General Certificate of Education
(Advanced Level)
BIOLOGY

Unit 10 - Applied Biology

Grade 13

Department of Science
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G.C.E. (Advanced Level)
Biology
Grade 13
Applied Biology
Unit- 10

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Message from the Director General

The National Institute of Education takes opportune steps from time to time for the development of quality in education. Preparation of supplementary resource books for respective subjects is one such initiative.

Supplementary resource books have been composed by a team of curriculum developers of the National Institute of Education, subject experts from the national universities and experience teachers from the school system. Because these resource books have been written so that they are in line with the G. C. E. (A/L) new syllabus implemented in 2017, students can broaden their understanding of the subject matter by referring these books while teachers can refer them in order to plan more effective learning teaching activities.

I wish to express my sincere gratitude to the staff members of the National Institute of Education and external subject experts who made their academic contribution to make this material available to you.

Dr. (Mrs.) T. A. R. J. Gunasekara
Director General
National Institute of Education
Maharagama.

Message from the Director

Since 2017, a rationalized curriculum, which is an updated version of the previous curriculum is in effect for the G.C.E (A/L) in the general education system of Sri Lanka. In this new curriculum cycle, revisions were made in the subject content, mode of delivery and curricular materials of the G.C.E. (A/L) Physics, Chemistry and Biology. Several alterations in the learning teaching sequence were also made. A new Teachers' Guide was introduced in place of the previous Teacher's Instruction Manual. In concurrence to that, certain changes in the learning teaching methodology, evaluation and assessment are expected.

When implementing the previous curricula, the use of internationally recognized standard textbooks published in English was imperative for the Advanced Level science subjects. Due to the contradictions of facts related to the subject matter between different textbooks and inclusion of the content beyond the limits of the local curriculum, the usage of those books was not convenient for both teachers and students.

As this book is available in Sinhala, Tamil, and English, the book offers students an opportunity to refer the relevant subject content in their mother tongue as well as in English within the limits of the local curriculum. It also provides both students and teachers a source of reliable information expected by the curriculum instead of various information gathered from the other sources.

This book authored by experienced subject teachers and subject experts from the universities is presented to you followed by the approval of the Academic Affairs Board and the Council of the National Institute of Education. Thus, it can be recommended as a material of high standard.

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Content

10

Applied Biology

Aquaculture

Food and agriculture organization (FAO) defines aquaculture as the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants.

Importance of aquaculture

Farming edible aquatic organisms is accepted as one of the best solutions for feeding the ever increasing human population. A healthy diet, high in protein is necessary to ensure that growing population does not succumb to sicknesses and diseases due to lack of essential nutrients. Harvests from wild sources of fish, crustaceans and other aquatic species cannot keep up with the demand presented by the growing human population. Trying to match the demand through commercial fishing would eventually result in over-fishing and the loss of those species entirely. It is accepted that while aquaculture is essential to meet the human demand for fish and fishery products, it also relieves the strain on wild species and allow them to continue to be a significant source of food for humans.

General characteristics of species that could be cultured

- Selected species should withstand the climate of the region in which it is cultured.
- It should grow well (should have a fast growth) in prevailing physical and chemical parameters of water in the area.
- It should be easy to breed (breeding techniques should be available) so that sufficient number of fertilized eggs/early fry could be obtained easily.
- Techniques of incubation of fertilized eggs and rearing techniques of hatchlings/early fry should be available so that the production of sufficient number of young organisms (seed) would be easy under culture conditions.
- If the eggs, larvae, fry, fingerlings, juveniles and adults of the species are hardy it is easier for the hatchery manager/ farmer (handling hardy species is easy).
- Food and feeding habits of each developmental stage of the species should be known (easy to provide nutritionally balanced diet for each developmental stage).
- It should not reproduce in grow-out ponds/tanks.
- If it reaches sexual maturation relatively late, it is advantageous.
- It should accept formulated food and grow well.

- It should be an efficient converter of economical foodstuffs.
- If it is accidentally released to natural water bodies there should not be adverse environmental impacts.
- It should tolerate high population density & grow well
- Having resistance to common diseases is advantageous.
- It should satisfy consumers by the taste, nutritive value, texture of flesh or appearance/ body color/ color patterns.

Ornamental fish culture

Ornamental fish keeping has been a hobby of humans for centuries of years; initially fish that had some colours were collected from wild and maintained in garden ponds for the joy of watching their aesthetic beauty. Ornamental fishes lure and draw a great attention worldwide through their attractive colouration, shapes and sizes of body and fins, swimming behaviours, ability to live under captive conditions and adaptability to live in little spaces. People keep fish in their homes for variety of reasons such as for decoration, children's education, enjoyment, relaxation of elderly or health affected individuals, prosperity and fortune of home occupants and to collect rare species and even to propagate them. Globally, ornamental fish keeping has emerged as one of the most popular hobbies being second only to the photography.

Species that are commonly used in freshwater ornamental fish culture in Sri Lanka

Guppy (*Poecilia reticulata*)
Black molly *(Poecilia mexicana*)
Swordtail (*Xiphophorous helleri*)
Platy (*Xiphophorous maculatus*)
Angelfish (*Pterophyllum scalarae*)
Discus (*Symhysodon discus*)
Siamese fighting fish (*Betta splendens*)
Kissing gourami (*Helostoma temmincki*)
Goldfish (*Carassius auratus*)
Koi carp *(Cyprinus carpio)*
(see Annexe 1)
(Scientific names are not required to memorize)

Aquarium

An aquarium can be defined as a container that is designed to hold water in which living organisms can be maintained over an extended period of time. Aquaria vary tremendously in size, shape and design ranging from a simple bottle containing some water (e.g. an empty jam bottle is used to keep a male Siamese fighting fish) to a multimillion Litres commercial exhibit tanks.

Maintenance of a home aquarium

There are activities that should be carried out daily, weekly, fortnightly and monthly in order to maintain environmental conditions (water quality parameters) within the optimum ranges for the fish kept in an aquarium. Provision of correct nutrition and maintenance of water quality within optimum ranges contribute for the well-being and health management of fish kept in an aquarium.

Daily:

1. Feed the fish with a nutritionally balanced diet following a correct feeding regime (suitable daily ration should be offered in 2 or 3 meals)
2. Check on the status of health while feeding and remove the affected individuals for treating in another tank/basin
3. Allowing fish to adapt for the changing intensity of light (to prevent unnecessary stress on fish),
   - Switch on the light of the aquarium several minutes after the room lights have been on or after the day break
   -Switch off the light of the aquarium several minutes before the room lights are switched off or shortly before natural lights fades

Weekly:

1. Fish should not be fed one day per week (not applicable for brood fish, fry and fingerlings)

Fortnightly:

1. Switch off aeration
2. Rake or stir up gently the surface of the rooting medium (under-gravel filter medium)
3. Scrape excess algal growth
4. Allow debris to settle
5. Siphon off the debris along with 20 – 25% of the aquarium water
6. Replace the volume siphoned out with freshwater in which temperature, pH and hardness match with conditions of the water in the aquarium
7. Switch on aeration

Monthly:

1. Take out some water from the aquarium in to a basin /another tank/ bucket
2. Collect the fish carefully using a hand net and introduce them into the basin/ tank/bucket and arrange aeration to it.
3. Rinse rooting medium (under-gravel filter medium)
4. Remove the aeration tube from air lift, scrape off any deposit (algal or calcite) from the opening and clean/scrape off air diffuser stones
5. Introduce the siphoning tube under the filter plates and suck out the accumulated organic debris

6. Check the terminals of light source
7. Remove dead and dying leaves from plants
8. Prune, thin out and tidy the plants and replace poorly grown plants
9.Rearrange the filter plates and the filter medium
10. Arrange the aeration and fill the aquarium halfway with clean freshwater/aged aerated tap water.
11. Reintroduce the fish with the water and then fill the aquarium to the original level of water using aged clean freshwater

No matter how much time and care is devoted things in an aquarium could go wrong from time to time. Equipment failure, excessive algal growth, poor water quality or occurrence of diseases could be the cause.

