SAMPLE

THE SCIENCE OF PLANT AND ANIMAL GROWTH IN AQUAPONICS

Lesson Aim

Explain scientifically, the factors that contribute toward both the quantity and quality of growth, of both plants and animals, within an aquaponic system.

PLANTS

When you remove the soil from a plant and take control of its roots, it is essential that you have a good understanding of how it grows.

Anybody can grow plants in soil with reasonable success, but to grow plants in aquaponics or hydroponics you must understand how the plant grows so that you can control the temperature, water, oxygen and nutrients in the root zone.

Plant Growth Factors

It doesn't matter whether a plant is growing in the soil or in hydroponics: either way, it still needs essentially the same things to cause and control its survival and growth.

Two main factors influence the growth of a plant:

- Genetics
- Environment

Genetic characteristics are diverse and varied, even within a species. They will give the plant a certain potential to grow and produce, but the environmental factors must also be just right for the plant's full genetic potential to be realised.

All plants need appropriate conditions for growth in both the aerial environment and in the root environment.

Important aerial environment factors are:

- Temperature
- Light
- Moisture (humidity)
- Atmosphere (gases and suspended particles in the air)

Important root environment factors are:

- Nutrients
- Water
- Temperature
- Atmosphere (i.e. gases such as oxygen in the root environment)

Quantitatively and qualitatively, different plant varieties need different things. There is no such thing as an ideal environment for hydroponic growing because every plant cultivar has a different combination of ideal requirements.

The ideal nutrient levels for one plant may be totally inappropriate for another plant. One plant may prefer most of the roots to be almost immersed in water, these roots requiring very little oxygen; while another plant variety may need much less water, and far more oxygen around the roots.

HOW PLANTS GROW

Plants are made up of microscopic cells. The cells are able to take in nutrients, water and gases, absorb energy from the sun and store it in chemicals within the cell.

Plants don't swallow food like animals. Plants take in food (nutrients) by soaking (or filtering) it through the walls of the cells, which then moves in the same way from cell to cell throughout the plant. Air moves into the plant a little differently, through pores (called stomata) which open up on the under-surface of the leaves. Dirty or polluted air can clog up these stomata and cause the plant to become starved for air. Once inside a plant, air can diffuse or soak into the cells, eventually going into solution. Plant takes carbon out of the carbon dioxide in the air (40% of the dry weight of a plant is carbon which comes this way). Some oxygen is used, but most of it is lost back to the outside air, by reversing this whole process.

When rain falls on plants it washes the stomata clean (this does not occur on indoor or greenhouse plants - they can often benefit from a washing down). Up to 90% of the normal weight of a plant is water. From this you can see the need for a good water supply.

Water is normally taken in through the roots, moves up through the plant, some being used, and some being lost through the leaves to the air.

The Structure of a Plant

Almost all plants grown in hydroponics are flowering plants. These plants have four main parts: roots, stems, leaves and reproductive parts.

Roots – the parts which grow below the soil. Roots absorb nutrients, water and gasses, transmitting these ‘chemicals’ to feed other parts of the plant. Roots hold the plant in position and stop it from falling over or blowing away.

Stems – the framework. The main stem and its branches is the framework that supports the leaves, flowers and fruits.

Leaves – required for respiration, transpiration and photosynthesis. The leaves, and also green stems, manufacture food by the process known as photosynthesis, and this is transported to the flowers, fruits and roots.

Reproductive parts – flowers and fruits: flowering plants reproduce by pollen (i.e. male parts) fertilising an egg (i.e. female part found in the ovary of a flower). The ovary then grows to produce a fruit and the fertilised egg(s) will grow to produce seed.

Roots

Roots absorb nutrients, water and gasses, transmitting these ‘chemicals’ to feed other parts of the plant. Roots hold the plant in position and stop it from falling over or blowing away.

When we grow a plant in aquaponics or hydroponics we must make sure that nutrients, water and oxygen are still supplied and that the plant is supported, as would occur if it was growing in soil.

