LESSON 1

PERMACULTURE PRINCIPLES

Aim
Explain the principles of permaculture.

Permaculture is an ethical approach to designing land use and community systems, to provide food, ecological habitats and other essentials needed for human survival.
The term 'permaculture' comes from the words 'PERMAnent' and 'agriCULTURE', and implies the permanence of culture. The term was first devised in 1978 by Bill Mollison (an Australian ecologist) and his student David Holmgren.

It embraces three main ethical principles as follows:

a. "Care of the Earth"
This includes all living things and non living things which together comprise the environment (ie. animals, plants, land, water and air).

b. "Care of People"
Permaculture systems should be developed to promote self reliance and community responsibility.

c. “Fair Share”
Set limits to consumption and reproduction, and redistribute surplus - pass on anything surplus to an individual's needs (eg. labour, information or money) in an attempt to pursue the above aims.

“Implicit in the above is the 'Life Ethic': all living organisms are not only means, but ends. In addition to their instrumental value to humans and other living organisms, they have an intrinsic worth."

As such Permaculture stresses both a positive approach and an attitude of cooperation, with respect to both the environment and all living things.

PRINCIPLES OF DESIGN

Permaculture is a system of agriculture based on perennial, and self-perpetuating, multi-use plants and animal species which are useful to man. In a broader context, permaculture is a philosophy which encompasses the establishment of environments which are highly productive, stable and harmonious and which provide food, shelter, energy etc., as well as supportive social and economic infrastructures.
Permaculture copies patterns from nature, it focuses on the way elements are placed in the landscape and in the way they inter-relate, rather then on the individual elements.
Other then food production, permaculture encompasses the use of appropriate technology eg. energy efficient buildings, recycling, waste water treatment, solar and wind energy and composting toilets.
In comparison to modern farming techniques practised in Western civilisations, the key elements of permaculture are low energy and high diversity inputs. The design of the landscape, whether on a suburban block or a large farm, is based on these elements.

There are nine key guiding principles of permaculture design:

Relative Location

Place components of a design in a position which achieves a desired relationship between components. Everything is connected to everything else.

Multiple Functions
The designer will determine a number of different functions for a design (eg. produce fruit, provide shelter). When a design is prepared, each function is then considered one by one. In order to make the design achieve a "single" function, the designer must:

- Deal with several different components which influence that function
- Make different and distinct decisions about each of these components

Every function is supported by many elements.

Multiple Elements
In permaculture, the term "element" is used to refer to the components of a design such as plants, earth, water, buildings. A design must include many elements in the design to make sure functions are achieved. Every element should serve many functions.

Elevational Planning
The design must be on a 3-dimensional basis, giving consideration to length, width and height of all elements (ie. components). This is then used to place various elements within the design. Particular emphasis is given to energy impacts.

Biological Resources
-Priority is to use renewable biological resources (eg. wood for fuel) rather than non renewable resources (eg. fossil fuels).
-Design so that biological resources are reproduced within the system.

Energy Recycling
-Energy use should be minimised.
-Waste energy should be harvested (eg. often pollution can yield useable energy).
-Design the system to optimise collection of energy by plants and animals. (eg. using plants that catch light, produce bulk vegetation and then rot to provide a store of nutrients). This way energy is caught, stored and reused in the system.

Natural Succession
-Design in a way that plant and animal life is always rich by ensuring new organisms emerge as old ones die.

Maximise Edges
The edge of two different areas in a system has more things influencing it than other parts of the system. This is because there is greater diversity there with components of two different areas having an effect. As such design of an edge is more critical, and potential for an edge can be greater.

Diversity
Design should be a poly-culture (ie. a system where a greater number of species are growing together). This ensures greater biological stability.

Design can be seen to have two elements: aesthetics and function. In other words, design (of any kind) can be influenced to varying degrees by the aesthetics or appearance of what you are trying to achieve; and/or by the function or purpose to be served by what you are trying to design.

Permaculture concentrates on function and gives low priority to conventional ideas of aesthetics. As such, a permaculture system does not need to look 'nice', but it does need to serve its intended purpose.

Reference: "Permaculture Design Course Handbook" by Mollison *et al*.