Water turning into green frequently, green algae growing on plants on aquarium décor and on the side glasses of the aquarium indicate that the aquarium is receiving too much light. The reduction of intensity and/or duration of light followed by partial water exchange may prevent this situation. Growth of brown algae as brown encrustations on plants on aquarium décor and on the side glasses of the aquarium are indications of insufficient illumination. Blue-green algal "mats" on plants on aquarium décor and on the side glasses of the aquarium indicate a high level of organic pollution. Physical removal of algal mats followed by partial water exchange, a review of the maintenance routine with a view to prevent further accumulation of organic pollutants (whether too much food are offered to fish, inadequate filtration or aeration, overstocking, etc.) are required to correct the situation.

Common diseases of cultured, freshwater ornamental fish

Ornamental fish kept in aquaria are susceptible to numerous diseases. Some of the diseases are infectious and some are non-infectious.

Infectious diseases

Invasion of fish tissues by a disease causing agent (a pathogenic virus, bacterium, fungus, or an obligatory/ oppourtunistic parasite), multiplication of it in/on fish tissues and increasing its' population may lead to the development of an infectious disease in ornamental fish. However, many infectious diseases could be avoided/prevented through better management practices (BMPs such as maintenance of water quality, correct stocking density of compatible fish with compatible plants, correct feeding regime) to keep the immunity of fish at a higher level and through correct bio-security measures (to prevent contamination by pathogens; Ex: quarantining new fish, plants and other aquarium décor).

Table 10.1: Common diseases of fresh water ornamental fish species

Disease	Group of the disease causing agent
Bacterial fin rot and gill rot	Bacteria
Heamorrhagic septicaemia	Bacteria
Columnaris disease	Bacteria
External mycosis	Fungi
Fish white spot disease (ich disease)	A Unicellular external, obligatory parasites
Trichodinosis	A Unicellular, external, opportunistic parasite
Gill and skin infestation	Obligatory/oppourtunistic, gill flukes and skin flukes

Environmental impact of ornamental fish culture

Some impacts of ornamental fish culture are beneficial while some could be harmful. The first benefit of ornamental fish culture is species conservation, and production of species that are difficult to obtain from the wild. Breeding and rearing of approximately 90% of freshwater ornamental fish traded globally are done under captive conditions; there is some environmental benefit or elimination of environmental damage via those breeding programs. The golden arrowana, and tiger barb (*Puntius tetrazona*) are two species that have been conserved via ornamental fish production. In addition to the sale of fish to hobbyists, fish are also being reintroduced to habitats in which they have been eliminated.

Invasive ornamental fishes/aquatic plants that are accidentally escaped to natural environment could affect a wide range of native organisms from zooplankton to mammals across multiple levels of biological organizations ranging from the genome to the ecosystem.

With imported live fish non-indigenous disease causing agents may also come in to a country. Haphazard use of broad-spectrum antibiotics and other chemicals as preventive/therapeutic treatments and release of treated water (containing those medications) in to the natural environment may cause antibiotic resistance/ resistance to chemicals used on pathogenic microorganisms including human pathogenic bacteria.

FOR EXTRA KNOWLEDGE

Bacterial fin rot & gill rot

Aeromonas sp and *Pseudomonas* sp are opportunistically pathogenic bacteria that are commonly found in freshwater in low numbers. If the culture water is organically polluted (due to accumulated faecal matter or excess feed) causing changes in water pH, fish will react by secreting excess mucus on gill surface and the surface of fins. Bacteria will be attracted to mucus, feed on mucus, multiply and increase their population. If bacteria establish on fin edges and begin to obtain nutrition from the tissues of fins, tissues between fin rays will rot away. Similar activities of bacteria on gill tissues will cause primary gill filaments to rot away causing difficulties in gas exchange. Bacterial fin rot and/or gill rot has been recorded in almost all freshwater ornamental fish species reared in Sri Lanka.

Heamorrhagic septicaemia

If a pathogenic *Aeromonas* sp establishes on the body surface and obtain nutrients from epithelial cells of fish, those cells will undergo necrosis (dying) and drop off. If walls of blood capillaries in the skin of fish are damaged, small haemorrhagic wounds (wounds with the appearance of bleeding) may occur on the body surface. Pathogen could then enter the blood stream of fish and develop haemorrhagic septicaemia (entry of bacteria in to internal organs such as liver, spleen and kidney causing internal bleeding and affecting the functions of those vital organs also).

Columnaris disease

Almost all freshwater ornamental fish used in Sri Lankan ornamental fish industry could be susceptible to this disease. Columnaris disease, wrongly termed as mouth fungus disease, is common in most of the guppy farms in Sri Lanka. At the initial stage small white patches appear near mouth and when the affected area enlarges it appears as a fungal infection. Necrotic cells (dead cells) drop off producing wounds in which peripheries are red in colour while the middle area appearing whitish. Affected tissues of caudal fin will gradually die, dead tissues will drop off finally eroding the caudal fin completely up to the caudal peduncle. If the gills are infected, gill filaments will be eroded and fish could die due to breathing difficulties.

External mycosis

Aquatic fungi, *Saprolegnia* sp could produce fungal infections in freshwater ornamental

fish. These fungi grow naturally on decomposing organic materials. When fungal spores are dispersed, if they drop on a damaged surface of gills, fins or body of fish they will germinate producing fungal hyphae. These fungal hyphae will obtain nutrition from fish tissues allowing the infected areas to undergo necrosis (death). Dead tissues will drop off producing open wounds. Fish eggs, newly hatched-out larvae are highly susceptible to external mycosis. Adult fish that has been living in polluted water at high water temperature also reported to get the disease.

Diseases caused by external, unicellular parasites

Ich disease (fish white spot disease)

Ich disease is common in all species of fish used in freshwater ornamental fish industry of Sri Lanka. Significant mortality of fish is reported in almost all farms during the colder months (December – January) of each year. White spot disease of fish is caused by *Ichthyopthirius*, an obligatory parasite (a unicellular ciliate); theronts (infective stage) swim and get in to the body of fish and occupy gills, fins and body surface of fish. It slowly moves among epidermal and dermal cells of fish, digest cell contents to obtain the required nutrition; as a reaction, some cells of fish will multiply and make a protective layer surrounding each parasite separately producing small nodule like structures. Those nodules could be observed by the naked eye as white spots which are broken when the fully grown parasites (trophozoites) come out from the fish body to complete the life cycle; when a large number of trophozoites comes out, blood capillaries of fish could be damaged resulting haemorrhagic wounds.

