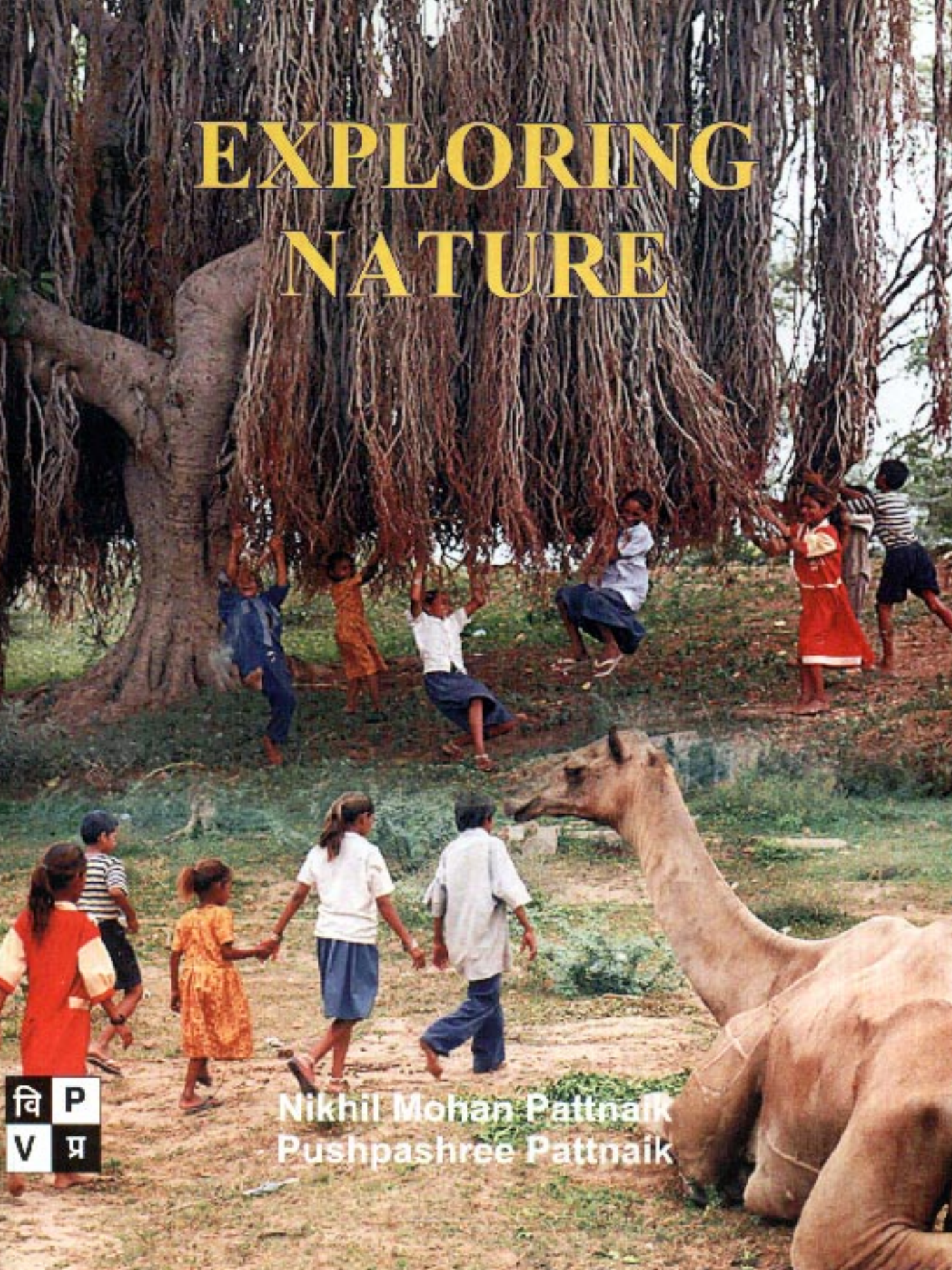
EXPLORING NATURE



Nikhil Mohan Pattnaik
Pushpashree Pattnaik

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Views from a nature corner

EXPLORING NATURE

A guidebook on activity based nature study

Nikhil Mohan Pattnaik
Puspashree Pattnaik

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Phones : 26864157,26864022 Fax : 26965986
E-mail : vigyan@hub.nic.in
Internet : http://www.vigyanprasar.com

Exploring Nature: A guidebook on activity based nature study

Author: Nikhil Mohan Pattnaik,
Puspashree Pattnaik

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National Council of Science & Technology Communication (NCSTC),
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Email: *sruianik@sancharnet.in*

Artwork : Braja Kishore Jena

Photographs: Srujanika

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Project Coordinator : B.K. Tyagi, NCSTC, DST

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Publisher's Note

The Publication Programme of Vigyan Prasar has taken shape in the last few years. Vigyan Prasar has brought out publications on a variety of topics of Science and Technology. Popular Science Classics, India's Scientific Heritage, Natural History, Health and Do-It-Yourself are some of the series that have evolved over the years. Our emphasis has been on bringing out quality publications on various aspects of Science and Technology at affordable prices. Further, Vigyan Prasar is putting in efforts to bring out publications in major Indian languages for various target groups.

The present book, *Exploring Nature: A guidebook on activity based nature study,* by Shri Nikhil Mohan Pattnaik and Smt. Pushpashree Pattnaik attempts to present simple activities to enthuse people in thinking afresh about the environment around them. The experiments/activities described in this book do not require expensive equipment and anyone with inquisitive and sensitive mind can carry out these experiments. These are an outcome of years of practical studies and experiments by the authors and their dedicated group. This book would prove useful to children, teachers and also those engaged in science dissemination.

November 09, 2004
New Delhi

V.B. Kamble
Director
Vigyan Prasar

Foreword

There is a wide diversity of living organisms which is the hallmark of life. Fruits, vegetables, fish, grains, etc., available in the local market, flowers in the parks and gardens, the large variety of birds in the neighbourhood, etc., are easy to observe and distinguish by size, shape, colour, smell and sound. If one has access to a simple microscope, several other forms of life can be seen in drops of water from different sources. Indeed, there is a large variation in size and complexity in the living world.

There are several similarity amongst organisms. It is educational to compare and contrast, categorize and segregate different life forms including several variety of grasses, cereal crops, flowers, butterflies, spiders, beetles, etc., which are easy to collect, study and release back from where these are collected. Several scientific systems of classification have emerged from observation of morphological and taxonomic characteristics - structure of roots, leaves, fruits and flowers, plants, number of legs in insects, mouth parts, wings, etc. Correlating local and scientific names of these large variety of life forms is interesting research.

Coupled with the process of modernization of agriculture is that of rapid urbanization - twin prongs of a pincer which threaten traditional habitats and life forms. On the one hand extinction of local species of plants, fish, mammals, etc., is being reported due to developmental pressures and on the other hand exotic weeds and insects are being introduced deliberately and some times inadvertently. Long periods of drought or heavy rainfall sets up a response system amongst plants and animals upsetting the food chain and habitats in the region. Rivers are often the receptacle for industrial or sanitary effluents which are poor in oxygen and threaten aquatic life. A forest fire can change the composition and balance of vegetation and animals, birds and insects in the region dramatically.

There are complex and multi dimensional factors at work and often in opposite directions. The impact of insensitive planning is becoming increasingly obvious. A non-formal approach to environmental education amongst middle and high school students and teachers can create sensitivity about biodiversity and develop better capacity for participatory decision making. The publication in your hand has evolved from the innovative work of Nikhil and Puspashree Patnaik who lead the science based voluntary organization 'Srujanika' at Bhubaneswar.

Several open ended activities included in the manual can serve to initiate a process of experiential learning understand and the importance of complex relationships in nature. These will become obvious to the readers as one progresses with the activities suggested while enhancing skills of observation and classification.

Resource persons organizing science activity camps and others involved with school ecology clubs and community science clubs will find this positively useful. Many resource persons and trainee teachers have made valuable contribution to this manual and due to demands of space they will have to, unfortunately, remain anonymous. We can add more activities and improve the explanations, illustrations, etc., in the next edition, so we welcome your suggestions and feedback.

(ANUJ SINHA)
SCIENTIST 'G' & HEAD
Rashtriya Vigyan Evam Prodyogiki Sanchar
Parishad and Science & Society Divisions,
Department of Science & Technology
New Delhi.

Preface

This book presents a series of simple activities relating to the living nature around us. The activities have been chosen to be interesting in themselves. When taken up as such, these activities should help in developing a habit for looking closely at things around and to bring about an appreciation for natural objects and processes. At the same time, enough background has been included to link the activities to broader concepts of science, particularly to that of biology and ecology.

Children can use this book directly. But it aims to be more of a resource book for the adults interested in working with children. These adults may be teachers, volunteer workers or just interested relatives. A few important points needs to be pointed out to the adult guides. That is local names and terms for the plants, animals and processes must be used while working with the children. For this they will have to interact with some knowledgeable, but sensitive, professionals to learn things for themselves first. They should also develop the habit of doing the activities themselves first before facing the children. This will also help them in collecting the appropriate, locally available, materials needed for their work. Lastly, please keep the approach informal and enjoyable.

This book is the result of the collective efforts of all workers of *Srujanika* who have spent many enjoyable years in learning, developing, adapting and practising with children these activities. Among the more involed were Sampad, Jeeban, Milan, Namita, Bharati, Geetanjali, Minati, Sibaji and Alekh. Over the past three years we have had a chance to share our experiences on this nature work with many friends in different parts of the country. This has helped us greatly in altering the presentations in the book in many ways. The book would not have been possible without the initiative, encouragement and even indulgence towards us, of all friends at the NCSTC. We are deeply grateful to all of them and to the numerous others who remain unmentioned here.

We hope that the users of this book will help us in improving it further with their valuable comments and experiences.

15 October, 2002 Nikhil Mohan & Puspashree Pattnaik

1. Introduction

In the widest sense nature includes everything. Things around us as well as those far away from us. We ourselves too form a part of it. But in a more commonly used sense it refers to things not made by man. And this again would include almost everything from stars and rocks to plants and animals. And also all processes from wind and weather to living and dying. In a still simpler way the term nature brings to our mind things that live and grow, ie., the living plants and animals. We also include in this view of nature the things and the surroundings that help in the process of living and growing. Thus nature would mean plants and animals; soil, air and water; forests, streams and even the desert.

While man has no role in creating nature, he shapes it in many different ways. He does so in course of his dependence on it for almost everything. Man looks to nature for food, shelter and almost all other basic needs. More importantly, nature provides a learning environment for the human beings. It also provides a setting for all his creative instincts. For children, free from all deeper thoughts, nature simply becomes a source of fun. It provides them with a familiar surrounding which they can relate to easily. They build a variety of relationships with nature's components and become an integral part of it in the process.

Nature and the child learner

As with everything else, children see themselves at the centre of their surrounding nature. Having placed themselves thus, they try to display a masterly *understanding* about it. This simply reflects the intimacy and familiarity they develop with nature in their early life. This simplistic *understanding* is often mistaken by the adults for a logical and knowledgeable one. As a result, the adults around them - teachers, parents and guides - try to strengthen this understanding and start loading them with facts, concepts and theories. Faced with such structured study quite early in their learning life, the adaptable child switches to a process of book-learning. As a result of such a presentation, devoid of fun and freedom, their fondness for and intimacy with nature

just evaporate. Unfortunately, this is the approach which prevails in our present system of education.

A different approach would be to accept that the child's fledging *understanding* is really just a sketchy personal picture based on make-believe *reasoning*. And also to realise that the impression in our minds that the child already *knows a lot* is a false one. We can then use the child's pre-existing interest as an excellent starting point for true learning. An excellent way to lead them on would be to *explore nature* in a guided manner through a variety of fun-filled hands-on activities.

These activities would enhance children's fascination for things around them, when taken up without any curricular pressure. Doing so in an informal out-of-clssroom setting will be even more effective. This will encourage and guide them into exploring the environment by themselves. In course of time it will help them in developing an even more intimate, but true, understanding about nature. In a way, this guided approach would also compensate, to however small an extent, for the loss of nature-based peer-learning opportunities of the older days. Such opportunities are disappearing fast as a result of many changes in our physical and social environment. Such group play almost always took place outdoors - in a natural setting, be it in a small backyard or in the wilderness. And most of the activities - from climbing trees for berries or to look at a bird's nest to splashing around in a stream looking for fish - taught one in very subtle ways to appreciate the intricacies of nature.

Thus the basic objective of this book is to present a selection of hands-on fun activities for children. These activities can be taken up independent of one another in any sequence and each one can be completed in a relatively short time. This would encourage a child to take these up either as an entertaining hobby or a science club project, either individually or with a group of friends. In a school setting this would help in fitting into the timetable easily. For curricular purposes, appropriate activities can be selected and be woven into a longer-term lesson plan, as needed. On the whole, this book can act both as a **guide book** for the user child or a **resource book** for a classroom teacher or for a science activist guiding children's activities.

Only such activities have been included which do not demand any special skills, equipment or environment. Hence, these can be taken up in a location and season independent manner, in contrast to field-based work, with only minor modifications. Once the love for nature is aroused and some basic experience relating to it is gained through this approach, specific field-based activities would become more meaningful.

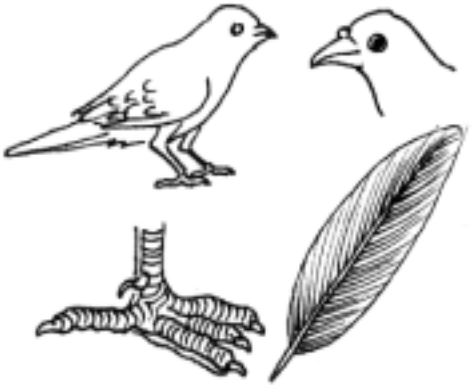
2. Ways with nature

A feel for nature: ***nature watch***

Generally speaking, one does not equate the act of just watching something with exploring it. With nature, however, this need not be stricktly correct. One can indeed learn and understand a great deal about nature by just keeping one's eyes, and other senses, open and watching it. This is because nature is so changing and dynamic. In fact, it is the interplay of so many living and nonliving components taken as a whole presents itself as nature to us. And because of this characteristic, nature keeps on changing in many many different ways - some extremely fast and some very slow. A small bird may scoot right past our eyes while an eagle would be gliding leisurely high above or a snail might be crawling along even more slowly. Changes in the seasons and meadows would show up in a few months but it would take years for a big tree to grow and show significant changes. By sitting out and watching even for a few hours one could come across a variety of animals busily going about an even wider variety of activities.

All these put together becomes an exciting activity - *nature watch*. To a casual observer it will be a relaxing and inspiring experience. But to a serious and persistent observer this simple watching would reveal many things about the living nature. With patience and perseverence it can be developed into a major skill and can yield valuable results. One can trace the roots of landmark discoveries like the theories of *evolution* and *continental drift* to such keen watchers, although with a very high degree of skill, perseverence and scientific background and insight.

A major watch activity familiar to all nature lovers is *bird watching*. Spotting, identifying and observing their living ways from a vantage point would come under its purview. A casual watcher would know the birds of the neighbourhood and, perhaps, a few interesting things about them. But someone involved seriously with it may travel to remote places and try to spot extremely rare or even previously undescribed species.



Another very popular and established watch activity, though not coming directly under the subject of living nature, is *sky watching*. In many ways this is an easy activity to start with, but can advance to a very involved and technically demanding stage. The naked-eye visibility, apparently fixed positions of the stars as well as their predictable appearance and disappearance in the night sky makes one's initiation easy. The interesting patterns with imaginative forms and lores associated with the stars makes it more fascinating.

The less-regular sky objects like the sun, moon, planets, meteors and comets provide the beginner with variety and change while still not catching them entirely unprepared. Advanced watchers find their challanges in catching the hard-to-see and the variables with different instruments. And still greater challenge and a chance of new discovery for the advanced amateur sky-watcher comes in the shape of comet-hunting. However, star-watching always provides an entertaining break for any nature lover while out looking for night life.

Such specialised activities like watching birds and stars, requiring long-term involvement, are beyond the scope of this book. Also, it would not be possible to do justice to these subjects in the limited space here. However, these being well developed areas, plenty of resource materials are readily available to help anyone interested in these directions.

Watching animals in the wild

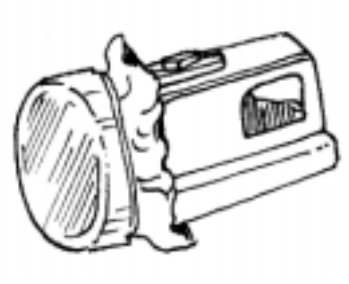
One can spot a variety of small animals even in a backyard or a city garden. A large park or an open field in the quieter countryside can provide one with a much larger variety. By waiting patiently the nature watcher can enjoy the activities of these animals.

On the ground one would find both land animals and birds looking around for food and burrowing or collecting materials for nesting. Birds perching, preening or feeding the young on the tree branches can be as interesting as, say, the antics of a group of monkeys - especially that of the younger ones.

While most animals are more active during early mornings and evenings, all times of the day or night will have something for the keen observer. One can identify the best timings for a particular area and for any particular types of animals after a few exploratory visits. One should also identify specific areas frequented by one's favourite species and suitable spots to observe them during the initial scouting.

Locating safe and comfortable perches which would offer unhindered view of a wide area, but from where the observer would not be very noticeable should then be the next step. The perch should preferably be on the down wind side of the area under observation so that the observer's smell carried by the wind would not scare away the more sensitive animals.

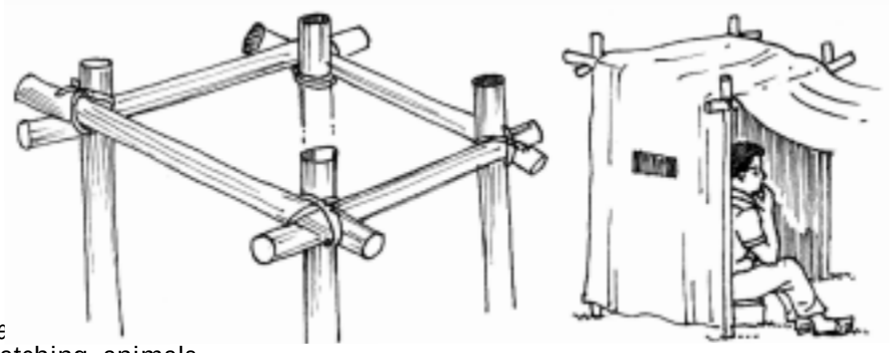
A torch light covered with red cellophane film is useful for night observation since most animals are not sensitive to red light and also since it does not disturb the dark-adapted human eyes. A pair of binoculars would be very valuable in getting a closer up view without scaring the animal. More powerful



Red light for night

binoculars would offer greater details, but would be heavier and will have a smaller field of view. Those with low power would make spotting easier but identification difficult. Hence, one will have to make a choice according to one's purpose.

For prolonged observation, especially during cool evenings, an improvised covered shelter - a *hide* or *blind* - can be easily constructed from light wooden or bamboo poles and greenish brown canvas or sack cloth. Windows can be cut into the cloth and covered with transparent sheets to aid viewing while keeping the cold wind and insects away.



A *hide* for watching animals.

Shrubbery and meadows do offer their share of animal sighting. But a shallow stream attracts still larger numbers and variety, especially at dawn and dusk. It will also provide glimpses of active aquatic and amphibian life.

Animals can also be attracted with food. Leaving food materials in somewhat protected places would bring out some animals. The type of food-bait would vary with the target animals, but grains, nuts, fruits and bread crumbs are generally enticing for birds, rodents and other small animals. Worms, meat or fish can also be used as baits and will attract some animals specifically. The ideal bait and its placing and timing will have to be worked out through trials over a few days. Once these are worked out and the target animals gotten used to it, observing their habits will be quite fascinating.

Of course, to arrive at a composite picture the observations are to be recorded and compiled. A field notebook and pencil should, therefore, be kept ready at all times. Sketches, however rough, would greatly enhance the value of the notes. It would be even better if some photographs can be taken. The rough notes and sketches can be transferred neatly in to a more permanent record back at home.

Exploring Nature: ***nature walk***

Watching animals and plants in their natural surroundings gives one a feel for the dynamic aspect of nature. But it does require some watching over a prolonged period of time and doing so with patience and persistence. However, the result in the end is rewarding; it gives one a deeper understanding on the observed things and events.

Another approach to get an overall feel is simply to walk into nature. By walking around an area one gets physically close to the natural features. It gives one an idea of the diversity of these features and helps in identifying those which would be of special interest. One can then stop at these things of special interest to observe closely and probe further. Nature walk also provides an opportunity to collect samples from the surroundings. Sorting and analysing these samples would give a better idea about the area as well as the collected materials themselves.

Preparing for the walk

An area which can be covered within a reasonable time at a leisurely pace should be chosen for nature walk. It need not necessarily be far away in the countryside. In fact, it would be better to do so around one's own home or work place a few times so as to know what all are to be found around the place. Even in the heart of a city one can find a park or a school campus for this. Of course, the type of things one comes across would vary from place to place and also from season to season.

As with nature watch, or for that matter any other nature activity, a pocket note book and pencil should always be kept ready on hand. This can be used for sketching out a map of the area covered and to mark on it specific features encountered during the walk.

Some other things one would need to carry on a nature walk are: glass and/or plastic vials and transparent polythene envelops, of various sizes for the collected samples, rubber bands to close the envelops, ink/medicine droppers to collect watery samples and spoons to scoop out soil and other solid samples, a large bag to carry everything back without crumpling them up.

Essentials for the *walk*.

During the walk

It is important to remember that the walk is intended to give a quick overall idea about various aspects of the area. Hence more attention should be given to the variety of vegitation, animals, land features - both natural and man-made, apparent changes that have taken place recently or over a longer period of time etc. rather than to details of, say, a specific tree. Forming a broad mental picture during the first walk would help in selecting points for further study.

Sketchings and collection from the *walk*.

Samples of soil and rocks, dead plants/animals, twigs, rotting leaves, bones, feathers or any other plant/animal body parts can be collected during the walk. Specimens of common small plants and animals - especially insects, water samples along with aquatic organisms can also be collected and brought for further study and preservation on return from the walk. Marking on the sketch map the places from where particularly interesting samples were collected will help in going back there for more detailed study on later walks.

While collecting samples it is important to take care of personal safety like avoiding stings and bites or contact with poisonous plants etc. General care should also be exercised while collecting samples from any water body/swampy area as well as from steep slopes and heights. Plants and their parts should be collected in limited quantities so that their growth is not seriously harmed.

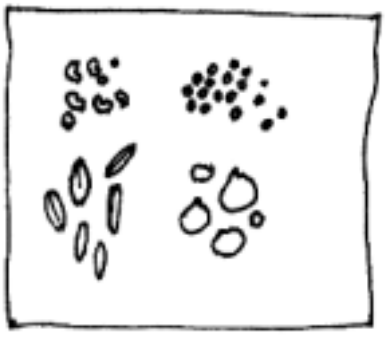
Analysing and preserving the samples

Samples brought back from the walk should be spread out on a sheet of paper and sorted into different types. Broad categorisations like living - nonliving, plant - animal, natural - manmade etc. would be a

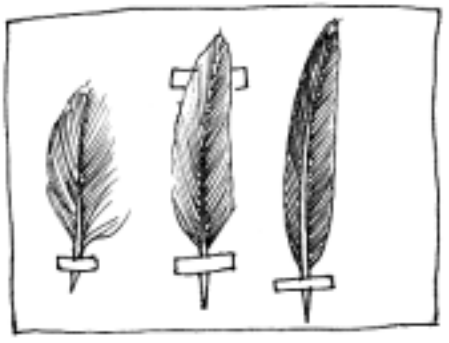
natural starting point for the sorting process. Further divisions within the broad groups can then be taken up in as many different ways as possible. This exercise would provide a good opportunity for interaction among the walkers. Discussions on the reasonings behind their sortings can be lead towards the science of systematics.

After sorting out and discussing about the samples, the non-living specimens can be kept in a collection as such. These can be presented as a pleasing display in a variety of simple and inexpensive ways, a few examples of which are shown here.