Nutrient supply in soil is a more complex matter than in hydroponics due to the ability of soils to bind mineral elements, the presence of organic compounds and microbial action on these.

Stems

The main stem and its branches are the framework that supports the leaves, flowers and fruits. The leaves, and also green stems, manufacture food by the process known as photosynthesis, and this is transported to the flowers, fruits and roots. The vascular system within the stem consists of canals, or vessels, called the xylem and phloem which transfer nutrients and water upwards and downwards through the plant.

Leaves
The primary function of leaves is photosynthesis, a process in which light energy is caught from the sun and along with carbon dioxide from the air, produces assimilate in the form of carbohydrates such as sugars which can be stored or used for growth. The energy can then be retrieved and used in an essential process known as respiration. Leaves are also the principle plant part involved in the process known as transpiration whereby water evaporating, mainly through leaf pores (or stomata), sometimes through the leaf surface (or cuticle) as well, passes out of the leaf into a drier external environment. This evaporating water helps regulate the temperature of the plant. Transpiration also acts to pull water and calcium up from the root system through the xylem vessels.

The process of water evaporating from the leaves is very important in that it creates a water gradient or potential between the upper and lower parts of the plant. As the water evaporates from the plant cells in the leaves then more water is drawn from neighbouring cells to replace the lost water. Water is then drawn into those neighbouring cells from their neighbours and from conducting vessels in the stems. This process continues, eventually drawing water into the roots from the ground until the water gradient has been sufficiently reduced. As the water moves throughout the plant it carries nutrients, hormones, enzymes, etc. In effect this passage of water through the plant has a similar effect to a water pump, in this case causing water to be drawn from the ground, through the plant, and eventually out into the atmosphere.

Reproductive Parts
Almost all plants grown in hydroponics are flowering plants, although many vegetable plants are not grown through to the flowering stage. These reproduce by pollen (i.e. male parts) fertilising an egg (i.e. female part found in the ovary of a flower). The ovary then grows to produce a fruit and the fertilised egg(s) will grow to produce seed.

There can sometimes be difficulty in obtaining a good crop because insufficient pollen or non-viable pollen reaches the female parts, resulting in insufficient fruit forming.

BIOCHEMISTRY AND AQUAPONICS

A basic understanding of plant biochemical processes will help you to understand how plants grow in aquaponics.

Biochemistry
Biochemistry is the chemistry of organisms. An organism is anything that is alive, or if not, was once alive (a "dead organism"). Metabolism is the process by which a body introduces into itself ("ingests") various energy-rich materials from its environment ("food"), and transforms these materials, with the release of energy, into other substances, some of which are retained by the body ("growth" or "repair") and some eliminated. Reproduction is the process by which one body produces another that is like itself in properties, structure, composition, and function, including metabolism and reproduction.

Biochemical Processes in the Cell
Several anatomical features are so small that they can be revealed only with the aid of an electron microscope. Some of these fine structures of the cell are non-essential inclusions, like blobs of fat, or particles of starch. Others, called organelles, perform essential functions and are reproduced when the cell divides. Some of these functions are well known; others still elude us.

Chloroplasts are organelles that occur in plant cells and that contain the green pigment chlorophyll. Chlorophyll is the catalyst for the process of photosynthesis, in which glucose is synthesised from carbon dioxide.

The nucleus is a well-defined structure which contains the genetic material of the cell; the nucleus thus is the site of the reproductive function. Each time a cell divides, it reconstitutes itself. This ability of self-duplication is retained by new cells and is transmitted repeatedly through successive generations of cells.

The reliability of this transmittal accounts for the continuity of species.

Photosynthesis

Photosynthesis is the biochemical process used by plants to capture energy from the sun and store it in chemical substances within the tissue of the plant. At a later stage when the plant needs that energy it is able to, through a process of chemical reactions, release that energy to be used.

The process can basically be described by the following equation:

Light energy
Carbon Dioxide + Water → Sugar + Oxygen
Chlorophyll

Mechanisms of Nutrient Uptake

Prior to their absorption into root cells, nutrients reach the surface of roots by three mechanisms: mass flow, diffusion, and root interception.

