The Royal Botanic Gardens Melbourne Education Service

Towards Sustainability

Teachers Kit
Introduction

Towards Sustainability is a kit designed to assist teachers with planning and curriculum development to maximise the learning opportunities provided by an excursion to the Royal Botanic Gardens Melbourne. It contains ideas for inspiring students to be proactive in caring for our planet. There are suggestions for pre-visit activities and follow-up ideas, background information and a resource list.

Gardens can readily become a context or theme to approach a number of the AusVels curriculum links. Learning outdoors through gardens, whether they are public gardens or school-grounds, provides a very useful and effective means of integrating curriculum and incorporating effective pedagogies. AusVELS statements for each program can be found on [www.rbg.vic.gov.au/education](http://www.rbg.vic.gov.au/education).

As you read through the kit you will find a diverse range of material providing background information including fact sheets, plant structure and function summaries, and detailed information about adaptations of plants found growing in the Royal Botanic Gardens Melbourne. A number of topics about gardening have been included to help teachers plan and maintain school gardens. You will also find historical information relating to Aboriginal people's connection to the site of the Royal Botanic Gardens Melbourne and the history of water use in the gardens.

It is not intended that this kit be printed and used as a comprehensive document but rather as a repository of ideas and information so that relevant sections or pages can be sourced as required.
### Table of Contents

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>2</td>
</tr>
<tr>
<td>Pedagogy</td>
<td>4</td>
</tr>
<tr>
<td>Sustainability Programs and Curriculum links</td>
<td>5</td>
</tr>
<tr>
<td>Plant Structure and Function sheet</td>
<td>6</td>
</tr>
<tr>
<td>Photosynthesis sheet</td>
<td>7</td>
</tr>
<tr>
<td>Plant Adaptations to Dry Climates</td>
<td>9</td>
</tr>
<tr>
<td>Sustainable Gardens</td>
<td>14</td>
</tr>
<tr>
<td>Plant Propagation</td>
<td>16</td>
</tr>
<tr>
<td>Pest Control and Companion Planting</td>
<td>18</td>
</tr>
<tr>
<td>Activity Ideas: Growing Healthy Gardens</td>
<td>20</td>
</tr>
<tr>
<td>Pest Management</td>
<td>21</td>
</tr>
<tr>
<td>Spray Bottle Cures</td>
<td>23</td>
</tr>
<tr>
<td>Worm Farms</td>
<td>24</td>
</tr>
<tr>
<td>No Dig Gardens</td>
<td>27</td>
</tr>
<tr>
<td>Soil Testing Activities</td>
<td>29</td>
</tr>
<tr>
<td>The First People</td>
<td>30</td>
</tr>
<tr>
<td>European Occupation and the Birth of Melbourne</td>
<td>31</td>
</tr>
<tr>
<td>Climate Change and the Carbon Cycle</td>
<td>34</td>
</tr>
<tr>
<td>Exploring Sustainability at the Royal Botanic Gardens</td>
<td>38</td>
</tr>
<tr>
<td>Working Wetlands at the Royal Botanic Gardens</td>
<td>41</td>
</tr>
<tr>
<td>Activity Ideas: Estimating tree heights, Measuring Dirty Water</td>
<td>46</td>
</tr>
<tr>
<td>Bibliography, Resource List and Acknowledgements</td>
<td>48</td>
</tr>
</tbody>
</table>

Pedagogy

We must join together to bring forth a sustainable global society founded on respect for nature, universal human rights, economic justice and a culture of peace. Towards this end it is imperative that we, the peoples of Earth, declare our responsibility to one another, to the greater community of life, and to future generations. The Earth Charter

Sensory, Physical, Emotional
Royal Botanic Gardens Education utilises the rich natural and cultural resources of RBG Melbourne and Cranbourne to provide opportunities to enliven and enhance the learning of students from kindergarten to tertiary, providing face to face engagement through stories, hands-on experience and the rich sensory environment of the Gardens. Learning is immersive and social and leads to the development of life-long, life-wide skills. Royal Botanic Gardens Education programs also address the critical curriculum, which means "educational processes which create a more just and wise social world" (McNaughton and Williams 1998). Ethically aware students are empowered to take action and make changes to ensure a sustainable and just world for future generations.

"Adults sometimes do not recognise the environmental awareness and concerns of many children today. Often, for these sensitive young people, there is an accompanying feeling of despair; the world they will soon inherit is filled with so many major problems, and they are so small, so young, so powerless. What can they do?"
Margaret Dunkle, Children's Bookseller & Publisher, October 1997 writing about Christopher Cheng's book "One Child", a book that offers a positive solution to children; a way that they can act to improve the earth.

"Real world projects make the lives of young people and their communities more sustainable through enhancing employment opportunities and developing a sense of commitment in students to cultural vitality."
David Sobel, Place Based Education Connecting Classrooms and Communities

http://www.cartadaterrabrasil.org/eng/index.html
Sustainability Programs at the Royal Botanic Gardens

<table>
<thead>
<tr>
<th>Organising ideas</th>
<th>Linked RBG program</th>
</tr>
</thead>
<tbody>
<tr>
<td>The biosphere is a dynamic system providing conditions that sustain life on Earth.</td>
<td>Climate Change, Biodiversity, Working Wetlands</td>
</tr>
<tr>
<td>All life forms, including human life, are connected through ecosystems on which they depend for their wellbeing.</td>
<td>Biodiversity on the Yarra, Minibeasts, Plants and Animals, The Rainforest</td>
</tr>
<tr>
<td>Sustainability of social and economic systems is closely related to sustainability of the environment.</td>
<td>Sustainable Gardening, Food programs</td>
</tr>
<tr>
<td>All people are connected through social systems on which they depend for their wellbeing</td>
<td>Connecting to Country, Food 4 Life, Food Forest</td>
</tr>
<tr>
<td>Communities throughout the world have a common interest in maintaining environments for the future and deserve to be treated equitably</td>
<td>With one Seed, Connecting to Country</td>
</tr>
<tr>
<td>A world view is important to ensure social justice and the effectiveness of action to improve sustainability.</td>
<td>With one seed, Connecting to Country</td>
</tr>
<tr>
<td>Sustainability action is designed to intervene in ecological, social and economical systems in order to develop more sustainable patterns of living</td>
<td>Working wetlands, Food programs, Sustainable Gardening, Guilfoyles Volcano programs.</td>
</tr>
<tr>
<td>Sustainable futures are shaped by our behaviours and by the products, systems and environments we design.</td>
<td>Climate Change, Sustainable gardening, Food forest, food 4 Life.</td>
</tr>
</tbody>
</table>

All education programs at the Royal Botanic Gardens are underpinned by sustainability principles. There is a focus on the teaching of knowledge, skills and values. Many of our programs encompass the cross curriculum priorities of sustainability.
The information and activities below and on the next two pages are relevant to the following programs: Sustainable Gardening, Climate Change, Food Forest, Plantworks, Plant Power, Water4Life and Water, Plants, Life. Familiarity with the process of photosynthesis is important for students to appreciate the role of plants in making food and absorbing carbon dioxide from the atmosphere.

### Plant Structure and Function

**Plants are Producers:**
they make their own food by **photosynthesis**

<table>
<thead>
<tr>
<th>Part of Plant</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roots</td>
<td>Take in water and mineral salts, anchor plant</td>
</tr>
<tr>
<td>Stem and leaf veins</td>
<td>Transport water and food</td>
</tr>
<tr>
<td>Leaf</td>
<td>Makes food by photosynthesis</td>
</tr>
<tr>
<td>Chlorophyll in leaves (green)</td>
<td>Use sunlight to trap energy for photosynthesis</td>
</tr>
<tr>
<td>Flowers</td>
<td>Attract pollinators and produce seeds</td>
</tr>
<tr>
<td>Buds</td>
<td>Form new leaves or flowers</td>
</tr>
</tbody>
</table>

**Activities:**

Collect leaves and look at the patterns of their veins. What are the veins used for?
Put a plastic bag over some leaves on a plant and watch what happens to the bag. The misting is caused by water vapour escaping from the leaves through the stomata in the leaves.
Make leaf rubbings using leaves with distinct veins. Compare the patterns in different plants. Do they vary according to where the plants live?
Squeeze the sap from succulents and plants with hollow stems like dandelions. Test sap for sugar and see how much the sugar content is.
Study some different flowers and work out what sort of animal might pollinate them.
Look for plants with catkins and other wind pollinated plants. What is different about these sorts of flowers?
Photosynthesis

The process by which plants make food using the energy from sunlight to combine the raw materials.

Carbon Dioxide + Water $\rightarrow$ Sugar + Oxygen

The sugar made by photosynthesis is turned into all the other substances that plants need. Sugar is the basis of the food for all living things.

The green stuff in leaves is called chlorophyll. It traps the sunlight and enables the plant to use it in its chemical factory.

Plants can't survive unless they carry out photosynthesis to produce their energy supply.

