **three layers of muscle** contract to **churn** and **mix** its contents
- “hunger pains” are felt when an empty stomach churns.
- the mucus lining of the stomach contains inner \_\_\_\_\_ which produce \_\_\_\_\_. Gastric juice contains \_\_\_\_\_ and \_\_\_\_\_ (hydrochloric acid). When the two combine, pepsinogen forms \_\_\_\_\_, a \_\_\_\_\_ that breaks down proteins into smaller chains of amino acids called \_\_\_\_\_. (further on in the digestive tract they are broken down individual amino acids by other enzymes. This is the reaction that takes place.



- HCl gives **stomach** a \_\_\_\_\_. Highly **corrosive**. This \_\_\_\_\_ in food and helps break it down
- *Why doesn't the stomach digest itself?* This is because its **inner wall is protected by a \_\_\_\_\_ secreted by mucosal cells.**
  - if HCl does penetrate, pepsin starts to digest the stomach lining ---> forms an \_\_\_\_\_ (an **open sore** on the wall of the stomach). **Too much gastric juice** can cause ulcers, as can too much nervous stimulation (i.e. **stress**), since this will cause over-secretion of gastric juices).
  - however, the #1 cause of ulcers is actually a \_\_\_\_\_ (*Helicobacter pylori*) that impair the ability of cells to produce mucus. Thus, most ulcers can now be cured with \_\_\_\_\_.
- after **2 - 6 hours** (depending on the type of food), the food has been turned into a **semi-liquid food mass** called \_\_\_\_\_, \_\_\_\_\_ and the **stomach empties into the first part of the small intestine** (called the \_\_\_\_\_). This emptying is controlled by the \_\_\_\_\_ at the bottom of the stomach.

## Small Intestine: The Food Processor

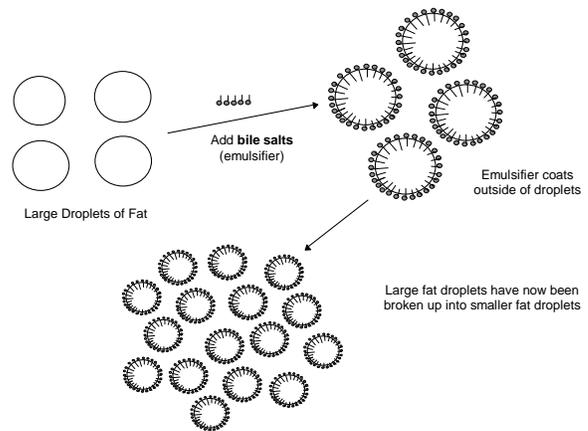
- In our story, only some digestion has thus far taken place. Most of \_\_\_\_\_ and \_\_\_\_\_ of most nutrients occur in the small intestine.
- Divided into three zones: the \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.
- is about \_\_\_\_\_ (~20 feet), compared to \_\_\_\_\_ (~ 5 feet) **for large intestine.**
- first **25 cm of small intestine** called the \_\_\_\_\_. The duodenum plays a **major role in digestion**. It is here that **SECRETIONS SENT FROM THE LIVER AND PANCREAS** break down **fat** and **peptides**, and secretions of the duodenum itself also break down other **nutrients**.
- the Liver **produces** \_\_\_\_\_, which is sent to the duodenum via a **duct** from the \_\_\_\_\_ (where bile is **stored**).
- **bile** is a \_\_\_\_\_ (it gets its green colour from **byproducts of hemoglobin breakdown** (another function of the liver).
- bile contains **emulsifying agents** called \_\_\_\_\_ which break **FAT** into **FAT DROPLETS**.



- \_\_\_\_\_ sends \_\_\_\_\_ into duodenum through duct
- the juice contains **enzymes** and \_\_\_\_\_  
\_\_\_\_\_ ( $\text{NaHCO}_3$ )
- $\text{NaHCO}_3$  makes **the juice** \_\_\_\_\_ ( $\text{pH} \sim 8.5$ ).  
It \_\_\_\_\_ and make the small intestine pH basic

- pancreatic juice contains \_\_\_\_\_ including **pancreatic amylase** (digests starch to maltose), **trypsin** (digests protein to peptides), and **lipase** (digests fat droplets to glycerol & fatty acids).

- *Note: the pancreas also has an **endocrine function**. It produces the hormones \_\_\_\_\_ and **glucagon**. Insulin is a **hormone** that causes glucose in the blood to be **taken up by cells** (i.e. **lowers blood [glucose]**). It is produced by different cells ( **$\beta$  cells** in "islets of Langerhans") in the pancreas than the ones that make pancreatic juice. Insulin is released directly into the **blood**, and it travels to target cells throughout the body. People who don't produce insulin or enough insulin, or who lack insulin receptors on target cells, will suffer from **diabetes**. Glucagon works opposite to insulin: Glucagon has the effect of **raising blood glucose concentrations**.*