Trichodinosis

Trichodina spp are oppourtunistic parasites (unicellular ciliates) that are common in water. Generally, it invades the body of fish latrvae whose immunity is suppressed. it feeds on mucus and when it moves on fish tissues (fins, gills and body surface), fish tissues may be mechanically bruised. Trichodina begins to feed on oppourtunistic bacteria that settle on those wounds and cell debris of fish. Young fish will die due to heavy infestation of these parasites.

Diseases caused by external multicellular parasites

Gill and skin infestation by flukes

Generally, gill flukes infest gills while the common site of infestation of skin flukes is the skin of fish. Respective flukes attach themselves to the surfaces of gill filaments and skin, feeds on mucus and scraped tissues of gills and skin. As a reaction thick mucus will be secreted by gill and skin tissues, wounded area (due to feeding) would be reddish and highly inflamed. When this occur on gills, it will disturb normal gas exchange; fish will display breathing difficulties (they will keep mouth opened with partially opened opercula) and come to the surface of water or gather near aerating devices. Heavy infestation could cause mortality in fry and fingerlings of fish. Secondary bacterial and fungal infections may contribute for mortality in adult fish also.

Nursery Management and Propagation

Issues in Nursery Management

Nursery is a specialized place for young plants and seedlings to be produced for transplanting in another place. Plant propagation and nursery management can be done in the field, orchard, forest or in a protected environment such as greenhouses, polytunnels or tissue culture laboratories. Main requirement of a nursery is to providing optimum/ favorable conditions for germination and seedling growth, which provides healthy, vigorous, evenly grown plants leading to best transplants.

Growers have to face several issues when they manage plant nurseries. The optimum capacity of a crop could be obtained only by providing optimum environmental conditions to the nursery plants. Some of the issues in nursery management practices are management of light, soil management (soil type, properties of soil and maintenances of soil), pest and disease control, water management (water quality and quantity), nursery structures and environmental controls (protected cultivation versus open air cultivation).

Management of light is a critical factor for rooting cuttings, seed germination, seedling growth as well as in tissue culture facilities. Light can be manipulated by controlling, quality (wave length) and duration (day length, photoperiod).

Soil management is a must to get a quality product. Soil texture, structure, and organic matter content influence the soil condition. Soil condition can be improved via application of fertilizer or manure into soil.

Pest and disease control is vital to get a quality product and to maintain the plant health. This is achieved via biological, cultural, physical, chemical or combination of these as integrated pest management.

Water management and humidity control is also critical factors, which governs the rooting of cuttings and regulation of plant growth. The type of irrigation used depends on natural conditions of the area, soil type, slope of the land, water availability and the crop to be irrigated. Adequate supply of good quality water is a must in a nursery.

During propagation and nursery management, nutrients are supplied to seedlings. Although there are number of ways to apply fertilizer, the type chosen depends on the form of fertilizer available, cultivated crop requirement and the environmental conditions prevailing. Fertilizer may be applied as either solids or liquids.

Detailed description of nursery structures and protected cultivation is given in next section

In addition to these, other issues faced by growers are;

- Lack of access to modern technology
- Lack of financial incentives to further improve the nursery and cultivation facilities
- Shortage of quality planting/ propagating materials
- Inadequate knowledge on suitable techniques and growth conditions that can be used to grow crops

Methods and Rationale of Protected Cultivation of Crops/ Protected Agriculture

Horticultural crops can be grown in various types of plant growing structures. These structures provide a more favourable environment for plants than the open air/ outdoor cultivation. In simple terms protected cultivation is growing crops under controlled environmental conditions (Fig. 10.1. A). Protected cultivation of horticultural crops will tremendously benefit in terms of enhanced productivity.

Protected cultivation technology is used to protect plants from adverse climatic conditions (wind, heavy rain, mist etc.) by providing optimum conditions to achieve maximum yield and the best quality. This type of cultivation can be done in green house (depending on the covering materials different structures are used such as polytunnels). Protected cultivation is mainly utilized to grow perishable horticultural produce such as, fruits, vegetables and ornamental plant.

Examples for plants grown in Protected cultivation in Sri Lanka

A simple form of green house is a structure where it is covered with material that allows light to penetrate inside and reach plants. At present with advanced technology, sophisticated modern green houses are constructed in horticulture industry, where the plants' microenvironment is more precisely controlled. Plants grown in green houses including polytunnels are ;

- Vegetables such as bell pepper, tomato, salad cucumber, cauliflower and lettuce
- Fruits- strawberries
- Ornamental plants- Carnations, roses, orchids

Figure.10.1. Photo images of protected cultivation (A) and open-air cultivation (B).

Tissue Culture – Principle and its importance

Tissue culture and micropropagation are two most interesting areas under biotechnology. In general, cell or tissue culture is culture of free living cells or group of similar cells.

More specifically, tissue culture is the ability to establish plant tissues (cells, callus and protoplasts), plant organs (embryos, shoots, roots) in aseptic, *in vitro* culture. The most common benefit of tissue culture is that of cloning or mass production of genetically identical organisms.

The main concept behind plant tissue culture is "totipotent" i.e., a single cell has the genetic programme to grow into an entire new plant. The concept of totipotent was first introduced by the scientists, Matthias Schleiden and Theodor Schwann who postulated the "cell theory" in 1838.

A tissue culture medium generally consists of inorganic salts, organic substances, water and gelling agent. Macro and micronutrients in appropriate ratios make the inorganic salt component. The organic substances include carbon energy source (usually sucrose) plant growth regulators (cytokinins and auxins), vitamins, miscellaneous compounds. Agar is incorporated as the gelling agent. These gels provide physical support for the explant and increase the aeration of the medium. There are several commercial media available for tissue culture (eg. Murashige and Skoog or MS medium, etc.).

Importance of tissue culture technique:

1. Rapid multiplication of clones
2. Mass propagation of specific clones
3. Genetic uniformity
4. Genotype modifications
5. Ability to produce plants in large numbers in a small space
6. Production of pathogen-free plants
7. All year around production of plants
8. Ability to produce plants which do not produce viable seeds

Examples for tissue-cultured plants are Anthurium (Anthurium andreanum), Banan, Pineapple, Dragon fruit.

Grafting and other propagation methods used in floriculture industry

Seed propagation method/ sexual propagation

The most common and widely used propagation method for plants is seeds. Therefore, production of high quality seeds is a prime importance in the horticulture sector. Growers wish to have high quality seeds with higher percentage of germination and higher viability and free of diseases and pest damages.

Seed germination is the beginning of the next sexual generation of a particular plant. For a seed to initiate germination following conditions must be completed.

1. The seeds must be viable
2. The seed must be subjected to suitable environmental conditions
3. Dormancies existing should be overcome

Anthrium and Orchid plants can be produced using seed propagation methods (At present tissue culture is culture methods).