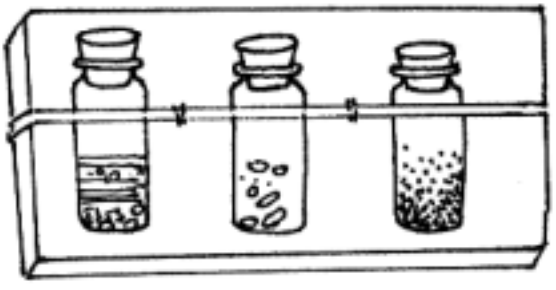
Maintaining a collection of non-living things.



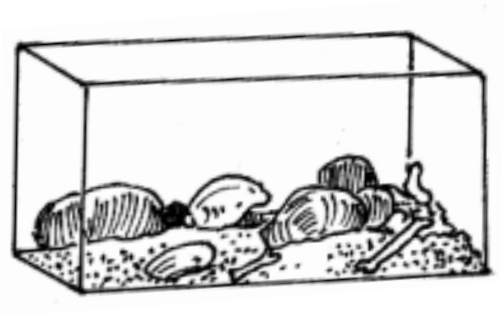
Small grains or pieces sprinkled on spots of glue on stiff paper.



Feather etc. mounted on card.



Placed in small glass phials (eg. those used for Homoeopathic medicines) or in transparent plastic jars of various sizes.



Displaying an old aquarium or transparent bread box or a box made with acrylic sheets as a display case.

The living specimens can be maintained for further study and perishable parts preserved for a collection using methods given later under appropriate sections. As far as possible, the unneeded living samples should be returned to the places where they were collected from.

Worksheet guide for nature walk

Place / Occasion:

1. Location: big city / small town / rural area / wilderness / forest
2. General features: meadow / swampy land / crop field / near a pond / other (specify)
3. Duration of the walk: 30min. / 1 hr. / 2hr / more
5. Distance covered:
6. Notable things seen during the walk:

5. Animals seen in the area:

	Land animals		Birds	Reptiles	Others
	Wild	Domestic			
How many					
What type					
Most common					

6. Types of plants found there

	Big trees	Shrubs	Herbs	Creepers
How many				
What type				
Most common				

7. How do the plants grow: solitary / clumps / patches / climbing / spreading / any other (specify)
8. Distribution of plants and animals:
   - How many plants of the same kind
   - How many different kinds
   - How many animals of the same kind
   - How many different kinds
   - Do all the plants of the same kind are of same height?
9. Is there any peculiarly shaped rock? A pile of garbage? Nonbiodegradable waste? Too much water?
10. How wet is the land? How open? How well covered with vegetation? How shady? How windy? How sunny?
11. Were there any lichen? Mosses? Ferns?
12. Any special features found in that area?
13. Draw a map of the area covered and mark out the inportant features noticed.

Nature hands-on: ***nature work***

Another way to get to know nature well is to probe it with a much greater degree of physical involvement through hands-on activities or *nature work*. This can be going up close to a natural object and studying it in detail. This can also be mimicking something natural by building models or setting up an experiment where natural phenomenon can be closely observed, monitored and even manipulated if desired. In the following sections, which will cover the bulk of the book, such hands-on activities will be dealt with.

It is important to bear in mind, however, that these are examples and samples. Many more activities can be devised based on these and those would touch still wider aspects of nature. This is what the nature-loving user of the book should attempt to do.

The activities selected here focus on the major divisions of the natural world, such as, plants, small animals, insects, soil etc. This has been done to maintain an easy relation with the general curriculum and texts on biology. This approach will also help in developing a background in the subject through supplemental reading while the interest is kept alive through the activities.

Some of the activities cross the boundaries of this subjectwise presentation by touching upon more than one area. Putting together model habitats like a terrarium or an eco-pond and stocking these with living and growing specimens are examples of this. Observing micro-habitats like a cowdung pat or a rotting log over a period of time is another example where the processes of growth and decay can be observed closely together while proceeding in a complementary manner.

In the end, it needs to be emphasised that this section needs *work to be done* for proper appreciation of the ideas presented. This appreciation for *nature work* would open up new ways for developing the ideas further.

3. Fun with plants

Studying the whole

Plants form one of the most visible components of our surroundings. Even in a highly built up area one can find tiny plants in form of mosses, grass and other small weeds. Ornamentals and other potted plants can even be found indoors. It would also be a real big wonder if a few large trees do not meet the eye, may be at a distance. Hence, any activity relating to plants is best started with the exercise of *plant mapping*.

In the simplest sense, *plant mapping* would mean an overall stock taking of the plants one sees in the area. Drawing up of such a plant map would involve noting/doing the following:

1. different types of plants seen. Such as,
   - **trees** - large plants with stout trunks that stand freely,
   - **shrubs** - bushy plants of medium height with branching close to the base,
   - **herbs** - small plants with soft stems, usually found in specific seasons, including the 'grasses' (in a non-botanical sense) that cover any ground,
2. the number of major plants, particularly trees;
3. how many different tree species and their relative abundance,
4. location of the various species in relation to one another - are these solitary or in clusters?
5. names of some of the main plants and what these are used for,
6. drawing a map of the area and marking on it the positions of the most noticeable plants.
7. sketching a profile of the plants as it appears from where you stand.

Drawing up a plant profile

Looking at plants from a distance gives us a quick overall idea of their variety and distribution in a given area. It also brings out some features which characterise each of the plants. Such characteristic features are most noticeable among the trees and can be used to recognise a particular tree at a glance. We can use some of these features to draw up profiles of different trees which will act as a fact sheet of information as well as an identification guide for each tree.

Canopy - the first impression

The first thing that strikes us about a tree is the shape of its canopy - that is the outline presented by its entire mass of leaves when seen from a distance. We are quite familiar with the roundish canopy of a mango or a banyan tree. The canopy of a deodar is like a long oval while that of casuarina is like a triangular spearhead. Palms are characterised by their fan like bunch of leaves on the very top of a tall slender trunk, with slight modification among close relatives like coconut or date palms.

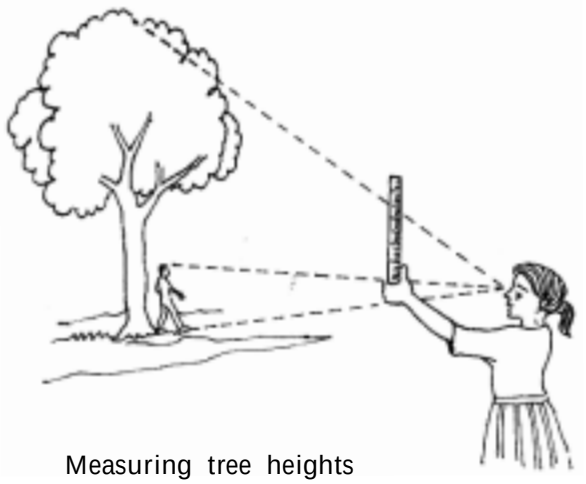
Within the same species some variations in the basic canopy shape can also be found depending on the local factors. For example, the basic roundish canopy of a mango tree growing in a windy hillside may be elongated on oneside because of the constant force of the wind on it. Other variations may come from seasonal factors. An example of this is easily seen in desiduous species - trees that shed their leaves in dry (hot or cold) weather. Such a tree would present solid-looking round canopy most of the year, but would be all branches and sticks, exposing what really was hidden inside, when the leaves drop.

A variety of canopies.

Measuring tree heights

Height of a tree is another thing that catches our eye from far. We have a general idea about the heights different trees grow up to. But that would be for a mature tree where vertical growth has slowed down considerably. Hence to compile the profile of a young tree or to keep track of its growth we need to measure its height.

We need not climb a tree to measure the height. There are many simple and interesting ways of measuring the height standing on the ground only. Here is one of the simplest.



Measuring tree heights

Ask a friend to stand at the base of the tree. Stand at a distance from where you can see the base as well as the tree-top without having to turn your head up too much. Hold a transparent plastic ruler at an arm's length and align its zero mark with your friend's feet and the tree base. Now look through the ruler and find out the length marking where your friend's head appears. Also note the marking where the tree-top is seen through the ruler.

If the tree-top remains above the ruler then walk back some more and take the measurements again both for your friend and the tree-top from the new spot. You can then get the tree height from a simple calculation:

$$\text{Tree height} = \text{Friend's height} \times \frac{\text{ruler marking for the tree-top}}{\text{ruler marking for the friend's head}}$$

Moving up close

As we come closer to a tree more and more features within the canopy will become apparent. Take note of the leaf groupings and branching patterns that would be visible. These will be quite specific for some tree types and would help in identifying them.

Closer still - at a touching distance

When we stand very close to a large tree its trunk becomes the most imposing thing before us. It also becomes very apparent that the trunk sizes vary greatly among different species, bearing no particular relation to the tree height. A slender areca nut palm can be much taller than a young neem tree, yet the neem trunk could be fatter. Still the girth of the trunk within a given species can give an indication of a tree's age and growth conditions. By measuring the girth over a long period of time one can work out the growth rate of a particular tree type and can apply it to estimate the age of another of the same species growing under a very similar condition. However, it will be difficult to use this rate of increase in girth under widely varying soil and climatic conditions.

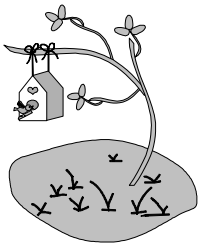
If a tree has been sawed off at its base one can get an idea of its age by counting the growth rings in the trunk. These rings - one for each year of its life - also tell us about the growth rate of the tree. Wider rings indicate faster growth and large differences in the ring thickness reflect climatic variation during the tree's life time. Tree rings can be more easily seen in logs at a saw mill and thin slices can be collected from there.

The tree as a habitat

Before looking at the individual parts of a tree let us look at it closely as a whole. Other than the parts of the tree itself, we should be able to see many other living creatures on the tree. A particularly old and large tree will appear to be a special habitat.

We can find many animals nesting, resting or just looking for food on the tree. This could include a variety of birds, mammals like monkeys and squirrels, may be a ke, a vine snake or a very rare egg eatin snake, the teeming insect life on the leaves, in the cracks of the bark or the fluttering butterflies and hiding moths. May be your pet cat is up there with some mischief in mind and a friendly dog clawing up the trunk after it. There could be patches of lichens, moss or other types of plants, parasitic or free-living, growing on it or a creeper using it for support.

Hence, on the whole, it may well be called a ***tree of life*** for real.



Worksheet guide for a tree profile

Place / Occasion:

1. Location: Big city / small town / rural area / wilderness / forest / backyard / road side
2. Select any one tree (write down the name)
3. How does the canopy look? (draw a picture):
4. How tall is the tree:
5. Are its branches spread out? Is it full of leaves?
6. Describe the leaves:
   Shape Size Colour Border
7. Prepare a leaf print and the leaf outline:
8. Describe the tree trunk
   Colour Thickness Surface texture Height
9. Take a print of its bark:
10. Are there any flowers / fruits on the tree? Describe them.
11. Any other interesting parts like thorns, aerial roots etc.?
12. Can you see any insects on or around the tree? How many?
13. Can you see any birds or animals on the tree? Describe them.
    Name Colour Size Number
14. Are they resting or nesting ? Is there any bird nest on the tree?
15. Draw a picture of the tree.
16. Collect any parts of the plant that can be preserved and include these as a part of the tree profile.

Some special plant types

Wide variation among the plants found even in a small area is quite amazing. Taking a closer look at some of these and making a collection where feasible will bring out the subtler variations. At the same time one can also learn more about many unusual types of plants. A few of such plants, which are found in most places are discussed below. Many other examples can easily be found in any locality.

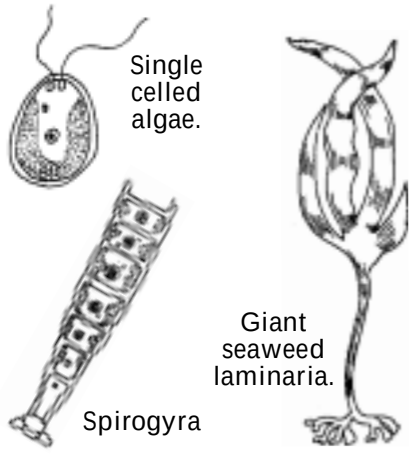
The tiniest plants

Algae: These are very small plants whose body is not differentiated into roots, stem and leaves. But they all contain the green, food-making pigment chlorophyll. They are the primary producer of food and oxygen in most aquatic environment. Because of their very common occurrence in water bodies and important role they are sometimes referred to as the *grasses of the waters*.

Algae are found in many different forms. Some consist of only a single self-contained cell, details of which can be seen only with a powerful microscope. But large numbers of these are very often found as a thin, green or brown coloured, floating layer on standing water bodies.

However, not all algae are physically small. In many ponds we can find bright green threadlike mass of alga *spirogyra*. The oblong cells of this alga are joined end to end to form filaments several centimetres long. A spiral chloroplast can be seen inside the cells under a microscope.

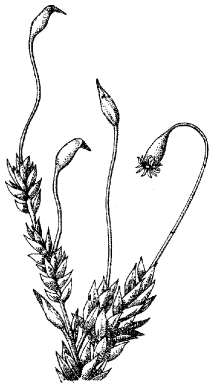
The giant seaweeds of various kind are algae too. These are made up of many many cells and can grow very large in size, still they lack true root, stem or leaves. An example of such algae is the giant sea kelp which grow longer than 30 metres.



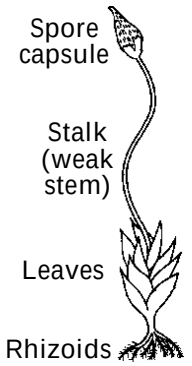
Algae are often found in close natural association with fungi. This very special symbiotic form called ***lichen*** appears as patches of different colours on rocks or trees. These are usually the first forms of life to colonize inhospitable areas like barren rock surface as soon as some moisture becomes available. Through their slow initial growth the area gradually becomes suitable for others. Lichen are very sensitive to harmful substances in the air and are killed off where air pollution is

high. On the other hand, their presence and spread indicates good air quality and the availability of moisture.

Moss: Another commonly found simple plant type is the moss. It is quite easy to see these as soft, slippery patches of green near a pond, a damp wall or almost everywhere outdoors during the rains. Moss is more advanced than the algae but still fairly backward among the plants. They have distinct leaves and stem but no proper roots.



A clump of moss

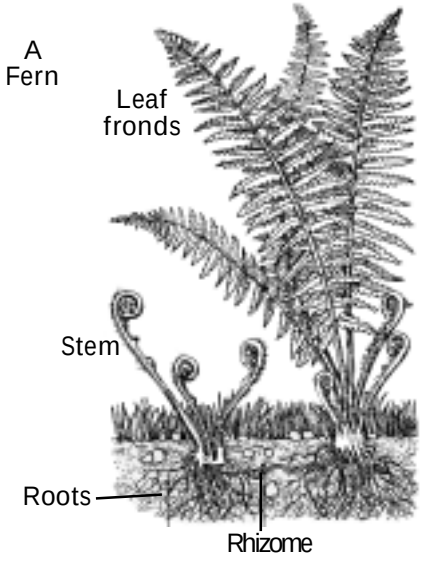


An isolated moss plant.

When seen under a low powered microscope it shows very small green leaves bunched closely together. It also shows root-like threads, called rhizoids, which anchor the moss to surface it grows on. The rhizoids also help the tiny plant in gathering nutrients like a root. Common moss are about one milimeter tall and grow as very closely packed clumps to form dense velvetty mats. When water is not available, mosses dry out and turn brown. But these can spring back to their growing green form even after a year or more.

Fern: While looking around in any swampy area or around a ditch we can find some small plants with pretty and delicate leaves. The leaves would be divided into leaflets and their tips may be curled up. The whole plant would appear as only a bunch of leaves coming out of the soil or from between rocks.

These interesting plants are called ferns - a class of plants that come next higher to mosses in terms of development and have separate roots, stems and leaves. But these do not bear flowers and reproduce through spores. The spore forming organs can be seen as blisters on the lower side of the fern leaves (these leaves are generally called fronds). The fronds come out of the ground as a coiled spring and slowly unwind outside into their normal stretched out shape.



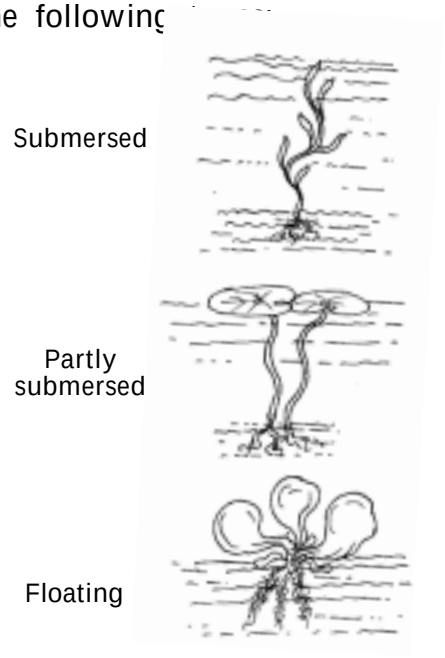
Most ferns are less than a metre in height. But just as there are giant forms of algae, ie., the seaweeds, some ferns grow upto 25 metres tall to fully deserve the name of *tree ferns*.

Plants that grow in water

When we talk about plants, we almost always think of the need for firm ground or soil on which these can grow. It is true that the vast majority of plants, especially the large ones, we commonly see are land plants. While these, as well as all other plants, require varying amounts of water to survive and grow, there are some plants that can grow only in water or in very wet areas. These are called the aquatic plants or *hydrophytes* of which there are very many different types. Because of the wide variations in their shape, size and growth conditions etc. apparent even to a casual observer, collecting and studying them would be quite an interesting activity.

First thing one notes about the water plants is their soft bodies and minimal roots. In many cases these have special air chambers which help them in floating and in supplying air to the submersed parts. The aquatic plants can readily be differentiated into the following

1. Submersed: Which grow completely under water, either anchored to the ground underneath or suspended in midwater (eg. hydrilla).
2. Partly submersed: These water plants are rooted in the underlying muddy layer and have long stems or stalks so that their leaves and flowers can remain floating on the water surface (eg. water lily, lotus).
3. Floating freely in water: Lemna, pistia, water hyacinth are some common examples of this type which are often found to cover water bodies.

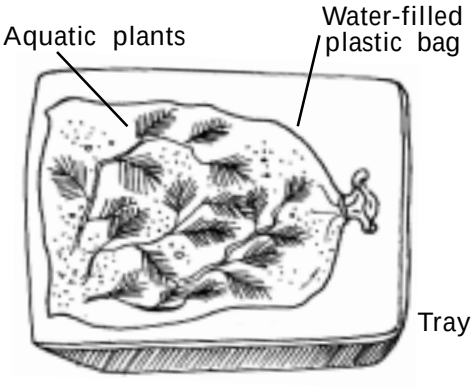


In addition we can also find some plants like water hyacinth and arrowhead which hug the water's edge and grow both in the soggy soil as well as in shallow water. Several plants like *arbi* (colocasia) can also be found growing in the swampy soil.

An activity with aquatic plants

Like all plants submerged plants also produce oxygen in course of their photosynthetic activity. This oxygen helps in supporting the aquatic animal population in that water body. Production of gas by such plants can be seen quite easily as decribed below.

Put some water plants, especially ones with fine leaves, that are growing suspended under water, in a transparent plastic bag. Tie up the opening of the bag after filling it up completely with water, yet keeping the bag limp. Leave the bag in sunlight and after a short while gas bubbles can be seen all over the plant.



These bubbles will soon grow and a gaseous pocket can be seen inside the bag. While additional steps are required to show that the accumulated gas is oxygen, this activity provides a quick and easy way to see the production of some gas under water.

Plants that need little water

Plants can also grow in deserts where very little water is available. Obviously, the plants growing under such conditions need to have some special abilities. Such abilities are generally brought about by suitable modifications in the structure of their body parts, ie., the root, stem and leaves. The group of plants which can make do with small amounts of water, and hence can grow in very dry places including deserts, are called *xerophytes*.

Some of these modifications include a very long tap root to draw water from deep. Others have short but fleshy roots near the surface to catch any little precipitation. The leaves are very fleshy and have thick covering in some cases. In many others these are transformed into sharp spines to avoid water loss as well as for protection. Stems of many dryland plants are thick and fleshy and have water-storing tissue inside.

The most familiar examples of xerophytes are the cacti. Cactus comes in a wide variety of sizes and shapes. Each of these also has different types of thorns and flowers. Cacti are found almost everywhere and are easy to grow and maintain in a living collection.

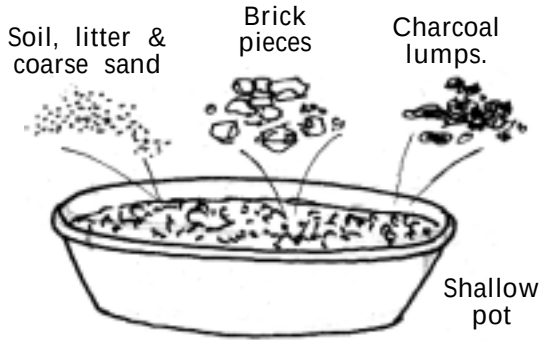
A variety of cacti.

Cacti belong to a group of plants called succulents, which are characterised by thick and leathery leaves and/or stems. While all cacti are succulents, there are many other succulents which are not cacti and do not have thorns.

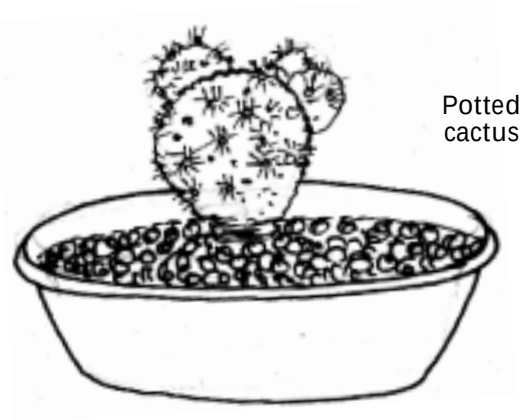
These are also easy to grow and maintain requiring little water and care. Soil and other planting conditions for these are similar to that of cacti. Some common varieties, available in most nurseries and gardens, are agave, aloe and bryophyllum.

Growing cacti and succulents

Cacti require good drainage and are grown best in a mixture of equal parts of light soil, decomposed leaf litter, coarse sand, small brick pieces and charcoal lumps. A small amount of lime helps in their growth. Shallow earthen or plastic pots with drainage hole in the bottom are ideal for growing cacti and other succulents.



Fill about two-thirds of the pot with the above soil mixture. Press some cacti cuttings into the soil and pack larger pebbles or granite chips around to hold the cuttings in place and to cover the soil surface. Water lightly and leave in a sunny place.



4. Fun with plants

Looking at the parts

Having taken stock of a tree as a whole, both from a distance and up close, and having appreciated it as a tree of life, it is only natural that we take a look at the individual parts of the tree. One would need to note the shape, arrangement, colour, smell, taste etc., as applicable, of the leaves, thorns, bristles, flowers and fruits as well as any other characteristic features relating to these parts. In addition to this basic exercise, one can try out many interesting activities, some examples of which are given below, to better appreciate the tree parts.

Bark - a tree's clothing

Variations in tree trunks can also be noticed in their bark. These mature barks can be of different colours, some are smooth while others are rough and some trees have bark that is unbroken but some others would be cracked. In addition to noting down the look and feel of any bark a permanent record of its texture can be made through a *bark print*.

Taking a bark print

Take a piece of strong, but not very thick, paper (parchment or bond paper works well) and hold it flat against the tree trunk. Rub on the paper with a piece of wax crayon using moderate pressure. Adjust the pressure so that the impression of the bark comes out clearly on the paper. This easily prepared bark print would be an interesting part of that tree's profile.