During this process plants take in water through their roots and carbon dioxide through stomata (small holes) in their leaves (or sometimes stems in arid-adapted plants).

In order for plants to get water up to the leaves from the ground, water has to be lost to provide a transpiration stream (like sucking liquid through a straw - if you stop sucking the liquid runs back down). This means that plants have to lose water in order to gain it! Arid plants have to have adaptations to reduce this water loss.

In the process of photosynthesis water and carbon dioxide are combined, using the energy from sunlight, to form glucose. Glucose is then converted into starch to be stored (it is a large molecule therefore can't move out of cells), transferred in the sap to other plants of the plant where it is needed as an energy source, or converted into other chemicals that the plant requires.

The by-product of photosynthesis is oxygen, which the plants release into the atmosphere.

All living cells need a constant source of energy. This is gained through the process of Respiration which occurs in all living cells all the time.

In respiration glucose is broken down into carbon dioxide and water and the energy that was stored up in the glucose molecule when it was formed is released. This energy is used in the cell for the creation of substances that the cell or organism requires, for movement, for nerve transmission and creation of new cells (which requires all the chemical building blocks of which cells are made).

Without plants to perform photosynthesis no other organisms could exist.
Photosynthesis

6 molecules of water

PLUS

6 molecules of carbon dioxide

in the presence of light and chlorophyll

FORM

1 molecule of glucose

PLUS

6 molecules of oxygen

○ = oxygen
● = carbon
● = chemical bond

= hydrogen
These notes feature plants from the Royal Botanic Gardens Melbourne, particularly from Guilfoyle's Volcano site.

**Plant Adaptations to Dry Climates**

Deserts are arid areas, which means there is a scarcity of available water. Apart from being very dry there may also be excessive heat that can cause plants to lose the water they have. Such environments may receive a great deal of water for a very short time before long periods of dry conditions. Plants from arid areas from different parts of the world have evolved a variety of adaptations to allow them to survive those environments. How can we make use of these features to save water while still having beautiful gardens?

**Spines and thorns**

Many plants adapted to arid environments have spines or thorns. These are actually modified leaves. Leaves are usually the major photosynthetic organs in most plants but in cacti this occurs in the stem. Leaves are the part of a plant that loses a great deal of water. Thorns can provide protection from browsing animals that would want the food and water of the plant.

Questions: How can plants photosynthesise if their leaves have become thorns?

Answer: The green stems of many arid plants become the main photosynthetic part of the plant.
Succulence

Most of the plants in the arid garden are succulents. This means they have evolved fleshy water storing leaves, stems or roots. This allows the plant to hold on to as much available water it can accumulate for when it is required.

Question: Not all succulents have spines for protection, particularly in Australian deserts. How might these plants survive browsing.

Answer: Plants may also contain chemicals that are toxic or unpalatable to animals. Eucalypts are one example of a plant with a strong toxic chemical in its leaves. In Australia it could also be argued that there are not many large, browsing animals (kangaroos are grazers or grass eaters). This means there may not have been much selective pressure for plants to develop elaborate protective mechanisms.
Hairy surfaces
Many succulents live in areas that have fog or dew. Hairy or felted surfaces can trap this moisture and make it available to the plant. This can also be an important function for spiny surfaces.

Question: Often the hairs are white or lightly coloured. Why do you think this is?
Answer: The light colours reflect heat and excessive light. This keeps the plant cooler and reduces the amount of moisture that it may lose.

Shape
Many arid plants have a rounded or even spherical shape. This reduces their surface area so that less moisture is lost to the atmosphere. Larger cactuses have stems that grow straight up rather than across. This reduces the area of the plant that is exposed to the sun, which also reduces water loss.

Question: Many cactuses also have grooves down their sides. What use would these have?
Answer: On cool, dewy desert nights any moisture that gathers can be channelled down to the roots of the plant.
Leaves
The leaves of many Australian plants that live in arid areas have sclerophyllous leaves. This means that they are tough and hard and resistant to drying out. The surface of the leaves has a thick, waxy cuticle. This is particularly common in the dryer parts of Australia. Leaves may be also very small, which makes them less likely to lose water.

Question: Why do you think eucalyptus leaves tend to hang straight down?
By hanging down they are less exposed to the direct rays of the sun. This reduces water loss through excessive heat. The narrow edge of the leaf can be directed to the sun rather than the large surface area of the flat surface.

The leaves of casuarina trees have been reduced to small "leaf teeth" to reduce the loss of water by transpiration. The twig (branchlet) now performs the photosynthetic function of the leaf. It is cylindrical in cross-section with the stomata hidden in grooves or ribs to protect them from water loss.

For more information go to this website:
Seeds

Many Australian plants have woody seed capsules as an adaptation. The seeds are protected from the heat of bushfires within the capsules but fire splits the seed pod open so that the seeds are released to germinate at a time when competition is reduced and conditions for growth are good.

The seed capsules of the Hakea have released seeds which have papery wings to aid distribution.

Grey leaves, often with hairs, reflect heat, aiding survival in hot, dry areas. Plants such as eremophilas grow well in such a climate.

Question: Many desert plants, including cactuses and aloes, are able to keep their stomata closed during the day and open at night. This reduces water loss but how do these plants get carbon dioxide so that they can photosynthesise?

Answer: Many groups of desert plants have a specialised way of photosynthesising called CAM (Crassulacean acid metabolism). They are able to chemically store the carbon dioxide overnight, when the stomata can be open as water loss is reduced in the cooler night temperatures. The stored CO₂ can be used for food manufacture during the day without the plant having to open its stomata.
Sustainable Gardens

The next few pages provide information about setting up and maintaining sustainable gardens. There is information about making plant propagation, controlling pests and using worm farms.

What are the benefits of a school garden?
The educational use of school grounds should not be underestimated. School gardens can be integrated into the curriculum to teach students about plant biodiversity, conservation and sustainable practices.

Teachers can start making use of school grounds without having an established garden. Discovery learning comes from planning, designing and implementing school gardens for a sustainable future.

School gardens provide opportunities to teach students in an active, 'hands on' learning environment. Gardens also give students results for their learning which enables them to gain insight into the overall processes of garden ecosystems.

Background Information

Organic gardening refers to gardening without the use of chemical fertilisers; this is a healthy and environmentally friendly alternative. Cross and Spencer state that "Pesticides and herbicides are chemicals that are manufactured to kill" and they point out detrimental effects on people, earthworms, insects, birds and animals and the cost of production as reasons for minimising their use. There are impacts on native wildlife (for instance the surfactants in some glyphosate products have had a negative effect on tadpole growth), they can affect the balance of micro-organisms in the soil and animals and plants can develop resistance to the chemicals, requiring larger and larger applications for the same effect.²

You don't need a lot of space to create a garden. Gardens can exist in the ground, in pots, window boxes, hanging baskets, terrariums, recycled milk cartons or polystyrene boxes. Plants can also be trained to grow up vertical structures such as walls, trellises, wire or anything else you can recycle.

Less than one fifth of the earth’s surface is covered with topsoil, which can sustain plant life. Urbanisation and development is encroaching on this land in the metropolitan areas, whilst in rural areas topsoil is being leached of nutrients by the continuing application of chemicals in the form of pesticides, herbicides, fertilisers, pollution and erosion due to land clearing.

Most organic gardeners have a great love for soil, because they understand how important it is to their gardening system! They take care of their soil by continually feeding it organic matter* and in turn are continually rewarded by the crops of healthy, nutritious plants. Organic gardeners work with and respect the earth, relying on natural methods and working with the seasons and biological systems.

* Organic matter: in this case the term refers to anything that was once living.

Organic gardening takes into account such factors as soil type, climate, plant selection, beneficial insects, companion planting, composting, mulching and water saving practices.

² Sustainable Gardens, Cross and Spencer 2009 pps 17, 21, 284
Effective Gardening

The whole environment has to be taken into account when establishing and maintaining a vegetable garden.
Is the site suitable for a vegetable garden? Take into account the aspect, ideally facing north with plenty of light and not too dry. Make sure you have a water source nearby as vegetables need plenty of water. Avoid trees in the vicinity of vegetable gardens as these compete for water. Some gum leaves can produce tannins that make soil conditions unfavourable to vegetables.
Caring for the soil should ALWAYS be of priority. Looking after the needs of your soil is the key to a healthy and productive vegetable garden. Any efforts put into improving your soil will be rewarded time and time again.

Propagation of plants

Different plants can be propagated in different ways. Many plants grow best from seed, some work better from cuttings and some plants are best propagated by division.
Propagation is a fantastic and economic way to create new plants from old!

Propagation of Lavender for a school herb garden

Growing herbs is a great way to start a school garden. Lavender is a plant that is easily propagated by cutting. Cuttings can be taken all year round but are probably best taken during spring and summer. When cuttings are taken from the plant it is best to remove the flowers and the bottom leaves. It is best to leave to top 2 or 3 leaves to enable the plant to grow. The most important thing to remember when taking cuttings is at the bottom of the cutting to cut just below the node and at the top of the cutting to cut just above the node. The node is the area of the stem from where the leaves and shoots and roots sprout.