- Mass flow, the most important of these mechanisms quantity-wise, is the movement of plant nutrients in flowing soil solution.
- Diffusion is movement by normal dispersion of the nutrient from a higher concentration (such as near its dissolving mineral source) through soil water to areas of lower concentration of that nutrient.
- Root interception is the extension (growth) of plant roots into new soil areas where there are untapped supplies of nutrients in the soil solution.

All three processes are in constant operation during growth. The importance of each mechanism is in supplying nutrients to the root surface for absorption by the root varies with the chemical properties of each nutrient. Nevertheless, mass flow, because of the large amounts of water flowing to and absorbed by roots as water is transpired from the plant, is the dominant mechanism and supplies about 80% of most nutrients to root surfaces.

The mechanisms of absorption into the root cells are not well understood. The cell walls are porous, and the soil solution can move through some or all of the cell walls, causing intimate contact of the soil solution with the outer membranes of the cells. For a nutrient to cross a cell membrane into the cell, it is believed that each nutrient ion must be attached to some carrier. The carrier-nutrient complex can pass through the membrane into the cell. The necessary carriers are different for many of the nutrients. This means of nutrient absorption allows the root to have some selectivity in the kinds of elements absorbed.

Some elements can be partially but not entirely excluded from absorption; others can be preferentially absorbed; even against a concentration gradient (can be absorbed from a low concentration soil solution and transferred to a higher concentration in the plant cell).

Plants also absorb nutrients through small openings in leaves, the stomata. Carbon enters almost entirely through the stomata as carbon dioxide, releasing the oxygen (0^2) produced during the photosynthesis in gaseous form. Hydrogen, as a part of water molecules, is absorbed through stomata, but this intake is usually small compared to the amount entering through the roots.

PLANT NUTRIENTS FOR GROWTH

The elements usually considered necessary to the life of all plants are Carbon (C), Oxygen (O) and Hydrogen (H). These elements are required by *all* living things as the basis of all organic molecules.

A number of other elements are required by plants and these are generally divided into two groups: the major elements or *macronutrients*, and the minor elements or *micronutrients* or *trace elements*.

There are six macronutrients of plants. They are Nitrogen (N), Phosphorus (P), Potassium (K), Magnesium (Mg), Calcium (Ca), Sulphur (S). These are needed by plants in much larger quantities than other elements.

The micronutrients include all those elements taken up by plants in only small amounts. These include Iron (Fe), Zinc (Zn), Manganese (Mn), Copper (Cu), Boron (B), Chlorine (Cl), Molybdenum (Mo), Chlorine (Cl). Although plants need smaller amounts of micronutrients, they are still essential for growth.

Nitrogen

This element is essential for good foliage and stem growth. When there is a flush of rapid growth, the plant's requirements for nitrogen are particularly high. Adequate nitrogen is essential for good fruiting and other plant processes, as it is required in the synthesis of proteins and enzymes in every living cell, though it is more closely related to the green growth. Leafy vegetables and foliage plants have particularly high requirements for nitrogen.

Phosphorus

Adequate phosphorus is essential to maximise root development, and for growth and energy transfer. Deficiencies lead to poor fruiting and spindly growth; other symptoms may include purplish tinting of leaves and poor seed set.

Potassium

Potassium is required by the plant in quite large amounts and is necessary to maintain cell turgor and the plant's water relations, including controlling the opening of stomata. It is very soluble and very mobile in the plant. It is known that good levels of Potassium are needed, in particular, for flowering and fruiting.

Magnesium

Magnesium is essential to chlorophyll (green pigment) formation and energy transfer processes. Developing fruit have a high requirement.

Calcium

The main role of calcium is to help stiffen or give support to foliage.

Sulphur

This element is not often deficient in plants, as many forms of fertiliser are provided as sulphates. Also, toxicity is rare due to high tolerances in many plants.

