

Nutrition:

How to obtain food:

This is descriptive - general zoologists might be interested in this:

Suspension feeders - whales, gills, clams.

Eat little particles suspended in the water.

Substrate feeders - caterpillars, many parasites.

Live in or on food source.

Fluid feeders - mosquitoes, aphids, ticks.

Suck out fluid from another organism.

Bulk feeders - humans, lions, buffalo.

Eat large pieces of food.

Some animals, like corals might be hard to put into one of these categories.

Corals are mostly suspension feeders, but they also photosynthesize (with the help of algae living in their tissues)

What kind of food does an animal eat?

Herbivore - eats plant food.

Carnivore - eats other animals.

Omnivore - eats anything.

Also note that food can be living, dead, or “in between” (?).

Examples of dead food include carrion (eaten by things like vultures and fungi)

What about “in between”? Parasitoid wasps are a good example.

Reason for feeding:

1) to obtain energy! Biological organisms need energy.

Most biological molecules have some kind of energy associated with them (remember the Krebs (= citric acid) cycle).

This is the single most important reason for feeding!

How do organisms get energy?

Plants get energy from sunlight (usually) => autotrophic.

Autotrophic - get energy from a source other than another organisms.

Animals get energy from other organisms (usually) => heterotrophic.

Heterotrophic - get energy from other organisms.

Some strange bacteria get energy from heat or other sources (they're also autotrophic).

2) to get raw materials for synthesizing needed compounds (differs from # 3, since these are "raw" materials).

Raw materials are things like carbon, oxygen, etc.

These are needed to put together more complicated molecules (e.g., some amino acids, carbohydrates, etc.)

3) to get essential nutrients that can't be synthesized (a little similar to # 2, but these materials are not synthesized).

Some complicated molecules (some amino acids, things like vitamins) can't be made by our cells, and need to be obtained in a finished form.

Reasons for feeding (the details):

i) Energy:

Energy is obtained by oxidation of organic molecules. Remember the Krebs cycle - this is how ATP is produced from organic molecules (in the presence of oxygen).

Primary molecules for providing energy are:

i) fats ii) carbohydrates iii) proteins

Fats give about twice the energy of the other two.

ii) Energy balance - short term:

Excess energy is stored as glycogen (consists of glucose sub-units) in the liver (and muscle). If energy is needed, glycogen is released and metabolized (oxidized).

iii) Energy balance - long term [**Fig., not in book**]:

Excess energy is stored as fat.

This is ideal for living through rough times (remember, fat has about twice the energy content).

But this does create problems:

In the U.S. (fortunately) we have more than enough food to go around.

Result: obesity is a serious problem.

Obesity has very negative influences on health, and after smoking is the next biggest cause of preventable deaths.

Leads to circulatory problems (e.g., high blood pressure), diabetes (type II), joint problems, etc.

(Some recent studies suggest obesity is just as bad as smoking).

As a result, diet and exercise are huge industries in the U.S.

See [Fig. 21.14,p. 442]; this illustrates the need for balance.

On the other hand, insufficient energy causes weight loss, then protein breakdown, muscle breakdown etc.

Result: undernourishment and in extreme cases, death.

(Some estimates indicate that over 3 million(!) children still die of starvation and related causes every year).

iv) raw materials:

Briefly, animals need organic carbon to manufacture needed organic molecules.

Another example is nitrogenous compounds. Animals (or plants, for that matter) can't fix nitrogen, so animals need to get this from diet.

Nitrogen is important for amino acids (see below), and other organic molecules.

v) essential nutrients:

These are compounds the animal can not manufacture, but are needed for survival. A good example is Vitamins.

There are four classes of classes of essential nutrients:

1 - amino acids (animals make about half of these). They are essential for protein synthesis.

2 - fatty acids (most diets are more than sufficient in these).

These are needed, for example, in cell membranes.

3 - vitamins (required in small amounts, but are essential). These are needed for various functions throughout the body.

See **table 21.16A on page 444**. Memorize columns 1 and 4 for exam (know what vitamins go with a given symptom) for Vitamins A, C, D, E & K (ignore B's).

Note that excess vitamins are bad for you.

For example: carnivore livers have enough vitamin A to be toxic.

Finally, note that not all animals work the same.

For example, gerbils can make Vitamin C, so for them it's not a "vitamin".

4 - minerals (again, required in small amounts). See table 21.18, p. 445. Please look it over, but don't worry about memorizing stuff.

Anatomy and physiology of digestion:

Overview:

Ingestion → Digestion → Absorption → Elimination [**Fig. 21.2A, p. 431**]

For animals we're most familiar with, digestion takes place outside the body cells, usually in a gastrovascular cavity.

Some animals, (venomous snakes, spiders, etc., actually start digesting their prey outside the body.

A gastrovascular cavities may be of two types:

- 1) single opening - e.g., hydras, flatworms. Mouth and "anus" are in the same place.
- 2) two openings, food proceeds from mouth to anus. Most higher animals.