Taking a bark print

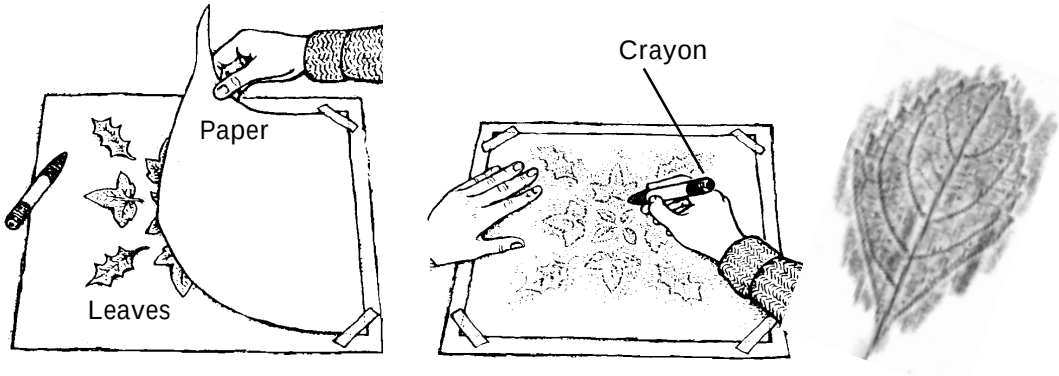
Bark prints

Leaves - makers of a tree

It is the leaves that give a plant its looks. This most numerous part of any tree comes in a wide variety of shapes, sizes and arrangements. In many cases leaves show special properties like aroma, taste, sensitivity etc. But the most obvious characteristic - *leaf shape* - is one of the most useful guides for plant identification. Hence, an accurate description of leaf shape forms an important part of the tree profile. Since pictures are always better than the words, we will explore below simple methods for taking leaf prints and for preserving actual samples of the leaves.

Leaf prints with crayon

Pick a healthy mature leaf and put it with the lower side up on a firm level surface. Cover it with a piece of strong but not very thick paper and rub a stick of wax crayon on the paper over the leaf. An impression of the leaf and its veins will come out clearly on the paper. It works well with most leaves except very soft ones, relatively tough ones with prominent veins work best.



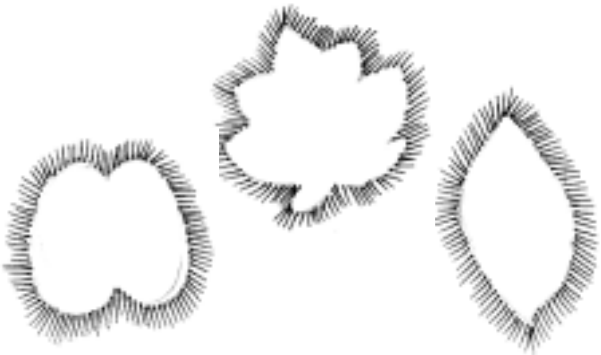
Leaves placed under paper | Crayon rubbed over the leaves | Leaf print

Taking leaf prints with crayon.

Leaf outlines

Place a well-shaped mature leaf, whose outline is to be prepared, face down on a piece of white paper laid on a firm, smooth surface. Apply short and sharp crayon strokes starting on the leaf and coming onto the paper across the leaf-edge. Cover the entire perimeter of the leaf with crayon strokes. On removing the leaf a silhouetted outline can be seen on the paper.

Preparing leaf outline

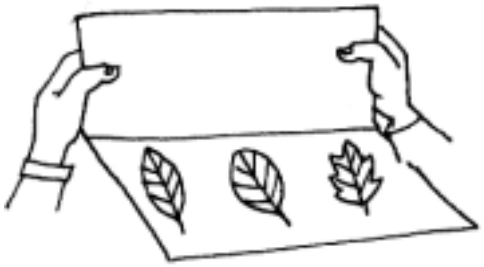


Leaf outlines from crayon strokes

Preserving leaves

Practically any leaf can be preserved by drying. Only, the removal of the leaf moisture should be slow and the leaf has to be kept flat during the drying process. Both of these can be achieved by keeping the leaves pressed between sheets of absorbent paper. Thick blotting paper would work the best, but ordinary (nonglossy) newspaper would also work. Bricks or heavy books can be used as weights to provide pressure.

Leaf pressing



Place leaves flat between folds of old newspaper or blotting paper.

Stack these up on a flat dry surface and cover with a hard board.

Apply some weight by placing bricks or heavy books on the board. Change the paper after a few days.

In a week or two the leaves would become dry. The actual time taken will depend on the leaves and the weather.

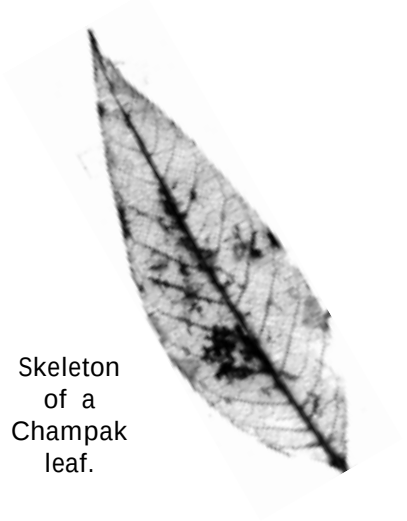
Leaf zoo

The pressed leaves would be flat and thin like paper. These would have kept their original shapes but all would have a brown colour. These can be pasted on paper as a part of the tree profile or to record the diversity of their shape and size. Another very interesting use of these pressed leaves would be to make collages which would resemble various animals. For this one should examine the leaf-shapes carefully and select those which have a natural resemblance to the appropriate bodypart. With a bit of effort one can make one's own *leaf zoo*.

A leaf zoo: Pressed leaf collages with animal shapes taking advantage of the natural appearance of the leaves.

Leaf skeleton

The most prominent features in the leaf prints taken earlier are the impressions of their hard veins. A network of these veins act as a skeleton to hold the softer parts together. Such leaf skeletons can be prepared by digesting the softer parts in hot caustic solutions. However, these can also be gotten in many cases from leaves rotting naturally. Leaves of pipal, champak, phalsa etc. give excellent skeletons after lying around in water or on damp soil for some time.



Skeleton of a Champak leaf.

Collecting other plant parts

Leaves form the most visible and nearly ever-present part of a plant. But there are many other plant-parts which are well worth a closer look. In addition to helping us in identifying a plant, these present us with a wide range of things to study and collect. Here we will touch upon a few of these briefly.

Roots

All larger plants, with only a few exceptions, have roots. These are almost as extensive as the trunk and branches. But being under the ground, well hidden from sight, these receive the least of our attention. We cannot look at the root system of large grown up trees easily. Still a look at the roots of some small plants - grass and weeds - would give us an idea of their large variety.

In order to preserve the delicate root fibres one needs to pull out the plant very gently. It is best to soak and loosen the soil around the plant first. Any adhering soil can be washed off by shaking the root gently under water. Mature woody roots can be preserved just by drying. Softer roots can be pressed as described for leaves and mounted on stiff paper.

A variety of roots.

Tap root system

Fibrous roots

Many plants have other types of parts under the ground which help them store food and/or create new plants. Bulbs, tubers, corms and rhizomes are examples which grow under the ground but actually are modified stems.

Under the ground but not a root.

Onion bulb

Potato tuber

Ginger Rhizome

Just as everything under the soil need not be a root, not all roots are always under the ground. Most common examples of these are prop or stilt roots of the banyan tree. Some others are:

Over the ground stil a root.

Stilt root of the banyan

Climbing root of betel vine

Epiphytic root of orchid

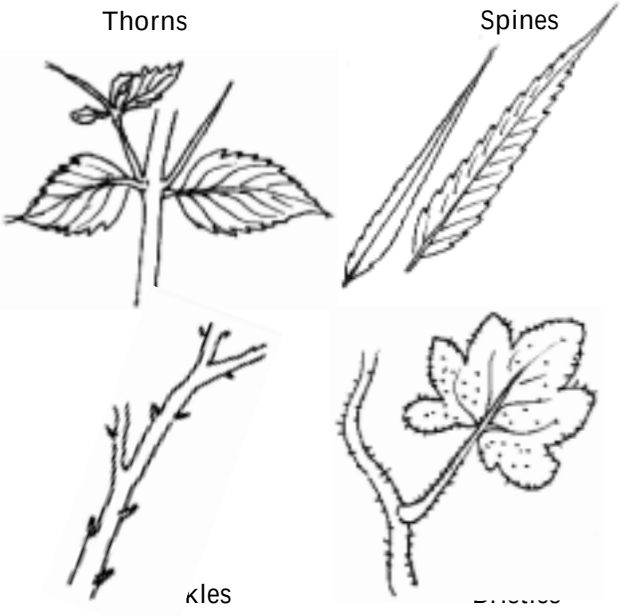
Plant parts that are not Universal

All plants have leaves and roots. That too practically at all times. But there are also some parts which are found only on some plants or on all plants but only during certain times. Parts like thorns and tendrils are found only on some types of plants but all through their lives. On the other hand, flowers, fruits and seeds are to be found on the plants but only at specific times.

Thorns

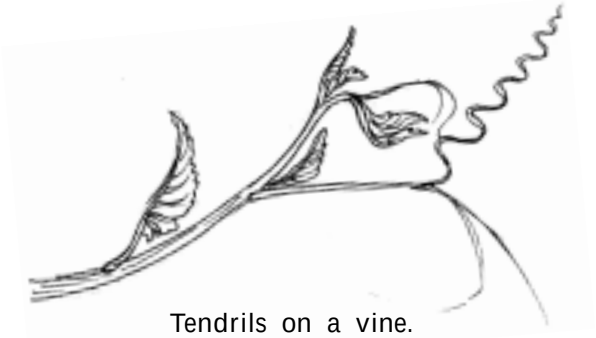
These hard pointed organs form a part of the plant's defence mechanism and come in many forms. While the term *thorn* refers specifically to modifications of the branches as in the lemon or bel plants, modifications or pointed parts of the leaves as in pineapple or prickly poppy (argemone) are called *spine*. Some other forms are *prickles* which are curved (eg. rose), *bristles* or short stiff needle-like hair (eg. prickly pear) and *stinging hairs* (eg. bichhuti).

A variety of pointed parts.



Tendrils

These are thin and curly parts which help many vines in climbing up. Tendrils are usually modification of leaves and are sensitive to contact. These coil around any object they touch and use that as a support for the vine.



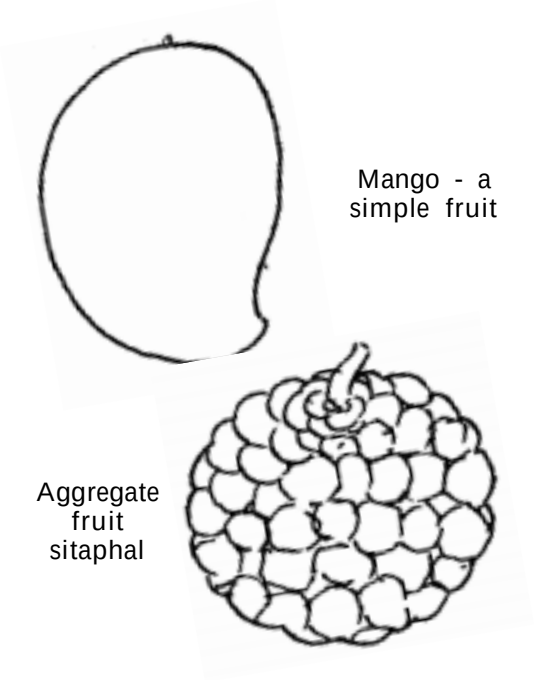
Tendrils on a vine.

Flowers

These are probably the most attractive plant-parts that appear with widely varying periodicity and other characteristics. Some plants bear flowers all year around, while there are a few which bloom only once in several years and some only once in their entire life time. Given the very wide diversity in their shape, size, colour, fragrance etc., collecting and studying the flowers can be very fascinating and instructive for a nature lover. Unfortunately, it is not easy to preserve the flowers in their natural shape. Still some with thin and simple planar petals can be preserved by pressing them like the leaves. However, the colour will be gone when these are dry.

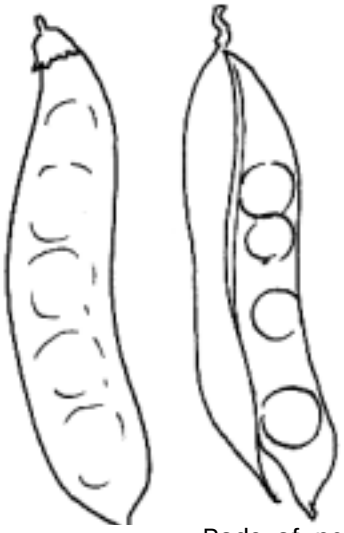
Fruits and Seeds

These followers of the flower also present a very wide variety in all respects. Because of their fleshy, bulky structure and of their perishable nature it is not possible to keep most fruits for any lenghth of time. Still looking at a collection of fresh fruits can give us an idea of their variety with respect to both their external appearance and the internal structure. The majority of collected fleshy fruits would probably be 'simple fruits' like berries or drupes with hard seeds (eg. mango). Still aggregate fruits like sitaphal or champak and composite ones like pineapple or fig would not be hard to come by.



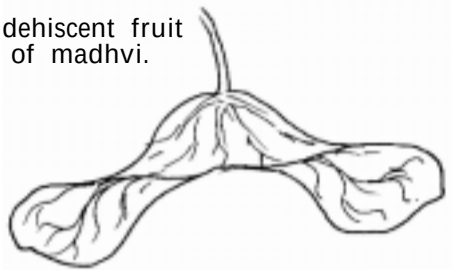
A variety of fruits.

There are also a large variety of fruits which are called 'dry fruits'. These do not have a fleshy coat around the seed and the seeds make up for the fruit's bulk. These seeds are surrounded by thin but hard, especially when dry, coverings or capsules. In some dry fruits these coverings can be split open and seeds removed fairly easily. Pulses like pea or gram and other beans are common examples of these capsular or *dehiscent* fruits. Many of these (eg. giant milk weed *calotropis*) explode when dry to facilitate seed dispersal.



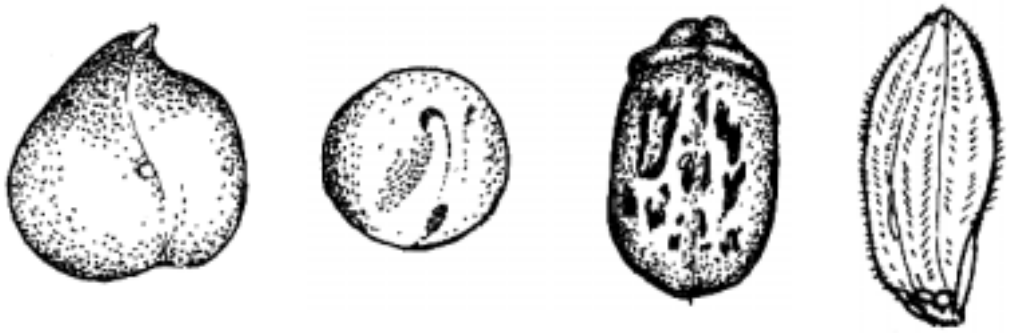
Pods of pea - a dehiscent fruit.

In many other dry fruits the seed and the covering are bound tightly. In some cases these are even fused together. These are called non-opening or *indehiscent* fruits. Some common examples are grains (eg. rice and wheat), nuts (eg. cashew nut) and winged fruits or *samara* (eg. madhvi).



Indehiscent fruit of madhvi.

Seeds, on the other hand, are designed to remain in a dried form for long periods. In fact, it is the dried form that we refer to as the natural state of the seeds. Thus it is easy to develop a collection of these and relate their shape and structure to a plant's life. It is interesting to note the structure of many seeds and dry fruits in relation to how these are dispersed.



Different types of seeds.

5. Fun with plants

Presenting a living collection

Plants, as we saw in the preceeding pages, form a group of excellent study material because of their easy availability in a wide variety and of the ease of handling them. Although plants are easily found in almost all places, a particular plant may not be easy to find at a particular time or place. It would therefore be desirable to build up a living collection of the species needed often. This can be done best in form of a permanent garden or of a large wooded area if facilities and resources are available and if there is a specific requirement for the same.

However for the purpose of this book small collections of living plants can be developed and maintained quite easily and inexpensively. Several ways are available which can be useful for presenting one's collection over short durations. These are particularly useful for maintaining for observation and study, in the convenience of one's own place of work, the plants collected during a field-trip. The process of setting these up can also be very interesting and educating.

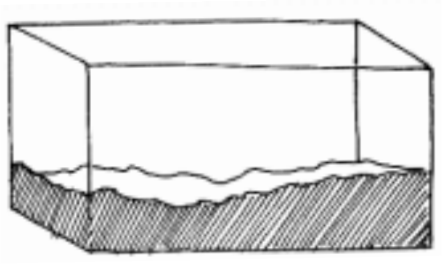
Terrarium - a 'house of soil'

This can serve as a small scale replica of any terrestrial environment complete with the living specimens. In its most general form it is a transparent, airtight container with some soil and plants in it. As we shall see later, this is also a very useful setup for keeping small living animals. A most readily available container suitable for this purpose is an old aquarium. Otherwise, a similar box can be made from perspex sheets in any desired size. Even simpler innovations, as outlined below, are also possible and are fun to make.

Setting up a terrarium

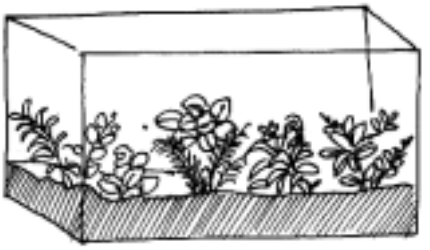
Collect some light soil mixed with rotted leaf litter and a variety of small plants with intact roots, preferably with soil adhering to the roots. Plants collected from a swampy area or after soaking the surrounding soil thoroughly would work the best. Use a trowel to loosen the soil if the plant does not uproot easily just by pulling at the base.

Spread the soil on the floor of the aquarium or other container to be used for the terrarium. Soil depth can be varied towards the different corners of the container to give it the shape of a natural landscape. Place the collected plants on the soil and press down gently. Arrange the plants so that the taller ones remain more towards the back and the sides. A small saucer can be buried in the soil near the centre and be filled with water. Small aquatic plants can be placed in the water and fern like plants just around the saucer.



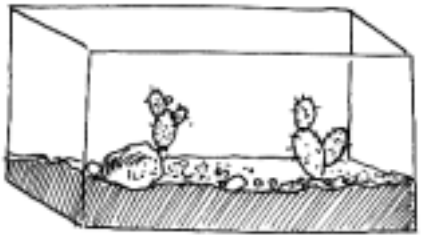
Soil spread on the floor of the terrarium container

Take care to keep the plants in their natural shapes and to avoid over-crowding. Sprinkle some water very lightly, put the lid on and keep it in a lighted place but away from direct sun. The plants will appear fresh after a short time and remain so for several days. Water lightly if any wilting is noticed. The plants would rot if the soil becomes too soggy. Leave the top open to allow any excess water to evaporate.



Completed terrarium.

This terrarium would represent an average garden or field where conditions are not too dry or wet. Other environments can be replicated in a terrarium by choosing appropriate soil base and plants. For example, a collection of cactii over a sandy base would mimic a desert situation, while a swamp can be represented using a soggy soil layer and quasi-aquatic plants.



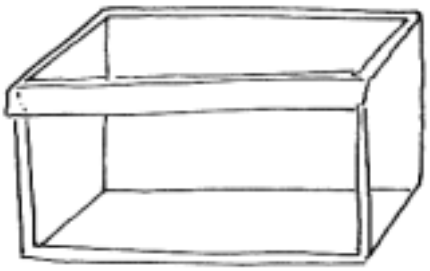
Desert terrarium.

Nature in a box

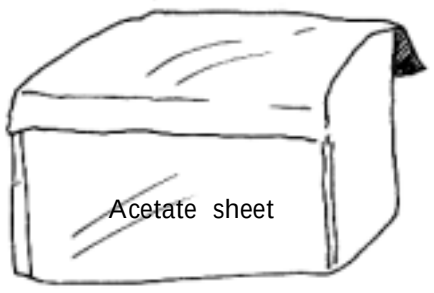
An aquarium or perspex sheets are not always easy to find. Even when available their size may not be very large. But it is quite easy to fabricate a moistureproof box with viewing windows from a discarded wooden

crate (commonly used for packing goods for transport) or from a sturdy cardboard carton.

Remove the top and an adjacent largest side from the box except for a small strip to hold the corners together. Line the entire inside of the box with polythene sheet to make it water resistant as well as moisture-proof. Fix transparent acetate sheet (available at large stationery shops) on the front and fold it back over the top to act as a flexible cover which can be opened. Seal the acetate edges covering the front onto the body of the box using adhesive tape and fasten with thumb tacks for extra support. Polythene sheet can be used if acetate is not available, but it will not be as transparent.



Box with top and front removed leaving a strip in the corner.



Acetate sheet fixed as the front window and as a flap cover on top.

Add soil and plants as before to complete the terrarium. Take care not to add too much soil in case of a cardboard carton to avoid its collapse under excess weight. A metal or plastic tray of suitable size can be kept inside the cardboard terrarium to hold the soil without damaging the paper. When complete, it can be presented as ***nature in a box***.

Garden in a jar

A terrarium can be of any desired size depending on the need and facility. The best containers for small terraria are transparent plastic jars with wide mouth which are commonly used for storing things in the kitchen. Unused or discarded ones are often easily found. A two-litre capacity jar provides a good amount of space and viewing surface for most purposes. But a twohundred millilitre jar will serve just as well if only a few small seedlings are to be kept.

Miniature terrarium: ***garden in a jar.***

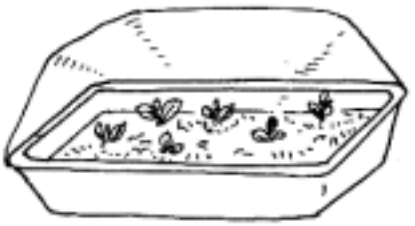
A terrarium can be set up in a jar in the same way as for a box, by spreading a thin layer of soil at the bottom and pressing in the plants. Only, special care has to be taken to add very little water since there is no way for drainage or evaporation and the soil surface is relatively small (a box or aquarium allows enough leakage of moisture).

It is easy and does not involve much effort and expense to set up a terrarium in a plastic jar. Hence a number of such small terraria can be prepared with different mix of plants and can form a ***garden in a jar***.

Building a greenhouse

A greenhouse can be seen as a very large terrarium where plants can be maintained under controlled conditions of temperature and humidity. Large greenhouses built with metal frame and glass covering can be found in professional nurseries or plant research centres. The transparent sides and top allow sun's light and heat to come in and make the conditions ideal for the plants to grow. The water vapour (a 'greenhouse gas') inside traps the heat keeping the temperature higher than outside. This proves particularly useful for growing sensitive plants and seedlings in cooler climate areas and seasons. Like in a terrarium, a greenhouse can be maintained with very little water for growing desert plants.

A simple and readymade model of a greenhouse is a cake box with a transparent cover. The bottom tray can be filled with soil which would hold the plants.



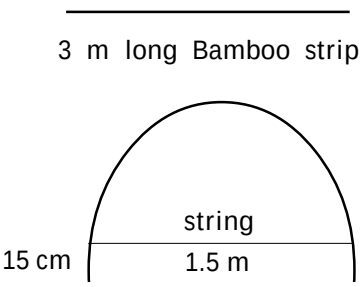
Greenhouse in a cake box

If such a box is not easily available, any rectangular tray fitted with wire arches and enclosed in a clear polythene bag will work as well.

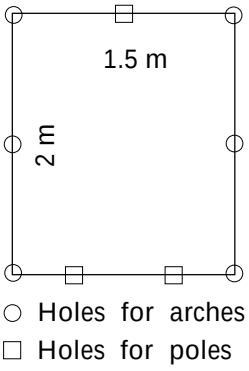
Miniature greenhouse on a tray.

But a real fun and functional greenhouse can be made out of split bamboo slats and polythene sheet as follows.