Iron

Iron is essential for the functioning of a number of pigments used in giving the green colouring to plants (e.g. cytochromes). Lack of the small amount of required iron will cause plant growth to stop and produce interveinal chlorosis in many plants. Iron deficiencies are more common than any other minor nutrient problem.

Zinc

Zinc contributes to the manufacture of carbohydrates and proteins by functioning as an activator of a number of enzyme reactions.

Copper

Very small quantities of copper are needed, although it is known to be essential for growth. Little is known of its function, but excess copper is known to be toxic, and, in some plants, causes an iron deficiency.

Molybdenum

Molybdenum is essential for nitrate reduction. It is a component of some enzymes, and is important in nitrogen fixation which occurs in the roots of legumes.

Boron

Boron may assist utilisation of calcium, and may play a part in formation of cell walls. It is involved in cell division and is essential to carbohydrate and nitrogen metabolism.

Chlorine

The function of chlorine in plant growth is uncertain, although it is essential for growth.

Aluminium

Essential only for some species including: peas, corn, sunflower and some grasses. Over 10ppm is toxic.

Sodium

Though not usually considered essential, sodium can replace potassium as a nutrient to a limited extent.

THE ROLE OF PH IN PLANT GROWTH

What is pH?

pH is a measurement of the hydrogen ion concentration in a particular medium, such as water, soil, gravel etc. More simply it refers to the acidity or alkalinity of that medium. The pH is measured on a logarithmic scale ranging from 0 to 14 with 7 being considered neutral, above 7 being considered alkaline and below 7 as acid.

The pH of a medium or a nutrient solution is important to plant growth. Each particular plant has a preferred pH range in which it grows. If a plant is subjected to a pH outside its preferred range at the least its growth will be retarded, or it may even die. Very low pH (less than pH = 4.5) and very high pH conditions (above pH = 9) can directly damage plant roots.

Most commercially grown hydroponic species prefer a slightly acidic solution in the pH range 5.8-6.5 however plants can survive in the pH range 5-7.5. As the pH rises from 6.5-7.5 or 8, some elements such as iron, manganese and phosphorus become less available and deficiency symptoms may begin to show, even though these nutrients are present in sufficient levels in the solution. Too high a pH will precipitate out iron in hydroponic solutions making it unavailable for plant uptake and causing chlorosis of the upper leaves. Some forms of iron chelate can withstand higher pH levels than others and this should be taken into consideration when formulating nutrient solutions using water supplies with naturally high pH and alkalinity. Growers should be aware that the availability of nutrients at different pH levels differs for soilless mediums than for mineral or organic soils and diagrams shown in reference books for soils are not accurate for hydroponic crops. Optimum pH levels differ for various crops with tomatoes for examples preferring an optimum pH of 5.8 - 6.0, while lettuce prefers 6.0 - 6.2.

Very high and low pH values can also affect plants as follows:

- As the pH of a medium changes so does the availability of nutrients. The majority of nutrients are most available at a pH range of 6 to 7.5. Somewhere in this range is generally considered to be the ideal for growing the majority of plants although there are plants that prefer higher or lower pH conditions. In some circumstances, particularly at very high or very low pH conditions, some nutrients may become 'locked' in the medium, becoming unavailable for plant growth. The nutrients may be there in the medium but the plant can't use them. At very low pH condition toxic levels of some nutrients such as manganese and aluminium may be released.
- As the pH of some media is raised more negative charges are produced on some colloid surfaces making them capable of holding more cations. This allows some media to hold larger quantities of nutrients. The majority of hydroponic/aquaponic media are not affected in this way as they are basically inert materials such as sand and gravel, however media that contains clays or some of those derived from volcanic materials can be affected.
- Like plants, microorganisms have a preferred pH range in which they thrive. Altering the pH may severely affect the populations of both beneficial and detrimental microorganisms. For example the bacteria that convert ammonium to nitrogen prefer a pH above 6. Most mycorrhizal fungi prefer a pH range between 4 and 8.

