GCSE Science

Hi my name is Sammy and I am the Bird Wise ranger for East Kent. My job is to make sure that the wintering birds are able to feed on our beaches.

Every year thousands of birds migrate from across the arctic to our coast. When they are on the coast it is my job to ensure that they are able to feed so they can get back to their summer breeding grounds.

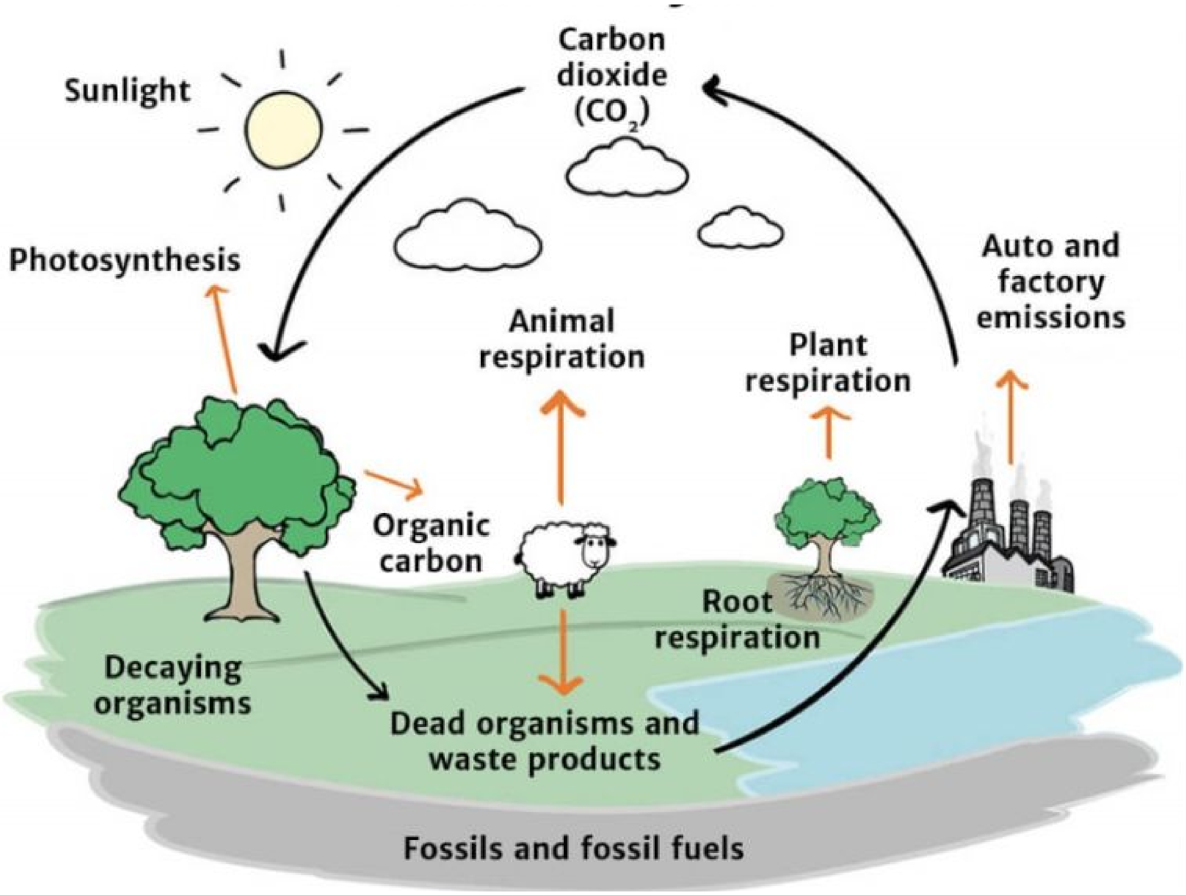
Feeding and digestion is important. It enables all animals to access important nutrients. Nutrient cycles help us to explain how nutrients are passed between organisms. All living organisms need nutrients in order to function properly.