Three or four cutting can be placed in the same container in a sunny spot and watered approximately once or twice a week. Over watering will cause the cuttings to rot. The cutting should strike (grow roots) within a month. You can check this by looking for new leaf growth. Different plant species take different amounts of time to strike and the success rate varies with the conditions.

Once the cuttings have struck and are growing they can be potted up into individual pots to allow them to spread their roots.
To find out what plants can be propagated consult a gardening book or ask at your local nursery.

Activity - Propagating plants

Try out the propagating techniques described on the next pages.
Compare different plants to see which have the best strike rate.
Have a class competition to see who can grow the healthiest plants from cuttings.
Establish a herb garden using cuttings students bring from home and propagate in class.
Try growing plants from runners or by breaking up bulbs and tubers.
Predict which plants would be most effective at colonising new areas.
Look for novel vegetative reproductive techniques such as the 'hen and chicken’ fern which grows new plants on the ends of its fronds. Find the weirdest propagation method for example using smoke water!
Simple Propagating Techniques

Many plants are easy to propagate asexually, that is by not using seeds. Taking a stem cutting is a simple asexual propagation technique. For some ground hugging plants it is quite natural for roots to grow from the stem. This is an adaptation that allows a plant to spread by taking root at different places. Most plants can do this with a little extra encouragement.

Because herbs are generally soft-stemmed plants, softwood cuttings are taken on herbaceous plants, which have very little woody tissue. These are best taken in spring when plants are actively growing. More woody plants are taken as semi-hardwood cuttings, which are generally best taken in autumn.

**Taking a semi-hardwood cutting.**
Herbs such as lavender and rosemary are easy to propagate as semi-hardwood cuttings around May.

Cut a length of stem about 10cm long. Make sure that the cut is clean, even, at the base of a growing node and on a 45 degree angle. A growing node is at the base of a leaf or the stem itself. Remove about two thirds of the foliage on the stem.

Fill a pot with propagating mix or growing medium. The propagating mix is a mixture of materials that should contain just the right amount of air spaces with just the right capacity to hold moisture. There are many suitable potting mixes commercially available; the more expensive options include perlite and vermiculite. A mixture of 5 parts sand and 1 part peat moss is also suitable.

Before placing your cutting into your medium, you can dip the tip into some rooting hormone. This is easily available in powder form. This promotes a higher strike rate but is not necessary.

The cutting needs be inserted into the medium half way up the stem. Measure how deep the cutting needs to go into the medium and make a hole for it with a dibber (stick or pencil) and then .... Dibbler
Other propagating techniques

*Pelargonium* or *Correa* (a native shrub) can be also be propagated like herbs, as outlined above. Plants in the Lamiaceae family, such as rosemary, lavender, mint and sage are very easy to propagate from cuttings. *Mentha australis*, or Australian River Mint, can be divided into sections with stem and roots and then placed in moist potting mix. It can also be propagated by stem cuttings, which if dipped in honey will apparently promote root growth. These need to be potted in an open mix (with sand) and kept moist.

Placing a plastic bag or half a drink bottle over the top is a good way to maintain moist conditions. *Kleinia* cuttings should be dried before potting, or at least placed in dry potting mix to prevent rotting of the tip. They may shrivel a little, but this exotic succulent should take root in a month or so.

*Carpobrotus rossii*, sometimes called "pig-face" is a native, succulent, ground cover, which can also be propagated from cuttings after being dried out, or at least placed in dry potting mix. *Aloes* and *Cotyledon orbiculata* can also be propagated in this way, by taking a stem cutting, drying and placing in dry potting mix.

*Asplenium bulbiferum* or “chicken and hen fern” can be propagated by cutting off plantlets from fronds and placing in potting mix. These plantlets need to be kept moist and warm. Placing a plastic bag or half a drink bottle over the top is a good way to maintain these conditions. Plantlets can also be placed in soil or potting mix, still attached to the plant, until they take root. *Stachys*, or "lamb's ears" can be propagated by breaking up clumps and placing in moist potting mix. Strawberries can be separated when their branching stems develop roots and then placed in potting mix.

Collecting seeds is another way to propagate plants such as *Acacia*. *Acacia* seeds will usually need to be placed in boiling water before they will germinate.

Resources

Pest Control and Companion Planting

Instead of asking “why are there so many insect pests in my garden?” try asking instead “why are there not enough predator organisms?” If there are lots of hungry predators to eat the pests, the pests will not have a chance to eat all the crops.

Umbelliferous and Compositae plans such as dill, fennel, daisies and marigolds placed around garden beds and in the orchard, attract predator insects (insects which feed on or parasitise pests). Ponds in the garden attract insect-eating frogs. Suitable nest boxes or thorny shrubs provide a habitat for insectivorous birds.
Mollison 1988

“There are in fact more good or beneficial insects in the garden than there are bad or harmful ones. Every time we gardeners spray an insecticide around, we invariably kill both the good and the bad.”

The ideal is to have a balance between predators and pests, so that the predators have enough food but pest numbers are kept under control.

Planting companion plants helps to establish that balance. Here are some ideas from Susan McClure in Companion Planting.

• Plants with strong perfume can mask crop plants to keep pests away. Many herbs are aromatic and make good companion plants.
• Nursery plants such as daisies and marigolds provide nectar and pollen to attract and keep the beneficial insects. They supplement the diet for predators when pests are scarce.
• Trap crops are plants that pests will flock to, such as nasturtiums. If planted near roses, the aphids will swarm to the nasturtiums and not eat the roses. The plants and pests need to be destroyed before the aphids reproduce. Mustard plants and radish attract caterpillars away from cabbages.

Companion Planting Tips
Much of companion planting rules are European or USA derived folklore which don’t always apply to Australian garden conditions, as we have many different pests and predators. For example in Australia all aphids are female, hence there is no need to apply companion planting rules that disrupt mating.
The companion crop works best when cover of at least 50% of soil area is achieved - in other words just one plant is not enough.

The following websites offer more advice about Companion Planting:

http://www.abc.net.au/gardening/stories/s1872509.htm
http://www.jackiefrench.com/companion.html
http://www.sgaonline.org.au/?p=583

3 Colin Campbell 1994
Some Useful Companion Plants

**Borage**: Blue flower
Beneficial particularly if planted with potatoes.
Provides increased nectar supplies for the parasitic wasps that prey on potato moth/caterpillar.

**Carpeting flowers**: Blue, yellow or white flowers such as alyssum, chamomile or bugle keeps thrips at ground level rather than attracting thrips to flowering fruit and juvenile growth.
A blast with the hose is also a very good option for managing thrips.

**Indigenous biodiversity**: Grow native shrubs around the garden. This will attract birds, wasps, skinks which will aid pest pest control once the plants become established.
Worth considering are *Callistemon citrinus, Correa pulchella, Cassiaodorata v prostrata* which is a prostrate shrub. Dense shrubs such as *Correa reflexa* and *Correa glabra* are good for attracting small birds.

**Nasturtiums**: Orange, yellow and red flowers.
Beneficial particularly if planted with cabbage.
The nasturtium disguises vegetable plants and repels aphids.
It also shrouds cabbage or other round headed plants like iceberg lettuce. This confuses moths and prevents them from laying caterpillar eggs on cabbages. Nasturtium flowers can also be used in salads.

**Peas and beans**: When grown with corn provide nitrogen in the soil which benefits the corn. The extra nitrogen provided when these plants are dug in will benefit all plants.

**Pineapple sage**: Red flowers
Birds and insects are attracted to the flower and feed on nectar.
Great near fruit trees as the fragrance can repel pests and attract predators.

**Sunflowers** attract beneficial insects such as hover-flies and bees to control pest and pollinate other crops.  

---

McClure 1995
Start with a bean seed. As it grows, watch it change, reach to the light, grow more leaves, entwine tendrils round a frame, produce flowers and then beans. Pick the beans, eat some, keep the others to plant again and watch them grow.

Find other, different, legumes to grow. Watch the way they grow and compare them. Cook the seeds and make delicious meals. Use dried pods to make percussion instruments. Compare germination and growth rates. Measure their heights and graph their progress as they grow.

Create a cultural garden. Work with your Language Other Than English (LOTE) teacher to investigate plants grown and eaten by people of that culture. Invite members of your cultural community to help you explore cultural traditions for using and preparing the plants and the festivals associated with them. For example, hold your own Italian tomato bottling party using oregano. Cook a spicy Indian dhal using legumes and chilies. Try making beautiful carved salad vegetables to go with a Thai curry.

Play! Leave space and loose materials in your garden for the children for creative play and to make their own discoveries. Plots with soil/mud, sand, water, pots, construction materials and pebbles are perfect for making mini landscapes, mud pies, works of art, cubbies, garden constructions, a fruit and vegie stall and so on.