ANIMALS

Fish and crustaceans are the most commonly used animals in aquaponic systems. The main types of fish used in an aquaponics system will be bony fishes (Osteichthyes).

Bony Fish (*Osteichthyes*)

The bony fish are the most diverse and numerous of all vertebrates (over 29,000 species). Bony fish are first seen in fossils from the Devonian (about 395 million years ago).

Bony fish have special adaptations and features that distinguish them from the cartilaginous fishes. The skin has many mucus glands and is usually covered with dermal scales. Their jaws are well developed, articulated with the skull, and armed with teeth. The sexes are separate, most are oviparous, and fertilisation is usually external. They also have an adaptation that allows them to remain buoyant. A special organ called a swim bladder housed under the bony skeleton is a gas filled chamber that allows the bony fish to remain floating in the water. Some fish have a connection between this organ and the digestive tract to allow the extraction of oxygen. Another special adaptation is the operculum, a flap on each side of the fish that covers the chambers housing the gills. A bony fish is able to breathe without swimming simply by moving the operculum.

BIOLOGICAL CHARACTERISTICS OF BONY FISH

Body shape

- Body shape related to the lifestyle of the fish.
- Fast swimming fish (e.g. Tuna, Marlin, and Mackerel) have streamlined bodies.
- Laterally compressed bodies are better for swimming around kelp beds or reefs.
- Flat bodies (e.g. Flounder) are ideal for living on the bottom of the sea bed.
- Body shape may also help with camouflage (e.g. Pipefish live in sea grass which has a similar shape to the fish's body).
- Slow moving fish (e.g. Blennies and Sculpins) have irregular growths on body that contribute to camouflage.

Colouration

- Colour is often used for camouflage, particularly in tropical species.
- Many fish can rapidly change colour by contracting or expanding pigment in special cells called chromatophores.
- Some chromatophores contain special crystals that reflect light giving the fish's surface a shiny appearance.
- Colour change may be for any of several reasons, including: camouflage, mood or reproduction.
- Open water fish and shallow water predators are rarely very colourful.

Locomotion

- Swimming is used to find mates for reproduction, chase prey or search for food, escape danger or to obtain oxygen. Cartilaginous fish need to swim to move water through gills from which they obtain oxygen.
- Muscle used for swimming comprises a large percentage of fish body weight (e.g. In Tuna, up to 75%).
- Bony fish have a swim bladder that provides buoyancy (Cartilaginous fish do not have this; hence they need to use pectoral fins to provide lift as well as thrust).
- Bony fish generally have greater manoeuvrability than cartilaginous fish.

Feeding

- Many bony fish are carnivores. Bony fish tend to hunt prey that is smaller than they are.
- Bony fish are diverse in what they feed on, however different species have evolved specific preferences, e.g. some prefer sponges, others sea urchins, some prefer seaweeds and others filter plankton for food.

Digestion

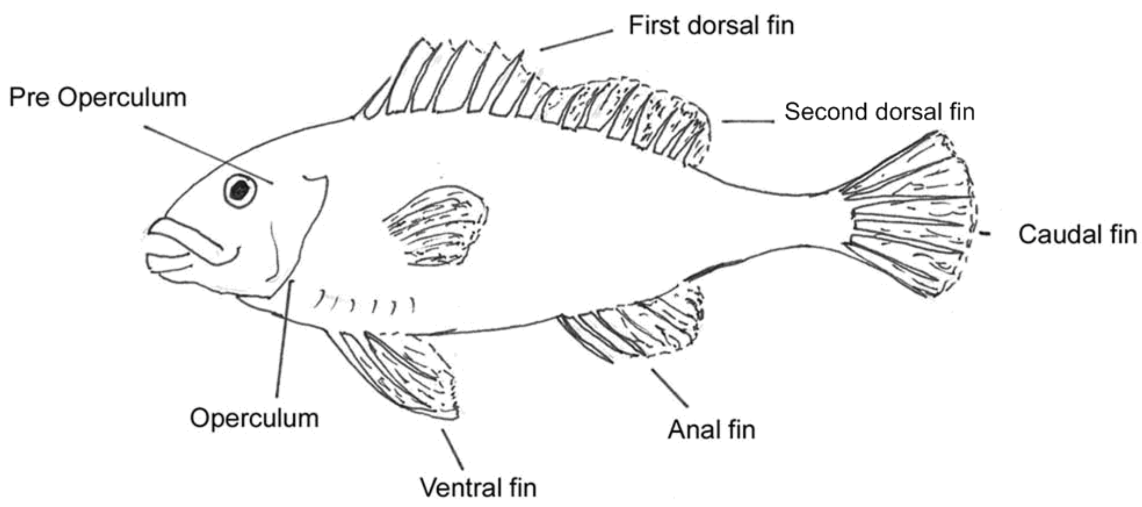
- In general, all fish share certain types of digestive parts including a stomach, intestine, liver, kidney and anus.
- Bony fish do have a more complex digestive system than cartilaginous fish.
- Carnivorous fish have a shorter, straight intestine.
- Fish that eat more difficult to digest plant material have a longer, coiled intestine.