There are seven different types of nutrient; carbohydrates, lipids, protein, vitamins, minerals, fibre, and water.

Carbohydrates are important because they provide energy. Carbohydrates come from plants, and are especially found in grain and seeds. Grain and seeds can be rice or wheat. Wheat can be ground to make flour which is used to make pasta and bread.

As animals get carbohydrates from plants, and carbohydrates are a part of a nutrient cycle the plant must get the carbohydrates from somewhere.

The Carbon Cycle



Carbon as a carbohydrate only forms a small part of the carbon cycle. Carbohydrates are only present when organisms are involved, this is called organic carbon. On the left side of the diagram is a large tree, this represents all plantlife, whether on land or sea. All plant life needs to make its own energy. Plants are able to do this through photosynthesis.

Photosynthesis is the process of using sunlight (photo) to synthesize carbon dioxide into carbohydrates. This process can be shown by the equation below:

Carbon dioxide + water →Glucose + Oxygen
Or
$6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

In the balanced equation we start with $6CO_2$, this means we have 6 molecules of carbon dioxide. When we see a large number in an equation this shows the number of molecules $6CO_2$. When a small number is shown this shows how many atoms there are. $6CO_2$, in this example there are 2 oxygen atoms in the carbon dioxide molecule.

In a balanced equation it is important that there is the same amount of atoms going in as coming out, making it balanced. Let's break down the equation;

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

$6CO_2$, here we have 6 molecules of carbon dioxide, in each molecule there is one carbon atom and two oxygen atoms. This means that we need to multiply the amount of molecules by the amount of each atom. This gives us 6 x 1 for carbon and 6 x 2 for oxygen.

Photosynthesis takes atmospheric carbon, in the form of carbon dioxide, and placed in the food chain.

Plantlife then provides glucose for respiration, this occurs in both plants and in the consumers of plants, animals. Respiration requires the oxidation of glucose and other nutrients, by taking oxygen from the outside environment and the removal of waste products from the reaction, in this case carbon dioxide and water. The equation looks familiar as it is the reverse of photosynthesis.

Glucose + Oxygen → Carbon dioxide + water
Or
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 12H_2O$

Respiration allows for carbon dioxide to be released from plants and animals back into the atmosphere. Respiration is required as the energy that is created from the oxidation of glucose powers the cells of the organism (plant, animal, bacteria, fungi, or protist).

The oxygen required for respiration is inhaled through the mouth and into the lungs. Inside the lungs/gills there are tiny alveoli which use gas exchange to get the oxygen from the air inside the lungs/gills to the pulmonary capillaries. If you see the word pulmonary it means anything to do with the movement of blood between the heart and lungs.

Once the oxygen is exchanged to the blood it is carried by hemoglobin, which is an iron rich component of the red blood cell, around the body to all the living cells to allow oxidation of nutrients to take place or respiration.

One respiration occurs the waste products are then released by the cell into the blood where they are carried to the kidneys where the waste is removed from the blood and passed as urine, or to the lungs/gills where it is passed as carbon dioxide. This exhalation of carbon dioxide passes carbon back into the atmosphere.

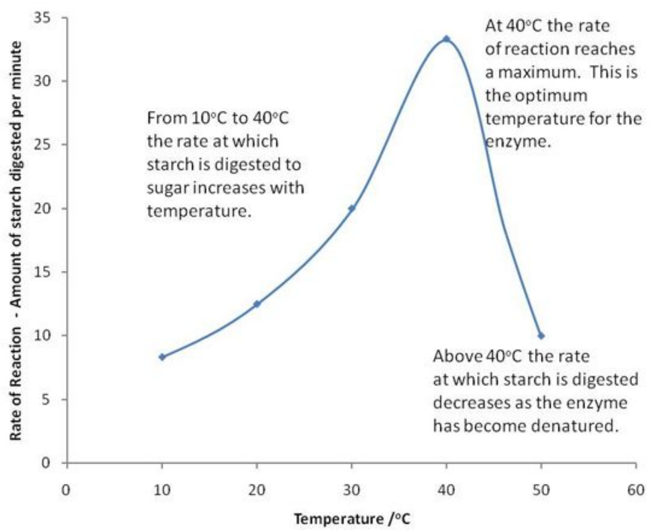
However, not all carbon is released from an organism as it is stored as unused glucose, which is called glycogen. It is important to have a glycogen store as animals are not able to constantly digest food. This store is used up during long periods of respiration.