PERMACULTURE IS A COMBINATION OF OTHER SYSTEMS/METHODS

There are many systems of farming or gardening which share things in common with Permaculture. We can learn a lot from studying these systems, many of which have been practised for a greater length of time than Permaculture. These other techniques are often applied to permaculture:

Sustainable Agriculture

Sustainable Agriculture was a concept that was developed before it became associated with the term 'permaculture'. It is fundamental to the principles of permaculture.

Sustainability

To be sustainable a farm must be able to produce perpetually and not impact on the local or broader environment.

Some points to consider on sustainability:

- Non- renewable resources must be avoided because outside inputs need to be available indefinitely or more preferably be available on-farm forever.
- Air and sunlight are two components that are generally readily available on most sites, most of the time.
- Crops are dependent on soil nutrients; harvesting depletes these nutrients. Nutrients must be replenished, through manures, legumes and nitrogen fixing bacteria, in order for cropping to continue indefinitely. To be sustainable these nutrients should be replenished without the aid of non-renewable resources such as oil, gas or deforestation. Declining soil structure and fertility through lack of soil stewardship, can lead to the need for new land to grow more crops, which in turn can lead to further soil structural decline, draining of wetlands and the decimation of forests.
- Crops are dependant on water. Natural replenishment of water sources should not be lower then the water used to irrigate crops. Natural rainfall should be relied upon as much as possible.
- Farming should not adversely affect environmental quality elsewhere ie. through the use of negative inputs such as: over-use of animal manures or application of synthetic fertilisers which may pollute rivers and seas. Or through unsustainable agro-forestry.

Masanobu Fukuoka, a microbiologist, left his career as a scientist to develop a sustainable organic farming system that replicates nature as closely as possible. The ground isn't ploughed – seeds germinate on the soil surface, species are chosen to out-compete weeds, and cover crops are slashed and left on the soil surface to break down. Straw from the previous season's crops is slashed and used as mulch: ducks are used to clean up unwanted pests and so on. Fukuoka's system is also remarkably low in labour inputs.

The following books by Fukuoka are worth researching:
The One-Straw Revolution: An Introduction to Natural Farming- ISBN 0878572201
The Road Back to Nature: Regaining the Paradise Lost by Masanobu Fukuoka, et al ISBN 0870406736.

Although these books are no longer in print they are readily available second-hand from suppliers such as amazon.com

Organic Growing

Organic plant growing is the production of plants without the addition of artificial inputs such as chemicals that have been artificially manufactured or processed. This includes herbicides, pesticides and fertilisers.
Organic growing of plants works with nature, rather than against it. It recognises the fact that nature is complex and accordingly endeavours to understand interactions between plants, animals and insects. It therefore encourages the gardener for example to learn about the life-cycle of pests and to use this knowledge to control them. It also recognises that the use of chemicals has to be replaced with labour and management. Organic gardeners/growers have to manage pests rather then eliminate them. They need to be vigilant and have the ability to recognise problems and act quickly to minimise the spread of both pests and disease. They may also need to accept some insect damage to the plants they grow as inevitable.

Organic gardening emphasises use of natural methods to control insect pests, diseases and weeds, and to enrich the soil. Thus practices such as mulching, composting, companion planting, green manuring and biological control are widely used by organic growers.

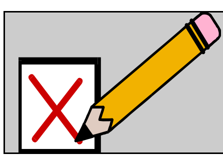
Definitions of Organic Growing

Organic gardening and farming has been given a variety of names over the years - biological farming, sustainable agriculture, alternative agriculture, to name a few. Definitions of what is and isn't 'organic' are also extremely varied. Some of the most important features of organic production, as recognised by the International Federation of Organic Agriculture Movements (IFOAM), include:

- Promoting existing biological cycles, from micro-organisms in the soil, to the plants and animals living on the soil.
- Maintaining the environmental resources locally, using them carefully and efficiently and re-using materials as much as possible.
- Not relying heavily on external resources on a continuous basis.
- Minimising any pollution both on-site and leaving the site.
- Maintaining the genetic diversity of the area.

Practices which are typical for organic systems are composting, intercropping, crop rotation, fallowing, mechanical, hand weeding or heat-based weed control, green manure crops and the use of legumes to increase soil fertility. Pests and diseases are tackled with environmentally acceptable, sprays that have little environmental impact and biological controls (eg. predatory mites). Organic gardeners should avoid the use of inorganic (soluble) fertilisers, super-phosphate for example should not be used because it contains sulphuric acid, rock-phosphate however is the acceptable alternative. Synthetic chemical herbicides, growth hormones and pesticides should not be used.