Vegetative propagation methods used in the Floriculture industry

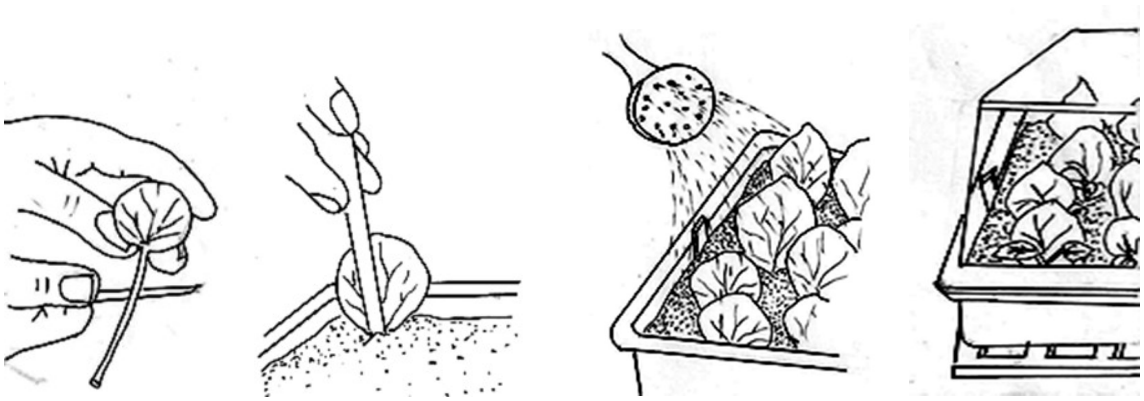
In nature, some plants can produce sexually via seeds as well as asexually or vegetatively. In vegetatively propagated plants, the new plant is nearly always genetically identical to the parent. The various methods of vegetative propagation include seperation and division, cuttings, layering and grafting. Most of these vegetative propagations methods are used in the floriculture industry.

Separation and Division: Separation is a propagation method where naturally detachable structures (eg. Rhizomes, bulbs, and corms) are used. During division, it involves cutting or dividing the plant into sections with both roots and stems (eg. stolons and rooted runners).

Corms:. Examples; *Alocassia/ Colocasia*??, *Gladiolus*
Runners: (eg., Spider plant/ *Chlorophytum comosum*).
Stolons: (eg. *Cyanodon* grass species, Mentha (mint), Stachys).

Cuttings: Cutting propagation is one of the most important clonal regeneration technique used in horticulture industry (for ornamental plants, fruit trees). Adventitious root formation is a prerequisite in this process. A piece of plant from the stem, leaf, root or leafy bud can generate into a fully developed plant (Fig. 2). The roots arising from stem, leaf, or bud tissue are known as adventitious roots. e.g. Roses, *Ficus*, *Dracaena* sp., African violets, Croton., Although stem and leaf-bud cuttings need only a new adventitious root system to be formed, for root and leaf cuttings, both the new shoot and root systems need to be formed.

Propagation via leaf cuttings: Begonia, African violet, snake plant *(Sansevieria)*,



A B C D

Figure. 10.2. Steps involved during propagation via leaf cuttings. A: Choosing a suitable leaf and trimming the petiole as required, B: Planting the leaf in potting media, C: Watering the leaf cuttings and D: Leaf cuttings with new plantlets in a propagator.

Layering: A method of vegetative propagation, where stems are rooted while attached to the parent plant. Some plants have a natural tendency to regenerate by self-layering, forming adventitious roots from the stem where they touch the soil (strawberry, Cynodon sp.). Layering technique is a good way of getting small number of new plants with relative certainty because the new plant is nourished by it's parent plant until roots are formed and rooted. E.g. Roses, *Hibiscus*

Figure. 10.3. Schematic diagram of a simple layering.

Grafting: This involves joining two separate plants so that they later function as one healthy plant that has the best characteristics of two parent plants. A root system is provided by one plant (known as root stock or understock) and the desired top part by the other plant (known as scion) e.g. Roses

During a graft union it is vital that the cambium of the scion is placed in close contact with the rootstock cambium (Fig. 10.4). Initially a callus (mass of undifferentiated parenchyma cells) bridge is formed between the scion and rootstock in a successful graft. These callus cells are originated from the scion and the rootstock.

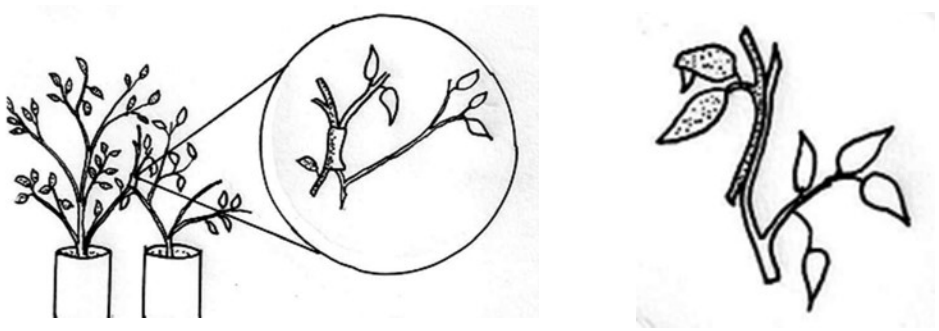


Figure.10.4. Procedure in making a side approach graft. A: Initial joining of the scion and the rootstock which are in separate pots and B: diagram of a completed graft union. Dotted plant indicates the scion and non-dotted one is the root stock

Floricultural practises found in Sri Lanka include cut flowers and Ornamental foliage plants. Anthurium and orchids are examples for cut flowers and Rose, *Dracinia* and Begonia are examples for ornamental foliage plants.

Food Preservation and Postharvest Losses

Importance of food preservation

Most kinds of foods are readily spoiled unless they are preserved using suitable methods of preservation. food preservation ensures that food could be stored for a particular period. During some seasons over production of certain food occurs and the excess production could be preserved (using suitable methods) and stored to be used later. Food preservation protects the food that is available for human consumption reducing the "food loss".

Food preservation

Food preservation is the process of treating and handling food to stop or greatly slow down spoilage (loss of quality, edibility or nutritive value) caused or accelerated by micro-organisms.

Food could be preserved before undergoing spoilage using suitable techniques which could prevent unnecessary wastage and contribute greatly to meet food requirement of growing human population by,

- eliminating avoidable losses
- making more nutritive food items from low grade raw commodity using proper processing and fortification,
- diverting a portion of food materials presently being fed to animals for human consumption by way of processing and
- fortifying low grade food and organic wastes and by-products into nutritive animal feed.

Principles of Food Preservation

It is essential to prevent contamination of harvested food from damaging agents by hygienic handling, transportation and storage.

Three basic principles of food preservation

- Prevention of entry of microorganisms into food (aseptic).
- Prevention of the growth and activity of microrganisms in food.
- Remove or killing of microorganisms in food.