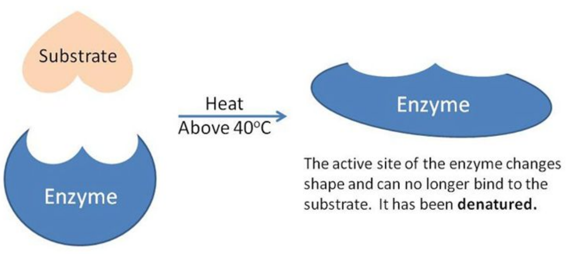
When carbohydrates enter the body in the mouth they are initially metabolized by an enzyme called amylase. Amylase is produced by the salivary glands. This enables the initial breakdown of carbohydrates. The chewed food then passes down the oesophagus (or sometimes esophagus) into the stomach, here the stomach churns the food. Once in the stomach amylase that is produced by the pancreas breaks the carbohydrates further.

From the stomach the broken down carbohydrate, now glucose, will pass into the small intestine (which is the longer of the two intestines). Here the glucose is absorbed into the blood.

During gas exchange in respiration and absorption of nutrients in digestion there are a few factors that increase the rate of the process.

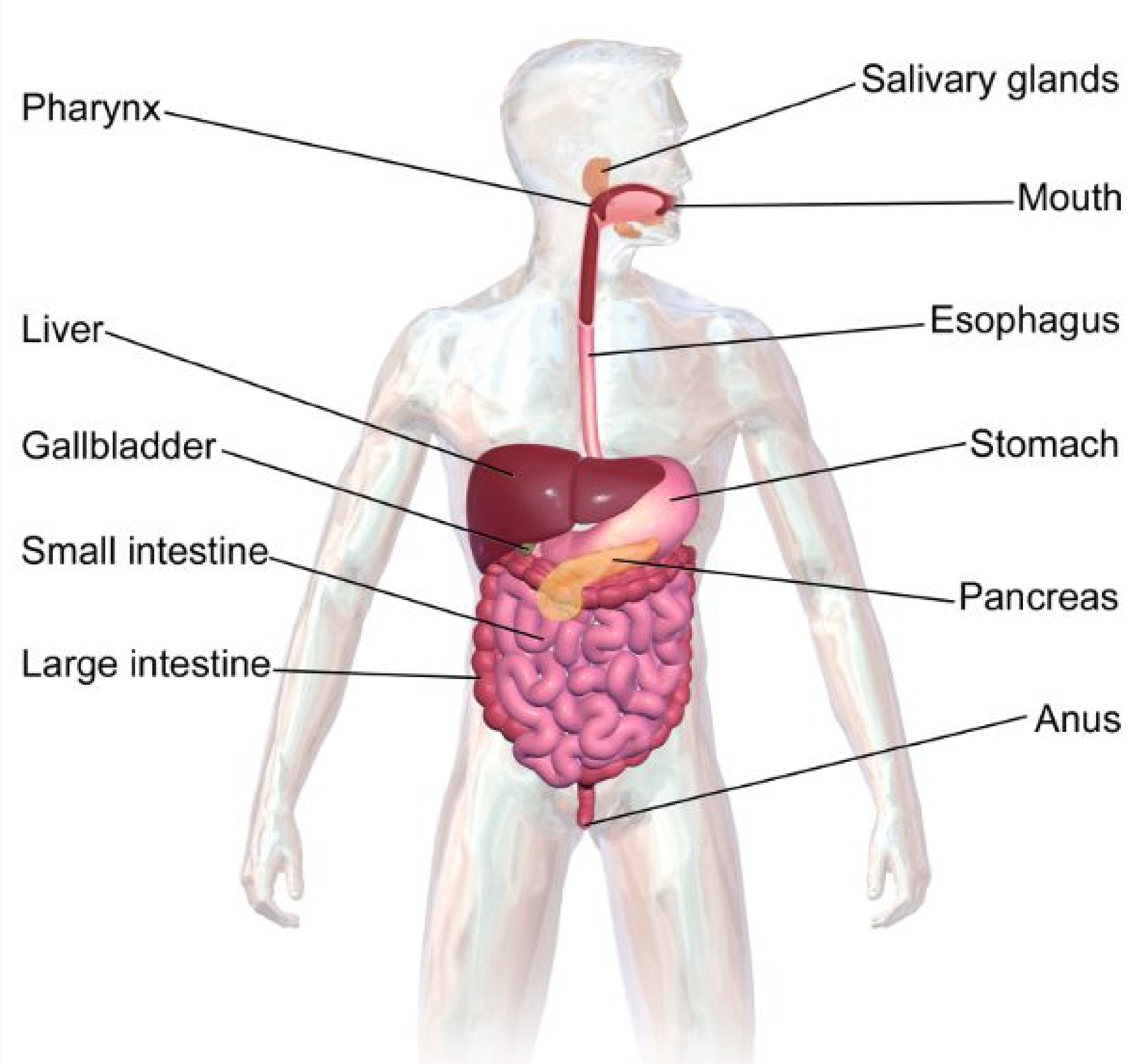
1. Large surface area - the larger the surface area the higher the rate of transport.
2. Rich blood supply - the closer the blood is to the surface of either the intestine wall or alveoli the easier it is to transport through a membrane.
3. In digestion temperature - the graph (right) shows that rate of reaction improves with a higher temperature, until it reaches the optimum temperature, at which point there is a sharp decline in the rate of reaction. This occurs because the active site of an enzyme (the bit that locks onto the nutrient) changes shape and cannot attach to the substrate (carbohydrates in this case). This is called the Lock & Key theory, with the enzyme being the key and the substrate the lock.