One of the foundations of organic gardening and farming, linking many other principles together, is composting. By combining different materials, balancing carbon and nitrogen levels, coarse and fine ingredients, bacteria and worms act to break down the waste products. Composting produces a valuable fertiliser that can be returned to improve the soil. Natural biological cycles are promoted, 'wastes' are re-used and the need for external supplies of fertiliser are reduced or cut altogether.



SELF ASSESSMENT

Perform the self assessment test titled ' test 1.1'

If you answer incorrectly, review the notes and try the test again.

No Dig Techniques/Sheet Mulching

The ‘no-dig’ method involves building a slow working compost heap straight onto the surface of the soil as a "raised garden bed", and planting direct into the pile. In the home garden, no-dig gardens can be a very effective, easy growing method, once established the garden requires minimal maintenance. Esther Deans in Australia has promoted this style of gardening through her best-selling gardening book: ‘Esther Dean’s Gardening Book - Growing without Digging’ 1955 (no longer in print). Ruth Stout the ‘Mother of Mulch’ also espoused this method in the United States from the 1950’s. The no-dig method has also been popularised by the permaculture movement - termed sheet mulching.

There are many advantages to be had by using techniques which do not dig or cultivate the soil at all. Soil life is undisturbed, and as a result, develops a thriving, balanced community. Management techniques in a no-dig system include mulching for weed control and moisture retention. Organic material is spread on the surface and left for the abundant soil life to drag it down underground. Diseased plants, such as mint with rust spores, can be flamed off in spring.

No-dig systems are often set up with raised beds. This confers added benefits. All cultivation, digging, sowing, planting and so on, can be done from the sides, around the beds, without treading on the soil. Soil quality therefore is particularly good in such a system.

No Dig Raised Beds - One Method

Although timber edges can be used to construct no-dig beds and may help to keep beds intact, this is not really necessary. Beds can be layered straight on top of the soil, without the use of edging. Straw can also be placed between the beds to create weed free pathways. Over time the straw in the paths will decompose, this can then removed and replaced with new straw, the decomposed material is then used to top up the beds.

A typical no dig garden could be made as follows:

1. Weeds are removed first by mowing, physically removing, burning or some other method.
2. Very thick layers of newspaper (uncoloured) is laid on the surface to inhibit further weed growth (up to 50 sheets thick is not uncommon).
3. A layer of straw or lucerne hay (weed seed free) is placed on top of the newspaper (at least 10 cm thick). Other materials such as weed-free compost, grass clippings, or sawdust might also be used.
4. The straw or hay is covered with rotted manure to a thickness where the straw or hay can barely be seen.
5. A further 8-12 cm of lucerne hay is placed on top.
6. The surface is sprinkled with blood and bone fertilizer, or chicken manure pellets. Small quantities of these materials may also be mixed with the hay, sawdust or other materials.
7. Plants are planted direct into the top layer with a few handfuls of good quality compost around the roots of each when planted.
8. Once the plants are harvested, the materials will have decomposed, just add more layers on top and plant a new crop. Eventually you will have an amazingly fertile garden full of worms.


Cover the ground with cardboard


Preparing the no-dig bed

Building ‘No Dig Bed’ Retainers.
Use timber to build four walls for each bed. Use a wood which will resist rotting such as red gum, jarrah (in Australia), oak (very expensive) larch, or sweet chestnut (in UK). Avoid recycled railway sleepers unless they are untreated. Old ones can contain high levels of creosote residue. Inexpensive pine can be used, but treat with one of the environmentally acceptable products now on the market. Check with your certification body to make sure that you are using an acceptable product.
The dimensions of the box can vary but commonly might be 20-30cm or more high, around 1.2 metres wide and 1-3 metres long. The box can be built straight on top of existing ground whether lawn, bare earth or even a gravel path. A slight slope is useful as it ensures good drainage. If the site is completely level, it may also be necessary to drill a few holes near the base of the timber walls to ensure water is not trapped. Weed growth under and around the box should be cleaned up before setting up the box. This may be done by, mowing, hand weeding, mulching, or a combination of techniques.

