1. The stomach is directly connected to the _________ above and the _________ below.
   
2. The major food digested in the stomach is _________, which is hydrolyzed by the enzyme _________.
   
3. Among its chemical aspects, every digestive enzyme has a preferred _________.
   
4. Before fats are digested they are emulsified by _________.
   
5. Pancreatic juices enter the small intestine by way of the _________ duct and contain _________ for the digestion of every type of food.
   
6. The liver first receives the products of digestion by means of the _________ vein; any excess glucose is stored as _________.
   
7. The secretion of digestive juices is controlled by _________ and _________.
   
8. The fingerlike projections lining the wall of the small intestine are called _________.
   
9. Every diet should include the _________ amino acids, the _________ fatty acids, and _________.
   
10. To remain slender, a person with a low basal metabolic rate should consume _________ food than a person with a high basal metabolic rate.

**Digestion**

1. After studying this figure, answer the questions below.

   ![Diagram of digestive system]

   a. In which part of the tract are nutrient molecules absorbed? _________
   
   b. The absorbed nutrient molecules enter what vein associated with the intestinal villi? _________
   
   c. In which part of the tract does pancreatic juice enter? _________
   
   d. In which part of the tract does bile enter? _________
   
   e. Which parts of the tract actually contain food in the state of being digested by juices that enter or are produced by that structure? _________
f. What parts of the digestive tract do not actually contain food and might be called accessory organs of digestion? **liver, gall bladder, pancreas**

g. What parts of the digestive tract do not have ducts entering them and do not secrete digestive juices? **large intestine**

2. Control of digestive juices.
   a. What is gastrin? **omit**
   b. What is secretin? **omit**
   c. What is CCK?

3. Liver. List six functions of the liver.
   a. **produces bile**
   b. **stores glucose as glycogen**
   c. **produces blood proteins from amino acids**
   d. **deposits iron and copper**
   e. **converts amino acids into glucose when glucose stores run out and produces urea in the process**
   f. **produces bile pigments from hemoglobin breakdown**

4. Chemical digestion.
   a. Digestion of carbohydrate (starch). Protein digestion begins in the (1) **stomach**. Here the ducts empty from the (2) **salivary** glands. The salivary juice contains the enzyme (3) **salivary amylase**, and this enzyme breaks down starch to the disaccharide (4) **maltose**. Starch is also acted on in the (5) **small intestine**. Here a duct empties from the (6) **pancreas**. Pancreatic juice contains the enzyme (7) **pancreatic amylase**, which breaks down starch to the disaccharide (8) **maltose**. Starch digestion is complete when this disaccharide is broken down to (9) **glucose**, a monosaccharide, which can be absorbed by intestinal villi. The enzyme that converts maltose to glucose is called (10) **maltase**, and this enzyme is secreted by (11) **intestinal** glands.

   b. Digestion of protein (meat). Protein digestion begins in the (1) **stomach**. The (2) **gastric** glands line the wall of the stomach. They secrete the enzyme (3) **pepsin**, which breaks down protein to (4) **peptides**. Another enzyme called (5) **trypsin** is secreted by the (6) **pancreas** and this enzyme acts on protein in the (7) **small intestine**, also breaking down protein to (8) **peptides**. Protein digestion is complete when peptides are broken down to (9) **amino acids**, molecules small enough to be absorbed by the villi. The glands that secrete peptidases are the (10) **intestinal** glands located at the base of the villi.

   c. Digestion of fat (butter). Fat is first emulsified by (1) **bile**, a substance made by the liver and stored in the (2) **gall bladder**. The contents of the latter enter the small intestine by way of the (3) **bile** duct. After the fat has been emulsified, it is broken down by the enzyme (4) **lipase**, also found in pancreatic juice, which enters the small intestine by way of the pancreatic duct. Fats are broken down to (5) **glycerol** and fatty acids, molecules small enough to be absorbed by intestinal villi. Actually, fats enter the (6) **lacteal** which are a part of the lymphatic system.
Food consists of the large organic molecules (1) **lipids (fats)** and (3) **protein**. In the mouth, the only type of food digested is (4) **carbohydrates (polysaccharides)**. The mouth has a (5) **7** pH. The food passes down the long tube called the (6) **esophagus**. A rhythmic contraction called (7) **peristalsis** pushes the food along.