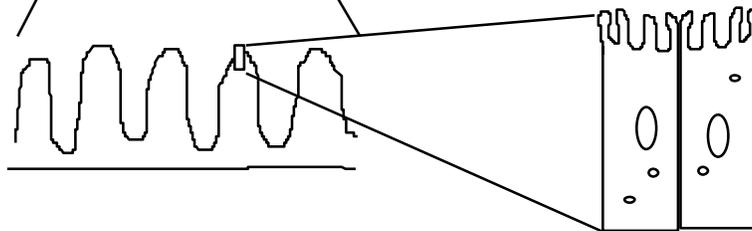


- **walls of the duodenum and small intestine** are lined with millions of \_\_\_\_\_ that produce juices containing enzymes that **finish the digestion** of protein and starch.
- secretions from the interstitial glands contain digestive enzymes: \_\_\_\_\_ digest \_\_\_\_\_ to \_\_\_\_\_. \_\_\_\_\_ also, \_\_\_\_\_ digests \_\_\_\_\_ (a disaccharide) to \_\_\_\_\_. Other enzymes made here digest other \_\_\_\_\_ (e.g. lactase digests lactose, the sugar in milk).

The lining of the small intestine is not smooth; it is long and convoluted.



The convoluted lining itself, under closer examination, is shown to consist of millions of finger-like projections called **villi** (singular = **villus**)



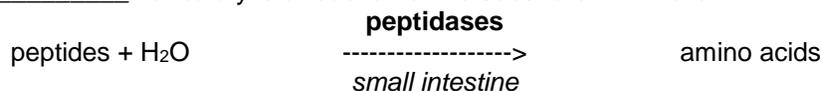
Lining of each villus made of columnar epithelial cells, that have **microvilli** (folds of cell membrane) across which nutrients are absorbed.

- bile (bile is an emulsifying agent, not an enzyme) sent from the **gall bladder** to the duodenum emulsifies fat to fat droplets in the duodenum.
- secretions from **pancreas** arrive at the duodenum. These secretions contain trypsin, which breaks down proteins to peptides in the duodenum. Lipase from the pancreas breaks lipids to glycerol and fatty acids.

### Comprehensive Summary of DIGESTIVE ENZYMES

- the breakdown of food (fats, carbohydrates, proteins) into molecules small enough to be absorbed requires the action of specific enzymes
- each enzyme has \_\_\_\_\_ where it works, and a \_\_\_\_\_ range in which it can operate
- all are \_\_\_\_\_ that catalyze a reaction of the substrate with **water**.

e.g.



## The Principal Digestive Enzymes!

| Source & Enzyme           | Substrate<br>(what they act on!) | preferred pH        | Product                   | Site of Action<br>(Where they work) |
|---------------------------|----------------------------------|---------------------|---------------------------|-------------------------------------|
| <b>SALIVARY GLANDS</b>    |                                  |                     |                           |                                     |
| <b>Salivary Amylase</b>   | Starches                         | neutral (~7)        | maltose                   | Mouth                               |
| <b>STOMACH</b>            |                                  |                     |                           |                                     |
| <b>Pepsin</b>             | Proteins                         | acidic (3)          | peptides                  | Stomach                             |
| <b>PANCREAS</b>           |                                  |                     |                           |                                     |
| <b>Pancreatic Amylase</b> | Starches                         | alkaline (~7.5-8.5) | maltose                   | Small Intestine                     |
| <b>Lipase</b>             | Fats                             | alkaline            | FA's & glycerol           | Small Intestine                     |
| <b>Trypsin</b>            | Polypeptides                     | alkaline            | peptides                  | Small Intestine                     |
| Chymotrypsin              | Poly & oligopeptides             | alkaline            | amino acids               | Small Intestine                     |
| Carboxypeptidase          | Polypeptides                     | alkaline            | amino acids               | Small Intestine                     |
| Deoxyribonuclease         | DNA                              | alkaline            | nucleotides               | Small Intestine                     |
| Ribonuclease              | RNA                              | alkaline            | nucleotides               | Small Intestine                     |
| <b>LIVER</b>              |                                  |                     |                           |                                     |
| <b>Bile</b> (emulsifies)  | Fat Globules                     | alkaline            | smaller fat globules      | Small Intestine                     |
| <b>SMALL INTESTINE</b>    |                                  |                     |                           |                                     |
| <b>Aminopeptidase</b>     | Polypeptides                     | alkaline            | amino acids               | Small Intestine                     |
| Tripeptidases             | Tripeptides                      | alkaline            | amino acids               | Small Intestine                     |
| Dipeptidase               | Dipeptides                       | alkaline            | amino acids               | Small Intestine                     |
| <b>Maltase</b>            | Maltose                          | alkaline            | glucose                   | Small Intestine                     |
| <b>Lactase</b>            | Lactose                          | alkaline            | glucose & galactose       | Small Intestine                     |
| Sucrase                   | Sucrose                          | alkaline            | glucose & fructose        | Small Intestine                     |
| Enterokinase              | Trypsinogen                      | alkaline            | Trypsin                   | Small Intestine                     |
| Phosphatases              | Nucleotides                      | alkaline            | sugars, bases, phosphates | Small Intestine                     |

- The \_\_\_\_\_ of the small intestine is well related to its \_\_\_\_\_ of \_\_\_\_\_

1. it is \_\_\_\_\_ with \_\_\_\_\_ walls

**to increase surface area**

2. \_\_\_\_\_ surface area further increased

by presence of **finger-like**

**projections** called \_\_\_\_\_ (a single one is called a "**villus**". Interstitial glands are at the **base** of each villi.