4. pH level - the pH level needs to be just right in order for an enzyme to fulfill its function. Hydrochloric acid is found in the stomach, and has a pH of around 1. This is very acidic. At this

level enzymes cannot function. However, this does aid the breakdown of proteins. When food enters the stomach the pH increases, this is because the liver releases bile into the stomach. Bile is alkali and therefore neutralizes the acidic gastric juices.



Carbohydrates have been broken down in digestion, oxidised in respiration and exhaled back into the atmosphere, or stored as glycogen. When an organism dies this glycogen, along with other nutrients, provides a food source for decomposers. These decomposers can be bacterium, animals, or fungi. These are all organisms that need death and decay to survive. In the food web they are very important as they are nature's recycling plant. Without decomposition the nutrient cycle would break down, there'd be no way to grow food, and also there'd be piles of corpses everywhere.

The decomposers put nutrients back into the soil. In the case of carbon this can become fossil fuels. Over thousands of years that trapped carbon can become; coal, oil, or gas. If enough pressure is applied, even diamonds. These fossil fuels are called carbon sinks, and are trapped in the earth's surface. This means that atmospheric levels of carbon dioxide are fairly static, volcanoes emit carbon dioxide when erupting. However, when humans mine or drill out these fossil fuels to be used in combustion reactions carbon dioxide is released.

A combustion reaction is the oxidation of carbon.

Carbon + Oxygen →Carbon dioxide

$C + O_2 \rightarrow CO_2$

When CO_2 is released into the atmosphere it causes an effect known as the greenhouse effect. This is because carbon dioxide allows heat into the atmosphere from the sun but doesn't allow the heat to escape. Acting as a blanket. The more fossil fuels burnt by factories and cars the more carbon dioxide in the atmosphere and the warmer the planet will get.