b. After passing through a sphincter (circular muscle), the food enters the (1) **stomach**. Here the primary food acted on is (2) **protein**. This organ has an (3) **acidic** (pH < 2) pH. The food, now called the acid chyme, passes through another sphincter into the (4) **duodenum** (small intestine) and the (3) **gall bladder** duct from the (2) **liver** and the (3) **pancreatic** duct from the (4) **pancreas**. Bile contains an (5) **emulsifier** which divides fat up into fat droplets. Pancreatic juice contains enzymes that act on (6) **carbohydrates**, (7) **proteins**, and (8) **lipids (fats)**. Lining the walls of the intestine are (9) **villi** and (10) **microvilli** glands. The latter finish digestion by converting (11) **maltose** and (12) **peptides** to amino acids. Thus the small nutrient molecules that are absorbed by the villi are (13) **glucose**, (14) **amino acids**, (15) **glycerol**, and (16) **fatty acids**. Fat products enter the (17) **hepatic portal vein**, and the other molecules enter the (18) **hepatic** portal vein, an organ of homeostasis. For example, this organ stores glucose as (2) **glycogen** and always keeps the blood glucose level constant. This organ can also remove amino groups from (3) **amino acids** and convert the amino groups to (4) **urea**, a nitrogenous waste product.
1. The amount of salivary amylase present in saliva of three groups of people is shown below.

Group A: whose diet consisted mainly of carbohydrates with irregular amounts of meat and milk.
Group B: living on a mixed diet of carbohydrates and protein.
Group C: whose diet consisted mainly of small mammals, birds, snakes and lizards.

<table>
<thead>
<tr>
<th>Group</th>
<th>Concentration of salivary amylase units/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>248</td>
</tr>
<tr>
<td>B</td>
<td>101</td>
</tr>
<tr>
<td>C</td>
<td>22</td>
</tr>
</tbody>
</table>

a. What was the hypothesis being tested in this investigation? (1 mark)

If a diet consists mainly of carbohydrates, then there will be an increase in the amount of salivary amylase produced.

b. Explain how the results support your hypothesis. (1 mark)

Group A has a diet mainly of carbohydrates and has the highest amount of salivary amylase recorded. Group B and C have less carbohydrates and also less salivary amylase being measured.

c. When Group C was given a diet similar to Group A’s, their salivary amylase production remained the same. What does this indicate? (1 mark)

Salivary amylase production may be dependent on other factors or more time was required for its production.

Group C may not have been on the carbohydrate diet long enough for the salivary amylase production to change.

d. Explain two possible effects the change in diet would have on Group C’s body functions. (2 marks)

Group C would have an increased amount of carbohydrates (and thus fiber) so they would see an increase in bowel movements or solid waste (feces) production.

An increased amount of glucose would be absorbed from the carbohydrate breakdown so the pancreas would produce more insulin which would cause the liver and muscle cells to store glucose as glycogen.
2. Fill in the following table on the digestive system. (4 marks; 1/2 mark each)

<table>
<thead>
<tr>
<th>Organ</th>
<th>Secretion</th>
<th>pH</th>
<th>Enzyme present</th>
<th>Food acted on</th>
</tr>
</thead>
<tbody>
<tr>
<td>mouth</td>
<td>saliva</td>
<td>neutral</td>
<td>salivary amylase</td>
<td>starch</td>
</tr>
<tr>
<td>pancreas</td>
<td>pancreatic juice</td>
<td>basic</td>
<td>pancreatic amylase trypsin</td>
<td>starch protein</td>
</tr>
<tr>
<td>gall bladder</td>
<td>bile</td>
<td>basic</td>
<td>none</td>
<td>fat</td>
</tr>
</tbody>
</table>

3. Describe one function for each of the following structures. (3 marks; 1 mark each)
   a. Liver produces bile, detoxifies the blood, breaks down hemoglobin from old red blood cells, produces blood clotting proteins, stores glucose as glycogen, produces urea from the breakdown of amino acids.
   b. Pyloric sphincter a group of muscles surround the passageway between the stomach and the small intestine; these muscles contract to close the passageway and relax to open the passageway so that chyme may move from the stomach to the small intestine in small increments.
   c. Small intestine produces maltase, peptidases, nuclease.