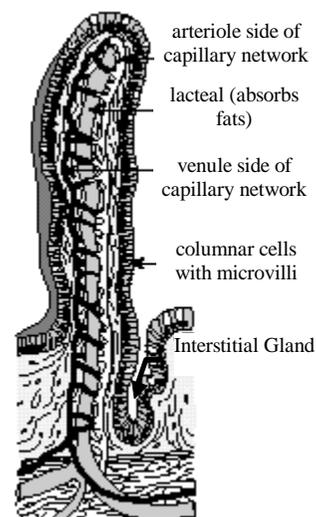
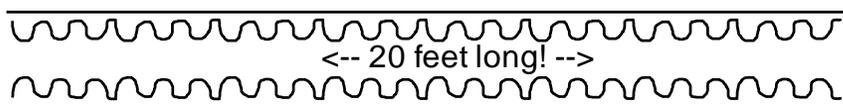
3. villi themselves are lined with columnar cells coated with \_\_\_\_\_. Each villi contains **blood vessels** and **lymph vessels** (lacteal).

- ABSORPTION** takes **place across the wall of each villus** ---> this can happen **passively** or **actively**. Recall that active transport across cell membranes requires **ATP**. The nutrient can now enter the blood or the lymphatic system, depending on what type it is.

- \_\_\_\_\_ a \_\_\_\_\_ and \_\_\_\_\_ are absorbed across the villi, are **recombined** into \_\_\_\_\_ molecules in the epithelial cells of the villus. The fats then move into the \_\_\_\_\_ of each villus and enter the \_\_\_\_\_ **SYSTEM**.

- \_\_\_\_\_ and \_\_\_\_\_ enter the \_\_\_\_\_ through the capillary network.

- The blood vessels from the villi in the small intestine merge to form the \_\_\_\_\_ which leads to the \_\_\_\_\_.



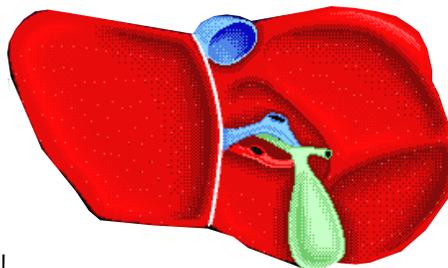
### The Liver

- a critically important organ in digestion & homeostasis

## FUNCTIONS OF THE LIVER

1. keeps blood concentrations of nutrients, hormones etc. \_\_\_\_\_ (e.g. converts glucose to glycogen and back to keep blood glucose levels constant).
2. \_\_\_\_\_ (e.g. carbohydrates to fats, amino acids to carbohydrates and fats).
3. **removes toxins from the blood** (\_\_\_\_\_). Removes of unwanted particulate matter from the blood through the mediation of macrophages.
4. Production of **Bile**. Up to 1.5 liters of bile per day!
5. \_\_\_\_\_
6. \_\_\_\_\_. \_\_\_\_\_ (deamination of amino acids and excretion of resulting ammonia as urea, uric acid, etc.)
7. \_\_\_\_\_ such as fibrinogen and albumin.
8. \_\_\_\_\_
9. **Storage of iron.**
10. **Storage of vitamins.**
11. In embryos (of vertebrates) , the liver **makes Red Blood Cells**

Underside of liver showing gall bladder



### Disorders of Liver (*not on exam!*)

- **Jaundice:** a **generalized condition** (there are numerous causes) many causes that gives a **yellowish tint** to the skin. This yellowish tint is due to the to build up of \_\_\_\_\_ (from the breakdown of red blood cells) in the blood, which is due to **liver damage** or **blockage of bile duct** (the latter is called "**obstructive jaundice**").
- Obstructive jaundice also causes \_\_\_\_\_ (made of cholesterol and CaCO<sub>3</sub>. Can block bile ducts. Removal of gall bladder often necessary.
- **Viral Hepatitis:** causes liver damage and jaundice. Two main types.
  - **Type A: *infectious hepatitis*** caused by unsanitary food, polluted shellfish.
  - **Type B: *serum hepatitis***: spread through blood contact (e.g. transfusions)
- **CIRRHOSIS:** usually caused **by chronic over-consumption of alcohol.**

ROH ---> Active Acetate --> Fatty acids

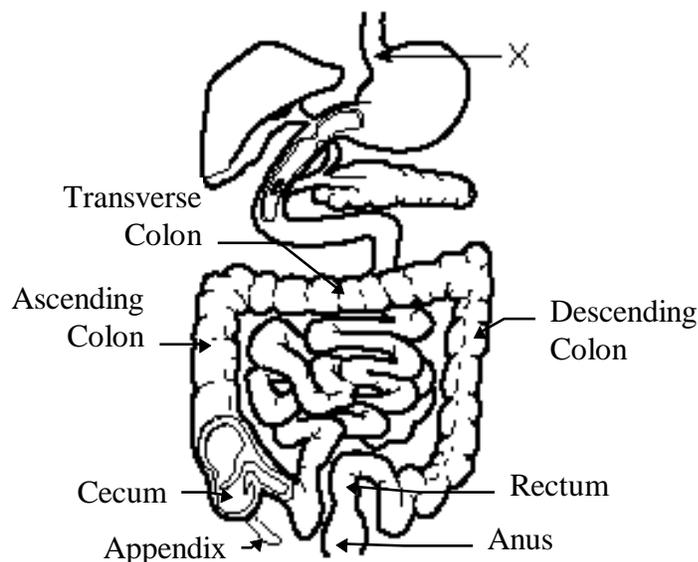
  - Liver fills up with fat deposits and scar tissue
  - Kills thousands of alcoholics per year
  - first step may be the presence of much more **smooth endoplasmic reticulum** in the liver cells.