To complete the loop of the carbon cycle carbon is then absorbed by plants through photosynthesis. With the reduction of forests in the world and the more carbon dioxide released, there is a disproportionate amount of carbon dioxide in the atmosphere.

Lipids are also known as fats and oils. These are essential for organisms as they act as an energy store and enable the storage of some vitamins and minerals (fat soluble). Lipids are found in both plants as an oil, and animals usually as a fat.

When an organism exhausts its supply of glucose and glycogen it will then use its lipid store. Lipids are harder to break down through respiration as they are much larger molecules ($C_{55}H_{98}O_6$).

	Glucose	Glycogen	**Lipid** (triglyceride)
Carbon atoms per molecule	6	6	**55**
Hydrogen atoms per molecule	12	10	**98**
Oxygen atoms per molecule	6	5	**6**
Oxygen atoms required for oxidation per molecule	**12**	**12**	**135**

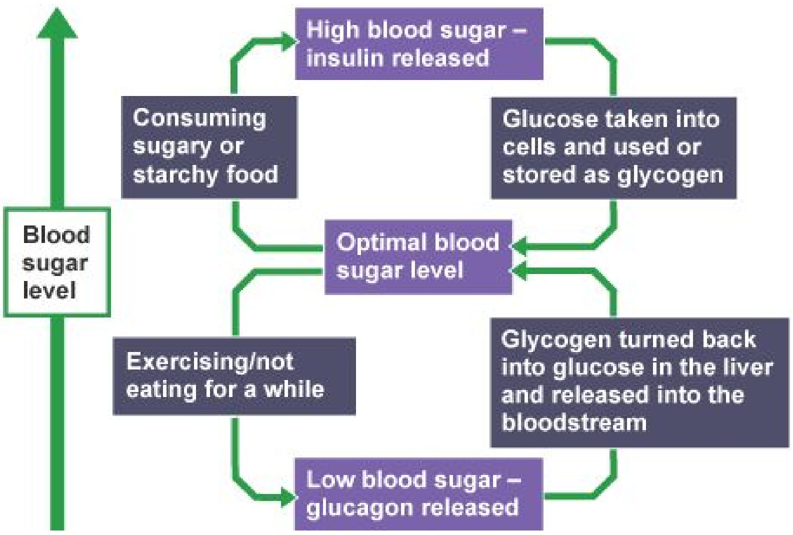
The above table demonstrates how much more oxygen atoms are required to oxidise the lipid molecule, 11.25 times more oxidation reactions than either glucose or glycogen. This would require lots of respiration of an organism without additional digestion of excess carbohydrates or lipids. This is why it is hard to lose weight.

Only some lipids do break down in the mouth in the same way as carbohydrates. Lipids, in the form of fatty acids, mostly are broken down into glycerides in the small intestine by lipase enzymes. Lipase is made by the pancreas and secreted into the small intestine in the same way as amylase. Bile, released by the liver into the stomach, aids digestion of fatty acids by emulsifying them.

Proteins are important in organisms as they catalyse metabolic reactions in enzymes, replicate DNA, cell signalling (communication between cells), providing structure to cells and organisms, and transporting molecules.

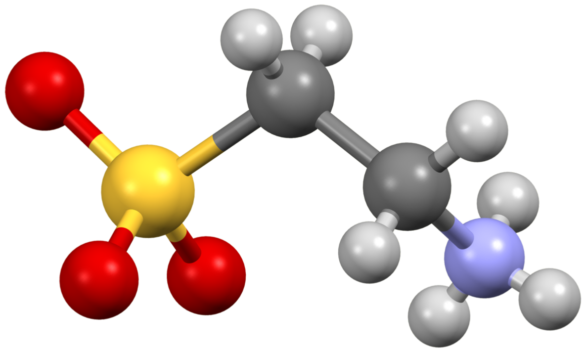
Proteins are broken down into amino acids by the acidic conditions in the stomach and the enzyme protease.