Once built, the box can be filled with good quality soil and commercial (organic) potting compost or some other soil substitute such as alternate layers of straw and compost from the compost heap. Another mix could be alternate layers of graded and composted pine bark, manure and soil. The growing medium must be friable, able to hold moisture, and free of disease and weeds (avoid materials such as grass, hay, or fresh manures that may hold large quantities of weed seeds).

A commonly used watering technique in these beds is to set a 2 litre plastic bottle (eg. soft drink or milk) into the centre of the bed below soil level. Cut the top out, and make holes in the side. This can be filled with water, which will then seep through the holes into the surrounding bed. Mulching the surface may be desirable to assist with controlling water loss and reducing weeds (Ref: Organic No Dig, No Weed Gardening by Raymond P. Poincelot - publisher Rodale Press 1986 ISBN 0878576118).
NB: this book may no longer be in print.

No-till Planting in Grass
Seedlings or established container plants can be planted directly into a lawn. No digging is done prior to planting. The roots of the plants tend to go deeper because they are in competition with shallow rooted turf grass species on the surface. The base of plants can be mulched and unplanted areas continue to be mown as a lawn. Drainage, soil compaction and water retention generally remain very good for plants grown this way in undisturbed soil. Research has shown excellent results for tomatoes, beans, corn and squash grown this way (Ref: Advanced Organic Gardening by Carr - published by Rodale). The technique can also be used for other types of plants.

A similar technique is called "Vegetable-Sod Inter-planting", where growing strips 20-40cm wide are mulched and planted as rows over an existing lawn or mowed turf. A narrow line may be cultivated sometimes down the centre of each row to sow seed into, if growing by seed, to hasten germination. Paper or organic mulches can be used to contribute to weed control in the rows. Crop rotation is usually practiced between the strips. This contributes towards better weed control. Clover is often encouraged in the strips of turf between rows to help improve nitrogen supplies in the soil.

This system may be less effective in areas of high rainfall and where grass tends to continue growing during the summer months, competition from grass species in this instance could be fierce

Crop Rotation
Crop rotation is more than just a seasonally progressive production system (such as a farm that grows lettuces in summer and cabbages in winter). Crop rotation is the practice of grouping crops together in their plant families, and growing them in their groups, moving each group round the growing area systematically on an annual basis. This is done primarily to reduce the build up of soil-borne pests and diseases. But it also contributes to better weed control, and improved soil health and nutrient balance.

Example of Plant Families (Vegetables)
Brassicaceae (Cruciferae): broccoli, Brussels sprouts, cabbage, cauliflower, sea kale, kohl rabi, turnip, swede, radish, horseradish, rocket etc.

Cucurbitaceae: cucumber, marrow, pumpkin, squash, cantaloupe (ie. rock melon), zuchinni

Liliaceae: onion, leeks, garlic, chives.

Fabaceae (Legumes): peas, beans, clover.

Poaceae: corn, other grains.

Apiaceae (Umbelliferae): celery, carrot, parsnip, fennel.

Asteraceae (Compositae): chicory, lettuce, endive, globe artichoke, sunflower.

Chenopodiaceae: silver beet, red beet (ie. beetroot) and spinach.

Solanaceae: tomato, capsicum, potato, egg plant (aubergine).

Examples of the value of crop rotation include:

- Weed control by growing crops that suppress weeds (crops with lots of leafy growth exclude light for example), before growing crops that are sensitive to weeds (such as onions), or by growing crops that can cope with weeds at the 'end' of a rotation, when weed populations may have built up.
- Using fertility inputs more effectively by growing a succession of crops that have different fertility requirements.
- To maintain or improve soil fertility by varying the kinds of root structures in the soil for example deep rooted plants use nutrients deep in the soil whilst surface roots utilise nutrients within the top-soil. The nutrients brought up by deep rooted crops gather in the leaves and stems – this green matter can also be returned to the soil to improve fertility. Deep rooted species also open up channels for air and water circulation.
- In organic systems, various crop rotation models are used, which provide a basis for growers to develop individual rotations to suit their needs. These models are organised to ensure that rotation effectively utilises soil fertility and prevents build up of pest, disease, or weed populations. Rotation models used by organic growers include:
- Gross feeder (eg. tomato), then legume (eg. beans), then light feeder (eg. carrots or onions) then green manure, then gross feeder again.
- Flower crop (eg. broccoli), followed by fruit crop (eg. peas), followed by leaf crop (eg. lettuce) then followed by a root crop (eg. carrot).
- Rotations should also be designed so that crops from the same family, do not follow one another (in some cases, gaps of many years may be necessary to get rid of pest or disease problems. Grow a crop or crops for half of the year, and graze the same area the other half.
- Grow several different crops on the land, and rotate them so the same crop is not grown in the same field more than once every 2 to 3 years (or preferably longer).
- Fallow areas between crops (ie. do not graze or grow a crop).
- Grow cover crops for green manure at least annually to revitalise the soil.