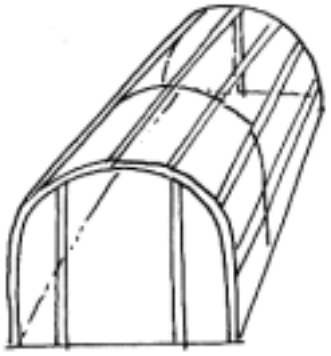
* Take three strips of split bamboo 2-3 cm wide and 3 metres long. Bend these into arches of equal size keeping the ends about 1.5m apart. Tie pieces of strings about 15 cm from each end to keep the bows in shape



Shaped into an arch and held with string.

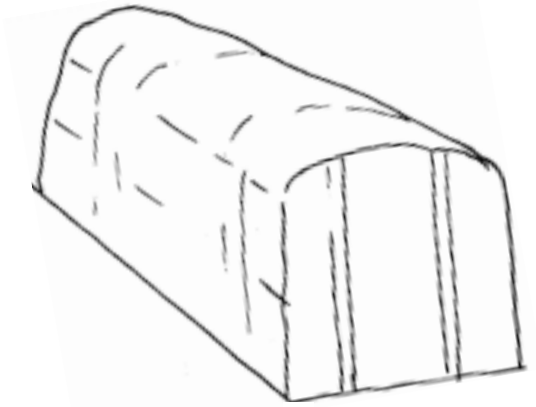


Layout of the greenhouse

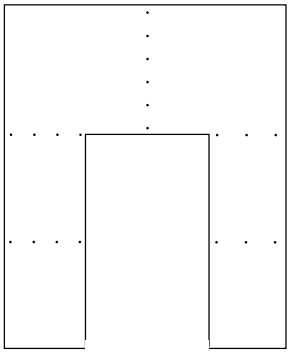


Bamboo framework

* Choose a level ground protected from the midday sun and from strong winds. Mark out a 1.5m X 2m rectangle - the width must be the same as the base of the arches. Dig four holes at the corners and two at the mid-points of the longer (2m.) sides. Push the ends of the arches into the holes and pack soil around to make them stand erect parallel to one another.
* Dig another hole at the midway on one of the shorter sides and erect a straight pole driving it firmly into the ground. Cut it off at the height of the arch and tie it up well. This will be the back of the greenhouse.
* Similarly, erect two poles vertically on the other side 40 cm from each corner. Cut off the excess bamboo at the height where the poles meet the front arch and tie up the ends to the arch. Tie a horizontal strip of bamboo to the top of the two front poles making sure it does not project beyond the arch. This will be the doorway to the greenhouse.
* Take 7 two-metre bamboo strips tie these across the three arches placing the first one at the topmost point on the arches. Fix three strips on each side of the top strip at distances of 25, 50 and 90 cm down the curved surface. Tie up the strips securely to the arches at all points they touch. Tie two horizontal strips at the back connecting the lowest and second lowest pairs of the cross strips. Again tie up at all points where the bamboo strips intersect. Now the frame of the greenhouse is ready and it should be quite rigid.
* Cut out a 4m X 4m piece of polythene sheet and spread it on the frame so that two sides reach the ground with the centreline resting on the topmost cross strip. Wrap the front end of the sheet around the frame of the doorway and fasten with adhesive tape or with large clothes



The completed greenhouse



Layout inside the greenhouse

pins. It can also be held in place by applying stitches at the corners and at a few other places.

* Once the front end is fixed, pull the sheet from the back at the ground level so that it stretches smoothly over the bamboo frame. Fold the excess sheet at the back towards the centre pole (there should be enough on each side for a good overlap) and fasten it there first at the ground level and then towards the top. Because of the curvature of the frame there will be more of polythene sheet at the top which will have to be pleated and folded. Push the polythene sheet on all sides close to the base of the frame and hold down with bricks or by making a bund with soil.
* Fix a piece of polythene sheet 1m wide and about 2m long in the front to act as a flap door. Now the greenhouse is ready.

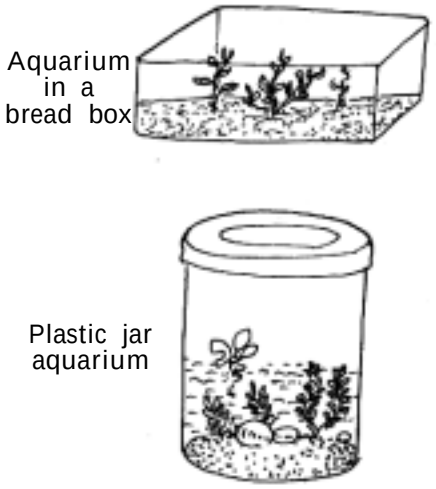
Leave aside some space near the entrance and divide the rest of the area into small plots for planting different things. The divisions can be made by placing bricks, stone pieces, bamboo strips or just soil bunds. Loosen up the soil and plant any collected samples. A small mound of rocks and soil can be made in one of the rear corners and small cactii planted on it. Creepers can also be trained along the rear pole and a refuge pile be made on the other rear corner where dead plants and uprooted weeds etc. can be left to rot.

Water thoroughly once the plants are in place and leave the flap door closed. After a while the temperature and humidity inside will rise markedly and plants will appear pleasantly fresh.

Keeping water plants

Most people are familiar with an aquarium and almost always associate it with keeping fish only. But in keeping with its literal meaning, which is *house of water*, the aquatic plants have a right to call it their home too. Hence an aquarium would be an ideal home for our water plant collection.

Instead of the expensive glass aquaria one can make small ones inexpensively with 2 to 5 litre capacity wide-mouthed plastic jars or food storage boxes (freezer box or bread box) with transparent sides. Place some clean pebbles and coarse sand at the bottom and fill with fresh water to a little below the neck. If municipal tap water is to be used, leave it in the open for some time for the chlorine to go away. Put a mixture of water plants without crowding too much. Adjust the water level so that the tops of the floating plants, often with their beautiful tiny flowers, can be seen easily.



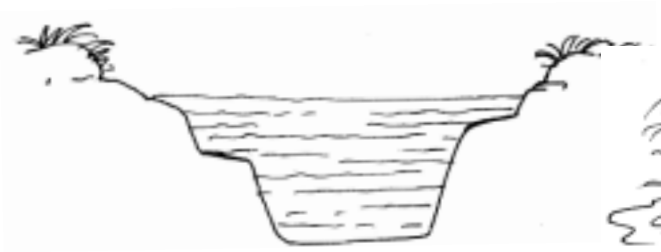
Keeping water plants in simple aquaria.

Keep the improvised aquarium away from direct sun but where it can get enough light. Change the water once in a few days removing any dead leaves and plants. Replace the plants with fresh ones as necessary.

Setting up an water garden (eco-pond)

A larger and more varied collection of aquatic plants can be kept outdoors in an artificial pond. Most simply this can be a large shallow tub buried in the ground to its rim and filled with water. Rocks and plants can be placed in it as in an aquarium.

A larger and more interesting pond can be made by digging a wide but shallow pit and lining it with polythene sheets to prevent water from seeping into the soil. The sides of the polythene sheet should spread out onto the edges of the pond and be pressed down under a soil bund. A layer of sand under the water will help in holding the polythene sheet down and to some extent protecting it from damage. The depth of the pond can be varied and ledges can be created at places to suit different plant types.



Cross-section of an eco-pond

An eco-pond with water plants

Such a water garden requires very little maintenance other than regular topping up with water. To avoid this problem one can apply a thin layer of cement plaster to the sides of the pond so that water does not seep into the ground.

Plants on a hill

A mound of rocks can also play host to a variety of plants. The plant to be found in a rocky area would depend on the amount of soil and water available. As expected these will be very different from what we would find around a water body or on an average field. The speciality of a rocky area can be modelled in our backyard by building a rock mound and planting the collected specimens on it.

We would need rock boulders of various sizes and some soil for this purpose. Mark the outline of the base of the mound to be constructed and put a line of large (but small enough to handle) rocks along it. Fill the inside of it with a layer of small stones, gravel and soil. Put a second layer of large rocks on the periphery but a little behind the lowest outline. Fill up the inside as before. Keep on adding layers of large rocks moving each layer a little mor a sloping outer face and filling up th steepness of the slopes can be varied on c Make sure that the rock pieces sit firmly another and the soil does not spill out. M soil inside by watering gently a few tin push in the roots of the plants at rock jo

A planted rock mound

Put different types of plants on di sides making a note of how much sun side gets. Water the hill sides as neec according to the plant types. The hill w prove a good companion to the eco-pon and the greenhouse in your eco-corner.

6. Fun with plants

Looking at some life processes

As members of the living world plants also grow, age and die. We get to see many of these life-processes everyday without paying much attention to them. Yet, plant physiologists and other specialists spend all their time in studying these. Even without their specialised knowledge we can get a feeling for these processes through some simple activities.

The commonest event in a plant's life that we are most familiar with is the starting of a new plant or *plant propagation*. Many times we might have had direct experience of this event when raising vegetables or flowers in the garden or when trying to keep the yard free of weeds during the rains.

From seeds to plants

When we think of starting a new plant the first thing that comes to our mind is the *seed*. The seed is like a sleeping plant with its own life-support system packaged around it. It contains the plant embryo and enough of an appropriate food mix to see the young plant through the process of germination and early life. The food could be stored in the seed around the embryo in form of *endosperm* (as in cereals) or it may be in like two special leaves known as *cotyledons* (as in pulses).

As we know seeds can remain for long periods of time and start to grow when the right conditions for germination are found. The most important condition is the availability of water and warmth. When this happens the seeds swell and soften by absorbing water. Finally, the seed covering breaks and the plant parts - first the root (*radicle*) and then the shoot (*plumule*) - emrge. The whole process, known as *sprouting*, is easy to carry out and observe.

Root and shoot emrging from a sprouting seed.

Sprouting Seeds

In many households sprouted seeds are prepared routinely for food. This is generally done by soaking the seeds - mostly *dals* like moong and gram - through the day and leaving these suspended in a warm place overnight after draining the excess water. This can be done in a way easier to observe as follows.

* Take some seeds of various dals like moong, urid, rajma, pea, chick pea, gram (fresh and whole, not split) etc. in a wide-mouthed plastic jar.
* Cover the mouth with a piece of nylon mosquito netting and fasten it with rubber bands.

* Add water to cover the seeds and leave aside to soak for several hours.
* Drain of the excess water by inverting the jar and leave it in a slanting position. It will work better if the jar has a slight constriction at the neck to hold a bit of residual water.

* After a day or so the seeds would have sprouted. Time required for sprouting will vary from seed to seed and with the temperature around. In a very dry place you may need to keep the seeds moist enough by adding some water and draining it off from time to time.

A few seeds can be removed at various times from the swollen stage to fully sprouted stage and examined. The seed coat can be removed and the parts separated with a pair of plastic toothpicks and the interior examined with a variety of magnifiers to reveal the developmental stages.

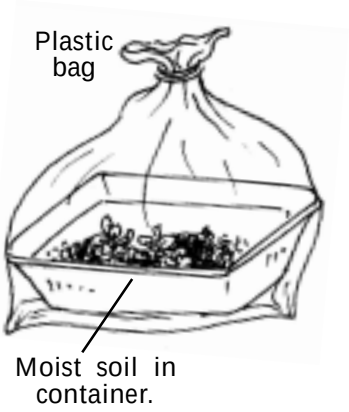
A garden of sprouts

Place a wad of cotton at the bottom of a shallow container and soak it well. Sprinkle some seeds that sprout easily and quickly - mustard and moong work well - and leave it in a warm place. Add water as needed to keep it moist. You can see

the seeds germinate and grow into a dense jungle of tiny seedlings in a couple of days. After growing for several days, if you pull at the top of the bunch of seedlings, these will come out as a single mass along with the cotton base. The roots can be seen to have crisscrossed through the cotton and to be holding onto it very tightly as they hold the soil.

Sprout signature of a place

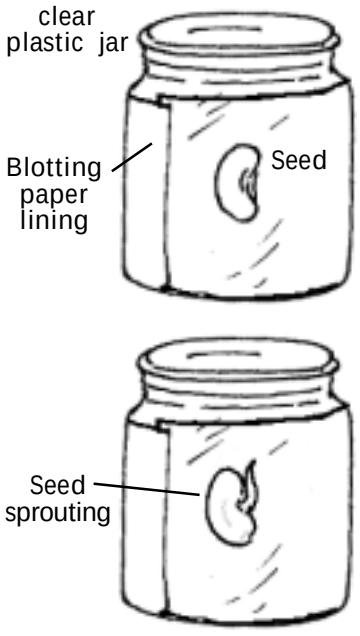
Collect some dry top soil without any vegetation from various places. Put these in separate containers and moisten with a small amount of water. Keep the containers in clear polythene bags, close the bag openings and leave in a warm place. Add water if the soil dries out after a few days. After some time you can notice plants growing in them. Examination of the plants would tell us something about the place where the soil was collected from.



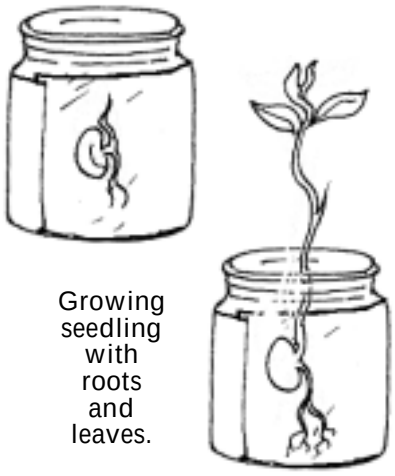
A close look at the sprouting seeds

Although we see a lot of plants germinating and growing in our garden we miss out on much of the process as it happens mostly under the soil. But we can have a good close look at it through a simple setup.

* Take a strip of blotting paper (or filter paper) just wide enough to fit below the neck of a wide-mouthed clear plastic jar (about 200 ml capacity).
* Line the inside wall of the jar with the blotting paper strip.
* Pack the lower half of the jar with cotton wool or any other absorbent material.
* Pull away the blotting paper from the jar wall slightly using a toothpick and put in various dal/bean seeds at different places. The seeds would stay stuck about midway down the jar.
* Put in some more cotton above the earlier wad and add water to soak the cotton thoroughly. Put the lid on and leave it in a warm place, away from bright light.



* Observe the seeds daily through the transparent walls to see the emerging parts of the new plant. Note in which direction they move, how they branch and so on. Open the lid and leave the jar in a lighted place when the shoots reach the top of the blotting paper. Soon the seedlings will grow right out of the jar and the leaves will turn green following their exposure to light. The roots can be seen growing around the floor of the jar and slowly getting enmeshed in the cotton.



Growing seedling with roots and leaves.

It can be seen that when a seed is placed upside down, either accidentally or by design, the root (which comes out first) will move upward a bit and then bend around to head downward. Many such interesting phenomena relating to a plant's early life can be seen easily through this activity.

Garden without soil

In the above setups we will get some fast growing plants. But after some time these will become rather stringy and pale. These will die off if left for a longer period. That is because all we have been providing them with is only water. So once the food store of the seed is used up the plants do not get any nutrients. In our normal plantings these nutrients are provided by the soil - more correctly, by the organic components in the soil (we will see more about it later).

It is possible, however, to maintain plants on water if soluble nutrients are added. In fact this process, called *hydroponic cultivation*, is being used in many places to produce commercial quantities of vegetables and fodder. We can make a small scale water garden using the seedlings grown above.

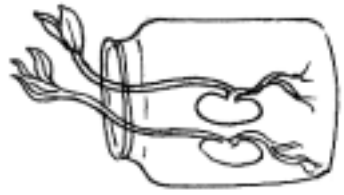
* Make a solution of Calcium nitrate (1 g), Potassium nitrate (0.2 g), Magnesium sulphate (0.2 g), Ferrous sulphate (0.1 g) and Urea (0.2 g) in one litre water. Keep on adding small amounts of this solution (*hydroponic mixture*) to the cotton on which the seedlings are growing so that the cotton remains just moist. Since the solution provides the most essential nutrients to the plant, healthy growth can be maintained over a longer period.

* A simpler hydroponic mixture can be made by dissolving about one gramme of any NPK (nitrogen-phosphorous-potassium) fertiliser mix in one litre of water and adding enough lime to keep the pH neutral. This works well if the local water contains sufficient iron and magnessium.
* The simplest and safest (for the plants) hydroponic solution can be prepared by soaking some fully cured cowdung manure and taking the strained supernatant. Since the potency of this solution will depend on the quality of the manure it is better to make a concentrated extract and work out the appropriate dilution through trials.

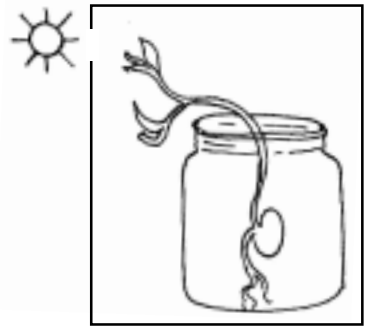
Which way to grow?

In the two foregoing activities we would be left with miniature jungles of young seedlings. These can be used for a couple of other interesting activities relating to the external factors that influence the direction of plant growth.

* Lay one of the jars or containers with the seedlings on its sides and leave it in that position for a few days. Moisten the cotton when necessary without disturbing the position. Soon you will notice that the seedlings are bending sharply upwards and continuing to grow. Set the container upright after the bends have become marked and let the growth continue. The plants will be seen to take another turn upward making a kink in the middle. This happens as the plant parts react to the force of gravity in such a way that the roots always grow downward and the stem upward.



* Keep a container with seedlings inside a cardboard box closed on all sides except for a hole at the centre of one side. After some days the plants can be seen to be bending in the direction of the hole. The driving force for this reaction is the light coming through the hole. This effect can also be seen if the plants are kept inside a room where light is coming in from one direction only.



A very special seed - ever ready for germ

Seeds come in a wide variety of physical packaging. As we saw above all of these carry enough food for their germinating stages. They also need an external supply of water for sprouting. But there are some very special seeds which carry the water needed for starting the germination process too!

One such special seed is coconut, in which the embryo is covered with several layers of protection like the husk and shell. There it rests on the food storing copra filled with water, which is simply liquid endosperm. Coconut can keep for a long time without germinating and travels great distances floating over oceans. But once it finds an warm environment the embryo begins to grow and emerges through the eye (holes in the shell). External water helps and hastens the process, but the seed carries its minimum requirements within!

Growing plants without seeds

Seed is the commonest plant part from which we start growing new plants. But a remarkable quality that plants have is that new plants can be grown from any of its parts. Of course, in case of most plants the use of some special techniques like plant tissue culture or hormonal treatment would be required for this purpose. Still there are many plants around us which we can, and often do, propagate through parts other than seed. The parts we can use for this purpose are stem, leaf or roots. Propagation through seeds is a sexual process, hence the new plants differ from the mother plant in many qualities. The asexual or vegetative process of propagation through other parts gives new plants that truely resemble the original plant.

Propagation through stems

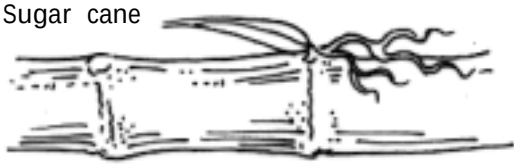
Most commonly this is done by taking cuttings from young but mature stem and planting it in light soil. Plants like croton, hibiscus, bougainvilla, coleus grow from the stems quite easily. Quite often roots

can be seen to emerge by just leaving the cuttings in water.

New plants grow from the nodes in the stem of plants like tapioca and sugar cane. Place a short piece of tapioca stem horizontally on wet soil and push it down so that the nodes are in close contact with the soil. In a few days roots would come out at the nodes followed by the new plants growing vertically.

Tapioca

Sugar cane



Plants from special forms of the stem

As we had seen earlier, many plants have stems that remain underground in modified forms. There they act to preserve the buds, the part where new growth starts, along with enough stored food for their growth. When the overground growth of the plant dies off the modified bud-carrying stem remains underground in a dormant phase and grows into new plants (more in number than the original) when the growing conditions are right again. Some of such modified stems with which we can start new plants are - tuber, bulb and rhizome.

Sprouting a tuber

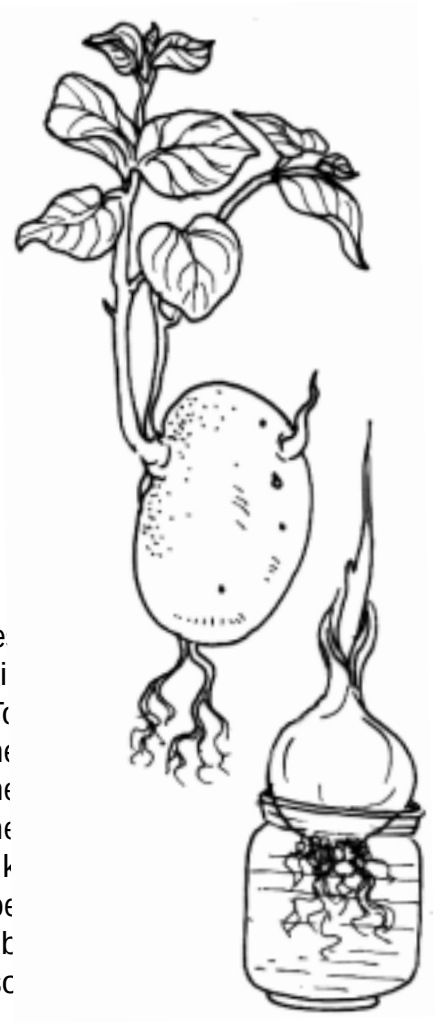
If we look at a potato, a tuber with which we are most familiar with, the buds can be seen as small spots - *eyes* - in depressed areas. When a potato is left around for a long time at normal temperatures it begins to shrivel and sprouts start coming out of the eyes. If enough moisture is available the sprouts will grow into small potato plants and then into mature plants if planted in soil.

To grow the sprouts better we can try the following:

1. Place a potato on wet soil in a cool and shady area and covering it with a piece of thick black polythene sheet. Keep the area moist and look under the sheet from time to time. Sprouts would start emerging in a few days. Remove the polythene sheet and put some loose soil around the potato to cover its lower half. Soon the tuber will rot

away and potato plants will take root in the soil. If you maintain them properly you can even get some potatoes from the plants.

2. For a shorter term activity just to see the sprouting, take pieces of a potato containing the eyes. If you are not sure about the eyes just cut up a whole potato into 2cm X 2cm pieces. Place these pieces skin side up on a layer of wet cotton in a shallow container. Cover it and leave in a cool and somewhat dark place. You will see the sprouts growing out in a few days.



Plants from bulbs

A bulb we all know well is onion. Sometime we find roots and shoots growing out of it i we just leave it around for a long time. Tc have a good sprouting place a bulb on the mouth of a bottle on which it just fits. Fill the bottle with water till it just touches the bottom of the bulb and leave it in a cool dark place. If the bottle is transparent, roots can be seen coming out from the bottom of the bulb into water after a few days. Shoots will alsc start growing upward soon.

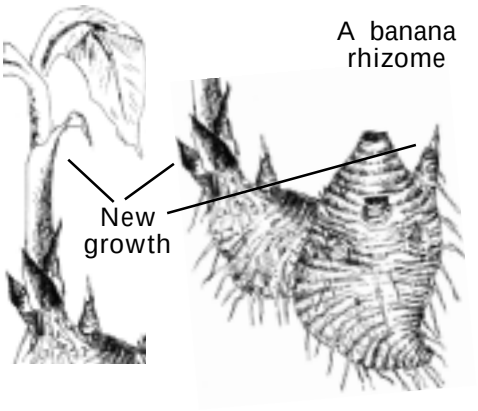
Corm is a special form of a bulb, often called a solid bulb, which has no peelable layers. Vegetables like *arbi* (*colocasia*) and *ol* (*amorphophallus*) are examples of corm and can be planted in the soil to yield new plants and well as more (than the one planted) corms under the ground. Flowering ornamentals like gladiolus and crocus have underground corms which give new sprouts and flowers every year.

Plants from rhizomes

Ginger is a rhizome that we can easily get in a form which can sprout. The other very familiar rhizome turmeric is usually cured by boiling in water before coming to the market and hence cannot grow.

Bury some fresh ginger in moist sand and after some days shoots will emerge. These can be planted in the garden for further growth.