Nervous system

- Most fish have a well-developed sense of smell (particularly strong in sharks). Olfactory sacs are located on both sides of the head. These open to the outside through nostrils.
- Taste buds allow determination of various chemical stimuli. These may be located not only in the mouth, but also on the lips, fins and skin. Taste buds can also be found on whisker-like structures called barbels.
- Bony fish rely on vision more than cartilaginous fish.
- Fish have a unique sense organ called a "*lateral line.*" This involves a series of small canals running along the body (in the skin, bone or cartilage). These canals open to the outside usually through visible pores. The lateral line detects vibrations of sound or water movement.
- Sound waves can also be detected by inner ears located beside the brain, just behind the eyes.

Behaviour

- Due to their well-developed nervous system, fish are able to respond to their environment in complex ways.
- Different types of complex behaviours are characteristic of different types of fish e.g. territorial behaviour, schooling, migration, reproductive behaviour.



CRUSTACEANS

Crustaceans are incredibly diverse with regards to size, shapes, colours and lifestyle. Crustaceans belong to the Phylum Arthropoda, which includes the land-dominating insects, spiders, millipedes and centipedes. The Phylum outnumbers all other animal groups. The group includes well known representatives such as lobsters, shrimps and crabs but also a wealth of microscopic organisms that form a large portion of both the planktonic and benthic fauna (bottom dwelling). Crustaceans have a rigid, calcium carbonate-based external skeleton. Growth is continuous throughout life therefore the animal will periodically molt (shed) the shell and replaces this with a new one. When the new shell is still forming, having already disposed of the old shell, the animal is particularly vulnerable to predators and will stay in a burrow or hiding place. Crustaceans have a segmented body; generally, the front (cephalothorax) and back (abdomen). The limbs are jointed and capable of moving in all directions.

The majority of crustaceans are known as decapods (meaning 10 legs). Shrimps, lobsters and crabs are members of this group. Decapods have the last five pairs of thoracic appendages modified as walking legs while the first three pairs, the maxillipeds, function as mouthparts. If one pair of walking legs has enlarged pincers (chelae) they are referred to as chelipeds. They are mostly secretive creatures remaining hidden for long periods in burrows and crevices. They are actively hunted by larger fish.

Decapods frequently exhibit elaborate courtship behaviour (sexes are always separate). Internal fertilisation occurs when the abdomens of the mating pair are close to each other.

Examples of non-decapods include barnacles, copepods, isopods, mantis shrimps and amphipods.

Crabs

Crabs fall into two main groups:

- True Crabs (brachyurans) – lack an obvious tail section.
- Hermit Crabs (anomurans) – possess a clearly evident tail section.

Hermit Crabs (anomurans)

There are many varieties (species) of hermit crabs. They are known for their curious habit of making their homes in empty shells. They do this to protect their soft skinned abdomens. To fit into the spiral of their home, the abdomen has become twisted and the number of appendages in the inside of the curve have been reduced. The first pair of legs carries nippers, the left nipper often enlarged to seal the opening of the shell when the crab withdraws inside. The second and third pair of legs is used for walking. The last pair of legs is reduced in order to grip the shell.