Methods of Food Preservation

Food preservation methods aim to prevent contamination in the first place and to remove or reduce the numbers of contaminants. Preservation of food is achieved by application of physical, chemical and/or biological methods. The techniques may be applied separately or in combination. Microorganisms need a source of food and water, and they also need a suitable pH and temperature to grow; one or several of the living conditions needed for the growth of microorganisms have to be removed by the food preservation technique.

Drying

One of the oldest methods of food preservation is drying. Food is dried mostly in the sun and drying reduces water activity of the food sufficiently to prevent or delay microbial growth allowing food to keep for weeks. Most types of grains are dried to increase shelf life. Wheat, corn, oats, rice, rye, and barley are left to dry to prevent spoilage. Hams are a great example of meats preserved through drying in ovens.

Thermal (heat) Treatment

Heating food is an effective way of preserving it because the great majority of harmful pathogens are killed at temperatures close to the boiling point of water. In this respect, heating is a form of food preservation. A preliminary step in many other forms of food preservation, especially forms that make use of packaging, is to heat the food to temperatures sufficiently high to destroy pathogens. In many cases, food is actually cooked prior to their being packaged and stored.

Pasteurization (preserving fresh milk Refer unit 9)

Freezing and chilling

Freezing is perhaps the most common of all modern food preservation methods both commercially and domestically. Commercially freezing is done in different types of freezers under extremely fast freezing or fast freezing (bringing the temperature of fish/meat down to a value between -18 to -30 oC within 15 minutes to 2 hours) to preserve the quality. Frozen products are stored in cold rooms (at -18 to -30 ^{o}C) until distributed in order to prevent the growth and spreading of spoilage microorganisms(the extreme cold prevent microbial growth).

Storage of food (fruits, fruit juices, vegetables, fish, meat, etc.) in refrigerators at low temperatures (chilling at 4 to 7 ^{o}C) reduces the growth and activities of spoilage microorganisms, preserving food for a short period (for 10 to 14 days).

Salting

Salting also is an older form of preserving raw foods. Salt has an ability to suck the moisture out of food through the process of osmosis. When the food is totally dry from salting, growth of microorganisms are inhibited. Meat is commonly preserved through salting.

Salting and drying

In preparation of dried fish (anchovy, tuna, etc.) fish are first salted and then dried in sun. Addition of salt makes the removal of water fast and the salt inhibits microbial growth on fish even though some moisture is still remaining in flesh.

Addition of Sugar (Sugaring)

Sugar is used in syrup form to preserve fruits and in crystallized form to preserve some food items like ginger and orange peel. Some fruits are glazed with sugar syrup for the fruits to get a superficial, protective coating. Some fresh fruits are cooked with sugar and then dried. High sucrose concentration produces osmotic stress on microorganisms and protects the food from microbial spoilage.

e.g. Jam, sugared toffees made with ash pumpkin

Smoking

Smoking is the process that cooks, flavours and preserves food exposing it to the smoke from burning wood. Smoke is antimicrobial and antioxidant and most often meats and fish are preserved by smoking. The aroma generated by hydrocarbons of burning wood enhances the taste, flavour and adds smokiness to the meat/fish while preserving.

Chemicals

Chemicals inhibit growth and activity of microorganisms while some chemical compounds can kill the microrganisms (e.g. preservation of fruit juice and production of pickels using chemicals such as sodium benzoate, EDTA, acetic acid, and brine solution).

Preservation of Food through radiation

The type of radiation used in processing food materials is limited to radiations from high energy gamma rays, X-rays and accelerated electrons. Processing of food by radiation involves exposure of food to short wave radiation energy to achieve a specific purpose such as extension of shelf-life, insect disinfestation and elimination of food borne pathogens and parasites.
(e.g. packets of spices, ground meat, etc.).

Postharvest Losses

Food losses that occur along the food supply chain from harvesting of a crop until its consumption is defined as postharvest losses.

Product quality at harvest is influenced by when and how theharvest is done; pre-harvest factors such as source of seed and quality that has been set during growth also contribute for the product quality at harvest. Product quality at harvest could be lost further during harvesting, handling, transporting, storage, domestic processing and distribution.

The postharvest losses can broadly be categorized as,

- weight loss due to spoilage,
- quality loss,
- nutritional loss
- seed viability loss and
- commercial loss.

Postharvest losses in production of cereals (e.g. paddy) fruits and vegetables

During Harvesting - Untimely harvesting

Paddy should be harvested at the best time (considering the variety of paddy). Delayed harvesting of paddy may result quality loss, nutritional loss, seed viability loss, weight loss and commercial loss; those losses could be further increased if paddy fields are flooded due to heavy rains just before harvesting. If paddy is harvested earlier it requires more drying (drying cost), grains with high moisture content are susceptible to mold growth & insect infestation resulting broken grains and low milling yield with significant commercial losses. In addition, depending on the method of harvest, part of the paddy crop may be left and ploughed in to soil which is a commercial loss. Fruits and vegetables also should be harvested at the best time (could vary with the variety) to have maximum quality and to obtain the highest quantity; if harvested too early, the crop will not be ripe/matured enough and if harvested too late it may spoil quickly leading to quality loss and nutritional loss, finally resulting economical losses. Harvesting of fruits and vegetables should be done without allowing physical/ mechanical damages to occur; if damages occur quality and storage life will be reduced as spoilage microorganisms will quickly invade through damaged areas.

During Handling

High shattering loss of paddy seed could occur which is a commercial loss. Harvested paddy should be dried, bagged and stored temporarily without allowing the paddy seed to absorb moisture and greater attacks by insects and rodents.

. In order to protect the quality, harvested fruits and vegetables should be handled hygienically kept in plastic cartons which could be kept in a shade temporarily. Harvested fruits/vegetables should be sorted to remove damaged, infested, moldy and over-ripe fruits / over-matured vegetables; sorting will reduce spoilage during transport and storage.

Transportation

Poor road infrastructure along with improper and poorly maintained modes of transportation results in large spillage of paddy seed and high contamination. Multiple movements of crop is another major reason for high transportation losses. Sometimes bagged paddy is loaded and unloaded from vehicles several times before it is milled. During each movement some grains are lost as spillage. During handling and transportation of rice, 2 – 10% losses occur in Southeast Asia. Those losses could be minimized using well planned, better mode of transportation with an efficient bulk handling system.

During the transportation of fruits/vegetables arranged at the bottom of stacked crates could be damaged by the

weight of the produce kept above; use of crates that could be stacked without putting the weight on produce at the bottom would solve this issue. Use of straw or something soft in between layers of produce within a crate will reduce the damages due to rubbing. Rough handling of crates containing produce should be avoided to prevent possible damages to the produce. Uncontrolled changes of temperature and excessive shaking could do great damages to the produce during transport. In tropical countries, if transportation is carried out at night time produce could be protected by high temperature of the day time.

Storage

Storage plays a vital role in the food supply chain, although losses occur at each stage of the supply chain from production to consumer level, storage losses are considered most critical in developing countries as maximum losses occur during the storage. Generally, after harvesting/ milling, grains are stored for short or long periods of storage as food reserves, and as seeds for next season. Poor storage infrastructure allows, rice to absorb excess moisture, rice grains with excess moisture to be infested easily by insects pests followed by invasion of spoilage microorganisms, rice to be attacked by rodents and other pests.