Green Manures/Cover Crops

Cover Crops

Organic systems should avoid bare soil wherever possible. Nutrients will be leached, soil structure damaged, and weed seeds will be able to germinate when soil is left bare of growing plants. On sloping ground, soil can be washed or even blown away if left bare of plants. Cover crops, including green manures, should be grown once the main crop has been harvested, to keep soil covered with growing plants until the area is needed again for the next harvestable crop. Cover crops offer the following benefits:

- Improved water penetration on flat surfaces during heavy rain
- More water absorbed, less immediate run-off
- More water retained through mulching effect
- Soil and ambient temperature changes moderated or reduced

- Plant roots encourage activity of all soil organisms
- More food and habitat for a vast range of wildlife
- Some cover crops (such as sunflowers) have a harvest potential
- Better soil structure maintained due to presence of plant roots deep in the soil
- Cover crops absorb surplus nutrients and water in over-fertile or wet soils
- Working conditions are more pleasant in an area covered plants
- Organic matter status (humus) of the soil is greatly improved
- Improved nutrient status of the soil over medium- to long-term.
- Soil erosion unlikely when covered with growing plants
- Compacted soil can be opened up by deeply penetrating plant roots

Cover crops are grown to improve the condition of the soil. They are most commonly ploughed into the soil, but they can also be cut and left to decompose on the soil surface. Cover crops and green manures are usually grown prior to planting the main crop but they can also be inter-planted between established permanent crops such as fruit trees or vines.

- Cover crops with deep root systems or long taproots are especially useful for improving compacted soil – the roots penetrate and open up the soil to air and water and protect the surface from erosion and desiccation.
- Deep-rooted crops such as safflowers and sunflowers bring nutrients from deep in the soil up to the surface via their roots. When they are dug in, nutrients are returned to the soil and become available to subsequent crops.
- Lime-tolerant cover-crops such as sorghum and barley can be grown to improve alkaline soils.
- Some cover crops are edible, e.g. potatoes and pumpkins.

Green Manures

Green manures are crops that are grown specifically to improve the soil. They improve the structure, organic matter content, and fertility of the soil. Their roots penetrate deeply, opening up heavy, waterlogged areas, and retaining nutrients that would otherwise have been leached away .When dug in, their biomass provides an ideal environment in which soil micro-organisms can flourish and multiply, enriching the whole area. This is especially valuable in hungry dry soils. When hoed off, the top growth may be left as a mulch, or composted, while their roots will release the nutrients they have absorbed during growth. Subsequent crops will benefit from a richer growing environment

Green manure crops usually include legumes and crops that provide bulky organic matter. Many species of beans, peas and other legumes are used, along with a wide variety of grasses and broadleaf plants.

Leguminous green manures are particularly valuable as these plants fix nitrogen from the air onto root nodules. This is known as ‘nodulation’ - the growth of rhizobium bacteria on the roots. In some circumstances, legume seed is ‘inoculated’ with rhizobium spores to ensure good nodulation. After hoeing off the tops, or digging in the entire plants, the additional nitrogen is released into the soil and becomes available to subsequent crops growing on that area.

Green manures should be mown down or cultivated into the soil when the plants begin to flower. It is also important to know that known organic matter ‘volatilises’ (or releases) nitrogen and other nutrients into the atmosphere as it dries out. This is one reason why organic growers frequently turn green manures into the soil, in preference to simply mowing them down. Leaving a thick layer of mown green manures on the soil surface can prevent erosion, however.