Hermit crabs don't molt like true crabs. As the hermit crabs grow it becomes necessary to move to larger homes, and they move to progressively larger shells. Fights often occur over ownership of the better shells. Most of the hermit crabs are scavengers, but some of them filter food particles from the water. This is done by use of their antennae.

Hermit crabs common in Pacific and IndianOceans include:

- Anemone Hermit Crab (*Dardanuspedunculatus*)
- Land Hermit Crab (*Coenobitaperlatus*)
- Coconut (Robber) Crab (*Birguslatero*)

True Crabs (brachyurans)

True crabs are more specialised crustaceans. The abdomen is not part of the tail; it is tucked beneath the thorax. The abdomen limbs are not used for swimming; they only hold the eggs in the female or transfer sperm in the male. The fantail is no longer present. The first pair of walking legs bears nippers and the remaining four pairs of legs are used for walking. Crabs scuttle sideways so they can lengthen their stride without danger of entangling their legs. The head and thorax are covered by a shield like carapace housing gills on either side of the body. The eggs hatch into planktonic larvae that settle and are transformed through various developmental stages eventually assuming the adult form.

True crabs common in Pacific and IndianOceans include:

- Shore Crabs (Percnonplannissimum)
- Soldier Crab (Mictyris sp.)
- Ghost Crab (Ocypodecerathopthalma)
- Spanner Crab (Raninoidesserratifrons) – East and west coasts of Australia.
- Mud Crab (Scylla serrata) -Indo-Pacific region from Hawaii, southern Japan, Taiwan, Philippines, to Australia, Red Sea and East and South Africa.
- Fiddler Crab (Genus Uca)
- Blue Claw Crab (Callinectessapidus) - widely distributed from Nova Scotia to northern Argentina, but along the coasts of North America, it is most abundant from Texas to Massachusetts.

Note: Not all crabs are edible - some are poisonous. This is also true for other crustaceans.

Lobsters

Rock lobsters are robust, large crustaceans with a long tail ending in a well-developed tail fan. The thorax and head are covered with a single shield, or carapace. There are no nippers on the ends of the walking legs. Lobsters have a pair of pincers called chelapeds, or "claws"--one is a heavier crusher claw and the other is a smaller feeding claw. The head has two pairs of antennae; they have compound eyes. These lobsters are popularly known as crayfish, but their correct names include either rock lobster or spiny lobster. Lobsters are actually related to Crayfish, which are freshwater creatures.

A spiny lobster is one of a few creatures making use of the large-scale ocean current system to transport its young away from the parent populations. Females lay several thousands of eggs approximately once every two years. The larvae moult through at least eleven stages before they metamorphose into a swimming stage. The young return many months later to resettle in their home habitat. This is done by the larvae employing a drifting existence. The lobster is tiny and transparent, but it can swim fairly long distances. At this stage the juvenile moves out of the plankton into the nursery areas, near the adult lobsters. The life cycle of spiny lobsters is geared towards producing large numbers of eggs and then larvae. Lobsters are very desirable for human consumption.

When lobsters grow, they have to molt (or shed) their shells and grow a new one. Lobsters live for about fifteen years. Lobsters are primarily scavengers which means they will eat almost anything, dead or alive. They generally hunt around for food at night. Its diet typically consists of crabs, clams, mussels, worms, and an occasional sea urchin. A lobster will eat another lobster if given the chance.

Lobsters common in Pacific and Indian Oceans include:

- Reef Lobster (Enoplometopusdebelius)
- Painted Rock Lobster (Panulirusversicolor)
- Slipper Lobster (Parribacuscaledonicus)

Below is a list of some of the lobsters found throughout the world. This is not an extensive list as there are many different species worldwide.