Design your own dream garden. Brainstorm possible shapes such as a spiral, mandala, rainbow, flower-shaped. Decide which vegetables, fruit, flowers or herbs would be best to grow. Send for a collection of catalogues to select plants. Research organic gardening methods such as No Dig Gardens and Permaculture to find out how these methods work with the environment rather than against it.

Think about how you can get enough water for you garden. Can you install a water tank or harvest rainwater by diverting flow from a gutter through your garden and then into the storm-water system? Perhaps you could recycle water from your washing machine or use the water that you run until hot water comes through.

Grow sunflower seeds. Look at the flower structure to see the tiny flowers in the centre. Look at the fibonacci patterns in the flower. Observe the animals that visit the flowers. Watch the caterpillars that eat the leaves and find out what sort of butterfly or moth they turn into and who are their predators.

Research companion plants and plant a selection with your crop plants to see which ones work best to attract predator animals and keep away pests. You will need to observe your plants regularly and work out a way of recording and presenting your data.

Try different organic sprays to see which are most effective. To provide reliable evidence you will need to plan a controlled experiment, repeat your results and work with large numbers. It might be most effective to do this as a class exercise. Look at page 27 and sustainable gardening australia website for recipes. [http://www.sgaonline.org.au/](http://www.sgaonline.org.au/)
Pest Management

Snails and Slugs
Snails and slugs have soft bodies protected by a layer of mucous. These pests hate dry conditions as they risk drying out. Dry mulch such as straw, eggshells, shredded paper are some options to keep snails and slugs away from delicious tender seedlings. Provide moist cool shelters like bricks and rotted timber for snails to shelter. Then routinely pick and squash them or feed them to ducks. You can place snail pellets (there are some pet-friendly varieties) in cylinders next to garden beds so the snails will crawl in to find them but children and pets are safe.

Aphids
Aphids suck sap particularly from new foliage, stems and flower buds. They can also transmit viral diseases from one plant to another. Soapy water or a strong jet of water will physically remove aphids.

Caterpillars
Caterpillars chew through leaves. They tend to hide on the undersides of leaves, along the veins. Grow trap crops to attract them and remove by hand or squash on the plant. However, without caterpillars there would be no butterflies to act as pollinators so achieving a balance is important.

Beneficial Animals
By providing homes and food for predators you also manage pest populations without the need for chemical controls.

Your garden will benefit from the presence of these animals but there need to be some pest animals around for them to eat or they won’t stay.

Lizards and Frogs
Lizards and frogs eat snails, slugs and flies. Both like to shelter in rockeries and crevices. Provide a heavily planted water refuge to attract frogs.

Dragonflies and Damselflies
Dragonflies and damselflies can hover in mid air and eat other flying insects such as mosquitoes and flies. The larvae live in water and eat mosquito larvae.

Ladybirds
A ladybird eats up to 1100 aphids before she produces her first eggs.

---

5 Campbell 1994
6 McClure 1995
Beetles
Beetles eat thrips, caterpillars, march flies, slugs, snails, aphids, scale, ants, termites and grasshopper and snail eggs.

Spiders
Never eradicate or spray spiders. Spiders feed on codling moth larvae or white flies as well as many other insects in your garden.

Praying Mantids
Mantids eat a variety of insects and are very useful garden companions.

Birds
Small birds such as wrens, robins, fantails and honeyeaters eat insects. Wattlebirds thrive on insects as well as nectar. By planting native trees and shrubs (especially thick and/or prickly ones) you provide cover for the smaller birds and a nectar supply to attract them.

A water supply such as a small pond (see photo on left) will also attract beneficial animals. Plant a variety of plants that provide nectar and pollen, such as carrot, celery, coriander, dill and parsley. Allow them to flower and seed. Also useful are cosmos, marigold, clover, lupin, broccoli, mustard and radish to attract predators.

For more information try the following websites.
http://www.abc.net.au/gardening/stories/s1805263.htm
Spray Bottle Cures

Many diseases and plant pests can be eliminated from the garden simply by good housekeeping practices. If excessive pest damage occurs it is often the result of unusual seasonal conditions. Organic farmers and gardeners have found a myriad of ingenious ways to reduce crop damage without putting themselves, families and the environment at risk. However, if you need to spray, an organic spray made from natural substances is a good alternative to a commercial, synthetic spray.

The following recipes require minimal effort and use ingredients easily found in the home or garden.

**Milk: A good spray for downy and powdery mildew**
Milk may be a natural germicide. It contains several natural amino acids and salts that are taken up by the plant; hence disease is sensitive to these salts.

- Mix milk with water in a spray bottle at a ratio of 1:9 or no greater than 1:1
- Spray on both sides of leaves weekly or after rain.

**Garlic: All-purpose spray**
Garlic is an effective fungicide. It has a pungent aroma which is useful in deterring many flying insects but it can also harm bees and other predators.

- Macerate 4 cloves of garlic with a bit of water
- Push through sieve
- Dilute this garlic paste with water and pour into spray bottle
- Add 1 tsp of grated pure soap flakes or a few drops of liquid soap (not detergent).

**Oil: All-purpose spray**
Oils work by covering insects or their eggs with a light film of suffocating oil. Oil spray may cause leaf damage when temperature is above 24°C. It is best used in winter or late evenings during warm weather.

- Mix 2 tablespoons of mineral or vegetable oil with a few drops of liquid soap with 1L water.
- Spray on plant covering all leaf and stem surfaces.

**Soap: All-purpose spray for soft body insects**
Soap sprays break down the waxy layer of insects' exoskeleton causing them to dehydrate.

- Mix 1/2 teaspoon of liquid soap per 1L water.

**Baking Soda: For rusts, mildews and scale**

- Mix 100g baking soda with 4.5L water.
- Add some liquid soap and spray over susceptible plants

References:
Various authors, *Vegetable Gardening*, Murdoch Books, 2004
Campbell, Colin, *Simple Pest and Disease Control*, Lothian, 1994
A simple guide to worm farming

Working on a stackable-layered tray system.

**Location**
Firstly assemble worm farm in a sheltered shady location. It may have to be relocated to under cover area in cooler months or loosely covered to keep some warmth in.

**Starting the farm**

**Collector Tray:** The primary function of the collector tray is to collect all liquid. Food wastes are about 80% water, which is released as the worms break waste down. This eventually drains from the bedding to the collector tray.

**First Working Tray:** Worms require moist bedding in which to live and lay their eggs. Worms are started off in this tray that has been lined with bedding material. This material can be a mixture of shredded paper, bucket of soil or aged animal manure, coir (coconut fiber), soaked cardboard or egg cartons. Spray this lightly with water.

**Second Working Tray:** Place this tray on top of the first working tray making sure the base is touching the bedding material. Place a small amount of additional food waste from kitchen in this tray and place the worms in their new little home. Worms do not like direct light and must be kept in a moist environment. Hence this tray must be covered with a moist/hessian bag, carpet or wet newspaper. The lid or cover can now be put on and worms left to settle for a week before checking the farm's progress and adding more food scraps. The worms will now start to grow and happily multiply.

**Food**
Once worms are settled in they require a regular supply of suitable food. Worms like most vegetables and fruit scrap (except onions and citrus, which have volatile oils. This will make them squirm for their lives to get away from the smell). Our friendly little hard workers do not have teeth, so scraps should be cut into small pieces or preferably mashed. Worms are voracious eaters.

**Menu**

As a guide worms will eat anything that was once living. This includes:

- Fruit and veges
- Leaves
- Dirt
- Hair / feathers
- Torn up newspaper, egg or pizza cartons (water soaked first)
- Worm fattener (chicken layer pellets, bran or wheat meal)
- Manures (well aged)
- Tea leaves/bags and coffee grounds
- Crushed egg shells (these will help with the pH balance)

Continue to regulate feeding to keep just ahead of worms' rate of consumption.

**Tray Management**
When the top working tray is full (this takes about 4-6 months) take the bottom working tray and empty contents on your garden, returning the tray to the top.
You can simply add 2/3 of the castings (worms and all) directly to your garden. Add the remaining 1/3 to your fresh bedding. This will inoculate the bin and provide some worms to get you going again, but it depletes your worm population for a while. Harvest the worm castings/compost (vermicompost) by moving it all to one side of the bin; add fresh bedding to the empty side. Many of the worms will migrate to the fresh bedding in a few days. The valuable worm castings can then be taken out and used.

**Liming**
Worm farms may need the addition of lime to manage the acid build up during the decomposition process. The amount or timing is not critical. An acid bed is not a good environment for optimum breeding or feeding. It also will be likely to cause smell and cause infestations of other insects. A preventative lime addition routine of a teaspoon sprinkled over the surface area each week may be required. You will know it needs more lime if you start to experience any smell or infestations. If you experience these problems, you may also be overfeeding and/or over watering.