Provision of proper storage infrastructure could prevent/reduce the losses that occur during storage of paddy/milled rice.

Uncontrolled changes of temperature could encourage spoilage microorganisms to grow faster spoiling the stored produce (fruits and vegetables). Storage of fruits and vegetables should be done in properly chilled rooms to reduce the rate of spoilage.

Domestic processing

In domestic processing of different food types at different areas of Sri Lanka following methods are used. The postharvest loss of food processing could be due to early harvesting, improper handling, etc. Postharvest losses that could occur during domestic processing could be reduced by following correct procedures (e.g. harvesting at the right time), hygienic handling to prevent microbial contaminations and proper storage (to prevent attacks of insects, rodents, etc.).

Drying (paddy/rice & other cereals), drying after thermal treatment (jack fruit, etc.), pasteurization (milk), freezing (fish and meat are temporarily stored in freezer compartment of a refrigerator), chilling (fruits, vegetables, etc.), salting (lime, etc.), salting & drying (fish), sugaring (homemade jams), use of chemicals (pickles),

Dengue and filaria

Dengue

Dengue is a vector borne disease which is caused by an arbovirus which is a RNA virus. Epidemics of dengue are reported in tropical and subtropical regions of the world. The virus is transmitted by two species of mosquitoes, they are *Aedes aegypti* and *Aedes albopictus*. The transmission of the dengue virus is dependent on biotic and abiotic factors. The biotic factors include the virus, the vector and the host and the abiotic factors include temperature, humidity and rainfall. The dengue virus is transmitted to human via the biting of an infected female mosquito. The infected humans can be symptomatic as well as asymptomatic and they are the carriers and multipliers of the virus.

The *Aedes* mosquitoes are small to medium sized (approximately 4-7 mm) and it is dark in colour. These mosquitoes have white markings/bands on its body and the arrangement on these bands are different in the body and the legs. They live about 2-4 weeks depending on the environmental conditions.

The life cycle has four stages, they are eggs, larva, pupa and adults. The adult female mosquito lays eggs singly on the inner surface of wet containers above the water level, preferably clear water.

Initially the laid eggs are white in colour and they become shiny black colour within few minutes from deposition of the eggs. These eggs are smooth, long and ovoid in shape and about 1 mm long. The eggs hatch within two days to become a larvae. The larvae rest with an angle to the water surface. If the eggs are not hatched, they can undergo dormant for a period of about six months. The body of larva consists of three major parts i.e. head, thorax and abdomen. After 4-5

days the larval stage becomes the pupa which is comma shaped and mobile. The pupa becomes the adult mosquito within 1-2 days.

Breeding sites

The female mosquitoes lay eggs in a wide variety of artificial and natural wet containers. They prefer dark coloured surfaces with clear (unpolluted) water. The breeding sites can be found in both indoor as well as outdoor. They include,

- discarded plastic containers- tins, clay pots, yoghurt and ice cream cups, bottles, cans, damaged ceramic items, coconut shells, etc.
- water storage containers such as cement tanks, barrels, etc.
- discarded automobile tyres, and machinery parts,
    - building structures such as roof gutters, concrete slabs etc
    - household/ institutional appliances including refrigerator trays, flower vases, ornamental ponds, squatting pans of wash rooms, etc
    - natural breeding sites such as leaf axils, tree holes, etc.

Symptoms of disease

Dengue can affect infants, young children and adults. It starts with flu-like symptoms. Sudden onset of high fever (40 ^{o}C/ 104 ^{o}F) could be accompanied by any of the following symptoms. They are severe headache, pain behind the eyes, muscle and joint pains, nausea, vomiting, or skin rash. These symptoms usually last for 2-7 days after incubation period of 4-10 days from the bite of an infected female *Aedes* mosquito.

Severe dengue (dengue haemorrhagic fever) is a potentially deadly complication due to blood plasma leaking, fluid accumulation, respiratory distress, severe bleeding, or organ impairment. Warning signs occur 3–7 days after the first symptoms in conjunction with a decrease in temperature (below 38°C/100°F) and include: severe abdominal pain, persistent vomiting, rapid breathing, bleeding from the nose and gums, fatigue, enlargement of liver reduced number of platelets, restlessness and blood in vomit. The next 24–48 hours of the critical stage can be lethal, in which symptoms may progress to massive bleeding, very low blood pressure, shock and death. Proper medical care is needed to avoid complications and risk of shock and death (dengue shock syndrome).

Controlling measures of the vector

The dengue vector controlling methods are mainly aimed at both immature and adult stage of the *Aedes* mosquitoes. Integrated vector management strategy includes environmental, chemical and biological controlling methods.

The most cost effective way is controlling the vector by eliminating its breeding sites. Removal of open source of water through the environmental management could be done by;

- having continuous water supply to minimize storage of water in cement tanks, barrels, and other containers,
- making mosquito proofing of water storage cement tanks, domestic wells, and over head tanks,
- construction of buildings without roof gutters
- removal of unserviceable roof gutters
- regular cleaning with scrubbing of water storage tanks, flower pots, flower vases, ant traps, refrigerator trays
- proper disposal of solid wastes
- proper storage of used tyres, household and garden utensils.

In addition to environmental management practices, biological controlling methods also can be used to control the vector. They include,

use of fish species which feed on the larval stages of the mosquito. The following fish species could be introduced to water storage tanks, barells, ornamental ponds, etc. to feed on the larval stages of these mosquitoes.

- Guppy (*Poecilia reticulata*)
- Dandi (*Rasbora daniconius*)
- Juvenile stages of Tilapia

The *Bacillus thuringiensis israelensis* (Bti) also can be used to control the dengue vectors. This is a bacterium that produces an endotoxin which is toxic to the larval stages of the mosquitoes.

Another method of mosquito control is thermal fogging which is a form of chemical method. When mosquitoes are exposed to sufficient dosage of this fog they are knoked down and killed.

There are several limitations in vector controlling methods, such as lack of sufficient knowledge in biological controlling methods.

When fish are used to control the vector,

- fish could die in the absence of food in the breeding site and due to changes in water quality parameters such as pH of water in breeding site
- when the domesticated water containers are filled with chlorinated water it may lead to the death of the fish.

when Bti is suggested to control the vector,

- there could be some breeding sites that Bti can't be applied

chemical methods such as fogging,

- could affect health of both humans and animals

Filaria

Lymphatic Filariasis in Sri Lanka

Filariasis is one of the oldest debilitating disease in the world. This is one of the major leading causes of permanent and long term disability. It does not kill people, but cause permanent disability. Filariasis is a mosquito borne disease transmitted by a thread like nematode, who lives in human lymphatic system. The disease is endemic in developing countries with poor socio-economic status and is often associate with poor environment sanitation. Filaria has been categorized as a neglected tropical disease.

Parasite

- 90% of infections are caused by *Wuchereria bancrofti*
- Human is the exclusive host of *W. bancrofti*

Vector

- In Sri Lanka it is transmitted solely by *Culex quinquefasciatus* mosquito
- *Culex* breeds in polluted water bodies; blocked drains, broken toilet pits, husk pits etc.