### Large Intestine

- consists of \_\_\_\_\_ and \_\_\_\_\_ (the rectum is the last 20 cm of the colon). Opening of rectum is called \_\_\_\_\_.
- colon has 3 parts (**ascending, transverse, and descending**)

#### Main Functions

- \_\_\_\_\_ from indigestible food matter (**feces**)
- \_\_\_\_\_ of \_\_\_\_\_
- feces also contains **bile pigments, heavy metals, and billions of** \_\_\_\_\_. While there is no question that they are parasites, they provide a valuable service for us. These bacteria **break down** some indigestible food, and in the **process produce some** \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_ and **other** \_\_\_\_\_ that are in turn absorbed by the colon.



## Disorders of the Digestive System (*not on exam!*)

### Diarrhea

- too much water is expelled in the feces.
- usually caused by \_\_\_\_\_ (in food, polluted water etc.) or \_\_\_\_\_.
- the symptom is actually a body defense against pathogen (an attempt to “flush it out”)
- loss of water can lead to severe dehydration. Causes millions of deaths per year in Third World nations

### Constipation

- feces are dry, hard, difficult to expel.
- Leading cause is **lack of dietary fiber**. Diet can be supplemented by fiber or natural fiber supplements (e.g. Psyllium husks). Most chemical laxatives are irritants -- cause increased peristalsis. They may also weaken intestinal wall such that their continued use is perpetuated (i.e. you may grow to “depend” on them.)

### Appendicitis

- a \_\_\_\_\_ located at bottom of cecum (segment joining large & small intestines). **No known function**, but can get infected, and even burst ---> can be deadly as it would fill the abdominal cavity with infections bacteria.

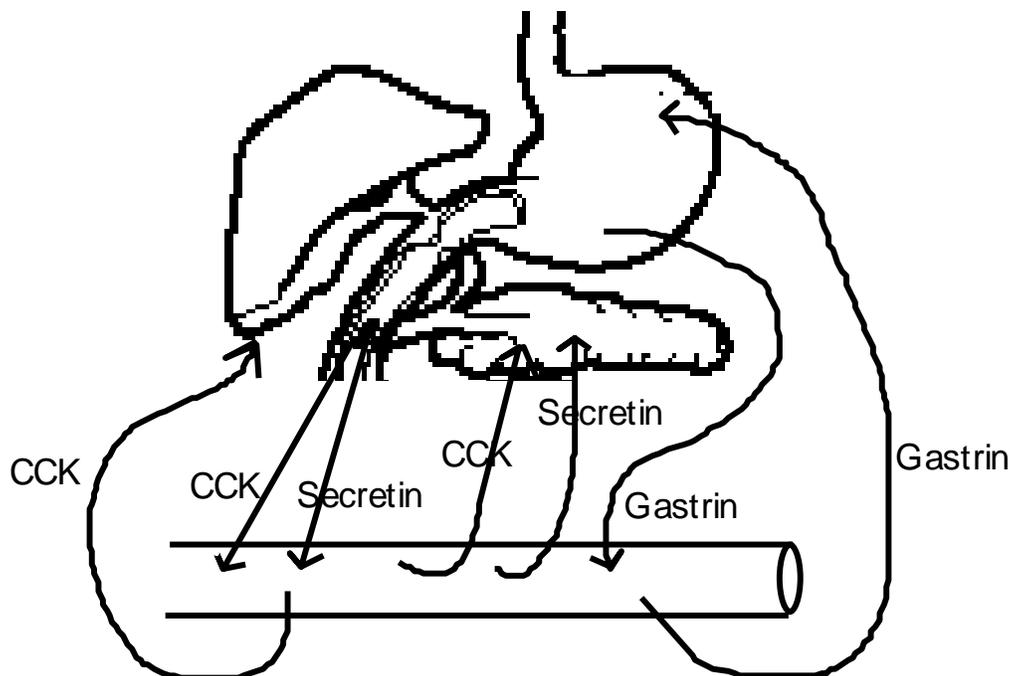
### Colostomy

- **removal** of rectum and anal canal
- intestine attached to abdominal wall, feces collect in plastic bag

## Control of Digestive Gland Secretion

- *generally speaking*, **the presence of food** in digestive system triggers digestive glands to secrete their enzymes.
- more specifically, \_\_\_\_\_ control secretion of specific digestive juices.
- There are **4 hormones** that we will look at: \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.

## The Specifics! *From start to finish*



- When food is eaten, **sensory cells** in the stomach detect the presence of \_\_\_\_\_. Other sensory receptors detect that the stomach is distending (i.e. **stretching**). This causes other stomach cells to release \_\_\_\_\_, a hormone, into the **blood**.
- Gastrin travels through the blood and finally reaches **other cells** (takes about 1 minute) in the stomach that produce **gastric juices**, and stimulates its release.