**Which Worm To Use**
Not all worms are suitable to stock in your worm bin however it is important to make sure composter worms are used as earth-workers will not do so well. Conversely you shouldn't add composters to the garden soil, as they are not likely to survive when soil dries. The exception to this is a heavily mulched and reasonably damp soil where food is maintained. Red Worms (*Lumbricus rubellus*), Tiger Worms (*Eisenia fetida*) or Blue Worms (*Perionyx excavatus*) are all suitable for composting.

**Reaping the Benefits**
When you notice that the worms have left the first tray, the castings are ready to use on the garden. A handful can be used in planting holes ensuring that the roots of plants have a wide range of nutrients and moisture available to them. Liquid worm castings also make an excellent fertiliser. A generous handful in a 9 litre bucket of water stirred vigorously can be watered onto plants weekly during the growing season will produce outstanding results. A wonderful advantage is that this mixture will not burn plants. You can drain the liquid fertilizer out of the tap and use it as it comes or dilute with water in a watering can. Excessive applications are wasteful. Soil has a limit to the amount of nutrient-laden moisture it can hold at a time; so small regular applications are best.

**Happy Worm Farming**

**Designs for worm farms:**
There are many types of worm farms. The photos show some different stackable tray designs.
Two-sided worm farm
The photos below show a two-sided system in which all the castings are removed from one side at a time.
Food scraps are chopped into small pieces and sprinkled into the working side of the worm farm, covered with wet newspaper and a handful of worm casts. The worm casts provide a suitable substrate for the worms to lay eggs. When one side is full the second side is started and the worms gradually migrate into the fresh food.
The first side is left until the food is completely broken down, then the worm castings are put into the garden, with a bin full retained to cover each layer of food scraps. The front panels of the worm farm slide up so worm castings can be removed easily. The photos show rich soil on both sides, with worms active in the side with fresh food scraps.
No Dig Gardening - Step by step guide

**What is a no dig garden?**
It's a garden above ground made of layers of organic matter that eventually rot down to produce a nutrient rich living soil where you can establish an ongoing seasonal supply of vegetables.

**Benefits**
- Reduces the use and effort of heavy garden tools
- Minimizes physical labor
- Makes productive use of restricted land space
- A great solution on compacted or silty soil
- Can be built over existing garden beds, lawns and even hard or rocky ground
- Low maintenance
- Can be built any time of year
- Encourages an organic environment

**Location**
- It should be situated a sunny area with at least 6 hours of sun light for best results.
- Not near towering trees that create shade and compete for moisture.
- It can be any size or shape depending on the space you have.
- Keep in mind that for easy access a rectangular shape that's not too high for little green thumbs works well.
- The site should be easily accessible
- Reasonably level
- If the ground is rocky or on concrete, addition of leaves, twigs, pine needles, bark, or seaweed should be raked in evenly before starting

**What is needed**
- Bricks, logs, recycled timber (ground treated or rot resistant), concrete blocks, large stones or straw bails (straw bails will eventually break down and have to be replaced approximately every 6 months)
- Newspapers
- Straw - Lucerne hay, pea straw or crop straw. Lucerne or pea straw are preferable as they break down easily and have high amounts of nitrogen
- Dry poultry manure or organic fertilizer
- Compost, any type will do. Can be ready made bags, mushroom or home made compost.
- Water
- Seedlings - quantity will vary depending on the size of the garden. It is best to start with a small bed about 2M x 1.5M and expand when you want.

**Building the No Dig Garden**

Once the area has been marked out and the framework secured, follow these easy steps.
1) Lay several thick layers of newspaper to cover ground about 5mm. Making sure to overlap all areas.
2) Soak newspaper with hose.
3) Cover the entire area with any clean and weed free straw about 20mm, leaving no gaps.
4) Water straw lightly.
5) Sprinkle organic fertilizer like chicken manure, which is high in nitrogen. Preferably pulverized than pallet form.
6) Cover this with a layer of straw about the thickness of an adult hand length.
7) Sprinkle a little more fertilizer evenly spread.
8) Finish off with a top layer of compost about 100mm thick. 9) Water in well.
10) Gently plant out seedlings and water them in straight away.

If making the garden on top of concrete or hard rock ground, the very first layer put down should be one of old leaves, small sticks etc to a depth of 75-100mm.

**Seedlings**

Plant to suit the climate and season. All nurseries can assist with this information. Reliable vegetables that may be suggested for children's interests are as follows.

In winter try garlic, lettuce, onions, parsley, chives, spring onions, bok choi, a lettuce mix, miniature cauliflower, turnip.

In summer try, beetroot, radish. Carrots, cherry tomatoes (miniature version works well in small beds), most herbs, lettuce.

There are many more however keep in mind the space available as spreading plants like cucumber or pumpkin use a lot of surface space. Many tomato varieties require staking/support in some fashion.

Be a little adventurous and try mixing in colorful or edible flower varieties like calendula or pansies.

**Change of season**

After a few months at the finish of summer or winter crop, the layers of the garden will have composted down, reducing its mass.

When ready for the next crop *No Digging* is needed. Just add a layer of compost and/or manure and plant the next seasons crop.

**References**

Bill Mollison: *Permaculture Two*, Tagari, 1979

[www.abc.net.au/gardening/stories/s2431665.htm](http://www.abc.net.au/gardening/stories/s2431665.htm)
[www.organicdownunder.com](http://www.organicdownunder.com)
Soils

Soil Testing
A soil pH test is the most important test you can do in the garden. Different plants like different pH levels, but most like it near 7 (neutral). If the pH is too high or too low, nutrients in the soil "lock up" and can't be absorbed by the plants, thus fertilizer not only goes to waste, but your plants literally starve to death.

Note: In wet soil at a pH of 7 (neutral) most elements are in the form of ions. In this state they are soluble and can be taken up by the roots. If the pH is too high or too low, the ions can join with other ions to form insoluble compounds and in this state they cannot pass through the cell membranes to be absorbed into the plants.

Rhizobium bacteria which take up nitrogen in the root nodules of legumes are less active at low pH, therefore in acid soils legumes have poorer growth.

Aluminium and manganese ions are released into the soil at low pH and can reach levels where they are toxic to plants.

Activity
Test the pH of soils around the school. Use the information on the chart to predict where most plants would thrive best and to determine which minerals might need to be supplemented.

Predict the effect of adding washing machine water to water the garden. Compare different washing powders to see which ingredients will change soil pH and affect the growth of plants.

(see Cross, Sustainable Gardens, p 172-175 for Greywater information)

### Minerals required by plants

<table>
<thead>
<tr>
<th>Macro-nutrient</th>
<th>Symbol</th>
<th>Available as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>C</td>
<td>CO2 from air</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>H</td>
<td>H2O</td>
</tr>
<tr>
<td>Oxygen</td>
<td>O</td>
<td>O2 from air</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>N</td>
<td>nitrate or ammonium salts</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>P</td>
<td>phosphates</td>
</tr>
<tr>
<td>Sulfur</td>
<td>S</td>
<td>sulfates</td>
</tr>
<tr>
<td>Calcium</td>
<td>C</td>
<td>calcium salts such as calcium nitrate</td>
</tr>
<tr>
<td>Potassium</td>
<td>K</td>
<td>Potassium salts such as Potassium phosphate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Micro-nutrient</th>
<th>Symbol</th>
<th>Available as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium</td>
<td>Mg</td>
<td>Magnesium salts such as magnesium sulfate</td>
</tr>
<tr>
<td>Iron</td>
<td>Fe</td>
<td>Iron salts such as ferrous chloride</td>
</tr>
<tr>
<td>Zinc</td>
<td>Zn</td>
<td>Zinc salts such as zinc sulfate</td>
</tr>
<tr>
<td>Manganese</td>
<td>Mn</td>
<td>manganese salts such as manganese chloride</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>Mo</td>
<td>Molybdenum salts such as potassium molybate</td>
</tr>
<tr>
<td>Boron</td>
<td>B</td>
<td>Borates such as potassium borate</td>
</tr>
</tbody>
</table>

Table based on Capon, Botany for Gardeners, 1996, p145
Historical Perspectives

The First People

Aborigines believe that they are part of the land, that they belong to the land. Instead of ownership they see themselves as custodians with a responsibility to look after and protect the land. This is a deeply spiritual connection.

Aboriginal people’s knowledge of biodiversity is directly related to spiritual life. Animals and plants are a vital part of the creation stories, and they play significant roles in passing on knowledge about culture, food gathering and respect for the earth's resources.

Inherent in the connection with the land in traditional Aboriginal life was a comprehensive knowledge of the living things in their environment - survival depended on it; they knew what plants and animals provided food, medicine, tools and fibre. They knew where these things were found, and they knew the right time to harvest, fish, hunt, gather and burn. They made careful observations and knew how animals behaved, how plants grew and how the seasons changed.

A key part of the spiritual relationship that Aboriginal people have with the land is based upon the idea of connection; connection between plants and animals, the non living elements, weather, seasons and cycles, soil, water. This is the basis of all ecological thinking upon which healthy biodiversity is dependent.