The Culex mosquito is small to medium in size (3 to 4 mm in length) and grey-black in colour. The nervures of wings of adult mosquito are beset with brown or blackish scales and the posterior margin of the wings is fringed with bristle and scales. Female lay eggs in the form of egg rafts that floats on the surface of water. After hatching, larva rests keeping its body with an angle to the water surface.

Factors associated with transmission

- Transmission in a community is influenced by
- Number of infected persons (prevalence)
- Density of microfilaria in blood of infected persons
- Density of vector mosquitoes
- Characteristics of the vector (affects development of larvae)
- Frequency of human vector contac

Methods of transmission

Filariasis parasite is introduced to human body by a bite of a female adult mosquito. When the mosquito suck blood from humans, larval stages of parasite falls on to the skin (do not inoculate in to the body as other mosquito borne disease agents). Then these larvae penetrate skin through the bite wound and enter into the human vascular system. From here, the larvae migrate to the lymphatic system Within one year larvae become matured in to adult worms. Adult male and female worms nests and mate in lymphatic vessels and produce large number of tiny, immature

eggs which hatch into microfilariae. Microfilariae migrate from the lymphatic system and enter the blood stream. Microfilariae live in lungs during day time and travel to peripheral blood during night. From here they transfer to mosquito when it takes a blood meal from human body.
Ingested microfilariae transform into several larval forms and again with another bite enter into human body.

Adult worm lives in lymphatic system for 5-6 years and microfilaria can lives for 1 year.
When adults worms block lymphatic vessels they get distorted and lymph flow does not occur smoothly. Lymph tends to accumulate in dependent parts of the body: legs, hands, testes, penis, and breast causing lymphedema. When microfilaria lives in lungs patients develop dry cough, wheezing, mild fever, weight loss etc.
Fluid accumulation in scrotum manifests as hydrocele. Presence of microfilariae in lungs manifest as occult filariasis. Occult filariasis is characterized by high eosinophilic count with chronic cough and wheezing which worsen at night with dyspnea, chest pain, fever and weight loss.

Clinical manifestations vary from asymptomatic to chronic lymphedema (elephantiasis).
After entering the human body the filarial parasite (L3 larva) develops into an adult worm and remains silent in lymphatics for several years producing microfilaria. These patients are asymptomatic and can only be detected through active surveillance.
Presence of adult parasite in lymphatic system for a longer period gives rise to late manifestations. They are due to dilatation of lymphatic vessels followed by their dysfunction, accumulation of fluid in tissues and increased risk of infection (lymphoedema). With recurrent infections skin of oedematous extremities becomes thickened and later on gives rise to warty, nodular, papillomatous appearance. Lymphoedema is graded according to the state of oedema and appearance of the skin

Controlling measures

- Personal protection from mosquito bites/ prevent mosquito bites by the use of mosquito nets, repellants, long sleeve shirts and trousers.
- Elimination of breeding sites: repair broken septic tanks, cleaning drainages, prevent dumping garbage in to drains, chemical control of aquatic plants in water reservoirs
- Prevent creation of breeding sites
- Use of larvivorous fish such as guppy, nalahandaya in water bodies.
- Screening healthy population with night blood films and detect people who harbour the infection but do not show any symptoms and treat them.
- Monitor vector mosquito population for infectivity

Limitations of controlling methods

Lack of sufficient kbnowledge among people about the disease, the vector, method of transmission, breeding sites and controlling measures.

Nanotechnology

Nanotechnology is an emerging science involved in designing, building and manipulating minute structures at the nanometer level. A nanometer (nm) is one billionth of a meter (10^{-9} m). Nanotechnology is the creation and use of materials and devices on the same scale as molecules and intracellular structures, typically less than 100 nm in size. The physical and chemical properties of tiny molecules are significantly different than bigger particles as they have a very high surface area to volume ratio.

American Physicist Richard Feynman in 1959 enlightened the world on nanotechnology.

Living organisms are built of cells that are typically 10 µm across. However, the subcellular organelles are much smaller. Proteins are even smaller with a typical size of just 5 nm, which is comparable with the dimensions of smallest manmade nanoparticles. This simple size comparison gives an idea of using nanoparticles as very small probes that would allow us to investigate the cellular machinery without introducing too much interference. Understanding of biological processes on the nanoscale level is a strong driving force behind development of nanotechnology. Nanotechnology has now become a big business with applications in material manufacturing, energy, electronics and engineering. But Applications of nanoparticles in biology and medicine are of particular interest. One of the most important applications of nanotechnology is in medicine. Applications of nanotechnology for improving human health are termed Nanomedicine. Nanotechnology can be applied for prevention diagnosis and treatment of diseases.

Titanium dioxide (TiO_2) and silver (Ag) nanoparticles are used for sterilization of operation theatres and surgical instruments in hospitals. These nanoparticles are able to destroy the microbes. Silver nano lotions are applied in theatres to prevent the entry of microbes. Nano particles are used in the production of antimicrobial coatings and nano - filters. TiO_2 and Silver nano filters prevent the entrance of tiny particles such as viruses. These nano filters are used to examine SARS patients. Nano device sensors are used to monitor blood pressure; blood oxygen levels and hormone concentrations. Nano particles can unclog blocked arteries and detect and eliminate cancer cells. Several nanotechnology enabled drugs are available in the market primarily in areas of cancer treatment. Scientists have developed “smart drugs” using tiny nanoparticles such as gold particles that are introduced into the body to seek out and target special cells such as cancer cells to deliver a cargo that would destroy those that are damaged rapidly and effectively in a silent manner with

very few side effects.

Spherical nanoparticles consisting of a dielectric core called nanoshells are used in the treatment of cancer. A nanoshell is slightly bigger than a polio virus. Gold nano shells are used in bio imaging enhancements as well.

In the treatment of diabetes a Nano device is attached to the body which can release the required dosage of insulin at required time intervals.

There has been successful application of nano-technology to the treatment and management of pain both in clinical and experimental studies like the fabrication of nano-formulated liposomes to deliver drugs for pain therapy,

Since nanocarrier systems can be easily transferred to the airways, many respiratory diseases can be treated using nanotechnology.
Viva gel is a vaginally applied microbicide in development for prevention of HIV and HSV (Herpes simplex virus). Viva gel is a product of nanotechnology which prevents the entry of HIV and HSV during sexual intercourse.
Nonocomposites are used to replace broken bones and to fill teeth as well.

Stem Cell Therapy

Stem cells are undifferentiated cells which can give rise to cells of the same type. They can divide by mitosis without a limit (or at least for the lifetime of the animal). They are capable of terminally differentiating into other cell types.
Stem cells are required wherever there is a recurring need to replace differentiated cells that cannot themselves divide. The stem cell itself has to be able to divide but it doesn't necessarily have to divide rapidly. In fact, stem cells usually divide at a relatively slow rate.
Stem cells are of two types.