Insulin is an example of a protein. Insulin enables absorption of glucose into the liver, fat, and skeletal muscle cells to store as glycogen or fat. This enables the organism to store energy. If the blood glucose concentration is too high, too much glucose in the blood, the pancreas releases insulin to store the glucose. When the blood glucose level drops, the pancreas stops releasing insulin. This is part of the endocrine system, hormones, and is called a feedback loop.

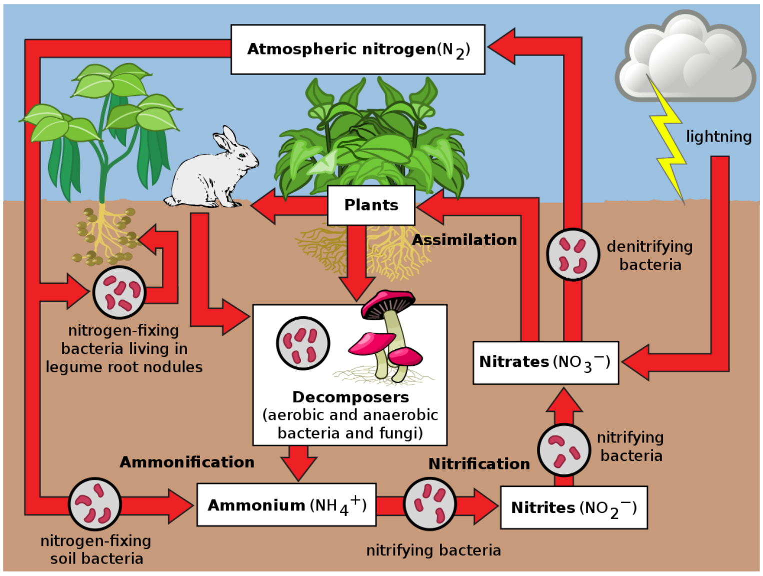


A negative feedback loop in this case is when the blood glucose concentration is too low, and the pancreas releases **glucagon**. Glucagon travels in the blood to the liver and converts **glycogen** into **glucose**. This constant feedback through the hormones is called **homeostasis**.

Nitrogen forms a large part of a protein molecule.



The yellow atom in the above diagram represents nitrogen and the red hydrogen. In this taurine (a protein) molecule you can see that without the nitrogen atom this molecule would be a vastly different structure.



Nitrogen is also recycled, in much the same way as carbon.

We have already looked at the role of decomposers, in the nitrogen cycle you can see how vital they are. During **decomposition** bacteria and fungi break down dead plants or animals and animal urine and faeces into ammonia NH_4+.

Ammonia is then converted into nitrites NO_2- by nitrifying bacteria, nitrites and then oxidised into **nitrates** NO_3-. **Nitrification** can also occur on atmospheric nitrogen gas through contact with lightning. Additional heat and oxygen quickens the process.

To become atmospheric nitrogen gas N_2 **denitrification** occurs. This does not benefit soil and plants as nitrogen is lost as a nutrient. This is carried out by denitrifying bacteria. Nitrifying bacteria are aerobic (they need oxygen), denitrifying are anaerobic (DO NOT need oxygen). Soil that is waterlogged, has a lack of oxygen and allows for denitrifying bacteria to thrive.