Some examples of sustainable resource management that protect biodiversity are:

- **Fire-stick farming**: Fire-stick (djiel-warrk) burns most likely occurred in late summer and early autumn before the rains. Burning was controlled and carried out in a mosaic pattern which enabled different animals to find different food types, and for different plants to germinate and grow. Firing the country kept denser vegetation from shading important food plants such as lilies and murrmung (yam daisy) and it promoted new tender grasses for herbivores such as kangaroo.

- **Digging**: Women searched for yam daisies and other edible plants, using their kannan or digging sticks as they dug for murrmung, thinning out the clumps, aerating the soil and replacing and propagating root pieces. This meant that soils were friable, encouraging plant and animal biodiversity and ensuring future supplies of vital food crops.

People of the Kulin Nation have lived in and used the Royal Botanic Gardens Melbourne area for about 50,000 years. It was rich in resources and a central place for clans to meet. They lived sustainably, taking only what was needed and leaving the rest to grow. The Yarra River (Birrarung, River of Mists) was crossed at the falls near Queen Street and Dights Falls in Richmond. There was a beautiful pool near the bottom of Elizabeth Street overhung with shady trees. Food consisted of kangaroo, emu, echidna, possum and waterfowl as well as eels, freshwater mussels, roots and berries. All would have been in plentiful supply here.

The high ground near Government House was ideal for a meeting place as they could see far out over the plains. Corroborees were held here so that they could meet up with other clans to discuss important issues such as marriage, politics, trade, disputes and celebrations. The ground on which the MCG stands was used for games by Aboriginal people too and they made footballs from possum skin (see a replica in Bunjilaka at Museum Victoria). Aboriginal People also used Birrarung for gathering food, fishing and for transportation. Canoes were made from bark stripped from River Red Gums. Scar trees can still be seen around Melbourne.

European occupation and the birth of Melbourne

The first settlers who came to Australia had no experience of surviving in a country where rainfall was haphazard, water scarce and the soil poor. They continued to live as they always had and their practices were unsustainable and damaging to Australia’s fragile environmental balance. Their mistakes are only now being addressed but much of the damage, for example extinction of species due to habitat loss, is beyond repair.

Melbourne was settled on a prime site, on a river, with flat plains for housing and farms.

The low Falls rockily crossed the river where Queen Street Bridge is now, stopping seawater going any further. Below was a natural pool or widening of the tidal river, later named as a Turning Basin for ships and perfect for mooring. On the other side of the Falls, upstream, was continual fresh water for drinking, at least at low tide. The combination of saltwater access and freshwater supply at this juncture, with higher land on the north side, made it the logical place for all to stake claims and notions of settlement and territory: Grimes’ ‘most eligible place for a settlement’, Batman’s ‘This will be the place for a village’, Fawckner’s getting on a doing just that. It’s because of the Yarra River that the city of Melbourne has to be precisely where it is, and eventually even the colonial government realised it.

Otto 2005 p17

Batman made a ‘treaty’ with local Aboriginal ‘chiefs’ in which he claimed to have purchased the 200,000 hectares of land in exchange for a quantity of blankets, knives, tomahawks, scissors, looking glasses, flour, handkerchiefs and shirts. It is believed that the people of the Kulin Nation thought they were conducting a tanderrum ceremony, a welcome to country, and did not understand the concept of buying or selling land. They must have been distraught when they found that they were shut out of traditional hunting and meeting grounds, shot at, poisoned and dispossessed of everything.

The new settlers did not understand the principles of sustainability long practised by the Aboriginal people. The city of Melbourne grew from a tent settlement on the banks of the Yarra River. Within a short time of the town’s establishment the water in the pool at the foot of Elizabeth Street was so fouled with rubbish, pollutants and dead animals that it was no longer potable. "The Yarra was one of the filthiest rivers in the world." Unfortunately they did not realise how little rainfall to expect and their attitude to water quickly led to Melbourne’s water supply failing. (Yan Yean reservoir was built in 1857) Early settlers regarded rivers as being of use as a

8

9 Barr 1992 p128
Powell 1989 15-18 Young
2000 p17-20
10 Flannery 2002 p53 Otto
11 2005 p68-72
12 Otto 2005 p56
means of transport, for powering machines such as water wheels and or disposing of rubbish. After the waterfall at Queen Street was blown up in 1883 to create space for a turning circe for ships the river was now tidal (and salty) all the way to Dights Falls in Richmond. This had serious implications for Royal Botanic Gardens which had previously obtained fresh water directly from the Yarra River.

Melbourne's water supply has always been tenuous. Water was first collected from the Yarra in buckets, but it then became a business as entrepreneurs set up pumps to fill casks which delivered water to residents from carts. Initially the Yarra River supplied the Gardens' needs with "orphan boys" using water carts to carry water to the garden beds.

A barrel on the cart was filled with a hand pump on the river then the horse was walked around the garden beds and water flowed to them through a canvas pipe attached to the barrel.

When Yan Yean Reservoir was built in the 1850s, using water from the Plenty River in Melbourne's north, water was piped to the highest point of the Royal Botanic Gardens and allowed to run through channels into the garden beds. As Melbourne's population grew, this supply was disconnected as there was not enough water to go round. Steam pumps were built to pump river water up to the newly created reservoir, Guilfoyle's Volcano, built in 1876 and this was satisfactory until the river became salty in 1883 (with the removal of the falls). The Volcano was then filled via an eighteen inch pipeline from Dight's Falls in Richmond. This pipe can still be seen under the Walmer Street footbridge (Kew) and at the top of the Volcano on the west side. Guilfoyle's Volcano continued to be filled from the Yarra River and Yan Yean reservoir until the 1930s when the Royal Botanic Gardens was connected the Melbourne Metropolitan water supply.14

---

13 Murray 1845
14 Vol. 1 Thematic Environmental History.
From the time they were founded, the Royal Botanic Gardens have been both recreational and scientific. Baron von Mueller was interested in the scientific and educational aspects, planting native trees in straight rows to showcase the diversity of Australian native plants. Public expectations changed and Guilfoyle was appointed as the new director to create a 'pleasure garden' for the people of Melbourne. Guilfoyle was inspired by the beauty of landscape. He created a sense of surprise by using curving paths, naturalistic clumps and massed plantings that open out to reveal beautiful vistas. He turned what was a swamp into a reflective lake, created beautiful flower displays and built ornamental garden structures.

Guilfoyle’s ornamental lakes originated from older meanders of the Yarra, cut off as billabongs long ago. The current configuration was formed in 1900. Because boats were unable to navigate along the winding river and the bends caused inconvenient flooding, the Yarra next to the Royal Botanic Gardens was straightened in 1900 and Alexandra Avenue built parallel to the new river bed before the water was diverted. The north bank of Long Island used to be the bank of the Yarra River.

Now the lake system is being changed back to a working wetland system and water and habitat conservation is a major focus of the Royal Botanic Gardens. (Please see fact sheets Working Wetlands, Water Conservation and Canna Bed)

The photo shows the construction, in 1874, of Guilfoyle’s volcano in the south eastern corner of the Royal Botanic Gardens Melbourne. This view has been taken looking south east over the ornamental lakes. Anderson Street is visible at the top of the photo.

15 Beardsell, 1999 pp. 40 - 41
Climate Change

The climate is constantly changing but there is overwhelming evidence that says that human behaviour is causing the climate to change at a rate that could have severe and irreversible ecological and social consequences. Weather is short term, climate can be observed to change over a minimum of 15 years.

Ways of coping with Climate Change

Adaptation
• This means learning to live with the effects of Climate Change.
• In Victoria this means less rain, less run off, faster run off due to big rain events, increased fire intensity and frequency, droughts.
• In Queensland, more frequent floods and cyclones.
• In Australia, generally more extreme weather events.
• Sea level rise

Strategies we can use: mulching, storing water in tanks, effective irrigation, plant choices, town planning for no new buildings on low lying areas.

Mitigation
• This means attempting to control the effects of climate change.
• In Victoria, for example we could reduce using electricity generated from burning coal and use renewable energy forms such as wind and solar. Gas is better than coal.

Strategies we can use: We can put less carbon into the atmosphere by:
• Growing our own food. Buying food grown locally.
• Planting trees and indigenous plants, habitat forming.
• Do anything that cuts electricity consumption e.g. light globes
• Get solar panels for schools/homes.

Sequestration
• This means to trap and store carbon.
• Artificial ways are expensive and may not be effective/safe/they don’t yet function.
• Natural ways are best. For example, trees store carbon so planting trees, conservation of land and sea habitats as they are natural storers of carbon, no till farming methods.