1. Embryonic stem cells
2. Adult Stem cells

1. Embryonic stem cells

Following fertilization of a sperm and an egg cell, the fertilized egg is called a zygote. The zygote divides rapidly. In humans, in around five to seven days after fertilization, the dividing cells create an embryo consisting of a small hollow cluster of approximately 100 cells called a blastocyst. The blastocyst is approximately a seventh of a millimeter in diameter. There is a small cluster of

around 30 cells tucked inside the blastocyst that form a structure known as the inner cell mass. These cells are the source of embryonic stem cells (ES cells).

ES cells are so special because they can eventually differentiate to form all of the more than 200 cell types that make up the human body. Therefore, ES cells are called pluripotent because they have the potential to develop into a variety of different cell types. Human ES cells (hESCs) are unspecialized cells with two major properties.

- ES cells can self-renew indefinitely to produce more stem cells
- Under the proper growth conditions, hESCs can differentiate into a variety of mature cells with specialized functions

2. Adult stem cells

Adult stem cells are found throughout the body after development. Adult stem cells are present in many tissues. There are many types of adult stem cells specialized for the genesis of different classes of terminally differentiated cells and hence each type of stem cell serves for the renewal of one particular type of tissue.

Eg. Epidermal stem cells for epidermis, Intestinal stem cells for intestinal epithelium, hemopoietic stem cells for blood, neural stem cells for central nervous system

Stem cells can be isolated and cultured in culture media in vitro. When adult stem cells are removed from the body and maintained in culture or are transplanted from one site in the body to another, they generally remain faithful to their origins. This creates practical limitation of using adult stem cells for tissue regeneration.

In contract, ES cells can be kept proliferating indefinitely in culture and yet retain unrestricted developmental potential. If ES cells are put back into a blastocyst, they become incorporated into the embryo and can give rise to all the tissues and cell types in the body, including germ cells. Under the proper growth conditions, human ES cells can differentiate into a variety of mature cells with specialized functions in vitro.

There are ethical concerns of obtaining human embryonic stem cells. Therefore, research on eHSCs is very controversial because of their source- an early embryo.

In late 2006, Scientists demonstrated the successful derivation of pluripotent stem cells from adult tissues by reprogramming human cells taken directly from a volunteer. These are known as induced pluripotent stem cells (iPSCs). Pluripotent stem cells hold promise in the field of

regenerative medicine because they can propagate indefinitely, as well as give rise to every other cell type in the body (such as neurons, heart, pancreatic, and liver cells), they represent a single source of cells that could be used to replace those lost to damage or disease. Since iPSCs can be derived directly from adult tissues, they not only bypass the need for embryos, but can be made in a patient-matched manner, which means that each individual could have their own pluripotent stem cell line.

Applications of stem cells

There are many potential applications of stem cells from growing healthy tissues to studying them to understand and treat birth defects to genetic manipulation for delivering genes in gene therapy approaches. Creating whole tissues in the laboratory using tissue engineering is another potential application for repairing tissues such as damaged heart muscles and damaged spinal neurons.

Blood stem cells (hemopoietic stem cells) taken from the bone marrow of a healthy immunologically compatible donor can be used to replenish bone marrow of patients with leukemia

Scientists believe that stem cell technologies will play key roles in developing treatments for diseases such as stroke, heart disease, Parkinson disease, Alzheimer disease, diabetes and many more.

The Human Genome project

The human genome has been the focus of biological research for the last two decades and will continue to be the center of attention for many years to come. It is a worldwide effort to identify all human genes of each chromosome along with several other goals. The human genome project is an enormous undertaking in genomics that is providing scientists with exciting insight into human genes, their locations and functions. It was originally a 13 year project (1990-2003) coordinated by the US Department of Energy and the National Institutes of Health. Additional contributions came mainly from UK, Japan, France, Germany, Australia and China.

The aims of the project were to

1. Identify all the genes (approximately 20,000 protein coding genes) in human genome
2. Determine the sequences of the 3 billion chemical base pairs that make up human DNA
3. Store information in data bases
4. Improve tools for data analysis
5. Transfer related technologies to private sector
6. Address, ethical, legal and social issues that may arise from the project.

A major quality assessment of the human genome sequence was published in 2004 indicating over 92% of sampling exceeded 99.99% accuracy which was within the intended goal.

The Genome Reference Consortium (GRC) which is an international collective of academic and research institutes with expertise in genome mapping is still working on the analyses of the data obtained from the Human genome project.
The sequencing of the human genome holds benefits for many fields, from molecular medicine to human evolution. Improved diagnosis of various diseases, identification of mutations linked to different forms of cancer, the design of medication and more accurate prediction of their effects, gene therapy and control systems for drugs, Study of human evolution and anthropology a are some of them.

Another proposed benefit is the commercial development of genomics research related to DNA based products, a multibillion-dollar industry.

The Human Genome Project, and the other genome projects such as Escherichia coli, yeast, mouse, *Arabidopsis thaliana*, and rice have already been completed. This has therefore opened the way to a comprehensive description of the molecular activities of human cells and the ways in which these activities are controlled. This is central to the continued development, not only of molecular biology and genetics, but also of those areas of biochemistry, cell biology and physiology now described as the molecular life sciences.

The genome projects will have additional benefits that at present can only be guessed at. It is evident that the human genome, in common with the genomes of many other organisms, contains extensive amounts of intergenic DNA. It was thought that most of the intergenic DNA has no function except occasionally it is known that some intergenic DNA acts to control genes nearby. Could the intergenic DNA have a role, but one that at present is too subtle for us to grasp? Though little is known about them, they are thought to have regulatory functions. The first step in addressing this possibility is to obtain a complete description of the organization of the intergenic DNA in different genomes, so that common features, which might indicate a role for some or all of these sequences, can be identified.

Annexe 1

Angel fish

Black molly

Discus

Fighter fish

Guppy

Koi carp fishes

Kissing Gourami

Platy fish

Sword tail

Gold fish

References

- Bruce Alberts et al. *Molecular Biology of the Cell* (2008), Garland Science (Taylor and Francis group)
- William, J. Thieman and Michael, A. Palladino. *Introduction to Biotechnology* (2009),Pearson Benjamin Cummings.
- Hartmann, H.T., Kester, D.E., Davies, F.T. and Geneve, R.L. (2011). *Hartmann and Kester's Plant Propagation: Principles and Practices*. 8th Edition. Pearson Education, Inc., NJ.
- Preece, J.E. and Read, P.E. (2005). *The Biology of Horticulture*. 2nd Edition. John Wiley and Sons, Inc., Australia.
- Ingels, O. (2004). *Ornamental Horticulture*: Science, ations, and Management. 3rd Edition . Delmar, Thomson Learning, Inc., NY.
- Guidelines for *Aedes* vector surveillance and control in Sri Lanka. (2016). National dengue control unit, Ministry of health, Sri Lanka.

Notes:

This is to acknowledge that some of the diagrams used in this book have been taken from various electronic sources using internet . This book is not published to make profit and sold only to cover cost.

The resource book is prepared according to the subject content and learning outcomes of the G.C.E. (A.L) Biology new syllabus which is implemented from 2017.

The content of this Resource book declares the limitation of the G.C.E. (A.L) Biology new syllabus which is implemented from 2017.