- Most digestion of food occurs in the **duodenum**. The acid chyme seeps in from the stomach and is first **neutralized**. \_\_\_\_\_, a hormone produced by the small intestine, mediates this neutralization by stimulating the release of **SODIUM BICARBONATE** by the **pancreas**.
- The presence of **amino acids** or **fatty acids** in the duodenum triggers the release of \_\_\_\_\_ (\_\_\_\_\_), which stimulates the release of \_\_\_\_\_ **by the** \_\_\_\_\_ and \_\_\_\_\_ by the \_\_\_\_\_
- A fourth hormone, \_\_\_\_\_ (also known as **Gastric Inhibitory Peptide**, or \_\_\_\_\_), released by the small intestine, slows digestion by \_\_\_\_\_ **stomach peristalsis** and **acid secretion** when acid chyme rich in \_\_\_\_\_ (which require additional digestion time) enters the duodenum.

Here is a great lil' summary for you!

| Hormone  | Released by What Part/ in response to what?                 | Acts on What Part?                              | What does it do?   |
|----------|---|---|--|
| GASTRIN  | upper part of stomach/in response to protein in the stomach | Gastric juice secreting cells at top of stomach | Causes secretion of gastric juices                                     |
| SECRETIN | Small intestine/Acid chyme from stomach                     | Pancreas  | Causes pancreas to release NaHCO <sub>3</sub> and pancreatic enzymes   |
| CCK      | Small intestine/Acid chyme in stomach                       | Pancreas and Liver (gall bladder)               | Causes liver to secrete bile and pancreas to secrete pancreatic juice. |
| GIP      | Small intestine/acid chyme rich in fats enter duodenum      | Stomach   | Inhibits stomach peristalsis and acid secretion (opposes gastrin)      |

### Human Nutrition: *You are what you don't eliminate!*

#### Main Classes of Nutrients

- carbohydrates
- proteins
- lipids
- vitamins & minerals

#### Carbohydrates

- primary source of \_\_\_\_\_ diet should **consist primarily of** \_\_\_\_\_ (not refined sugars)
- carbohydrates are digested eventually to **glucose**, which is stored by liver as **glycogen**
- glucose is only fuel **brain** will use

#### Fats

- most fats can be made by \_\_\_\_\_ (linoleic acid is an exception)
- fats in food are mostly found in **animal products** (meat and dairy). These are especially high in **saturated fats**. (saturated fats tend to be solid at room temp.)
- **high fat and protein diets are number one cause of death in North America** (heart disease, strokes, hypertension, many forms of cancer, many other disorders and diseases).
- You should get about **15%** of your calories from fat. Most Americans and Canadians get between **40** and **60%** of their calories from fat!
- **high in calories** (> twice as many per gram (9.1) as carbohydrates or protein (4.4))

#### Proteins

- protein is necessary for tissues, metabolism, enzymes etc.
  - it is **NOT** an energy food
- of twenty types of amino acids, 8 cannot be manufactured by humans --- called \_\_\_\_\_.
- \_\_\_\_\_ s the most common form of malnutrition in **poorer countries**. The swollen abdomen of starving children is caused by **edema** due to the lack of plasma proteins in the blood.
- protein deficiency is \_\_\_\_\_ a problem in North America.
- most North Americans eat **more than 2 to 3 times** the amount of protein they need.
- **high protein diets are usually also high fat diets.**

## Vitamins and Minerals

- vitamins are **organic compounds** that the body **can't produce** but must be present in the diet (though they are only required in very **small amounts**). **Lack of any one vitamin can cause serious health disorders.**
- \_\_\_\_\_ : deficiency leads to **rickets** (bowing of legs). Manufactured naturally by skin upon exposure to sun.
- \_\_\_\_\_ : deficiency leads to **scurvy**
- \_\_\_\_\_ : deficiency causes fissures of lips (**cheilosis**)
- \_\_\_\_\_ : deficiency causes dermatitis of areas of skin exposed to light (called **pellagra**)
- many vitamins are **coenzymes**. e.g. **Niacin**: coenzyme of **NAD**. **Riboflavin**: coenzyme of **FAD**.
- best source** of vitamins is **fresh fruits and vegetables** in a balanced diet.
- Vitamin supplements, in moderation, have not been clearly established as being either harmful or significantly beneficial.
- Some advocates of mega-vitamin therapy have reported efficacy of Vitamin C (as well as certain other vitamins) as effective in treating everything from cancer to mental illness.
- Mega-doses of **fat-soluble vitamins** (e.g. Vitamin A) should never be taken ---> dangerous levels can build up in body.
- Here is a summary of the important vitamins in human nutrition:*