The Food Connection
• Buying food grown locally, using farmers markets reduces fuel use in transporting goods.
• How do we work out where a food item has come from? If we are in the fruit shop, in the supermarket?
• Discuss/introduce sustainable/organic practices such as composting, worm farms, mulching, water storage, plant selection.
• Also, discuss best time of year to grow…perhaps we should not be growing during January as we need too much water to keep plants alive.
• Grow our own vegetables
• Use a water tank for your garden
Planting Indigenous plants
• Trees store carbon.
• Soils store carbon and especially soils that are healthy, vegetated and moist.
• Fungi store carbon and they rely on plants for their survival.
• Saving and growing more habitat means protecting biodiversity against the effects of climate change.
• Indigenous plants are more likely to survive, and therefore planting them is a sustainable gardening practice.

The Role of Botanic Gardens
Botanic gardens around the world have an important job to do.
• Protecting endangered species and save seeds (e.g. Millennium Seed-bank)
• Researching effects of climate change on plants (this is pretty important as plants provide humans and other animals with everything they need to survive.)
• Educating people about what they can do.
• Working with other botanic gardens to share knowledge and resources.
• Sequestration of carbon by planting trees.

Carbon Cycle

All living things are made of carbon compounds. Carbon comes initially from the air in the form of carbon dioxide. It is converted to carbon compounds by plants in the process of photosynthesis and becomes part of the bodies of animals when they eat plants. All living things break down carbon compounds such as sugars to obtain the energy they need in the process of respiration. In this process carbon dioxide is formed and released into the air. CO₂ is also formed during decay and burning. To reduce atmospheric CO₂ we need to grow more plants so that more CO₂ is used up and less released. Burning coal releases CO₂ that plants sequestered thousands of years ago.
Climate Change Resource List

The following websites provide international and local information about climate change.

http://www.ipcc.ch/index.htm
Intergovernmental Panel for Climate Change (IPCC)
The IPCC is a scientific intergovernmental body set up by the World Meteorological Organization (WMO) and by the United Nations Environment Program (UNEP). Its constituency is made of:

• The governments: the IPCC is open to all member countries of WMO and UNEP. Governments of participate in plenary Sessions of the IPCC where main decisions about the IPCC work program are taken and reports are accepted, adopted and approved. They also participate the review of IPCC Reports.
• The scientists: hundreds of scientists all over the world contribute to the work of the IPCC as authors, contributors and reviewers.
• The people: as United Nations body, the IPCC work aims at the promotion of the United Nations human development goals

http://www.bgci.org/.../plants_and_climate_change.ppt
Botanic Gardens Conservation International Education: A useful powerpoint presentation for communicating about the links between plants and climate change.

http://www.bgci.org/climate/whichfuture/
The report details how plants and climate change are intimately connected, and explains why it is crucially important for us to act now to save the world's plants.

http://www.sustainability.vic.gov.au
Victorian Government website showing their response to Climate Change and other sustainability issues

Books
(and Gore, Al, *An inconvenient Truth* DVD)

Learning Experiences

Plan 10 actions that you can carry out at home and school to reduce climate change.

Weather patterns
Find Melbourne's rainfall and temperature records for the last 100 years. Make a graph of them and look for any patterns that emerge. Has there been a cyclic pattern or is there a noticeable trend over time? Compare records for other parts of Australia and other parts of the world.
Investigating Carbon Dioxide

Collect some indicator solution (soil or fish tank testing kit or make some red cabbage indicator). Blow into the indicator through a straw (be careful not to drink any) and note the colour change that occurs.

What is in your breath to cause the change?

Research respiration to find out when and where it occurs and what is formed. This process is like slow burning. Find out other processes which release carbon dioxide.

Why do countries want to have a carbon tax or an emissions trading scheme? What is the purpose of these initiatives? Below are some websites to start fact-finding.


Have a debate to consider which method your class thinks is the best way to reduce the effects of climate change.

Write a song about carbon, its forms and uses, including why too much carbon dioxide is undesirable.

Design a children’s picture book to encourage them to look after the environment and feel empowered to make a difference. (look at Belonging by Jeannie Baker, The Tomorrow Book by Jackie French or One Child by Christopher Cheng for ideas)

Rain Gardens

Plan ways of collecting run-off to use to water gardens. How can you reduce the erosion caused by run-off? Design a system to collect rainwater, slow down the flow to reduce erosion and allow the water to be absorbed into the ground. Try out your ideas using sand trays. How can you remove impurities and rubbish washed down with the rainwater? Could you build this at home or at school?

http://raingardens.melbournewater.com.au/ Melbourne Water provides brochures about rain gardens also
http://www.abc.net.au/gardening/stories/s2294599.htm This is a Gardening Australia fact sheet on building a rain garden.

Conserving water

Locate a part of the school ground that is dusty or muddy. Design a way of improving the area to make it more pleasant and user-friendly without using water. For help please refer to the Melbourne Water website http://www.melbournewater.com.au
Exploring Sustainability at the Royal Botanic Gardens

Lower Yarra Habitat - Long Island


(Winner of the 2004 Savewater Awards for Garden Design/Construction Category)

This project has transformed an area comprising largely weedy plant species and low value exotic plants into a space which represents a significant collection of indigenous plant communities that existed, prior to European settlement, more widely in the CBD and region of the Lower Yarra. Today, these plant communities are very fragmented or non-existent in this region. The planting of 29 wetland species (14,000) and 67 terrestrial species (10,000) of locally ‘known provenance’ plant species from five plant communities has significantly increased the Royal Botanic Gardens’ indigenous plant biodiversity. These communities include:

- Swamp Paperbark Thicket
- Riparian Scrub
- Grassland Woodland
- Cliff Escarpment Shrubland
- Wetland Community

By enriching the plant biodiversity, this project also strengthens the links with other remnant vegetation, habitat and fauna along the Yarra River corridor. Locally, habitat has been improved for significant local avian fauna such as the Giant Egret, Nankeen Night Heron and Reed Warbler, which are present on the site. It is hoped that diversity of other fauna and invertebrates will increase over time. Research, such as frog surveys, has been undertaken to establish base data and measure any changes in the frog population as the habitat on Long Island develops. It enables a focus on the importance of plant conservation and biodiversity.

The Boonwurrung people now have a site to demonstrate their history and culture through the work of our Aboriginal Liaison Officer. Included in this collaboration are aspects to enhance the successful Aboriginal Heritage Walk program and any other associated events.
Long Island Irrigation

On average, this collection has initially received minimal irrigation to establish the plants or about a 70-80% reduction in water use compared to other equivalent and well-managed irrigated areas in the Gardens. Ultimate savings of over 95% are expected as the plants reach maturity. Water sensitive design principles were integrated into landscape planning, including careful plant selection and zoning according to plant water requirements. Stormwater drains directly from path surfaces into garden areas for plant use and bio-filtering prior to entering the lake system.

The terrestrial plant species generally require minimal irrigation, as they are adapted to the local climate and rainfall regime. The Riparian Scrub and Swamp Paperbark Thicket communities represented in this collection are proximate to the Ornamental Lake and are able to use this water supply rather than need irrigation. The Grassy Woodland and Cliff Escarpment Shrubland communities are zoned higher up on Long Island because of their adaptations to seasonal dry periods.

Long Island Wetland

This area was formerly part of the main Ornamental Lake. However, to aid the establishment and life cycle of indigenous aquatic plants, it was physically separated from this water body. The wetland area is also being used as a model to consider effective establishment of macrophytes (water plants) and the improvement of water quality in the Royal Botanic Gardens Lake System. Blue-green algal blooms are normally almost an annual event in the Ornamental Lake. However, within the wetland or billabong, no blue-green algal blooms have occurred since it was constructed and aquatic plants were established.

The reduction of blue-green algal blooms and improvement of water quality in the Lake System is a key consideration for the Royal Botanic Gardens, if the Lake water is to be a component of future sustainable water use.

The Long Island Project is generously supported by Parks Victoria and Conservation Volunteers Australia.
Water Conservation Garden

This garden showcases plants with low water requirements.

Many people think to have a garden that does not use a lot of water means not having plants that flower however this garden has many beautiful flowers with interesting leaves.

Plant strategies for survival
- grey foliage
- furry leaves to reduce water loss
- fleshy succulent leaves to store water
- waxy or furry finish to leaf
- thick or shiny reflective surface
- growing close to the ground
- deep running roots.

Use of organic mulch

Organic mulch is any organic material that can be spread on top of the soil to stop wind or sun from drying out the soil. Mulch keeps the roots of the plants cool, and it helps to stop weeds which compete for water. Mulch also helps stop erosion.

This is an ideal garden to plant at school as it can survive long stretches without water, even surviving school holidays.

Many Australian natives and herbs from the Mediterranean are ideal for a water conservation garden.

Watering

The best time to water your garden is in the early morning before the heat of the day, or in the evening after the sun has gone down. The most efficient watering method is a drip system. Plants prefer good water once a week rather than a short burst every day. A long soak encourages deep root growth.
Working Wetlands

The Royal Botanic Gardens is an urban environment which is used by thousands of people each year. It is a resource used for scientific, educational, conservation and recreation purposes. There are many factors that effect the management and sustainability of this resource in an urban environment.