Composting

The effect on the crop is nothing short of profound. The leaves acquire the glow of health; the flowers develop depth of colour; root development is profuse. Vegetables and fruits are always superior in quality, taster and keeping power to those raised by other means.

Sir Albert Howard on compost, from: “An Agricultural Testament” 1940.

Compost is indeed the powerhouse in any growing system, but is particularly valuable in organic growing where chemical fertilisers are not used. Its benefits cannot be underestimated.

- It improves soil structure in all types of soil.
- It provides slow release nutrients for plants to use when required.
- It increases the level of soil micro organisms beyond measure.
- Composted soils produce plants more resistant to pest and disease attack
- Compost making is a environmentally sustainable method of recycling ‘waste’ material,
- Garden produced compost is effectively cost – free.

Compost bins
There is a wide range of compost containers now available from garden centres, local councils, hardware shops and via direct mail. They are usually made of plastic (often recycled), or wood. These are useful for composting small amounts of waste and for making compost in small gardens where you don’t want to look out at an open heap of rotting waste. Fixed bins can be difficult to aerate, and are prone to becoming too dry or too wet. Rotating bins are more expensive but provide quicker, more reliable results.

It is equally possible to produce compost successfully in a heap without any container. Systems where large quantities of compost are made will often use this method. Always have the heap covered to prevent the material becoming either too dry or too wet.

Make sure that, wherever you have your compost area, it is accessible for all the equipment you’re likely to be using. If you propose to turn the material using machinery, allow enough room to do so.

What can be composted?
Any organic material, if left long enough, will eventually rot down due to the action of micro-organisms. Composting is simply a way of harnessing and maximising this process. It speeds up the rate of decomposition, and minimizes nutrient losses.
The raw material for successful compost making is a mixture of organic materials, such as:

- lawn clippings
- weeds
- leaves
- paper/cardboard waste
- seaweed
- pruning material
- plant debris
- straw
- manure
- pre-meal kitchen waste

Ideally, the mixture should contain around 25 times woodier, carbon-rich material, than moist, nitrogen-rich material (grass clippings, kitchen scraps, green plants). This gives the best C/N ratio and results in effective composting.

What is the C/N ratio?
The micro-organisms that break down plant materials require food in the form of nitrogen, phosphorous and potassium. The most important requirement is the ratio of the percent carbon (C) in the materials, to the percent Nitrogen (N). This is called the carbon/nitrogen ratio. Woody waste has 25 times as much carbon as it has nitrogen, so its C/N ratio is simply expressed as the number 25. A C/N ratio of around 30 is required for compost activity to take place at an optimum rate. To get a suitable C/N ratio it is necessary to mix materials with a high C/N ratio, such as wood shavings, with materials that have a low C/N ratio, such as green plant waste.

Materials to avoid in a compost heap:

- Protein-rich kitchen waste, such as meat or fish. It can attract vermin, and become putrid in hot weather.
- Roots of perennial weeds (unless the compost will heat up sufficiently – see below)
- Seed heads of annual weeds
- Too much of any one material in one layer. A large quantity of grass clippings should be added in layers not more than 4 – 6 cm deep.
- Layers of evergreen prunings. These need to be managed differently (see below)
- Diseased plant material – particularly those diseases that are soil-borne, such as club-root (brassicas), white rot (onions), potato cyst eelworm.
- Material that has been sprayed with herbicides (such as lawn clippings).
- Thorny or spiky plant material. The thorns will not decompose sufficiently and can cause injury once the compost is spread on the soil.

Animal manures are a good addition to a compost heap. The most commonly used are sheep, cattle, poultry, horse and pig. Animal manures should be composted for a minimum of six weeks to prevent problems such as burning of leaves and roots from the presence of high levels of ammonium ions in the fresh manure. The ammonium ions are rapidly lost during composting. Large quantities of manure are best covered and composted separately.
If manure from an inorganic source is brought onto an organic system, check with your certification body to verify how long it must be composted before it can be used.