A familiar plant that multiplies through rhizomes underground is the banana. The real banana stem stays underground as a rhizome, divides there and sends up new plants as suckers. What looks like the stem or trunk above the ground is really a bundle of leaf stalks. Although it can grows upto a height of 7m and girth of nearly 1m it is only an herb without a woody trunk.



A banana rhizome

New plants from leaves

Many succulents have buds in the serated edges of their leaves and these leaf buds grow into new plants. When a leaf falls on the soil and water is available (they generally need very small amounts of water) root hairs start growing out of the leaf notches and the young plants follow soon after. Sometimes when the conditions are adverse new plants start growing when the leaf is still on the mother plant.

This interesting process can be seen with the leaves of bryophyllum (pathar chatta or pate gaja). Take some mature leaves from the plant and keep on damp soil or on a layer of wet cotton away from direct sun. You can see the growth of the roots and the whole plant if you keep watching for a few days. A leaf kept between the pages of a discarded magazine will also start growing with help of stored moisture, but it will die out if not transferred to the soil in time.

New plants emerging from a bryophyllum leaf.

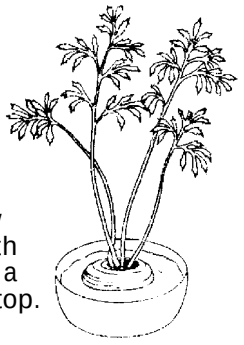
Plants growing from other parts

Plants contain buds, called axillary buds, in many other parts of their body which can produce new growth. We will see two examples of such growth here.

A growing carrot top

Slice off a 1cm piece from the top of a carrot which has the base of the leaf stalks still attached. Place this on a layer of moist cotton in an upright position, i.e. with the leaf base pointing up. Keep the cotton dam

damp by adding water as needed. You will see fresh leaves growing out of the top and root hair growing into the cotton. You can grow it further by planting in the garden.



New growth from a carrot top.

Growing a pineapple plant

Get a pineapple with the clump of leaves intact on the top. As with the carrot above, cut off a 1cm slice from the top along with the leaves. Leave it aside for 2-3 days for the juice to dry up. Press it onto a pot of light soil so that only the fruit portion goes into the soil leaving the leaf base outside. Keep watering it lightly as needed and new leaves will grow in a couple of weeks. Growth can be speeded up by enclosing the pot along with the pineapple top in a clear plastic bag and closing its mouth. It will need some watering, although less than the open pot, so keep watching it.

and from a pineapple top.

When the new growth is noticeable, it can be transfered to the ground or to a larger pot for full growth and eventual fruiting. Incidentally, try to take a close look at a pineapple plant in flower. Tiny blue flowers bloom on each section of a base that looks like a miniature pineapple and present a real pretty sight.

Plants and water

All plants need water, even the ones growing under the driest conditions. Water is collected by the roots from the soil and it moves up to all parts of the plant, often rising to great heights. But how much water does a plant draw up and what happens to it? Some simple activities described here will give us an idea about it.

Plants take up water

Make a *garden of sprouts*, as described earlier, by sprinkling moong or mustard seeds on wet cotton kept in a shallow container. After 4-5 days when the sprouts have grown tall and lanky add some coloured water (washable red ink or any food coloring works well) to the container till it covers the cotton. Keep noting

Coloured water gets taken up by the plants.

the colour of the seedling stems. They would appear the same colour as what has been mixed with the water. Time taken for the colour to move up indicates the rate at which water is being drawn in by the plants.

The same effect can also be seen by placing the stem of a freshly cut soft flower or roots of any soft herb in coloured water. After some time the colour would appear in the petals or the stem. Original colour of the flower should be white or some light shade so that any change would show up easily. A white hibiscus works well.

Where does the water go?

Take some thin and transparent polythene envelopes of fairly large size (30cm X 20cm). Put the tip of a branch inside the envelop and close the opening of the envelop by tying it around the branch with twine. Choose a branch that hangs down so that the tied end of the envelope stays up. Tie several envelops on different types of branches with different types and quantities of leaves. Number the envelops and make a note of which is on what plant.

Water collects in a bag tied to a branch.

Examine the envelops after a 2-3 days. Do you find anything other than the leaf debris in it? Is there some water in the polythene envelop? Untie the envelops carefully without spilling the containts and bring it back to your work place. Compare the quantities of water collected in different envelops and try relating that to the type of tree, nature of the leaves etc. Can you note anything else? Does the collected water have any particular colour or smell. Why?

The water found in the bags answers our original question - what does the plant do with the water it draws in. A major part of it comes out through the leaves - a process known as *transpiration*. Judging from the water collected from a few leaves in this activity we can easily guess that a very large amount of water is drawn in and let out daily by the plants.

Transpiration through the leaves provides a part of the driving force to raise water to the tree tops. It also serves to keep the plants cool. It would not be possible for the plants to survive their continuous exposure to sunlight without this effective cooling mechanism. Release of this large quantity of moisture into the atmosphere also affects the local environment making it more favourable for the growth of other plants and more pleasant for the animals.

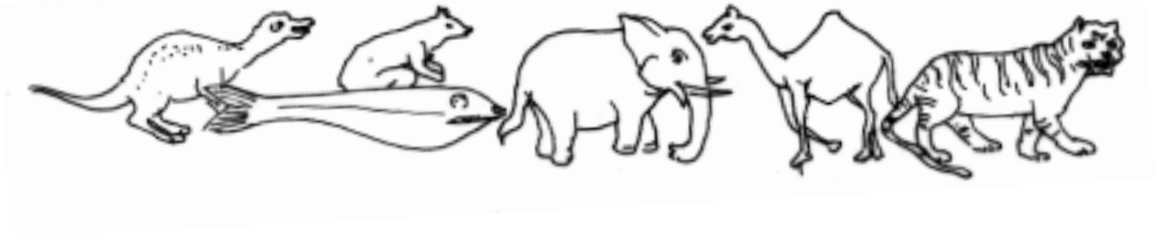
7. The world of animals

More visible species

Animals form the other major visible part of the living world. Microbes, though far more numerous, lead their life more or less unseen and we will deal with them separately later. Two main qualities set the animals apart from the plants - animals can move around and being unable to make their own food from the simplest chemicals, they have to depend on the plants for it. Like the plants the animals are also very diverse in shape, size, life style and living places etc. Some animals live only on land, some others only in water and there are some which enjoy best of both the worlds of land and water. And there are yet others who spend most of their lives high above the ground.

Animals can be divided into two main groups depending on whether they have a backbone or not. Those with a backbone like us are called *vertibrates* and those without it *invertibrates*. Only about 4% of all the animals are vertibrates. Yet when we think of animals only these ones come to our mind. All large animals, reptiles, fishes, birds and amphibians belong to the vertibrate category.

The animals we interact with the most in our daily lives belong to an even smaller group - the mammals. These animals, including humans, have hair on their bodies, bring up their young ones by feeding mother's milk, maintain a constant body temperature and have relatively larger brains. While the total number of animal species known is over a million, there are only 4000 species of mammals. But they are found in a wide range of habitats and many of them are associated closely with human beings. The smallest mammal is the bumblebee bat weighing only 2 grammes and the largest is the huge blue whale (upto 33 metres and 191 tonnes). It is also the largest among all animals that ever lived. Giraffe, the tallest animal, growing upto 5.5 metres, is also



Getting to know the larger animals

Unlike with the plants possibilities for our explorative activities with animals are rather limited because of various reasons. Ethical and psychological considerations limit our activities with animals to mostly observing them live. Killing them for samples is not desirable except when absolutely essential for professional studies. Again, most such observations can only be from a distance. Observing animals in their own environment would be most profitable, but that is not possible for most of us. However, a zoo provides us with a chance to see a variety of wild animals from a wide range of habitats.

For observing over a longer period with some degree of continuity we can choose some species in our own yard or a nearby wilderness as in our *nature watch* activity. Among the relatively larger animals a variety of birds, reptiles, amphibians and a few mammals can be found in most backyards, especially in the rural areas. (We will deal separately with insects and smaller animals, which are easier to find and handle, later).

But the best opportunity to study animals is provided by our pets. It is common to find a cat family sharing our home. Pet dogs are almost as common. It is easy and not too unusual to keep pet rabbits, pigeons, swans/geese, mice also. In the countryside cattle and poultry are easy to find and handle. Thus with a little bit of prior planning many nature study activities can be designed around these animals.

Learning with a cat family

Cats make great pets. In addition to giving us enjoyable company they can help us learn a lot of things about animals in general and mammals in particular. It is quite easy and a lot of fun to watch a litter of kittens growing up. If we keep a careful watch on our cat we can even see the birth and the first few hours of a kitten's life.

The mother cat does all the midwifery, including the cutting of the umbilical cord, herself during the birth of her kittens. Then she dries and cleans the kittens by licking and soon the kittens' fur becomes fluffy. Even before they are completely dry, the kittens crawl up to the mother's teats and start to feed on her milk. Even if you miss the earliest events, the cuddly kittens are all fun to watch from now on.

If we watch closely some of the points we can notice are:

1. The eyes and ears of a newborn kitten are closed and it has no teeth in its tiny mouth. Still it can feel its way around and, guided by the mother's smell, it crawls up against her for feeding.
2. Eyes start to open about a week after birth and become fully open around two weeks. Temporary milk teeth also appear at this age.
3. When about one month old the kitten can walk well and start trying out solid food. The mother cat brings them mice and other live prey.
4. At eight to nine weeks the kittens are ready to face the world on their own. They are quite active and keep prouncing upon anything that moves. They keep on playing among themselves and with the mother. The mother encourages such play with her flapping tail and mock attacks. All this play is really a training for hunting and self-defence.

Using the above general scheme of development of baby cats can you prepare a detailed record on your own kittens? Try to measure their length, height and weight and to draw their pictures at various times. If possible, take a few pictures. Note how the mother carries the kittens around and how limp the kittens appear when being carried. How does the mother react if the kittens are taken away? How does the mother treat them after a few months?

Other animals around the home

Dogs and puppies are also quite common pets and can be watched closely. Try to observe a litter of growing puppies and compare their development with that of the kittens.

* How do the time-scales of their growth compare? Which is more agile and active at the same age? Do both puppies and kittens to catch their own tails? Which of the succeeds more often?
* How do their play differ? How involved is the mother dog with the playing puppies? Does she bring them any prey or food she finds?
* Also see if you can find various similarities and differences in the body stuctures of a cat and a dog - how do their paws and claws differ? What about whiskers, teeth and tongue? Can you relate these to the way they hunt?

There are many other interesting points to note about them. How many can you find? If you play with the puppies and kittens together long enough, you can also make them friends.

Other mammals like rabbits and mice can also be kept as pets and observed. Try and see how the process of raising the young differs from that of cats and dogs. Do they prepare a bed for the babies to be born on? Do the young rabbits and mice have hair on their body at the time of their birth?

If you get a chance to watch a cow giving birth you will notice that the calf is up and moving about in only a few hours after birth. How does it compare with the other animals we saw. With most animals parental care is needed only for a few weeks to a few months. But in case of human beings it is the longest. In addition to the total physical care which may be needed for two to three years, human children need mental, emotional and social care for ten to fifteen years, at the least! Does that make the humans so special?

Birds around the home and yard

These feathered friends - birds are the only animals to have feathers - are quite common in any locality. From the ever present crow, although now they are getting to be rare in some places, in the backyard to the nonflying pets around the house like hens, ducks, geese and swan, they are an attraction for all of us. They too can help us learn about nature, especially about the ways of the birds.

Bird watching is quite an advanced area of study. Even as a hobby it requires a fair degree of involvement over a long period of time. But with a little bit of effort anyone interested can recognise the birds commonly found in any area. Specific guide books and experienced friends are usually available to get one started in this work. With some practice we can recognise the common birds at sight and from their calls. We can also gather much information on their feeding, nesting and other interesting habits both by direct observations and from secondary sources.

Neighbourhood birds usually visit any place with some trees around. They come looking for food and safe nesting places. Water birds naturally stay around water bodies or swampy areas. Early mornigs and dusks are the best times to find birds in their most active state. Finding

out the places where they nest would help in keeping track of their movements and in watching their young ones.

Making birds our guests

In addition to being on the look out for the birds in the area we can set up some feeding arrangements which would make them visit us regularly. We can also attract them to be our guests for a longer time by providing nesting facilities.

Making a feeding table

A simple bird feeding table can be made with a flat wooden board about 30 cm square and fixing four pieces of batten around the edges to make a raised border about 2 cm high. Fix this feeding table at a height convenient for viewing, but should be high enough to prevent cats and dogs from jumping at the birds. Put any kind of grains, bread crumbs or other left overs on the table and watch the birds that come to feed on these.

Feeding arrangements for birds.

Alternatively, the board can be suspended from a tree branch. The string connecting to the branch can be passed through a piece of 20 cm square tin sheet to prevent rats and squirrels from coming down. The bird table can be made even better by providing it with a cover which will protect the food from rain.

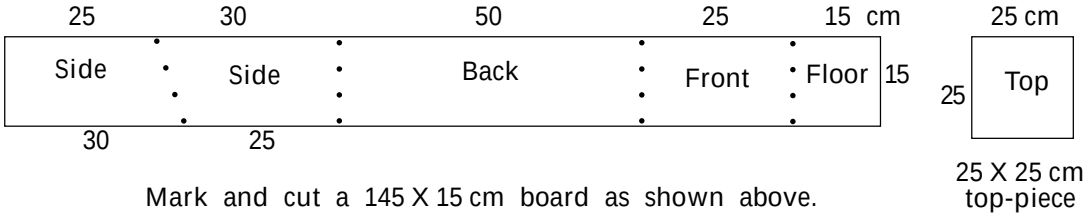
A plastic saucer or even a coconut shell simply suspended from a branch will also serve as bird feeders.

Make a note of the types of birds that are coming to feed and the variations among the visitors at different times of the day or in different seasons. Make a collection of feathers that fall around the table as a record of the visitors.

Building a bird house

Different birds find different types of nesting places and build their nests in many different ways. Many small birds will not mind nesting in any suitable container - *bird house* - placed in a safe place. The simplest bird house would be an earthen pitcher placed securely, with its mouth tilted slightly downward, in the fork of any tree at a safe height.

With a little bit of work we can build a bird house where we can examine their nests easily after they have flown away. Take 19 mm (commonly available 3/4th inch) thick board 15 cm wide and 145 cm long. Cut on the broken line (· ·) as shown below to get the pieces needed for the bird house. Make the top from a separate piece of board 19 mm thick and 25 cm square.

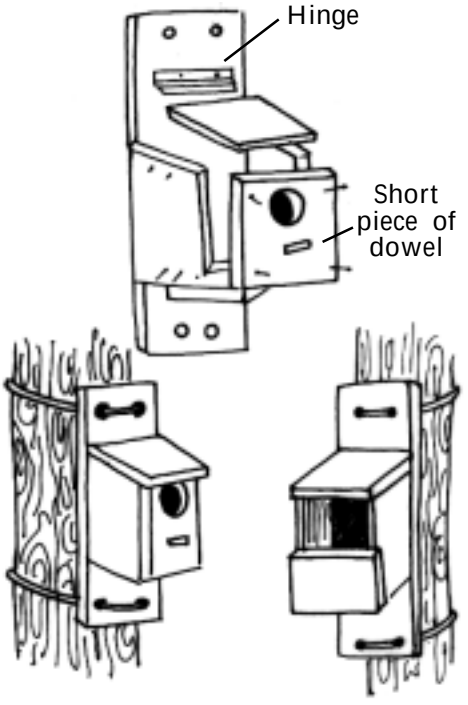


Mark and cut a 145 X 15 cm board as shown above.

25 X 25 cm top-piece

* Make a 5 cm wide hole in the front piece towards the upper edge.
* Fix the other pieces on the back piece so that the back projects out equally on the top and bottom. Make two holes each at the top and bottom of the back piece for fixing it with strings.
* Attach the top piece with a hinge hanging out equally on both sides and fix a small latch to keep it closed against the body of the bird house. A short piece of dowel may be fixed below the opening to project out and act as a perch.
* Alternatively, the top piece can be fixed down with nail or glue and the upper one-third of the front may be left open.

and put it together as shown below.

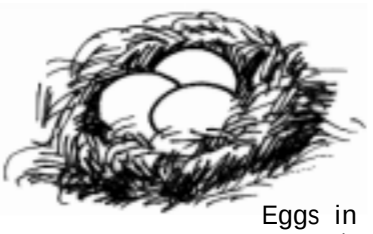


Tie the bird house to a tree securely with the front opening pointing away from the normal wind and rain direction. Late winter is a good time to leave the house on a tree so that birds would find it ready when they start their nest building in spring. With luck you can get a bird family to keep you company for a few months. They would normally fly away when the babies grow up. You can then bring the house down and examine the abandoned nest and put it back up after cleaning.

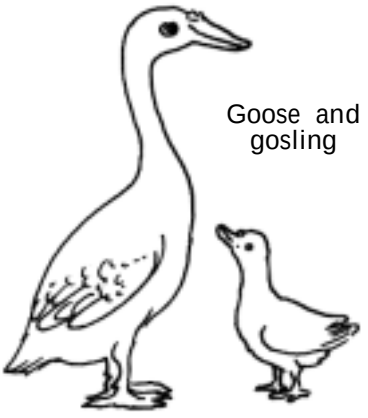
Taking a closer look at the nest

Wild birds will generally abandon the nest along with any eggs if these are handled or disturbed. However, with pet fowls it is possible to take a look at the nests and the way they incubate their eggs for hatching. Geese start laying eggs just before winter whereas hens do so all through the year. With pet hen or geese the eggs can be removed for safe keeping as these are being laid, usually a day or two apart.

After about a month they will start looking for a place to build a nest. Place some straw in a safe place and place the eggs on it. Soon they will fluff up the straw and shape it to a nice and soft bowl-shaped nest. They will line the inside of the straw bowl with down feather from their breast for extra softness and warmth. The mother hen/goose then spreads out her body and wings to keep all the eggs covered. From time to time she will keep pushing the straw inward to keep the nest compact and will also roll the eggs. This will continue for about a month (21 days for the hen) during which she will hardly eat or leave her nest. The eggs will then hatch and the little geese (goslings) looking like larger chicks - fluffy yellow balls - will head for water within a day of being born. Chickens will remain close to their mother on dry ground.



Eggs in a nest



Goose and gosling

Hatching out of eggs - the last minutes

Even though we can watch a goose incubate the eggs and see the little ones soon after hatching, we will still miss out on how exactly the chick comes out of the shelled egg. Luckily for us it is not too difficult to arrange a set up where we can watch this process with hen's eggs from very close quarters.

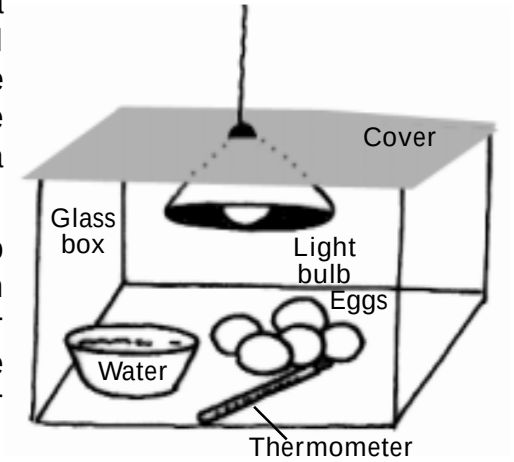
To get chicks we need fertilised eggs from a hen that has mated with a cock. Such eggs are available in many rural areas but they have to be incubated for 21 days at 39^0C for hatching. Although it is possible to build a makeshift incubator for the purpose maintaining the near constant temperature is a difficult task. Fortunately, poultry farming has become quite a common commercial activity these days. So there are many hatcheries which specialise in producing fertilised eggs and raising

chicks from these eggs. For this they incubate the eggs in large incubators for the required 21 days at 39^0 C.

If we can get a few eggs that have been incubated for 18 to 19 days, most of our work is done. We have to maintain the temperature over the final two days when the tolerance to fluctuations is somewhat higher. The following setup works quite well for the purpose.

* Suspend an electric light bulb with a metal reflector inside a covered aquarium (or any other suitable transparent container) and record the temperature under the light with a laboratory thermometer.

  Change the bulb and its height so that the temperature remains between 37 and 39 degrees. Put the eggs under the light once the temperature stabilises. Place a bowl of water near the eggs to provide humidity.



* Keep a close watch on the temperature making sure that it never rises above 40^0 or falls below 35^0. You may need to put some additional cover on the container or switch off the light for sometime to hold the temperature. In case of power failure for a long time, short (to keep the flame low) pieces of lighted candle can be kept around the eggs.
* Keep watching the eggs for any signs of movement or any chirping sound coming from inside. Depending on the temperature some hatching may take place on the twentieth day.
* Faint pecking noise can be heard after an egg shows some rocking movement. Soon afterwards a small break will appear on the egg shell.
* It will enlarge into a crack shortly and will grow further. A wet and sticky chick would be visible partially within the egg.
* The shell will then split into two halves and the chick will emerge as quite a messy creature. The whole process may take an hour or more. After all that pecking and pushing it would be too tired to get up.

It will gather its strength slowly and try to stand up on its wobbly legs which are just getting used to their stretched out form. It will also dry up slowly on exposure to air and in about an hour it will become the fluffy yellow chick we are familiar with. It will also start looking for food

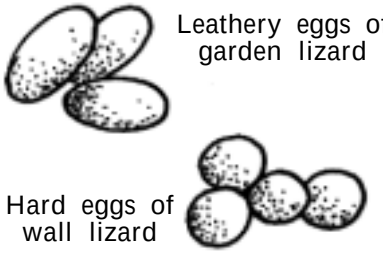
The egg starts to crack ... breaks apart and the wet sticky chick comes out.

and will peck at grains and insects. Sooji (rice bran) makes a good starter food for them for the first couple of days.

After the chicks are dry and fluffy remove them to another more roomy encloser with more ventilation but with a lamp for warming. Provide them with food and water and protect from cats. It is a lot of fun watching and handling these cuddly chicks especially when they have been born right in front of you.

Eggs that hatch by themselves

Unlike with the birds, eggs of lizards hatch by themselves. After the first rains you might notice a garden lizard depositing its eggs in a deep burrow in the ground. If you can locate it after the mother lizard leaves (she covers it up real well) collect a few of the leathery eggs along with some damp soil. Keep it in a transparent container covered with mosquito netting and keep the soil moist by sprinkling water as needed. The baby lizards will emerge on their own when the time comes. These can be kept in a terrarium if insects can be provided as food. Otherwise let them out in the garden and they will take care of themselves.



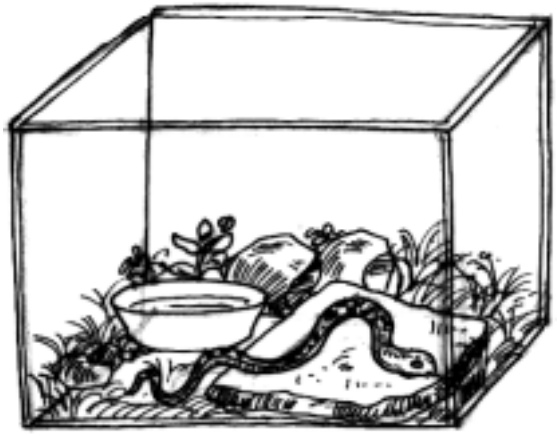
It is even easier to find eggs of the wall lizard (gecko). It prefers out of the way places like behind books and papers, little used boxes, empty bottles left around high on the shelf etc. to lay its eggs. It usually lays one or two eggs which have hard shells unlike the garden lizard eggs.

These white and almost round eggs, about half a centimetre in size, are often found while cleaning up a place. Just leave these in a transparent container covered with mosquito netting and the babies will hatch out in time. Keep the eggs in a place where you can see them regularly. They will die if not released or given food after hatching.

Keeping small animals

We can find a variety of small animals around the house and the yard. We can catch many of them and keep them for some time for watching them closely. An ideal home for them can be made by modifying a terrarium slightly.

Take a large aquarium or a large box with the two larger sides made with transparent material like perspex sheets. The other two sides of the box can be covered with fine mesh wire (or nylon net). Cover the top with mosquito netting and hold in place using elastic bands.