Melbourne’s water supply has been in a state of depletion over the last ten years due to a number of contributing factors: significant droughts, the growth of Melbourne’s population and the effect of climate change. These factors have contributed to the need of a sustainable water management program within the RBG.

The Working Wetlands project aims to revitalise the lake system at the Royal Botanic Gardens. The current reduced water volume and poor visual quality of the lakes are symptoms of an ecosystem under threat.

In recent times, issues including evaporation, lack of seasonal flushing and water circulation and increased nutrient levels have reduced the water volume and quality within the lake system. Blue-green algal blooms are problematic during summer and low water levels have exposed mud flats in Ornamental Lake and Nymphaea Lake.

The Royal Botanic Gardens is a leader in water conservation practices and has already made significant reductions in its water use in the last decade whilst managing a complex heritage site. Prior to 1995 water consumption at the RBG was 250 mega litres per annum; between 2000 – 2010 sustainable efforts were made to reduce the number to 130 mega litres.

Current climate change predictions including drier landscapes with less rainfall and higher temperatures are expected to increase the amount of water required to maintain the RBG collections. It is predicted that water irrigation requirements will increase to 180 mega litres per annum.

The Working Wetlands project brings together water quality and water saving strategies enabling the RBG to:

- improve the long term health of the lakes and in the process reduce the likelihood of blue green algae blooms in the Nymphaea, Central and Ornamental Lakes
- create new wetland ecosystems which will support wildlife such as water birds
- improve the general amenity of the Lakes by returning lake levels to their normal depths
- reduce the amount of dirty water that flows into the Yarra River and Port Phillip Bay
- provide a healthy lake system that is the foundation for water storage that can be used for irrigating the RBG’s priceless plant collections
- provide a unique opportunity for RBG staff to educate visitors about the environment and effective water management
- in the future, reduce the garden’s reliance on potable (drinking) water for irrigation
How does Working Wetlands work?

External storm water is diverted from Anderson St, Birdwood Avenue and Domain Road via the storm water drain into the Gardens lakes systems.

Storm water run-off from the streets that surround the Gardens carries a variety of pollutants including detergents, fertilisers, litter, animal faeces, oil and petrol. This storm water pollution flows into the Yarra River, before being dumped into Port Phillip Bay.

Gross pollutant traps (circular screens) have been built near these storm water diversions (one near Gate A and the other between Gates E and D - just south of Nymphaea Lake). These traps collect gross pollutants travelling through the storm water system and remove the debris before the water is filtered through the newly constructed wetland system.

The circular screen separates gross (large) pollutants from the incoming water and keeps them in a separate chamber. Solid items in this chamber are kept in continuous motion to stop them from blocking the screen. Heavier pollutants sink into a litter sump. Circular screens trap coarse and some fine sediment and can retain oils, so they remove many of the pollutants in storm water.
The gross pollutant traps (GPT’s) are cleaned by means of a vacuum or basket lift mechanism. A host of materials including empty cans, bottles, soil, and leaf litter are captured and removed by the device. Pollution collected is categorised as organic (leaves- which can be recycled), litter (general rubbish) or sediment (soil). Unfortunately finer particles, which may contain nutrients and heavy metals, are unable to be captured by GPT’s. The collected material is then taken to landfill.

Gross pollutant Trap – Circular Screen

The water then flows into the newly constructed Floating Treatments Wetlands in Nymphaea Lake, Central Lake, Ornamental Lake and Long Island.

The water firstly flows into the receiving wetland and sediments settle out in the first pond.

The water then moves through pools of varying depths over a number of days. During this time, the Floating Wetlands within the lakes which have been planted out with macrophytes (aquatic plants) which use bio – filtering to control pollution.
The bio-film of living microscopic fungi and bacteria are the ‘engine’ of the wetland – they remove nutrients from the water. The plant roots mass harbor this beneficial bacteria that produces the sticky biofilm. The nutrients in the water are taken up by macrophytes and the bio-film growing on them.

The water flows out of the wetlands with reduced nutrients and with little suspended sediments. Some of this filtered water enters Ornamental Lake to be circulated through the system again and the rest is diverted to the storage tanks via a pump which is then filtered, and UV treated before being used in the irrigation system.

Pumps will circulate lake water via underground pipes from the Ornamental Lake to Guilfoyle’s Volcano. From Guilfoyle’s Volcano, the water will flow by gravity to Nymphaea Lake, and the process is repeated again.

**Elements of Working Wetlands**

**Floating Treatment Wetlands:** a constructed treatment floating wetland island engineered and designed to enhance the processes and interactions that occur in natural wetlands between water, plants, microorganisms, soil and the atmosphere to remove contaminants from the water in a relatively passive and natural manner.

**Bio- filtration:** a pollution control technique using live material to capture and biologically degrade and process pollutants. It is commonly used in waste water and capturing chemicals from surface run off.
**Macrophytes**: an aquatic plant that grows in or near water, it can either be emergent (growing above the water), submersgent (growing under the water surface) or floating (growing on the top of the water).

**Rock Riffles**: placement of quarried rock on the bed or banks on a slope that is steeper than the natural stream to create a graded weir. Benefits include control of water flow, stabilization of sediment, creation of wild life habitats and increased oxygenation of the water.

**Biofilms**: mass aggregate of microorganisms

The floating treatment wetlands are made from recycled plastic covered in coconut fibre (coir) and have been planted with predominantly indigenous plant species.

Plants require nutrients to grow, however high nutrient levels (nitrate and phosphate) are one of the more common pollution problems in Australian waterways, and are the main cause of algal blooms. Plants growing in and around the wetland absorb these nutrients as do the bacteria from water and soil, thus reducing the chance of algal blooms.

These wetland areas will help attract and retain water birds and other native aquatic fauna in the lake system. Long-necked tortoises, eels and native water rats will find more cover and in the wider range of plants around the water’s edge. Introduction of some sloping gradients to the lake edges will encourage migration and increase frog populations.

**Further reading and references**

- RBG Environmental Stewardship Policy 2011
- Community Engagement and Consultation Strategy Working Wetlands project Feb 2011
- Shortlands Wetland Centre- wetlands.org.au
- [ecolinc.vic.edu.au](http://ecolinc.vic.edu.au)
Learning Experiences

Estimating tree height

Try this maths activity in the school ground or at home.

The height of the tree divided by the length of its shadow is equal to the height of a stake divided by the length of its shadow.

Therefore, to estimate the height of the tree:
- measure the length of the shadow of the tree
- hammer a stake in the ground and measure the height of the stake
- measure the length of the stake’s shadow
- calculate the tree’s height using the formula

(\text{length of tree's shadow} \times \text{height of stake}) / (\text{length of stake's shadow})

Based on Burke's Back Yard information:
see also:
http://www.landlearn.net.au/fieldwork/tree_measurement.htm
Information about calculating tree height, circumference and volume.
http://www-saps.plantsci.cam.ac.uk/worksheets/activ/prac7.htm
Methods of estimating tree height using geometry written for children

Filtering dirty water

In many suburbs you will see rain gardens being built to filter storm water from streets before it goes into waterways.

Investigate how these gardens work by making silt and rubbish traps of rock and sand. Pour dirty water through the traps and see how effective they are in removing debris and suspended materials.

Research which plants are most efficient at absorbing excess nutrients, oils and other pollutants found in storm water.
Design a garden to prevent polluting materials being washed into the bay.

Write a story that shows the benefits of keeping our rivers and oceans clean.

Paint a picture or make a collage showing the importance of keeping rubbish out of waterways.
Bibliography


Beardsell, David and Cam, *The Yarra, A Natural Treasure*, Royal Society of Victoria, 1999


Hutchinson, Frances, *What Pest is That?*, Bay Books, 1992


Murray, R.D., *A Summer at Port Phillip*, Edinburgh, 1845


Presland, Gary, *The Place for a Village, how nature has shaped the city of Melbourne*, Museum Victoria, 2008

Young, Ann, *Environmental Change in Australia Since 1788*, Oxford University Press, 2000

Vol. 1 Thematic Environmental History. [Vic_Water_Supply_study_Vol1_partB.pdf](http://www.dpcd.vic.gov.au/__data/.../Vic_Water_Supply_study_Vol1_partB.pdf)

Recommended Resources


(and Gore, Al, *An inconvenient Truth DVD*)


Picture Books


French, Jackie, *The Tomorrow Book*, Angus and Robertson, 2010

McRae, Rodney *Cry me a River*, An Angus and Robertson Publication, 1991

Acknowledgements

*Principal writer and project coordinator* Dorothy Dhaeze

*Contributing writers*: Joe Blake, Sophie Kenny, Lana Phillips, Christine Joy, Gary Shadforth, Emily Kinns

*Photographs: front cover* Malcolm Jackson, *Purple Swamp Hen* RBG collection, *other photographs*

Dorothy Dhaeze