The basic conditions needed in a compost heap:

- A good mixture of materials, as described above. Too much dry material will slow the process down, and too wet a mix will become smelly and slimy.
- Moisture - take a handful of the material from about 15 or 20cm deep in the heap, and squeeze it. It should be about as moist as a moderately squeezed wet sponge. If it is too dry add water, or plenty of fresh green waste (grass clippings are ideal). If it is too wet, drag out the material and mix with plenty of carbon-rich material. Junk mail and cardboard works well for this purpose. Put everything back into the container once it has been mixed. If mixing is not possible, use a spade to make slits or holes in the wet pile and push dry material into these gaps.
- Oxygen - this is incorporated by turning the mix occasionally. Decomposing micro-organisms require oxygen to survive. If turning the heap is not possible, then make sure that there is a good mixture of fine and coarse materials. This will create air spaces.
- Warmth – keep the heap covered at all times. The sides should not be slatted. Wind blowing through slats will dry out a heap. Rain sluicing through will cool materials down and wash nutrients away. In hot countries, composting is often done in pits or trenches in the soil, to prevent material from drying out.
- Temperature - if the temperature drops below 40C the rate of decomposition decreases, if it goes over 60C many of the micro-organisms causing decomposition will die. Temperature conditions will always vary from one part of a compost heap to another. Usually the centre of the heap is the warmest and, for this reason, decomposition is usually faster in the centre of the heap. So it is advisable to mix up the contents of a heap from time to time.

Hot heaps versus cold heaps

Much has been written about 'the hot heap'. This is where a large quantity of compostable materials is piled together – a minimum of one cubic metre is the recommendation – and mixed well. Organisms in the materials become very volatile and active, which creates heat. Temperatures in a hot heap can soar to 80C and above. After a few days, the organisms start to die off, and the heap starts to cool. At this point, the heap is turned in order to incorporate more oxygen, and mix uncomposted material from the sides, to the middle. The temperature will rise again. This turning process can be done several times, resulting in finished compost within a few weeks, even in winter. However, this is a time consuming process, and not always possible or practical.
Many compost heaps remain cool, as their volume is small, and material is added 'little and often'. If this is the case, compost will take much longer to mature – usually around 12 months. It is most important that this type of compost heap should not be overloaded with large quantities of one type of material, such as a huge pile of hedge clippings, or a thick layer of grass clippings.

Always make sure that the balance of wet to dry material is correct. Remember, weed seeds in a cold heap will not be killed.
Although a cold heap will take much longer to produce finished compost, both methods will produce an excellent product, rich in fertility for your farm or garden.

The benefits of a hot heap are:
- Compost produced quickly
- Weed seeds killed in the heat

The benefits of a cold heap are:
- No time spent turning the heap

How to build a compost heap
- The easiest way to build a compost heap is simply to pile materials in a heap, or in a container of some sort.
- Use a good mix of organic materials. Wet material should be in thin layers (no more than 3cm thick) covered by dry organic material, such as dry straw or shredded paper.
- If using a large amount of dry material such as straw, wood shavings or paper, add some manure to boost the levels of nitrogen in the composting material. To prevent sawdust from packing down in a solid layer, mix well with coarse material, such as chopped stalks, and plenty of green waste to add nitrogen.
- If possible, turn the heap with a garden fork weekly. Remember to keep the heap covered, especially in wet weather. In hot countries, or long spells of dry weather, it may be necessary to water the heap occasionally.
- In warm conditions, a heap that is regularly turned and aerated can be ready in around six weeks; in colder weather it can take several months.

A compost heap should be made on bare soil. If piled onto a solid base, such as concrete, liquid will soon start to seep from the waste material. This can cause contamination of drains and water courses. If you intend to produce large quantities of compost, make sure that you comply with your local environmental regulations covering management of leachate.

The Finished Product
Compost is ready to use when:
- It is crumbly and generally an even texture. (Material such as straw, or flower stems might be still intact.)
- It should drain well, but still have good moisture holding capacity.
- It should be dark in colour.
- It should smell earthy and sweet, not of rotten eggs.
- Temperature should be air temperature. All heating/cooling should have finished if the hot heap method has been used.

How to Use Compost
- Compost can be used either as mulch spread on the surface of the ground, or spread a 2.5cm layer onto the soil and then dig in to the top 15-20cm. Coarser compost is the most suitable as mulch.
- Do not leave compost too long (particularly in warm weather) before using it, as nutrients can be lost over time.
- Don't plant in pure compost alone. Compost is good for most plants, but doesn't have everything a plant needs or may be too rich.