[**Fig. 21.3A & B, p. 432**].

Mammalian digestion (not too different from most other vertebrates).

Oral cavity → Pharynx → esophagus → stomach → small int. → lg. int.
[**OVERHEAD, fig. 21.4, p. 433**]

1) Oral cavity [**Fig. 21.5, p. 434**]:

Physical and chemical digestion of food starts here:

Teeth break food into smaller pieces

Taste monitors the food being eaten (why?)

Saliva lubricates food and begins chemical digestion

amylase breaks down **starch** and **glycogen**.

[try this - leave a piece of bread in your mouth for several minutes!].

2) Pharynx and esophagus:

Food moves past the trachea (windpipe).

As it does, the epiglottis closes off the opening to the trachea (the glottis).

This prevents food from entering lungs (i.e., prevents choking).

[Fig. 21.6A, p. 434]

Esophagus conducts food from pharynx to stomach using peristalsis.

Peristalsis is a muscular contraction that forces something (e.g. food) in a particular direction **[Fig. 21.6B, p. 435]**.

3) Stomach **[Fig. 21.8, p. 436]**:

Food is broken down chemically and mechanically:

Gastric juice has a pH of 2.

This disrupts the extracellular matrix (i.e., dissolves stuff that holds cells together).

Note: gastric inhibitors (medicines such as prilosec, etc.) seem to show that one can manage with a higher pH.

A low pH is also very important in fighting pathogens.

Pepsin breaks proteins down into smaller polypeptides.

Actually, the stomach actually releases *pepsinogen*, which is converted to active form (pepsin) by stomach acids (WHY?).

The contents are mixed and slowly released through the pyloric sphincter as “acid chyme”.

The *pyloric sphincter* acts as a control to prevent particles that are too large from entering the small intestine.

The *cardiac sphincter* controls the entrance to the stomach.

The term *cardiac* simply refers to the fact that it's closer to the heart.

A *cardiac sphincter* that doesn't work correctly can cause GERD (acid reflux).

4) Small intestine:

The first 25 cm or so is known as the *duodenum*. Several substances are released in this area **[Fig. 21.10A, p. 438]**:

pancreas:

buffer (neutralizes acid).

hydrolytic enzymes (e.g. trypsin; these break up proteins further)

nucleases (deal with nucleic acids)

amylase (starch). This is also found (in a slightly different form) in the oral cavity.

lipase (deals with fats, but only after bile has been released!)

various other compounds (see table 21.10 on p. 438 if interested)

liver :

The liver manufactures bile.

Bile is then stored in the gall bladder, and released when needed.

Bile acts as a “detergent”

It breaks down fat down into small pieces/particles so that lipase (from the pancreas) can break down fat.

Note that the liver has many, many, other functions!

In essence, carbohydrates, fats, nucleic acids & proteins can all be digested by these various chemicals that are released by the pancreas and liver.

The rest of the small intestine is used to absorb the resulting nutrient “soup” and water.

Most of the nutrients are absorbed in the capillaries lining the small intestine

Blood from the capillaries moves into the hepatic portal vein and from there into the liver.

The liver processes and stores nutrients, as well as breaking down any toxins **[Fig. 21.11, p. 440]**.

Strangely, fats (fatty acids) are absorbed by the lymphatic system (which returns blood to the heart).

Structure of small intestine:

Highly folded:

Folds have villi. Villi have microvilli, which finally absorb nutrients **[Fig. 21.10B, p. 439]**.

5) Large intestine (=colon) [Fig. 21.12, p. 440]:

The large intestine reabsorbs any leftover water.

This is almost it's only function!

If material moves too slowly -> constipation.

If material moves too rapidly -> diarrhea.

The terminal portion of colon is the rectum. Feces are stored there until they are eliminated.

6) Cecum:

Helps digest cellulose (this is difficult to digest - bacteria help break it down).

In humans this is small and called the appendix, but does have a little lymphatic tissue, and seems to have a very small function in the immune system.

Technically there is a difference: we have an appendix, not a cecum, but let's not worry about little details like this.

Many herbivores (like rabbits) have proportionately much larger cecums [Fig. 21.13 441].

7) Other ways of dealing with cellulose (animals that don't have a cecum:

Be big. Elephants, for example, are big enough to ferment some of the plant material.

Fermentation: breaking down molecules without oxygen (not necessarily making alcohol).

Have a four chambered stomach. Many antelope, deer, cows, etc., pre-treat cellulose with bacteria, and then re-chew the food (cud) [Fig., not in book].

Essentially, swallow food, coat it with bacteria in one part of the stomach.

Then regurgitate food, re-chew (mixes up bacteria and food), and swallow, this time to a different part of the stomach.

Control of digestion

How is digestion controlled?

Just a simple example [Fig., not in book, but see first part of fig. 21.8, p. 436]

food (smell, taste, etc.) → release of gastrin from stomach wall.

gastrin → stomach releases more gastric juices.

If pH becomes too low, gastrin release is inhibited, and pH starts to climb again.