| Name, Formula, and Solubility   | Important Sources   | Functions  | Result of Deficiency or Absence (in humans, except as noted)  |
|---|---|--|---|
| <b>LIPID-SOLUBLE VITAMINS</b>   |   |  |   |
| <b>A</b> (C <sub>20</sub> H <sub>30</sub> O), antixerophthalmic   | Plant form (carotene, C <sub>40</sub> H <sub>56</sub> ) in green leaves, carrots, etc.; is changed in liver to animal form (C <sub>20</sub> H <sub>30</sub> O), present in fish-liver oil (shark); both forms in butter, milk | Maintains integrity of epithelial tissues, especially mucous membranes; needed as part of visual purple in retina of eye   | Xerophthalmia (dry cornea, or tear secretion), phrynoderma (toad skin), night blindness, growth retardation, nutritional croup (hoarseness) in birds  |
| <b>D</b> (C <sub>28</sub> H <sub>44</sub> O), antirachitic  | Fish-liver oils, especially tuna, less in cod; beef fat; also exposure of skin to ultraviolet radiation   | Regulates metabolism of calcium and phosphorus; promotes absorption of calcium in intestine; needed for normal growth and mineralization of bones<br>Antioxidative; maintains integrity of membranes | Rickets in young (bones soft, yielding, often deformed); osteomalacia (soft bones), especially in women of Asia   |
| <b>E</b> , or tocopherol (C <sub>29</sub> H <sub>50</sub> O <sub>2</sub> ), antisterility                     | Green leaves, wheatgerm oil and other vegetable fats, meat, milk  | Antioxidative; maintains integrity of membranes  | Sterility in male fowls and rats, degeneration of testes with failure of spermatogenesis, embryonic growth disturbances, suckling paralysis and muscular dystrophy in young animals                           |
| <b>K</b> (C <sub>31</sub> H <sub>46</sub> O <sub>2</sub> ), antihemorrhagic                                   | Green leaves, also certain bacteria, such as those of intestinal flora  | Essential to production of prothrombin in liver; necessary for blood clotting  | Blood fails to clot   |
| <b>WATER-SOLUBLE VITAMINS</b>   |   |  |   |
| <b>B</b> complex Thiamine (B <sub>1</sub> ) (C <sub>12</sub> H <sub>17</sub> ON <sub>4</sub> S), antineuritic | Yeast, germ of cereals, (especially wheat, peanuts, other leguminous seeds), roots, egg yolk, liver, lean meat  | Needed for carbohydrate metabolism; thiamine pyrophosphate, an essential coenzyme in pyruvate metabolism (stimulates root growth in plants)  | On diet high in polished rice, beriberi (nerve inflammation); loss of appetite, with loss of tone and reduced motility in digestive tract; cessation of growth; polyneuritis (nerve inflammation) in birds    |
| Riboflavin (B <sub>2</sub> ) (C <sub>17</sub> H <sub>20</sub> O <sub>6</sub> N <sub>4</sub> )                 | Green leaves, milk, eggs, liver, yeast  | Essential for growth; forms prosthetic group of FAD enzymes concerned with intermediate metabolism of food and electron-transport system   | Cheilosis (inflammation and cracking at corners of mouth), digestive disturbances, "yellow liver" of dogs, curled-toe paralysis of chicks, cataract   |
| Nicotinic acid, or niacin (C <sub>6</sub> H <sub>5</sub> O <sub>2</sub> N), antipellagic                      | Green leaves, wheat germ, egg yolk, meat, liver, yeast  | Forms active group of nicotinamide adenine dinucleotide, which functions in dehydrogenation reactions  | Pellagra in humans and monkeys, swine pellagra in pigs, blacktongue in dogs, perosis in birds   |
| Folic acid (C <sub>19</sub> H <sub>19</sub> O <sub>6</sub> N <sub>7</sub> )                                   | Green leaves, liver, soybeans, yeast, egg yolk  | Essential for growth and formation of blood cells; coenzyme involved in transfer of single-carbon units in metabolism  | Anemia, hemorrhage from kidneys, and sprue (defective intestinal absorption) in humans; nutritional cytopenia (reduction in cellular elements of blood) in monkeys; slow growth and anemia in chicks and rats |
| Pyridoxine (B <sub>6</sub> ) (C <sub>8</sub> H <sub>12</sub> O <sub>2</sub> N)                                | Yeast, cereal grains, meat, eggs, milk, liver   | Present in tissues as pyridoxal phosphate, which serves as coenzyme in transamination and decarboxylation of amino acids   | Anemia in dogs and pigs; dermatitis in rats; paralysis (and death) in pigs, rats, and chicks; growth retardation  |
| Pantothenic acid (C <sub>9</sub> H <sub>17</sub> O <sub>3</sub> N)  | Yeast, cane molasses, peanuts, egg yolks, milk, liver   | Forms coenzyme A, which catalyzes transfer of various carboxylated groups and functions in carbohydrate and lipid metabolism   | Dermatitis in chicks and rats, graying of fur in black rats, "goose-stepping" and nerve degeneration in pigs  |
| Biotin (vitamin H) (C <sub>10</sub> H <sub>16</sub> O <sub>3</sub> N <sub>2</sub> S)                          | Yeast, cereal grains, cane molasses, egg yolk, liver, vegetables, fresh fruits  | Essential for growth: functions in CO <sub>2</sub> fixation and fatty acid oxidation and synthesis   | Dermatitis with thickening of skin in rats and chicks, perosis in birds   |
| Cyanocobalamin (B <sub>12</sub> ) (C <sub>63</sub> H <sub>90</sub> N <sub>14</sub> O <sub>14</sub> PCo)       | Liver, fish, meat, milk, egg yolk, oysters, bacteria and fermentations of <i>Streptomyces</i> ; synthesized only by bacteria  | Formation of blood cells, growth; coenzyme involved in transfer of methyl groups and in nucleic acid metabolism  | Pernicious anemia, slow growth in young animals; wasting disease in ruminants   |
| <b>C</b> , or ascorbic acid (C <sub>6</sub> H <sub>8</sub> O <sub>6</sub> )                                   | Citrus fruits, tomatoes, vegetables; also produced by animals (except primates and guinea pigs)   | Maintains integrity of capillary walls; involved in formation of "intercellular cement"  | Scurvy (bleeding in mucous membranes, under skin, and into joints) in humans and guinea pigs  |

Certain \_\_\_\_\_ are also needed by the body.