Vivarium - a house of life

Arrange a variety of materials on the floor to provide different types of nesting. Put damp soil with some grass and herbs in one corner with a shallow bowl of water next to it, pile some rocks with a lot of gaps in another corner, put a patch of sand near the rocks, leave a few small earthen pots lying on the side, place a small flat stone towards one side and so on, basing on your experience and observations. Place a potted plant or some twigs against one of the sides.

Sprinkle water to keep the interior slightly humid. You can keep anything you catch in this special terrarium - more appropriately called a **vivarium** or *house of life*. Some of the animals that can be kept comfortably are frog/toad, lizard, snail, insects, mouse, crab, scorpion etc.

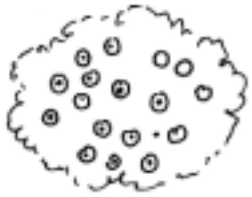
You can even keep some small snakes in the vivarium. The safest snake to handle is the striped keelback. This nonpoisonous snake is also very mild mannered and is easy to handle. But do not attempt to work with snakes unless you are absolutely sure about the identification.

Handling snakes is not a very hard thing to do, but requires practice and some experience. When you know your snakes well, you can even make a special serpentarium where you can keep live poisonous snakes as well. But for the users of this book we suggest leaving the matter till they have some experience with an expert.

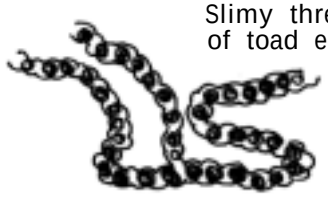
Growing tadpoles and frogs

The eggs of birds and reptiles are fairly large and are covered with a hard or leathery shell which is opaque. But inside the egg there is sufficient nutrients for the embryo to grow and mature into a baby outside the mother's body. Unfortunately, the shell prevents us from seeing how the embryo grows. In case of mammals the embryo grows inside the mother's body drawing all nutrtion from her. Here too we cannot see the growth process that goes on inside.

We can see some of these steps with the eggs of frogs and toads. These amphiabian eggs are easy to find in any pool or ditch at the beginning of monsoon. Frog eggs are found as a mass of white foam in which the individual eggs, looking like mustard seeds, are embedded. Eggs of toads are stretched out as slimy threads on which the single black eggs are arranged like a string of beads.

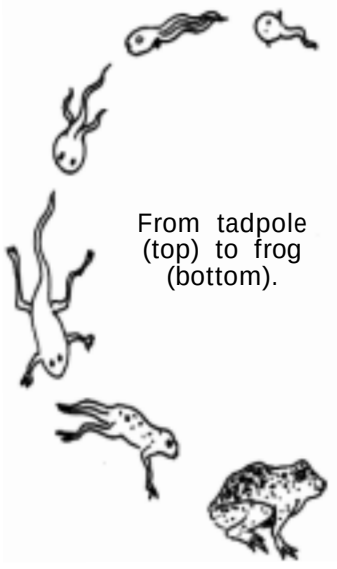


Frog eggs in foamy mass.



Slimy threads of toad eggs.

To see growth of the amphibian eggs -



From tadpole (top) to frog (bottom).

* Collect a few eggs along with some pond water and some weeds growing in it.
* Keep it in an aquarium or in a transparent plastic jar. Place it away from direct sun.
* Change the water every other day, removing any rotting weeds at the same time.
* You can remove an egg everyday and examine it under a low-power microscope to see the growth in size and changes in its appearance.
* In 7 to 10 days the eggs will hatch and tiny tadpoles would come out. They will eat weeds to begin with. But in a few weeks, when their hind legs starts growing, they would require tiny insects or pieces of meat or boiled eggs.

Development of tadpoles into frogs takes about four months and maintaining them over this entire period would require a lot of attention. It is easy to lose interest since changes are very slow. So it is better to watch the growth for about two weeks and leave them in the pond. You can watch them there for the rest of the growth process.

8. The world of animals

Tiny animals that creep, crawl, hop, fly

So far we have been dealing with animals that we can see quite easily. But as we mentioned at the beginning, these represent only a very small fraction of the animal world. Although much less seen by us, because of their small size or hard to see living ways, they are far more numerous and very widely distributed. They too have many interesting things about them and have important roles to play. These small animals, larger than 0.5 mm and upto the size of an earthworm, are technically refered to as *macrofauna* or *macroinvertebrates*. In a more disparaging sense these are often called *minibeasts* or simply *creepy-crawlies*. Here we will be referring to these interesting organisms simply as ***tiny animals***.

A majority among these tiny animals are the **insects** which are the most abundant living creatures on earth. There are about one million species of insects known and they account for about 80% of all known animals, varying in size from barely visible to about 15 cm (goliath beetle). They are also among the oldest surviving animals and were the very first animals to fly. Insects and their close relatives like spiders, scorpions, centipede and crustaceans (e.g. crabs) all belong to a large group (*phylum*) known as *arthropoda* or animals with **jointed legs**.

Most of the small animals we will find in our hunts to follow would belong to the arthropoda group. But we will also come across some other tiny, but more advanced, animals which we will include in our study. We will discuss them separately as they appear.

Where to find them

Insects and their kin have adapted themselves to all kinds of living places. We can find them everywhere starting from the comfort of our own homes to the arid deserts and frigid poles.

Our own housemates

Many small creatures run about our house whether we like them or not. We may not mind the wall lizards trying to catch insects around the light

or the frog jumping about. But mice, cockroaches, bedbugs, flies, mosquitoes, spiders, termites, ants, wasps and the other insects that visit or live in our house may not be as welcome. Yet we can find them all there. We can also find tiny beetles in the flour and rice that has been stored for a while. There might be fleas and ticks on our pet cats and dogs and lice in our hair too.

Looking for them and drawing up an illustrated catalogue can be a good nature activity. Many interesting information like the time or season of their visit, nesting places inside the home, food preferences and any other peculiarities about them can be compiled easily by observing them over a period of time. Can you make this into a group activity as well?

Looking in the garden

Even a casual glance at a garden will catch a few fluttering butterflies. A closer look would reveal others like honeybees and wasps feeding around the flowers. Walking among tall grass would make crickets and grasshoppers jump out. Different types of caterpillars can be found munching away on their favourite leaves. There will be spiders in out of the way corners either spinning a web or waitng quietly for a prey to get caught. And there will be lizards and frogs waiting to catch any of these insects for lunch.

Another type of place the insects and other macrofauna like is damp sheltered ground. Hence we are more likely to find some of these creatures under rocks or dead leaves, especially under a shady tree or near some water. A piece of wood lying around and rotting provides a good home for these little creatures and turning it over would expose a good variety. It is better to replace the rock or the rotting wood as you found them so that the insects etc. are not disturbed too much.

A compost pit forms a natural part of a garden. Besides the dead plants and leaves some animal refuge and kitchen waste are also added to it. Thus it acts as a good source of food while providing a comfortably warm and moist living place. Hence it is a good idea to look for tiny creatures by shifting through a compost pile. Even if a regular compost pit is not available, one can make a small one either on the ground or in a wooden crate.

If a large garden is available, a remote corner of it can be set aside to grow into a wild patch. Divert a stream of water to pass through it or create a small artificial pool in that area. Water liberally to keep it humid and help in fast and dense growth. This will be a good home as well as

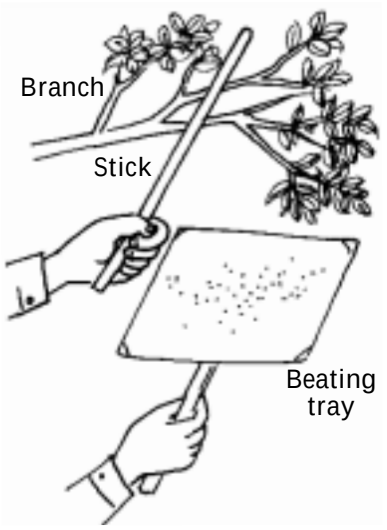
an attractive breeding ground for the insects and other tiny animals. If the area is large enough with some larger bushes you can also find larger animals like birds, snakes, rabbits etc. coming there.

Catching insects and tiny animals

Insects can be captured unharmed with many simple devices which can be prepared or set up with commonly available materials. Each of these devices or traps will also help us in catching specific types of insects. Some of these are passive, more in the nature of traps, that do not require much physical involvement in the actual process of capture. Others are actual implements which we will make ourselves and use for catching insects actively. Some of these are described below.

Beating tray

Many insects like to rest on leafy branches, especially during hotter parts of the day. Hence this is a good place to look for these creatures. This is best done with a **beating tray**, which is simply a piece of white cloth spread directly on the ground or stretched on a wooden frame fitted with a handle. An umbrella, opened and placed upside down, can also be used as the tray.

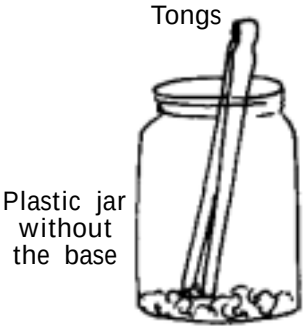


Find a leafy branch that is hanging down from the lower part of a tree. Hold the tray below the branch and give the branch a single sharp hit with a stick.

Do not disturb or shake the branch before hitting. Do not break the branch either. The sudden tap dislodges many tiny creatures which fall on to the cloth tray. Collect the insect you want in plastic jars.

Halter jar

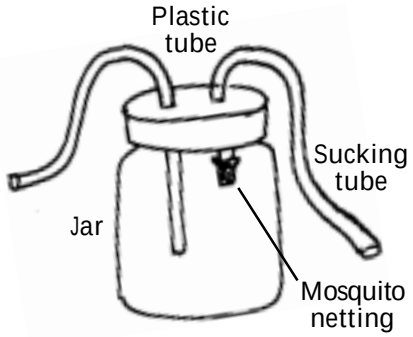
Cut the bottom off a large (2 litre) transparent plastic jar with wide mouth. With the cap on plop the jar down on any small animal that is resting or moving away on the ground. This will arrest the creature within the jar. Open the lid and transfer your catch to a suitable cage with a pair of tongs. Stinging runners like scorpions and centipedes can be handled comfotably with this aid.

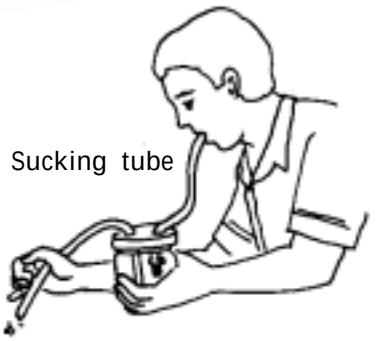


Pooter

* Put two marks towards the two opposite edges of the cap of a small (200 ml capacity) clear plastic jar with a wide mouth. Make two small holes on the marks by piercing with a hot iron nail. Widen the holes with a knife point or the scissor blades so that a flexible plastic (clear vinyl) tube 6 to 8mm dia. will fit tightly into it. The holes on the cap should be made carefully so that the tube is not loose.

* Fit each hole in the lid with a 15 cm long tube. One tube should be pushed farther down into the jar so that its end hangs about 2 cm above the bottom. Only about 2 cm of the other tube should be pushed inside the jar. If necessary, apply some rubber glue for sealing where the tubes enter the lid.
* Fasten with rubber band a small piece of mosquito netting over the mouth of the tube that is pushed only a little into the jar. This will be the sucking tube.
* Hold the body of the jar in one hand and the free end of the tube that goes deeper into the jar with the other. Bring this free end near any insect and suck through the other tube. The insect will be carried into the jar.

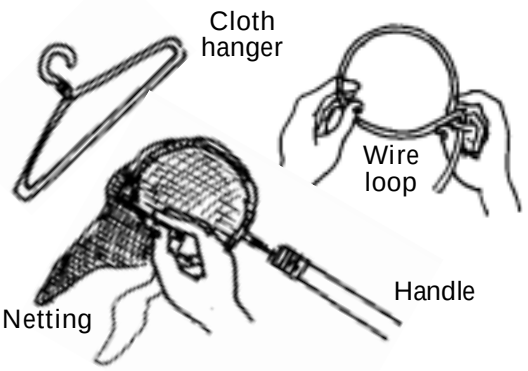




When one round of collection is complete, the body of the jar can be unscrewed from the cap and kept aside after covering the mouth with a piece of mosquito net. The cap and tube assembly can then be fitted on another jar and more insects captured with it.

Sweep net

* Bend a strong alluminium cloth hanger into a round loop. Straighten out the hook to act as a short handle and give it a few more twists to hold both ends of the wire firmly. The loop can also be made out of stiff wire if a hanger is not available readily.



* Take a 30 cm wide piece of nylon mosquito netting cloth just long enough to go around the circumference of the loop. Stitch the two ends of the netting to get a 30 cm long tube.
* Stitch one end of the tube onto the cloth hanger loop and close the other end with a straight stitch or just by tying it up.
* Attach a short and strong wooden handle to the straightened out hook and tie it up securely. The sweep net, also called the brush net, is now ready.

Hold the wooden handle firmly in both hands and sweep along the tops of tall grass. Try sweeping at other places where the vegetation is different. Sort out your catch by emptying the net onto a tray and make a record of what is found where.

This is a good way to catch grasshoppers and crickets that rest in grassy area and hop away swiftly when approached.

Butterfly net

The loop for an improvised butterfly net can be made from a cloth hanger or stiff wire as described above. But the bag has to be made from a softer material like lining cloth or cheese cloth. It should also be a little longer and the mouth wider. We will also need a longer handle to reach out to the butterflies from a distance. The bottom end of the bag should be closed by stitching and the corners should preferably be rounded.

Hold from the far end of the handle and reach out to the butterfly preferably from below. Bring the butterfly into the net by moving the net swiftly. Turn the handle so that the mouth of the bag closes. Remove the captured butterfly gently by reaching into the net bag.

Banana trap for butterflies

Crush an overripe banana at the bottom of a transparent plastic jar with a wide mouth. Leave it on or under a bush where butterflies are fluttering about, especially on a sunny day. The fragrance of the banana

would attract butterflies into the jar. Close the jar when butterflies settle down on the banana for feeding. The jar can be left out again after removing the first catch.

Are there differences in the type of butterflies caught around different bushes?

Pitfall trap

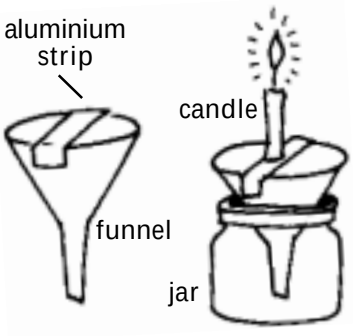
This simple device is particularly useful for capturing insects that crawl around at night.

* Take a large wide-mouthed jar and bury it flush with the ground in an out of the way place. An area covered with bushes and shrubs is more likely to give a good yield.
* Place four small stones around the jar mouth and place a board or flat stone on these as a roof. The clearance between the ground and the roof should be small - around 3 to 5 cm.

Set the trap in the evening and examine the contents the next morning. Pieces of meat, fruit or any other food can be placed in the jar as baits to attract particular types of creatures. Compare the catches with different baits and from different places.

Candle trap

All of us have seen how many kinds of insects get attracted towards light. We can take advantage of this behaviour to collect many types of nocturnal insects. The simplest of such light traps is a lighted candle placed over a funnel with a collecting jar underneath.

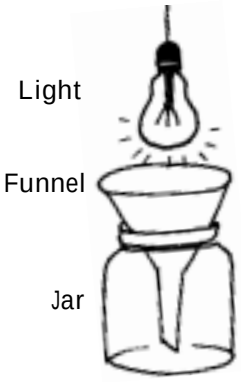


* Place a 1 cm wide aluminium strip across a large funnel. Bend the ends of the strip down the side of the funnel so that it does not fall off.
* Fix a candle at the middle of the strip. Place this trap either at the window of a dark room or outside protected from wind.
* Light the candle and leave it for a while.

When the insects fly around the flame some of them fall into the funnel and slide down the steep sides into the collecting jar below. The collecting jar can be changed as desired.

Electric light trap

Suspend an electric lamp over a large plastic funnel placed over a collecting jar. Some of the insects attracted to the light will fall into the funnel and slip into the jar below.

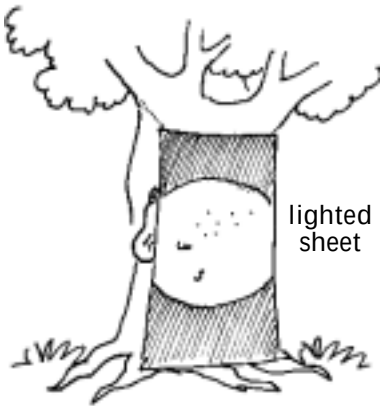


Different kinds of insects can be attracted by using a plain bulb, a frosted bulb, a compact fluorescent lamp etc.

Light Sheet

Many moths are too large to slide down through the funnel stem of the ordinary light trap. Hence a variation of the same is more useful for these insects.

* Suspend a white sheet from a branch or between two trees. Tie up or weigh down the corners so that it does not flutter in the wind.
* Shine a torch light directly on the sheet. Insects including moths will get attracted and will settle down on the sheet. These can be collected into jars by gently tapping on the sheet, using a pooter or picking up with soft tipped tweezers.



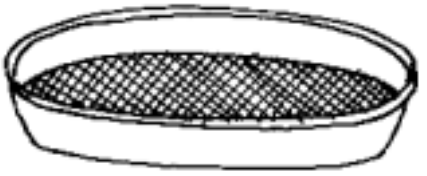
Tiny animals on and under the ground

Most insects and other tiny animals we have been looking at so far live above the ground. Many live on grasses or on larger shrubs and trees, some under rocks or decaying pieces of wood. There are also a large variety of others which live inside the carpet of dead leaves (*leaf litter*) covering the ground under all vegetation and yet others within a shallow layer of loose topsoil. We can collect and examine these macrofauna in some simple ways.

Locate a cool and moist place under a bush. Remove freshly fallen leaves from the top by brushing away gently. Collect the crumbly leaf material close to the soil along with a layer of loose topsoil by scraping into a plastic bag.

Sifting and sieving

Back at your work bench empty the collected material onto a large and somewhat deep pan or tub. Stir the litter and soil mixture with a stick at the centre of the pan spreading it into a thin layer. Larger creatures would start running away and can be picked up with soft tipped tweezers.



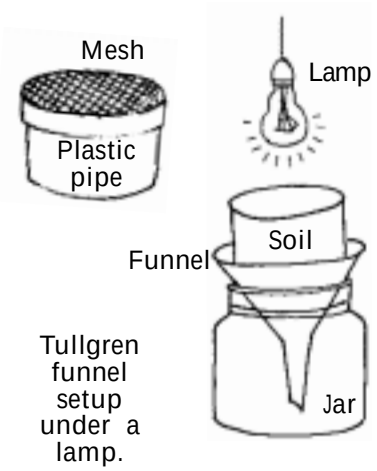
sieve for sifting soil litter

Put the collected material on a wide mesh sieve and shake gently. Small creatures will fall through the sieve and can be collected.

Warming out

Many tiny creatures hang on to the leaf litter and soil lumps tenaciously and cannot be separated by simple sifting or sieving. But warming the material gently will drive these out. This is best done with a device called the **Tullgren funnel**.

* A simple Tullgren funnel can be prepared by fixing a wide-mesh wire or plastic screen on one end of a 5cm tall piece of hard plastic pipe (grey pvc pipe used for water supply or sewerage) with a diameter of 7.5 cm.
* Place this mesh-ended pipe on a funnel with the mesh downward. Keep the funnel on a transparent plastic jar with a piece of wet blotting paper at the bottom.
* Fill the pipe with the some freshly collected litter and shine a 25 watt lamp on it. Adjust the height of the lamp so that it does not heat the litter too much too fast.



Tullgren funnel setup under a lamp.

Slow warming (and drying from the heat) will drive any creatures in the litter towards the bottom. Finally they will come out through the mesh and slide down the funnel wall into the collection jar below.

Among the small creatures that can be found in the litter and soil mix are ants, termites, some types of spiders and beetles, larvae of fly, beetle and moth, springtails, mite, roundworm, snails, slugs, centipede and millipedes. Earthworms (technically called *megafauna* because of their greater length) are also generally found in the litter and topsoil layer, especially in very damp places or after a rain shower.

Tiny animals in water

All animals need water and the smaller ones like the insects and other invertibrates need it even more. They generally prefer a damp environment among the vegetation or in the moisture rich soil. And there are others - both small and large - which cannot live without water. We can find a wide range of these aquatic small animals in any water body. It is quite an adventure to go looking for these in a nearby pond or water filled ditch.

If we watch quietly near the pond, especially in a little used corner where there are some weeds, we can see many of these floating on the water surface or scurrying about in shallow waters. If the water is clear and sun is shining brightly we can also see some creatures on the rocky or muddy floor. We can make a *underwater viewer* to have a better look at the things in deeper waters.

Underwater viewer

* Take a 5 cm diameter light weight PVC pipe (used for household plumbing work) about 1 m long. Smoothen the ends by rubbing gently on a cement floor or sandpaper.
* Spread a piece of transparent polythene or acetate sheet on one end. Fold the edges down onto the tube wall and hold in place with rubber bands.
* Trim along the rubber band and cover with several round of adhesive tape (PVC tape used for electrical insulation works the best). Make sure that no water would leak in between the pipe wall and the plastic sheet.
* With the covered end down gently push the tube under the water till it comes close to the bottom. Look through the open end and you will have a very clear view of the things there. Take care not to puncture the polythene covering by hitting any pointed things underwater. A sturdier viewer can be made by gluing a disk of clear perspex to the end of the tube.

If you hold the viewing tube in a fixed position for a while the aquatic organisms would resume their normal activity which can then be seen. A wider tube offers a larger viewing area, but it will be harder to

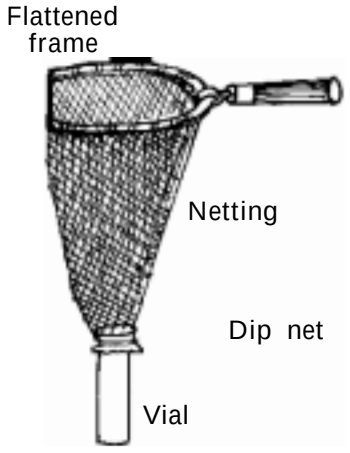
push under water. You can try out differrent sizes and materials and prepare the one that works best for you.

Pond dipping

Collecting aquatic organisms is not a very difficult process. The simplest way to get samples of small animals that stay at or close to the water surface is to skim. Pond skimming can be done by passing a large tea strainer just under the water surface and lifting it off along with anything caught in it. If necessary, a long handle can be attached to the strainer for reaching farther out into the pond.

To catch the creatures that move about lower down in the water we can use a **dip net**. This can be prepared by a minor modification of the brush net we had used for the insects.

* Prepare a wire frame from an aluminium cloth hanger and flatten the front (away from the handle) portion to have a bow like shape. Stitch up one end of the mosquito netting tube on the frame.
* Gather the other end of the netting around the neck of a small glass vial and tie up securely. Add a long, sturdy handle and the dip net is ready. To collect aquatic organisms either just dip in and lift out the net or sweep it across fully dipped in the water.



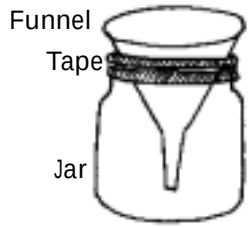
Larger creatures will get caught in the bowl of the net while some smaller ones will be in the vial full of water. For real small organisms, including many microscopic ones, a finer net material is used. Such a net, called the **plankton net**, is used by the professionals and can be quite expensive to make.

Tiny animals that prefer to stay close to the pond bottom can be caught by pushing the flat end of the dip net along the floor of the pond. This process, sometimes called **pond dredging**, works best in water bodies with a fairly level floor without much plant growth on it. After pond dipping or dragging place the net in a bowl and remove the vial by untying the bottom end of the net. Cap and label the vial for examining after your return. Pour some water over the net in the bowl and swish around to realease the captured organisms. Remove any large pieces of debris and strain the water to get your catch.