Common Name	Scientific Name	Location
Clawed Lobsters		
Daum's Reef Lobster	*Enoplometopus daumi* Holthuis	East Indian, Western Pacific Oceans; imported from the Philippines, Indonesia
Hairy/Red Reef Lobster	*Enoplometopus occidentalis*	Tropical Indo-Pacific
American Lobster	*Homarus americanus*	Throughout the Northwest Atlantic, from Canada all the way to North Carolina, although most prolific in Maine and Massachusetts
European Lobster	*Homarus gammarus*	Mediterranean, Atlantic to Norway
Spiny Lobsters		
Caribbean Spiny Lobster	*Panulirus argus*	Common in the tropical West Atlantic
Green Spiny Lobster	*Panulirus gracilis*	East Pacific; Baja south to Peru, including the Galapagos
Banded Spiny Lobster	*Panulirus marginatus*	Hawaii
Ornate Spiny Lobster	*Panulirus ornatus*	Red Sea, East Africa to the western Pacific and Fiji Islands.
Hawaiian Blue Lobster	*Panulirus penicillatus*	Collected out of Hawaii for trade, also found in the Eastern Pacific.

SHRIMPS & PRAWNS (CLASS MALACOSTRACA)

Shrimps and prawns are valuable food resources in many countries. The two names are often confused, although there are differences. Prawn usually refers to members of the super-family Penaeoidea, and shrimp refers to the members of super-family Caridea. Shrimps and prawns (as well as lobsters) inhabit every sea environment, with many species. Often they go unnoticed, because of their small size, or because they have cryptic or transparent colour patterns, or because they live, perfectly camouflaged, in association with other animal species.

The 'cleaner shrimps' are the most conspicuous crustaceans during daylight. They clean parasites from fish. They occupy permanent 'stations' that are used by a variety of fishes (moray eels, groupers, triggerfishes) that hover at the station. One or two shrimps begin cleaning the parasites. They even enter the mouth and gill cavity. So, whilst the fish get cleaned of their parasites the shrimps get a free feed.

Shrimps common in Pacific and Indian Oceans include:

- Mantis Shrimp (Odontodactylusscyllarus)
- Snapping (Pistil) Shrimp (Alpheus sp.)
- Harlequin Shrimp (Hymenocerapicta)
- Bumblebee Shrimp (Gnathophyllumamericanum)
- Cleaner Shrimp (Lysmataamboinensis)
- Marbled Shrimp (Saroninermis)
- Crinoid Shrimp (Periclimenesamboinensis)

The five main commercial deep water species of prawns of the Indian Ocean include

- Pink Prawn
- *Aristaeomorphafoliacea*
- *Penaeopsisballsi*
- *Plesiopendaeusedwardsianus*
- *Aristeusantenatus*

The main commercial shallow water species of prawns of the Indian Ocean include:

- White Prawn (*Penaeusindicus*)
- Tiger Prawn (*Penaeusmonodon*)
- Brown Prawn (*Metapenaeusmonoceros*)
- Bamboo Prawn (*Penaeusjaponicus*)
- Zebra Prawn (*Penaeussemisulcatus*)

The main commercial deep water species of prawns of the Atlantic Ocean include:

- Gamba,
- Carabinero
- Listado

The main commercial shallow water species of prawns and shrimps of the Atlantic Ocean include:

- Parapenaeopsusaltantica - Prawn
- Penaeusnotialis - Prawn
- Commensal Shrimp
- Cracker Shrimp
- Sand Shrimp
- Broken-backed Shrimp
- Oriental Shrimp
- Zebra Shrimp

SUGGESTED READING

Refer to, and read any reference material you have access to that relates to the aim of this lesson.

This may include any of the following:

- Books in your own possession, or which you find in a library
- Periodicals you have access to (i.e. magazines, journals or newspapers)
- Websites

Spend no more than 1 hour doing this.

SET TASK

Research the anatomical characteristics (body structure) of one species of fish commonly used in Aquaponics in your region or country. You may do this in any way you wish (e.g. Internet searches, books, interviewing experts, or even obtaining a fish perhaps from a fishmonger, and dissecting it).