Companion Planting
Companion planting is growing specific combinations of plants together for mutual health benefits and to reduce pest and disease incidences. It can be as simple as inter-cropping (growing another species with the main crop), providing edge plantings or more complex such as growing plants together for mutual benefit.

There is no scientific explanation for the effects of companion planting however companion plants are believed to work in several ways:

- Act as a barrier to the crop
- Camouflage the crop
- Confuse insect pests
- Attract insects away from the main crop
- Produce exudes from the roots that appear to deter pest attack
- Produce chemicals that repels pests or masks

Pest and Disease Management

The basic principle of pest and disease control in organic growing is to prevent rather then to cure. When intervention is required, organic growers should not rely on substances as the preferred method of control as this does not agree with the principles of organic growing. Management techniques should be integrated - based on biological and cultural control techniques.

Pest and disease infestation can be minimised by growing vigorous plants, in robust healthy soils, within a biologically diverse environment. Organic growers must have also have a good understanding of how organisms ie. crops, pests, diseases and weeds interact with each other, and the environment in which they live.

Pest and Disease Prevention Includes:

- Crop rotations to prevent the build-up of soil borne diseases
- Legumes and green manures
- Manure and compost to improve soil life and fertility
- Biological diversity
- Selecting pest and disease resistant varieties

Resistant Plant Species and Cultivars

Genetically resistant types of plants are selected naturally. Plants susceptible to a prevalent disease or insect pest tend to disappear while resistant types remain. While geneticists and plant breeders work to develop new varieties of plants which will resist pests, disease and other problems, there are many older, 'heirloom' varieties of fruits, vegetables and other plants which already possess natural hardiness against pests and diseases. Also, the use of seeds and cuttings from healthy, locally grown plants is preferable to bringing in plants from elsewhere which may be less well adapted.

Biological controls

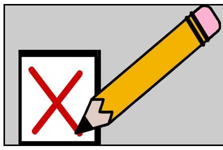
A balance usually develops in nature among organisms, both plant and animal. Certain organisms are antagonistic to others and retard their expansion. Changes that upset this balance by eliminating one of the organisms may lead to proliferation of pests and subsequent attacks on vulnerable crops. Biological control in such a situation would consist of introducing the antagonising organism of the pest into the area, thus bringing it into balance.

Encourage natural predators that already exist locally ie. lizards, frogs dragonflies, spiders, and birds. To be effective they need places to shelter and breed (eg. hollow logs), food (insects, nectar, pollen), water, shelter belts, ie. suitable plant species etc.

Many insects are also good predators of pests:

- Ladybird beetles and their larvae - eat aphids
- Hover flies (Syrphid flies) - eat aphids
- Lacewing - will control mites, caterpillars, aphids, thrips, mealy bugs, some scales.
- Praying mantis - eats most other insects, pests or otherwise.
- Wasps attack many types of insects including caterpillars. Some plants (eg. chamomile, celery, hyssop, tansy, dill, and yarrow) can be planted to attract these wasps.
- Woolly aphids parasites are attracted by clover (*Trifolium sp*.)
- Lacewings which feed on aphis and other insects are attracted by sunflowers.
- Goldenrod (*Solidago sp.)* attracts preying mantis and some other predators.

- Hoverflies are attracted to Buckwheat.

	**SELF ASSESSMENT** Perform the self assessment test titled ' test 1.2' If you answer incorrectly, review the notes and try the test again.

SET TASK

1. Construct your own no-dig garden bed. This may be quite large or small – it depends on how much space you have to work with. If you don't have any room, ask a friend or relative for use of a small patch of their yard. 1m square will get you started with enough room for herbs and flowers.

2. Search the Internet for information on permaculture developments. Find out all that you can about various sites, both in your own country and beyond, including the goals of the designer, the types of plants and animals being grown, the techniques used to establish and maintain the system, etc.
   Begin to compile a resource file and continue building this throughout the duration of the course.

3. If possible, visit at least three different permaculture sites, and again find out what you can about the designer's goals, techniques used, etc. If accessibility makes this impossible, you may be able to conduct virtual visits by finding well illustrated permaculture properties presented on web sites or in videos.

	**ASSIGNMENT** Download and do the assignment called 'Lesson 1 assignment'.