1. \_\_\_\_\_: gram amounts needed daily. **Na, Mg, P, Cl, K, Ca**. Have generalized important uses.
  - e.g. \_\_\_\_\_ makes up structural component of important tissues (e.g. bone, cartilage), and is also a necessary ion for the transmission of nerve impulses across **synapses** and the initiation of **muscle contraction**.
2. \_\_\_\_\_: ("trace elements"). Minute amounts (micrograms) needed. Very specific. e.g. **Fe** (for hemoglobin), **Iodine** (for the hormone **thyroxin**), **molybdenum** (required for vitamin B<sub>12</sub>), **selenium**, **chromium**, **nickel**, **vanadium**, **silicon**, **arsenic**, **cobalt**.

## DIETING

- **Reducing the \_\_\_\_\_ and/or increasing the amount of exercise** will eventually result in weight loss. Best way to do this is to **reduce your FAT** intake, while doing some sort of aerobic exercise three times per week.
- There are \_\_\_\_\_ that must also be accounted for when considering weight loss.
- An individual's \_\_\_\_\_ (**BMR**) is the amount of calories (1 C is the amount of heat needed to raise the temp of 1 kg of water one centigrade degree) the are needed to maintain his or her body at rest (this # is affected by age, weight, health etc.).
- The recommended daily intake of calories for a **woman 19 - 22** whose height is 5'4" and who is basically sedentary (only light exercise) is 2,100 C.
- For a **man 19 - 22**, height 5'10", the recommended number of calories is **2,900**. Of course both of these figures are only average estimates, and will go up if the person is more active.
- *Below is a table of the number of calories utilized by various activities.*

| Activity                  | Calories Burned per hour |
|---------------------------|--------------------------|
| sitting at rest           | 100                      |
| dressing and undressing   | 118                      |
| slow walking              | 200                      |
| vigorous exercise         | 450                      |
| swimming                  | 500                      |
| jogging                   | 570                      |
| walking briskly up stairs | 1100                     |

### So What's the Problem with the Average Canadian Diet, Anyway?

- It is way too high in fat and protein. High fat and protein diets are bad for the human body and the planet Earth!
- meat is **not** the best source of protein. Along with dairy products, it **is** the best source of **pesticide residues, antibiotics, and growth hormones**.
- high protein diet is also the leading cause of many diseases such as **osteoporosis**
- there are many "complete" vegetable proteins. Broccoli is higher in protein *per calorie* than steak. "Food-combining" is unnecessary
- **raising meat for human consumption is the most wasteful way** (in terms of **food used, non-renewable resources consumed, water used, land used, environment deteriorated, and pollution produced**) of feeding humans.
- meat and dairy foods contain "**zero**" **fiber**. Lack of dietary fiber leads to constipation (meat eaters tend to be chronically **constipated**) and can lead to **colon cancer**.
- *But **don't believe me** if you don't want to -- **do the research yourself**. Here are just a few of the hard facts...*
- The average Canadian or American will consume approximately: \_\_\_\_\_ **cows**, \_\_\_\_\_ **hogs**, \_\_\_\_\_ **sheep/goats**, \_\_\_\_\_ **chickens**, \_\_\_\_\_ **turkeys**, \_\_\_\_\_ **eggs**, \_\_\_\_\_ **kg of seafood**, and \_\_\_\_\_ **kg of butter/margarine** in their lifetime.
- The average North American man's risk of death **from heart attack** is \_\_\_\_\_ %
- His risk if he avoids meat-centered diet: \_\_\_\_\_ %
- Risk for complete vegetarian (vegan): \_\_\_\_\_ %
- Percent of **cancers** linked to diet: approx. \_\_\_\_\_ % (conservative estimate)

- Following is an abbreviated list of diseases which are closely linked to high-fat diets, and which can be often improved, prevented, and even occasionally cured by the adoption of a vegetarian diet:

|                 |                   |                    |
|-----------------|-------------------|--------------------|
| Strokes         | Heart Disease     | Osteoporosis       |
| Kidney Disease  | Breast Cancer     | Colon Cancer       |
| Prostate Cancer | Pancreatic Cancer | Ovarian Cancer     |
| Cervical Cancer | Stomach Cancer    | Endometrial Cancer |
| Diabetes        | Hypoglycemia      | Kidney Disease     |
| Peptic Ulcers   | Constipation      | Hemorrhoids        |
| Hiatal hernias  | Diverticulosis    | Obesity            |
| Gallstones      | Hypertension      | Asthma             |
| Salmonellosis   | Trichinosis       | "Mad-Cow" Disease  |