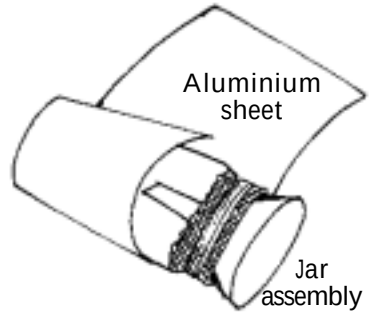
Aquatic light trap

There are many tiny creatures in water which show a particular attraction towards light. A specific trap - *aquatic light trap* - can be prepared to collect these from water.

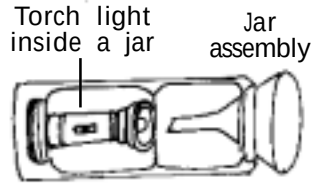
* Take a half-litre transparent plastic jar and a funnel with a mouth wider than the body of the jar. Remove the cap of the jar and place the funnel on it. Put adhesive plastic tape (pvc tape used for electrical insulation) all around the junction of the funnel cone and the jar mouth.



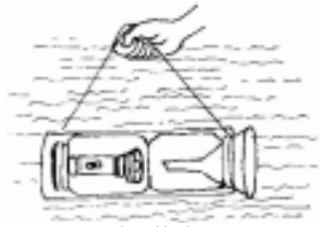
* Take a piece of lightweight aluminium sheet (available in hardware stores) and roll it tightly over another jar of the same size. Tie up well or apply adhesive tape so that the aluminium sheet keeps its tight-fitting tubular shape.



* Push the first jar attached to the funnel into aluminium tube so that the two jars remain back to back and the cone of the funnel rests against one rim of the tube.
* Find a small torchlight that fits inside the jars used. Switch it on and put it into the jar without the funnel so that the light points to the first jar and the funnel end.



* Pack some sponge or crumpled paper around the torchlight inside the jar so that it remains near the centre of the tube. Put the cap on the torchlight jar tightly so that water will not get inside. (You may need to pull the mouth of the jar out of the tube to fit the torchlight and the cap. Also do this near the pond just before putting it into the water so that the batteries do not run down unnecessarily).
* Tie a long string to both ends of the aluminium tube to act as a handle. Fill the first jar with water and place the whole assembly horizontally on the pond bottom or just suspend it in mid-water by the string handle. You will probably need to add some weight around the tube to keep it under water.



aquatic light trap under water

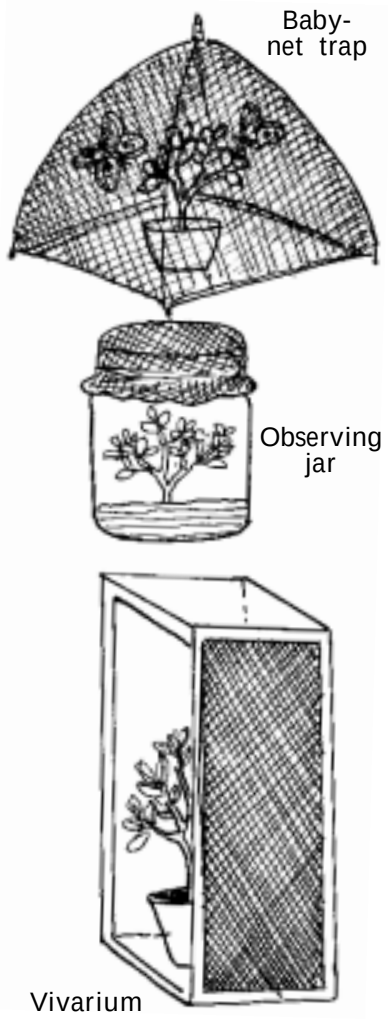
Bring it up after about 15 minutes with the funnel end up. Remove the funnel after draining out the water from it and examine the water inside the jar under a low-power microscope. If the number of organisms is small, leave the jar standing vertically for some time, remove a sample from the bottom with a long dropper for examination.

Try out this trap at different water bodies, depths, vary the time (day or night) etc. to get an interesting experience.

Studying insects and friends

On a bright sunny day we can see many butterflies fluttering about everywhere. But they do not stay around long enough for us to have a good look at them. We can keep them captive for a while in their natural environs with the following simple arrangement.

Choose a flower bed with the butterflies you want to look at. Cover a portion of it with a collapsible mosquito net used on baby beds. It will work even better if the butterflies are coming to a potted plant. The plant can be kept in a convenient place and the net put on it when the butterflies visit it.



Insect homes

Clear plastic jars can be used to carry the insects back home and for keeping them for a short time. Place a small branch in the jar for the insects to rest upon. To provide ventilation, stretch a piece of mosquito net cloth over the mouth of the jar and hold in place by tying or with rubber bands.

A vivarium (p.58) can be made specifically for insects. A vivarium is generally made longer than taller. But the insectarium should be of a tall design. Make a box covered with perspex sheets on two sides and the other two covered with stiff nylon window netting. The top should be a hinged board so that it can be opened as needed.

Put a potted plant of suitable size in the box and release the butterflies or moths in it.

Make a grassy patch on the floor if crickets and grasshoppers are being kept. Lean a dry twig in the insectarium on which the resting insects can be seen better. Cover the soil in the pot with clean sand and keep it moist. This will provide moisture in the chamber and will also provide a place for grasshoppers to lay eggs.

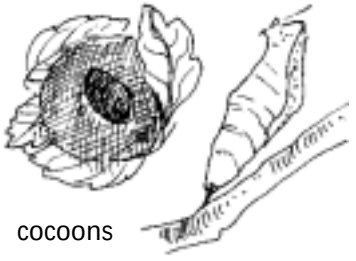
Butterflies lay their eggs on the leaves they eat. So it will require some knowledge about the species, their food plants and breeding details for observing a whole life cycle. But raising moths and butterflies half of the way - from the larval caterpillar stage to the adult - is quite easy.

From caterpillars to moths and butterflies

Watch the caterpillars outside for some days to get an idea about their mature size. Collect some of those which are about fully grown along with the branches on which they are feeding. Keep in an insectarium by sticking the branch into a pot of moist sand. Put in some fresh branches with tender leaves every day and clear out any bare twigs, faeces, dead caterpillars etc. at the same time.

Caterpillars on a branch

In a few days the caterpillars will stop eating and will be ready to turn into pupae. Put a dead twig with several branchings for the pupa (more specifically called crysalis) to stick onto. Some caterpillars spin cocoons around themselves. Others get encased in a thin shell and stay hanging from a branch in a particular position.



cocoons

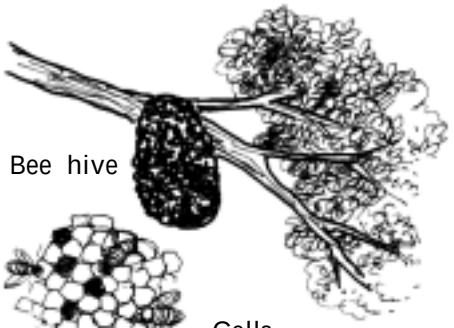
The time taken for the adults to emerge from the crysalises varies widely. Some remain as pupa for the whole winter. So it is important to keep these in a place where they can be observed frequently and can released soon after emerging.

It is interesting to note that there are about 30 times more moths than butterfly species. Since the adults emerge during their natural active times - butterflies in the day and moths in the night - the caterpillars we would have collected are more likely to start fluttering in the cage during the night. Once you know the expected time from your first experience, you can wait to see the process of emerging. It can be as exciting as a chick coming out of the eggshell.

Honey bee - a social insect

Honey bees, ants and termites are called **social insects**. In a sense groups of these are single families living in a common colony where all work, including caring for offsprings, are shared.

Bee hives are fairly common in wooded areas and even on tall buildings in a city. But it is not possible to take a look inside them when occupied. However, much of the activities of a bee society can be seen in an artificial hive box where selected species of bees, chosen for being less aggressiv and for producing more honey, are grown in bee farms or even in individual backyards.

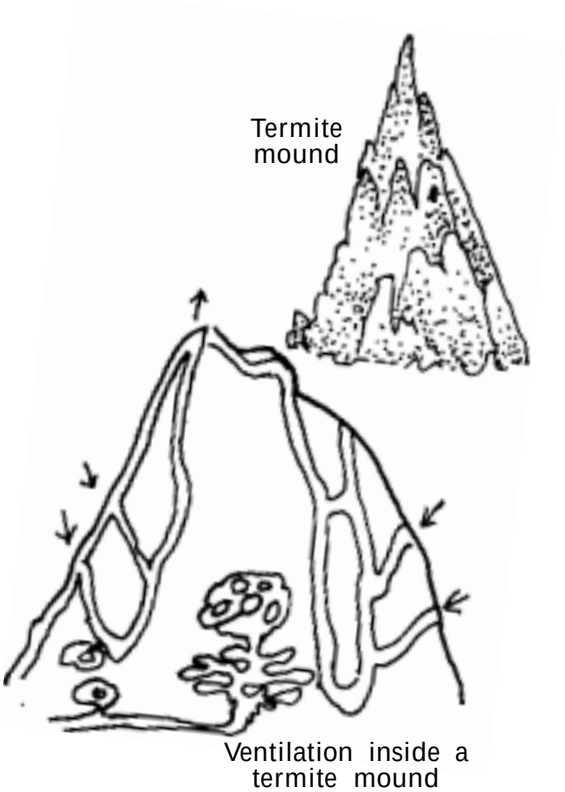


Locate someone who keeps such bees and plan a visit during the specific times like when honey is extracted and when the colonies are divided. You can see, and possibly be able to collect specimens of, the different life stages of this important insect.

Termites and their mound

Also known as white ants, these social insects are great builders. In some parts of the world termite mounds - as their homes are known - of enormous sizes are found. We can find mound of moderate sizes in most places, especially in damp wooded areas.

Interestingly, termites do not live in the portion of the mound that rises above the ground. They require a cool, damp and dark environment which is maintained under the ground. The raised structure with many external vanes and internal channels serves primarily as a cooling and ventilation device.



Ventilation inside a termite mound

Find a termite mound and keep track of its growth. Note the seasons when it grows more, when it slows down and so on. Do you ever see the white ants on the outer surface of the mound? Do you see any openings at the growing tips of the mound? Then how does it grow upward?

Saw off an edge of a vane vertically and take a good look. You can see the crisscrossing channels inside. If you keep watching, you can see a large number of termites carrying tiny grains of sand, moistened with their saliva, to the damaged edges and placing them there. In a short time they will seal off the openings with flat faces. If you notice after several days the damage would have been repaired back to its original shape!

Take good care of your mound and it will provide you with plenty of excitement.

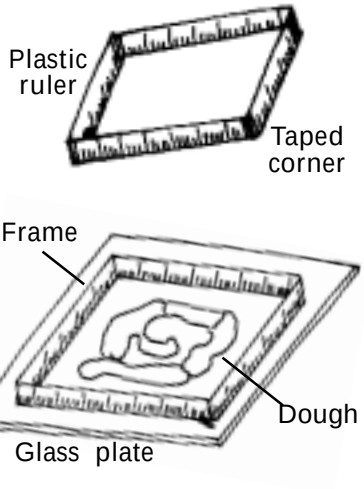
Growing an ant colony

The social insects we come across most frequently are the ants. Whether the biting red ants or the tickling black ones, they are all around our house. If we cannot see one, all we need to do is to put some sugar out and they will appear promptly. Watching them hurry about in their line, touching each other as they pass along and often coming to-gether to carry off something much bigger than themselves can be quite fascinating.

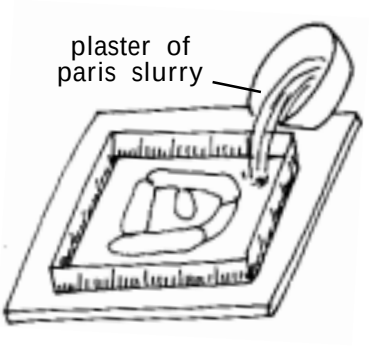
Unlike the termites, ants live closer to the surface and go about much of their business in light. They are also more tolerant to higher temperatures and dryness. Hence it is possible to maintain a colony of ants in an artificial housing without too much trouble.

A small model of ant house - **formicarium** - can be made as follows.

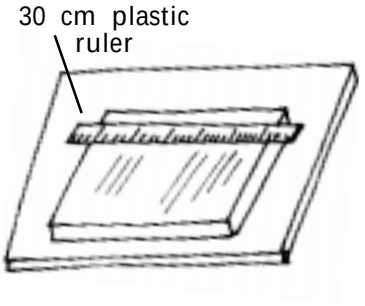
* Tape four 15 cm plastic rulers to make a square frame and place it on a smooth surface. A 20 cm x 20 cm glass or perspex plate works well as the base.
* Make a stiff dough of whole wheat flour (*atta*) and add enough oil (vegetable or til oil in winter) to make it non-sticky.
* Roll some dough into a cylinder 10 cm long and two-thirds the thickness of the rulers and place it inside the frame to one side. Roll out thinner cylinders, about half the thickness of the rulers, and arrange them on the base-plate in a connected



design. Put a few dough balls at some of the corner junctions. Make sure that there is at least a 2 cm gap between the dough and the frame on all sides. Press gently on the dough at all points so that it sticks to the glass plate well.



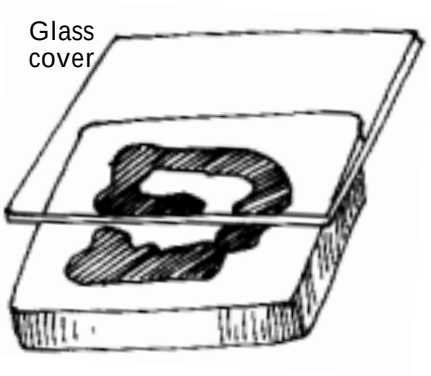
* Make a thick but flowing slurry of about 500 g fresh plaster of paris in water. The normal variety is less expensive and easier to work with than the quick setting variety. You can make the perfect slurry with a bit of trial and practice.



* Ask a friend to hold the frame down on the glass plate and pour the slurry uniformly over the dough design till the frame is completely full. Make sure that air bubbles do not get trapped in the slurry.
* Pass a longer ruler or any other smooth edge corner to corner on the frame so that the slurry fills all parts of the frame completely and the excess comes out. This will also give a smooth back to the finished formicarium.

Leave aside for some time for the plaster to set. Remove the frame by cutting the tape at a corner. After drying overnight slide out the plaster square from the glass plate and remove the dough with a soft flat spatula or stick. It has to be thin enough to move freely within the grooves. The plaster would be soft still, so be gentle. Bits of dough remaining in the grooves will come out later when fully dry.

Let this completed formicarium dry thoroughly - it will take several days. Clean it well and smoothen any rough edges. Put some loose soil and leaf litter in a corner away from the wide groove (the feeding chamber). Place any food in the wide groove. Ants will come in to get the food if left open. When ants are in, cover with a glass plate and put a piece of cardboard over it. If your remove the cardboard after some time you can see the ants moving between the hiding place and food.



Formicarium

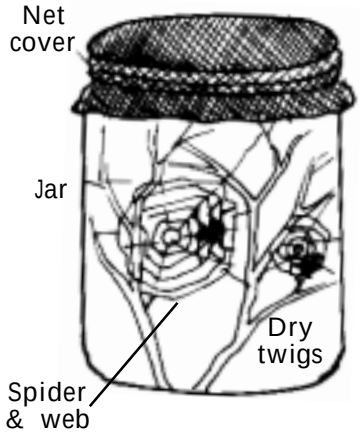
Since the ants caught this way will be only workers they will not survive for long. To keep a viable colony make a bigger formicarium (30 cm square or larger) and find a queen ant by looking around their nesting place. The nests can be found under rocks or dead wood and the queen will be about 5 times the size of a normal ant.

Put soil and leaf litter in the rear half of the formicarium and keep it covered with cardboard to provide a dark living area. The front portion along with the feeding chamber can be left visible under the glass cover.

After some trials you may have a successful colony to watch and learn more about the living ants.

Insect kins - spider

It is common to find spiders while looking for insects. This relative of insects also has jointed legs, but eight of them instead of the six on the insects. They are present both inside and outside the home. The indoor and outdoor spiders look different and the nets they spin are different too. Spiders are easier to catch and do not require any special devices. Leading them gently into a jar with a stick or branch does the trick.



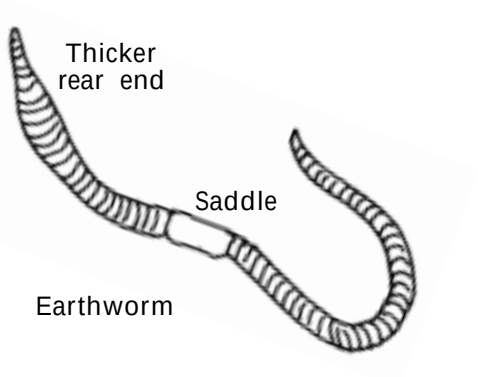
Cover the mouth of the jar with a piece of mosquito net and leave aside for some time. The spider would start preparing its web. Once the web is ready it will not try to run away. Remove the jar covering once in a while and put in a place (like under a light or outdoors) where some insects will fall in. That will take care of feeding the spider.

We can collect some egg packets of the spider along with it. In a few days the jar will be swarming with little spiders. It will be difficult to maintain all of them. Hence it is best to leave them where you had collected the eggs from. Spiders can also be kept in the insectarium along with other insects.

Wormery - a house for the earthworm

Earthworms are familiar to us as the long stretchable worms that come up when we work the garden soil. They even crawl about in the open after a heavy shower. These worms play a very important role by keeping the soil loose by digging channels through it and mixing up the layers. Because of this work they are often referred to as *nature's farmer*.

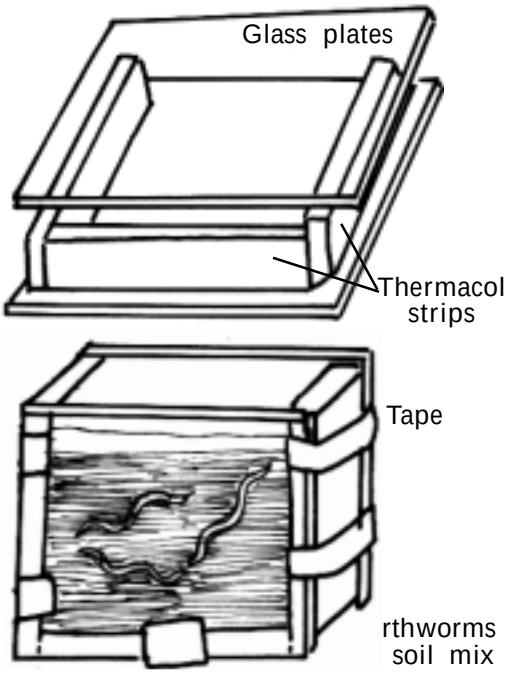
Earthworms have round bodies made up of ring or segments and belong to the group annelida (segmented worms) The body segments can be noticed clearl from outside. Mature worms have a thi section on the body about onethird wa down from the head - the more pointed end. This bulging portion, the saddle, forms the cocoon for the eggs later on.



Movements and feeding activities of earthworms can be observed in a model house which we can build. This earthworm house - the **wormery** - is essentially a thin layer of soil sandwiched between two transparent glass or plastic plates.

To make one, we will need two 15 cm x 15 cm pieces of glass or perspex, 2.5 cm thick thermacol sheet and adhesive pvc tape.

* Cut three 2.5 cm wide and 15 cm long strips of thermacol and place on three sides of a glass plate.
* Lay the other plate on it and fix the two plates with pieces of adhesive tape. Trim any portruding thrmacol and stand the assembly with the open side up.
* Fill the inside with layers of different types of light soil, leaf litter and compost. These should be moist but not very damp. Put some vegetable scrapings on the top and some earthworms on it.
* Put a strip of thermacol loosely on the top of the fillings as cover. Keep the wormery in a dark place.

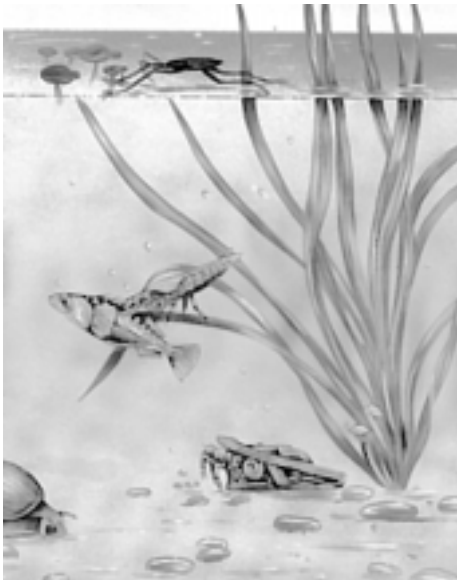


Take out the wormery from time to time and observe any tracks visible through the sides. Remove the thermacol piece on top and sprinkle some water if the soil dries up. Add bits of fresh vegetables once in a few days. If the worms stay healthy they would mix up the soil layers in a few weeks. Record any peculiarities you can notice with them.

Observing aquatic organisms

Insects and other small animals collected from water bodies can be kept in an aquarium. These can be kept for a longer time in a regular aquarium with air supply arrangement. But if this is not available, a simple aquatic habitat can be set up in a large plastic jar as described earlier (p.36) for keeping water plants.

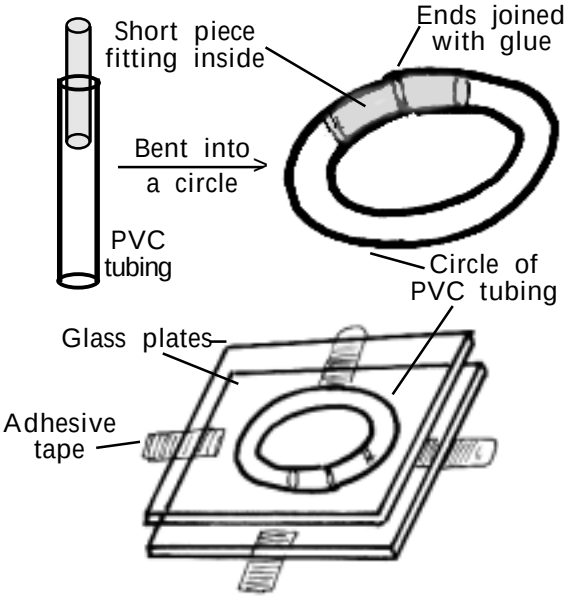
Some submerged aquatic plants would help provide oxygen when exposed to sunlight. Because of its small volume changing of water would be needed more frequently. While stocking an aquarium, whether a large one or a small improvised one, care has to be taken to keep the carnivorous species separately. Insects like water scorpion and dragonfly larva can eat up others even larger than themselves.



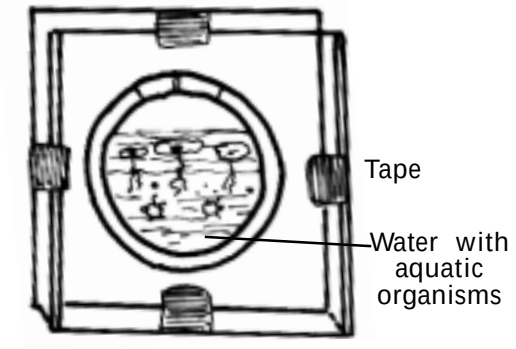
Aquatic viewing chamber

For close observation of aquatic organisms a simple device can be made where these can be kept in a thin layer of water and be seen from any suitable angle.

* Take a 30 cm piece of stiff PVC tubing with a diameter of about 10 mm. Apply rubber cement (dendrite, fevibond etc.) to the inside of both ends and join the ends together by inserting a short piece of tubing that fits tightly inside.
* Fix this on a 15 cm square glass or perspex plate with rubber cement. Allow to dry thoroughly. Apply a thin coating of vaselin or machine grease on the circle of tubing.



* Fill the inside of the circle to about onethird depth with water containing the organisms to be observed. Place another plate of the same size on the top and press down firmly. Fix the two plates together, with the tubing and water sandwitched in between, with adhesive plastic tape.