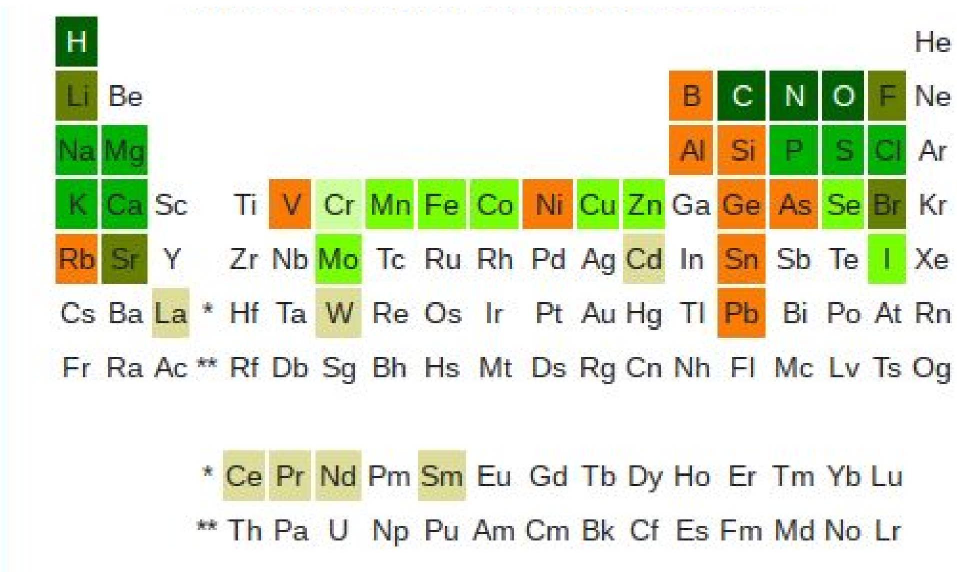
For the cycle to be complete nitrogen needs to get back into the soil. This is called **nitrogen fixation.** Here nitrogen is fixed to the soil by bacteria that lives on the roots of legume plants (ex. beans, peas, and clover). There is a symbiotic relationship (where both organisms benefit from each other) as the bacteria give the legume nitrogen in exchange for carbohydrates. There are also nitrogen fixing bacteria free in the soil. Once in the soil plants are able to absorb nitrogen and pass it along the food chain. At which any point an organism dies and decomposers break down the nitrogen into ammonia.

Vitamins play a vital role in the functioning of organisms' organ systems. Vitamins cannot be synthesized (created) by the organism in sufficient quantities and must be ingested. Vitamin D, for example, enables the body to synthesize minerals such as phosphate and calcium. Vitamin D is different from other vitamins as exposure to sunlight can allow for the absorption of this vitamin as well as diet.

Vitamins can be stored in different ways in the body. They can either be stored in fat or in water. If stored in fat they can stay within the organism for longer. Within water they are in the body for much shorter and are easily passed with urine.

Vitamin	Solubility	Function
A	Fat	Aids vision
B group	Water	Ensures proper use of energy throughout the body Aids nervous functions
C	Water	Aids immunity to illness
D	Fat	Aids in absorption of minerals
E	Fat	Prevents blood toxicity Aids reproduction
K	Fat	Aids blood clotting and energy storage

Minerals are essential for the function of organisms



Those highlighted on the periodic table are required by organisms to function. The basic organic elements, quantity elements (needed in high amounts), essential trace elements, possible effects from lack of these elements, some evidence that there are effects from a lack of these elements, and Essential in non mammals.