4. In an experiment designed to test the effectiveness of two protein digesting enzymes (enzyme X and enzyme Y) under various conditions, the following procedure was carried out:

- Identical protein substrates were placed in a series of numbered beakers.
- The temperature and pH of the beakers were varied.
- Similar amounts of enzyme (either X or Y) were added to the beakers and the resulting activity was observed.
- The contents of the beakers were checked after two hours.

The results of the experiment are summarized in Tables 1 and 2.
### Table 1: Product levels resulting from the action of enzyme X.

<table>
<thead>
<tr>
<th>Temp (°C)</th>
<th>pH 2-3</th>
<th>pH 4-6</th>
<th>pH 7-9</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>beaker 1: moderate product</td>
<td>beaker 4: no product</td>
<td>beaker 7: no product</td>
</tr>
<tr>
<td>37</td>
<td>beaker 2: high product</td>
<td>beaker 5: no product</td>
<td>beaker 8: no product</td>
</tr>
<tr>
<td>62</td>
<td>beaker 3: no product</td>
<td>beaker 6: no product</td>
<td>beaker 9: no product</td>
</tr>
</tbody>
</table>

### Table 1: Product levels resulting from the action of enzyme Y.

<table>
<thead>
<tr>
<th>Temp (°C)</th>
<th>pH 2-3</th>
<th>pH 4-6</th>
<th>pH 7-9</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>beaker 1: no product</td>
<td>beaker 4: no product</td>
<td>moderate product</td>
</tr>
<tr>
<td>37</td>
<td>beaker 2: no product</td>
<td>beaker 5: moderate product</td>
<td>high product</td>
</tr>
<tr>
<td>62</td>
<td>beaker 3: no product</td>
<td>beaker 6: no product</td>
<td>no product</td>
</tr>
</tbody>
</table>

a. Identify enzyme X. (1 mark)

pepsin

b. Identify enzyme Y. (1 mark)

trypsin

c. What is the common product of these enzymatic reactions? (1 mark)

peptides

d. Where in the body does each of the enzymes function best? (2 marks)

Enzyme X: stomach

Enzyme Y: small intestine

e. How would the amount of product change, if a heavy metal such as lead were added to beaker 1 at the start of the experiment? Give an explanation for your choice. (2 marks)

The heavy metal would denature the enzyme and no product would be formed.

f. Which experimental condition appears to be the least suitable for the functioning of both enzymes? (1 mark)

Temp 62°C, pH 4-6
5. For each combination of substances below, decide where digestion will or will not occur at the maximum rate. Give an explanation explaining why digestion does not occur at a maximum rate.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Digestion occurs at a maximum rate? (yes or no)</th>
<th>Explanation if digestion does not occur maximally</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. trypsin, NaHCO₃, egg white, warm gently</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>2. salivary amylase, water, egg white, warm gently</td>
<td>no</td>
<td>salivary amylase breaks down starch not protein</td>
</tr>
<tr>
<td>3. pepsin, HCl, egg white, freeze</td>
<td>no</td>
<td>the temperature is low so the enzyme and (egg white) substrate will be moving slowly (pepsin)</td>
</tr>
<tr>
<td>4. pancreatic amylase, HCl, heat to boiling</td>
<td>no</td>
<td>pancreatic amylase functions optimally at pH=8 and a temperature = 37°C; boiling denatures the enzyme</td>
</tr>
<tr>
<td>5. lipase, NaHCO₃, fats, warm gently</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>6. maltase, HCl, maltose, warm gently</td>
<td>no</td>
<td>maltose functions optimally at pH = 8; HCl will make the pH acidic and thus denatures the enzyme</td>
</tr>
<tr>
<td>7. peptidases, fat, HCl, warm gently</td>
<td>no</td>
<td>peptidases break down peptides not fat; HCl will make the pH acidic and the enzyme functions in basic condition</td>
</tr>
<tr>
<td>8. pepsin, HCl, egg white, warm gently</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>9. trypsin, starch, water, warm gently</td>
<td>no</td>
<td>trypsin breaks down protein not starch</td>
</tr>
<tr>
<td>10. HCl, egg white, water, warm gently</td>
<td>no</td>
<td>there is no enzyme to break down the protein (egg white)</td>
</tr>
</tbody>
</table>