- This is only a partial list, and that there are many more illnesses and health problems directly connected to the consumption of animal foods, including eggs and dairy products.
- Women who eat 3 or more **eggs** per week, for example, have 3 times the risk of developing fatal ovarian cancer.
- Women who eat butter and cheese 2-4 times per week have a 3.2 higher risk of developing breast cancer than those who have them once or less.
- The average measurable bone loss (ie. amount of osteoporosis) in 65 year old meat-eating females is 35%, compared to half that for female vegetarians the same age.
- Every country in the world that has high rates of colon cancer, prostate cancer, breast cancer, strokes, and heart disease also has corresponding high rates of meat intake.
- Overall, there can be no question anymore, in light of the growing library of scientific evidence, that a vegetarian diet is better suited to human physiology, and is healthier, than a meat-based diet. And that is under the best of circumstances. As it turns out, animal products today are much more dangerous than they were as little as ago as 50 years ago.

- **The \_\_\_\_\_ of Modern Animal Products**

Modern factory farming methods, by their nature, must use drastic measures to produce animals and plants as cheaply as possible. To accomplish this, modern farm animals consume diets that are a **chemical smorgasbord of hormones, antibiotics, fillers**, and what could only be classified as **garbage**.

- For example, cows are routinely fed such delicacies as **concrete dust**, which increases water retention (and hence, market weight), and **processed chicken manure**. These poisonous residues are not readily cleared from their systems.
- Farm animals will **bioaccumulate** the **fat-soluble chemicals** they are fed or injected with. They are injected regularly with **hormones to promote faster weight gain**, and with **antibiotics** and other drugs to combat the many diseases which are rife in such stressful and filthy environments as modern factory farms. So often are they injected for one reason or another, in fact, that **broken hypodermic needles** are considered a significant source of contamination in meat.
- And there are health consequences for humans as well. The **insecticides** sprayed on crops fed to animals, the **fungicides** and **pesticides added to animal food**, and the **toxic chemicals** used to kill off the parasites which flourish in crowded farms accumulate in animal fat stores, such that humans who consume these animal products receive drastically concentrated amounts. The EPA has stated that "**Foods of animal origin are the major source of pesticide residues in the diet.**".
- At least 80% of the toxic chemicals in the average American diet come from meat, dairy products, fish and eggs.
- Less than 1 out of every quarter million slaughtered animals is **tested** for toxic chemical residues. The consequences to human health are enormous, ranging from **sterility** and **impotence** to **cancer** and immune system overload (which results in increased susceptibility to all kinds of diseases).
- The addition of **hormones** to milk and beef cattle diets is the single reason for the enormous increase in precocious onset of puberty in pre-adolescents, as well as other infant health problems.
- So high is the **breast milk** [of most meat-eating American mothers] in DDT, PCB's, dieldrin, heptachlor, dioxin and so on that it would be subject to confiscation and destruction by the FDA were it to be sold across state lines.
- There is another disturbing consequence of this routine use of **antibiotics** (approximately 55% of all U.S. antibiotics are fed to cattle) in animals: the effectiveness of antibiotics is declining rapidly for humans. In 1960, 13% of Staphylococci infections were **resistant** to penicillin. By 1988, this had risen to 88%.

## The Environmental Impact of a Meat-Centered Diet

- Not only are flesh foods bad for health, the widespread raising of animals for food has had catastrophic effects on our environment.
- The primary cause of \_\_\_\_\_ is carbon dioxide emissions from fossil fuels
- \* Fossil fuels needed to produce a meat-centered diet vs. meat-free diet: \_\_\_\_\_
- \* Area of **tropical rainforest** consumed for one-quarter pound hamburger: \_\_\_\_\_ **square feet**
- \* Amount of corn grown in United States & Canada eaten by human beings: \_\_\_\_\_ %
- \* Amount of corn grown in United States & Canada eaten by livestock: \_\_\_\_\_ %
- \* Amount of oats grown in United States & Canada eaten by livestock: \_\_\_\_\_ %
- \* Amount of **protein** \_\_\_\_\_ by cycling grain through livestock: \_\_\_\_\_ %
- \* Amount of **dietary fiber** wasted by cycling grain through livestock: \_\_\_\_\_ %
- \* How frequently a child dies as a result of malnutrition: \_\_\_\_\_
- \* Potatoes that can be grown on 1 acre of prime land: \_\_\_\_\_
- \* Beef that can be produced on 1 acre of prime land: \_\_\_\_\_
- \* Amount of U.S. agricultural land used to produce beef: \_\_\_\_\_ %
- \* Grain and soybeans needed to produce 1 pound of edible flesh from feedlot beef: \_\_\_\_\_ **pounds**
- \* Protein fed to hogs to produce 1 pound of protein as hog flesh: \_\_\_\_\_ **pounds**
- \* Protein fed to chickens to produce 1 pound of protein as chicken flesh: \_\_\_\_\_
- \* **Overgrazing of farmlands** and **soil erosion** are two problems that will have enormous consequences in the 21st century.

Add to this the \_\_\_\_\_ and \_\_\_\_\_ of farm animals inherent in modern factory farming, and there **really isn't much good to be said about the practice of flesh-eating.**