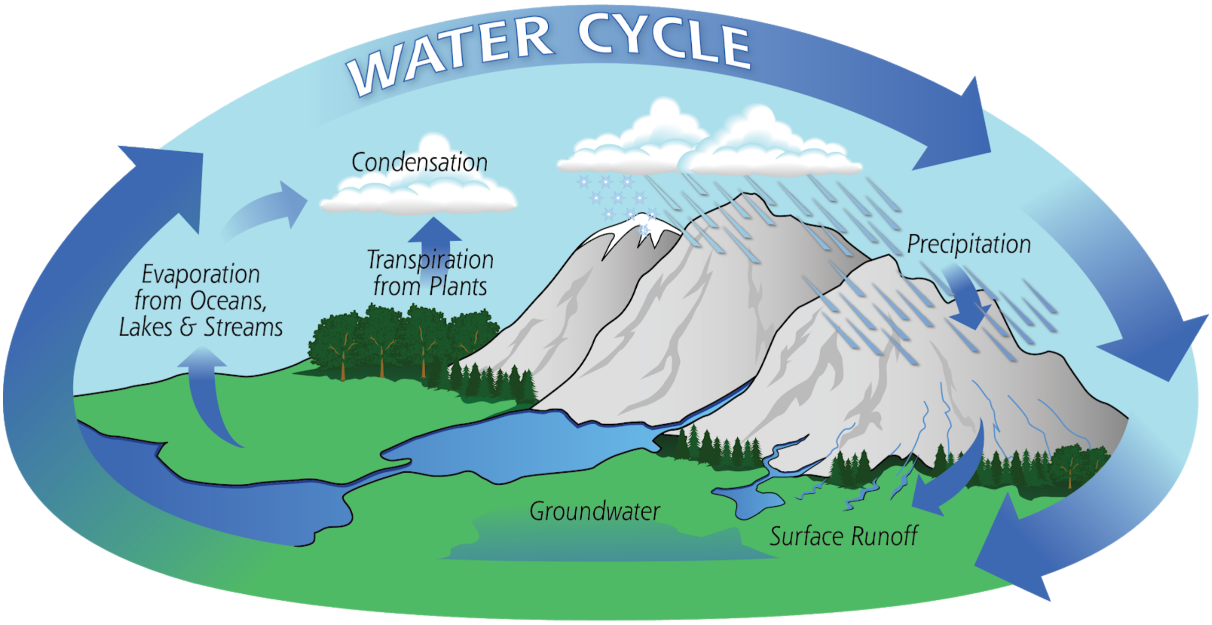
Mineral	**Function**	**Deficiency**	**Diet Source**
Calcium	Builds bones and teeth	Stunted growth, osteoporosis	Dairy products
Iron	Hemoglobin formation in red blood cells	Anemia - weakness, reduced immunity	Meat, eggs, fruit
Magnesium	Protein synthesis, enzyme action. Nerve transmission	Weakness, confusion, reduced hormone secretion, muscle spasms	Nuts, legumes, whole grains, fish, chocolate
Zinc	Part of; enzymes, insulin, genetic material	Reduced growth, delayed puberty	Fever, nausea, vomiting, diarrhea

Fibre is material in food that cannot be digested. This is made from the cellulose in cell walls, and is therefore found in plant based ingredients. Examples of this are; fruit, vegetables, and cereals.

Fibre is important because it begins peristalsis, which is the muscular contraction of the digestive system. This moves food through the digestive tract. Lack of fibre can lead to constipation.

Water makes up around ⅔ of the human body and is found in the cytoplasm in the cells. Water is very important in the cytoplasm as that is where all the organelles and dissolved nutrients are stored. Water also reduces the viscosity (thickness) of blood.

Water is essential to life, and much like carbon and nitrogen is recycled. The diagram below shows how this works.



If we start with water in lakes, rivers, and streams. Here animals access the water to drink but of course not all water is consumed.

As the water flows towards the ocean it erodes the rock and soil on its route. This picks up minerals which are transported to the ocean. This is what makes the sea salty.

As the sun **evaporates** water vapour, changing state from liquid to gas, from surface water the minerals are left behind. Once the water is **evaporated** it cools and **condenses** into clouds.

Within clouds is where the water changes state back into liquid. Once the water droplets within the cloud are heavy and large they fall as **precipitation**. **Precipitation** occurs in different forms; rain, snow, sleet, hale, or fog.

The water returns to the ground where it flows to lowland areas where it either remains on the surface or **perculates** (passing through porous ground) beneath the surface and forms groundwater. As groundwater it forms underground lakes and rivers, which will resurface as springs. To prevent flooding and mass **water runoff,** greenspaces, such as; woodlands, grasslands, and meadows can slow the flow of water and allow for **percolation** and absorption through the plant's roots.

Questions

Name the 7 nutrients?

For each nutrient state why it is important to an organism?

Give an example of where you may get each nutrient in your diet?

Describe the carbon cycle?

Draw and label the water cycle?

Write the balanced equation for photosynthesis?

State the function of enzymes?

Define water soluble vitamins?

Choose a mineral and describe its function and a result of a deficiency?

Describe the nitrogen cycle?

Go back through the workbook and check your answers