The assembly can now be lifted up and viewed against light as convenient. It can also be placed flat as a transparency on an overhead projector and an enlarged view can be seen on the screen.

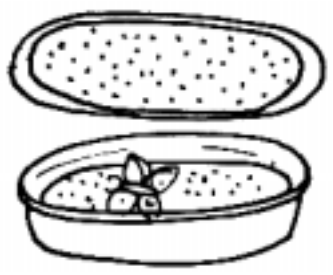
In case the water leaks, mark the spot and apply more rubber cement after drying well. Because of the low water volume the organisms will die out soon. A chamber with thicker layer of water can be prepared by using V-belt material (available at machinery shops) of suitable width in place of the tubing.

Preserving dead specimens

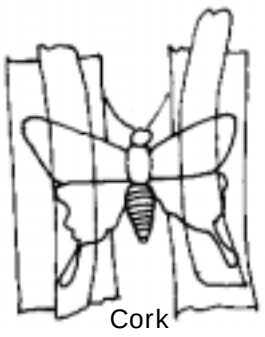
Professional biologists need to preserve specimens of various species in the best possible condition. For this they need to kill some live ones they collect or breed. But for the purpose of the nature lover a collection of dead organisms found during their explorations would be quite adequate. Many dead insects and other tiny animals can be found in the fields. In spite of our best care some may also die while being kept for observation. Quite often it is possible to retrieve almost whole birds, mice, lizards etc. killed by our pet cats or wild birds of prey. Such specimens like moths, butterflies, other insects, frogs, birds, rats can be preserved in the following ways.

Preserving insects

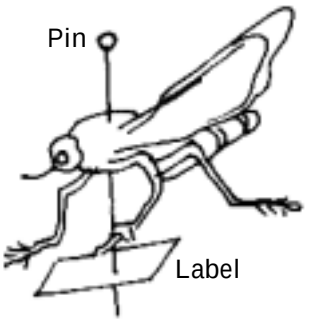
Insects have a hard scaly *exoskeleton* covering their bodies. Because of this the dead insects retain their shapes even after the fleshy interior dries up. To display the insects in a particular position, one needs to fix it in that position when it is freshly dead. If the specimen has already dried up when found then it can be softened by keeping it suspended over hot water in an airtight container. Once it becomes soft it can be spread out in the desired position on sheets of cork. It can then be left to dry while being held in that position with pins or tape.



Softening in a moist chamber



Setting in position on a cork board.

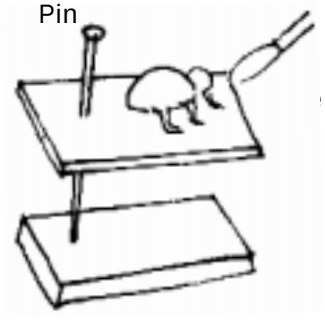


Piercing with a mounting pin through thorax.

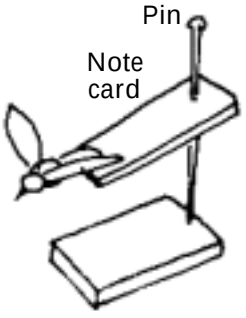
For their permanent mounting a long sharp pin can be driven through the thorax of large insects while the body is still soft. Special stainless steel pins are available for this purpose, but inexpensive alpins can also be used for a short term work.

For mounting larger beetles the mounting pin can be driven through a wing case. Small beetles can be mounted on a small card by applying glue to their legs. For small insects like flies and wasps it is useful to glue them by the tip of the abdomen onto a card. This way we can see their underside also.

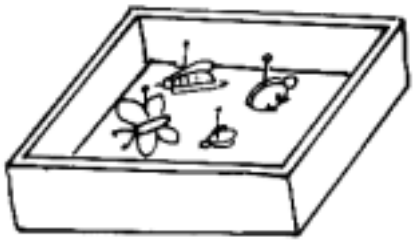
The insects should be kept in a cork-lined box along with a card bearing the details about them afixed on the same mounting pin. For long-term storage, the specimens should be protected from other insects by placing a wad of cotton soaked in creosote (available inexpensively at Homoeopathic medicine stores) inside the insect box.



Mounting small beetles with glue.



Mounting a fly.

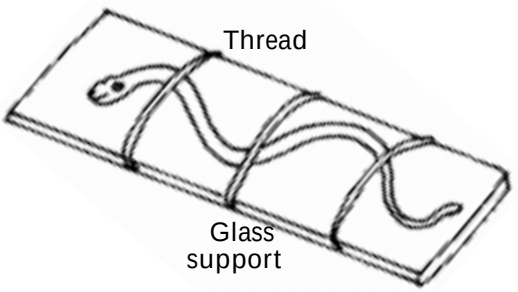


An insect box

Preserving soft-bodied animals

Animals with soft and fleshy body like fish, frog, rat etc. can be preserved by keeping them immersed in 4% formalin (formaldehyde solution). Formalin is normally sold as a 40% so' ion. Hence it has to be diluted with 9 times its volume of water.

Stretch a dead animal on a strip of glass and tie with uncoloured thread to keep it in the desired position. Alternatively, pin it on a slab of cork. Immerse the animal along with the cork or glass support in formalin. If it is a very large animal its abdomen should be slit for the formalin to get inside easily.



Setting the spec. nape.

Depending on the size of the animal it will take two to four weeks to get fixed thoroughly. Supporting pins, thread and cork etc. can then be removed if necessary. The fixed specimen should then be placed in a bottle with fresh formalin solution (4%) and capped tightly. The edges of the cap should be sealed with adhesive plastic tape to prevent leakage of formaldehyde vapour.

Once the specimens have been left in formalin for several months, they can be taken out and dried. They will hold their shape and can be kept dry in any display case like dry insects. Some insect repellent like creosote would ward off harmful organisms and prolong the life of the specimens.

Dead animal in formalin.

Fixed specimen after drying.

Formaldehyde vapour is quite noxious and should be handled in a well ventilated area. Any spillage should be washed well with water.

Worksheet guide to studying insects and tiny animals

1. Where to look:

   Near a house / under a rock / in a rotting log / inside a house / inside a vehicle / under the bark of a tree / in a straw heap / cow dung / near a pond / in a rice field / inside water / near a garbage pile / any other.

2. Are all kinds of insects found on all type of plants and at all places? Or different ones on particular plants and in different places?

3. How many of them can you identify? Write down the common names.

4. How many of them you can catch with a -

   a. pooter, b. sweep net, c. butterfly net, d. light trap, e. aquatic trap?

5. Did you find any caterpillars? What type? On what plant?

6. How many types of spider webs could you see? Where were they? Make a sketch of their webs.

7. What kind of crawling creatures did you find? Can you identify them?

8. Could you collect some tiny organisms from soil?

9. Were there any earthworms? In what type of ground were they most common?

10. What kind of other tiny creatures you can see near a -

    a. pond, b. garbage pile, c. rice field, d. manure dump, e. compost pit, f. grass field, g. swampy area?

11. Are there any small tadpoles in the pond? Collect some and keep them in a bowl to observe their growth.

12. Draw pictures of the tiny creatures you saw today.

9. The micro-world

Life forms that we cannot see

To most people the living world ends with the large plants and animals. They do not think much of the tiny creatures that far outnumber their larger relatives. But as we saw in the previous section the tiny creatures are just as diverse and versatile as they are interesting to study. Going a step further, we will find a whole different world of teeming life that remains invisible to our naked eyes. We will also see just how important they are in maintaining all life on the earth.

Many of these very small organisms, generally known as ***microorganisms***, can, however, be seen through microscopes of intermediate magnifying powers. Such instruments are now available widely in many schools and in all colleges and hospitals. Hence, with some planning and pursuation it would be quite possible to take a peep at this fascinating microworld with the help of these institutions. Low-cost projection microscopes (which project the image internally onto a ground glass screen) with magnifications of 100x to 400x are also fairly easily available. These can show some larger microorganisms clearly and that too in their living state. These are ideally suited for inexperienced viewers and for viewing in a group.

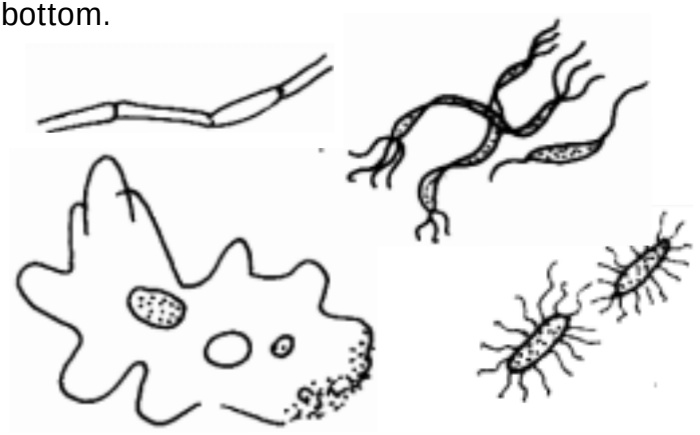
Where to find microorganisms

Microorganisms, the simplest of living organisms, exist practically everywhere. Not only are they to be found in all sorts of environments, they are also there all around us in soil, water, air and even in and on our body. Some interesting samples of these can be collected as follows:

1. Any standing water, especially with a greenish or brownish colour, is likely to have a rich population of microorganisms. A look at a drop of such water under the microscope would be worthwhile. In case only a few are found in the drop, a concentrated sample can be obtained by passing a plankton net with very fine mesh in the water a several times and taking the water in the bottle.

2. Look for a small pool of water, like in an empty flower pot, in which some grass or wood is rotting. Take a drop and observe under the microscope.
3. Collect a dying lilly leaf or any other decaying broad leaf from a pond. Gently crape the under side of the leaf with a scalpel or razor blade. Shake the scrapings into a little bit of water and examine a drop of that water under the microscope.
4. Get a lump of aquatic weeds and shake the roots, a little bit at a time, vigorously in a small bowl of water. Allow the water with a few broken pieces of the weed in it to stand for some time and examine the muddy layer at the bottom.

While examining the samples collected as above, try noticing how the shape, size and movement of the organisms vary from sample to sample. Try to identify the more common ones with the help of someone who knows more about them.



Micro-zoo: a variety of microrganisms

Diversity of micro-life

A look at a drop of pond water under the microscope would show a myriad of microorganisms that vary widely in their shape and size. This variation also extends into their functions and life processes. In fact, this forms the basis for a whole branch of scientific study called *microbiology*. It is difficult to take up many amateur activities with the microorganisms because of their extremely small size. Still, we will try to get a bit familiar with them in the following sections.

Bacteria - the smallest free-living organisms

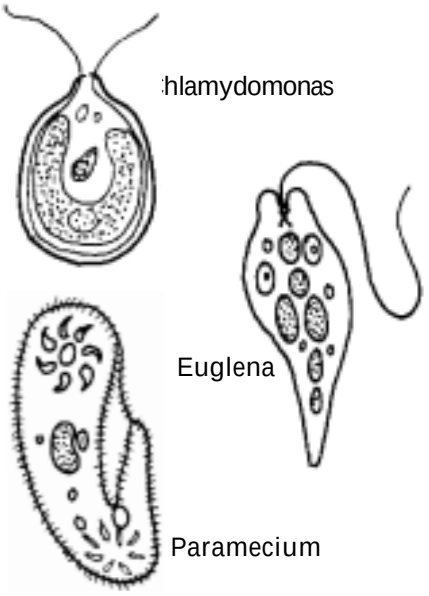
With their sizes in the range of a micrometre (one thousandth of a millimetre) these are the smallest organisms that can live independently. They are also the first life-forms to have evolved on the earth and the simplest in terms of their body structure and function. Yet these organisms, which can also be thought of as living single cells, are the most common form of life around us.

Bacteria can be found in the air, water, soil, food, bodies of other living or dead organisms. Most bacteria exist without affecting us in any manner. However, some of them are helpful, or even indispensable, to us while some other can be quite harmful. Although too small to be seen or felt directly, their presence can be experienced through their actions. Some of the bacterial actions familiar to us are the curdling of milk, spoiling of food, decomposition of organic residues, ulceration of wounds and the causing of diseases like cholera and tuberculosis.

Protozoa - the 'first animals'

Next up on the ladder of size and complexity are the protozoa which were once considered to be animals. However, these diverse single-celled organisms are now grouped separately as members of the *kingdom protista*. These are divided further within the group based on how they move about.

Some of the more familiar protozoa are amoeba, paramecium, euglena, trypanosoma and plasmodium. While most of the protozoa are harmless and some even helpful to man, a few live as pathogenic parasites on animals. Malaria causing plasmodium and entamoeba histolytica which causes amoebic dysentery are known to most people in our country. Parasitic trypanosoma are the pathogens of African sleeping sickness. Helpful protozoa include those in the intestines of cattle and of termite which are the real digester of cellulose in the grass or wood they eat.



A few protozoans
(magnified 200 - 600x)

Euglena and paramecium

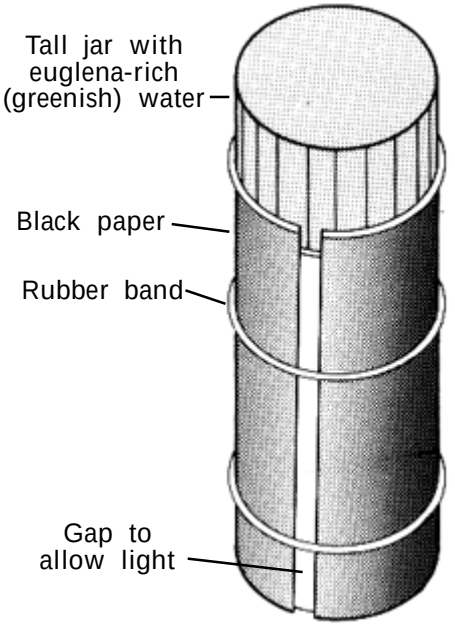
Two interesting protozoans are euglena and paramecium. Most euglena can prepare their own food through photosynthesis. However, they also have the ability to live by absorbing food from the surroundings if light is not available. Thus they combine the properties of both plants and animals in them. Euglena grow in large numbers in water bodies contaminated with rich organic materials like fertilisers. Sometimes pond

water inside agricultural farms appear green because of these euglena which contain the green photosynthetic pigment chlorophyll.

Paramecium is fairly complex organism considering its single-celled structure. These exist in large numbers in muddy waters, especially the scums that float on such water bodies. Paramecia can be recognised easily under a microscope because of their characteristic slipper-like structure and flipping movement, especially the way they reverse the direction of movement on meeting an obstacle.

Effect of light on euglena

An interesting activity can be devised with such euglena-rich water to show their attraction for light. Fill a transparent jar with the greenish water. Cover the jar with thick black paper leaving a narrow gap on one side. Leave it in a normally lighted room. After a day or so remove the paper without disturbing the water. Look from the sides to see a differential distribution of the green colour of the euglena.



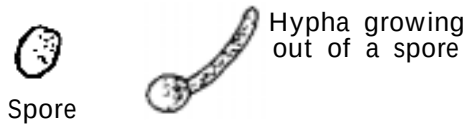
Growing paramecium

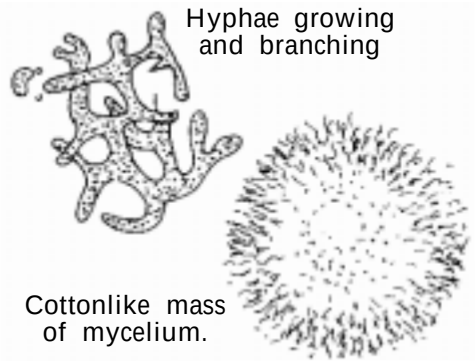
Take some straw or dry grass and cut into small pieces. Soak the chopped hay in water and add some muddy water from a pond or drain. Examine the water under a microscope after a few days. A large number of paramecium will be found in the water.

Fungi - bridging the micro and macro

Fungi span a wide range of sizes. These include the microscopic yeast composed of a single cell to large mushrooms in the range of a kilogram in weight. Although most fungi are multicellular they are treated more as microorganisms because of their simple structure and less advanced metabolic processes. Fungi cannot make their own food and have to absorb their food from outside. As they cannot move about they have to grow very close to their food source. In fact, most fungi grow right on and into their food materials.

The primary unit of the body of a fungus is a hypha. The threadlike hypha grows and branches rapidly and produces a mass that looks like a wad of cotton. This cottonlike mass, called mycelium, spreads out on whatever the fungus is growing on, usually a dead organism. Specialised parts of the mycelia penetrate the food material and absorb nutrients from it. Mycelia can break up into fragments and each piece can grow into a new fungus.



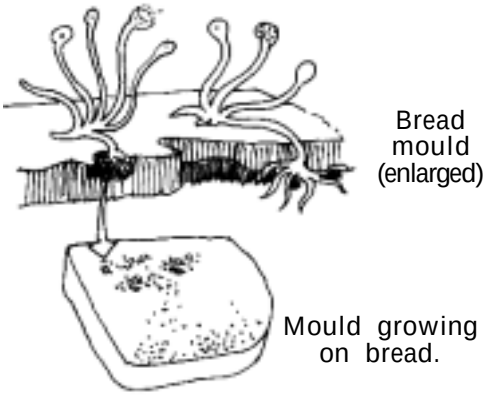


Moulds - the simpler fungi

Some of the fungi most familiar to us are the moulds - the cotton or stain like growths found on rotting fruits or spoilt food. Moulds grow on a wide variety of organic materials including wood, paper, leather and cloth. While most prefer warmer environs some can grow at near-freezing temperatures.

A common mould is the bread mould (*Rhizopus nigricans*) which grows as silvery mycelia on stale bread left in damp surroundings. When examined under the microscope the fungal mass is found to consist of several different kinds of hyphae.

Blue-green coloured growth often found on bread is that of the moulds of genus *Penicillium*. These are also found on rotting oranges, lemons and other fruits as well as on meat, leather and cloth. Another group of moulds that also grow on foods often are those of genus *Aspergillus*. They are found as yellow or black ring like growths.

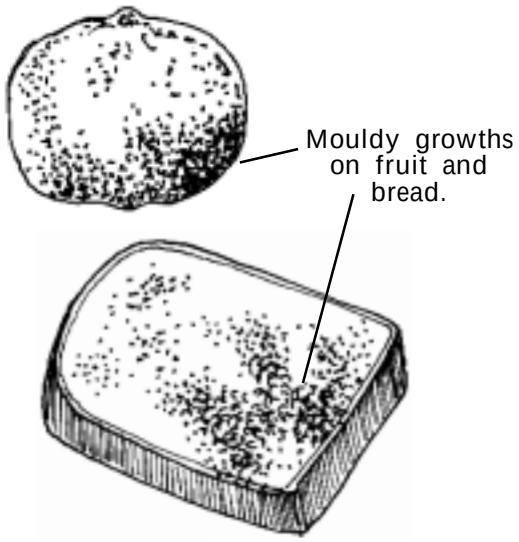


Other types of moulds found growing on bread are *Neurospora* (red) and *Mucor* (grey). All these visible colourful parts of the fungi are really their reproductive parts. Spores which are formed in and shed from these parts help in spreading the fungi around.

Growing moulds

Spores of various fungi are always to be found in the air. These are even more abundant in the soil and house dust. So when some moist organic matter is left exposed to open air some spores get a chance to settle on it. If enough moisture is present and the place is sufficently warm, the spores start growing hyphae (*germinate*), feed on the organic matter and develop into a characteristic mass of mycelium.

The easiest to grow are the bread moulds. To do this, place a slice of bread on a flat dish, moisten it lightly with water and sprinkle some house dust on it. Cover it with a transparent container and leave in a warm, dark place. Look at it after a few days, making sure it does not dry out. A cottony growth of fungal mycelia will be found on the bread. More than one type of fungi, as distinguished by their colour and shape of the growth, may also be found on it.

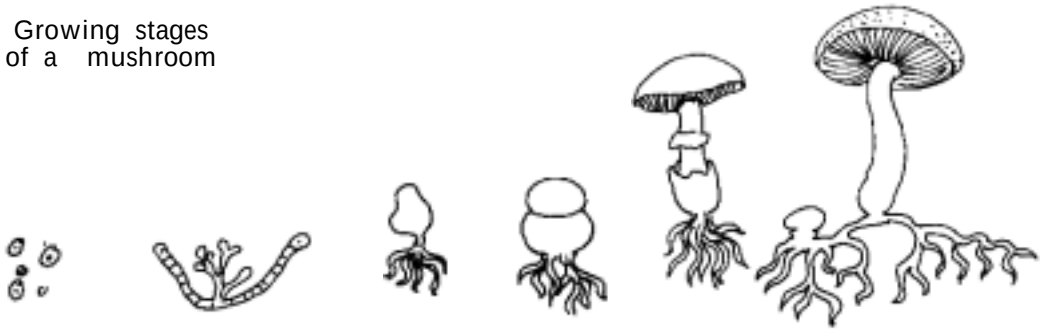


Place pieces of fruits, vegetables and other moist food material on the dish as in case of the bread above. A variety of fungi can be found to grow on them after a few days.

Mushrooms - the more visible fungal forms

The group of fungi known best to us, although rarely recognised as such, are the mushrooms. Mushrooms and their generally poisonous counterparts - toadstools - are found in large numbers after the first rains either on rotting organic matter or on soil. These are easily recognised by their typical umbrella like structure which actually is its reproductive part or the fruiting body. The rest of the fungus grows under the soil or inside the organic matter.

Mushrooms comprise of a mass of hidden hyphae and the visible fruiting body. The visible part has a bulged base, an elongated stalk and a cap. Once enough mycelia have grown under the ground and if it is warm and moist outside, small knobs of hyphae form on the mycelia. These bulging mass of hyphae or the botton stage push out just at the

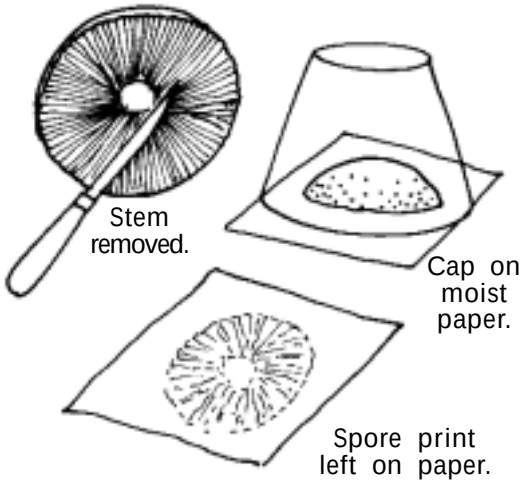


ground level. Once exposed to the moist air the stalk part absorbs large quantities of moisture and swells up. As a result it elongates rapidly and pushes the cap well above the ground. The fully opened cap has numerous ridges or *gills* on its underside which hold the spores. These spores are then discharged from the exposed cap and spread out to grow into new mushrooms.

Many types of mushrooms are both a delicacy and a good source of nutrition. But many more are inedible and foul smelling. There yet others which are extremely poisonous. In general, mushrooms growing on animal residues and those which are brightly coloured are poisonous to varying degrees. It is often difficult to identify the poisonous ones with certainty, even for an expert. Hence extreme care is necessary while working with mushrooms in the wild. It is best to avoid handling the species you do not know for certain.

Taking a spore print

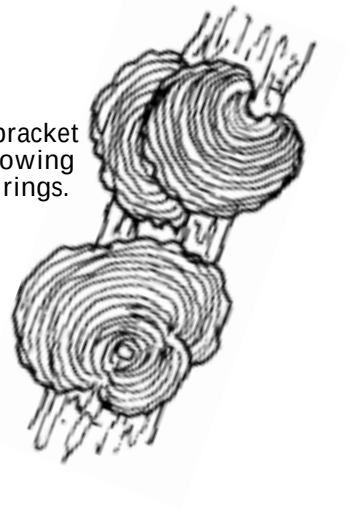
Collect some fully opened but fresh mushrooms and carefully remove the cap. The gills on the underside of the cap can now be examined closely. Place the caps with the gills down on sheets of moistened white blotting paper and cover with a dish to prevent drying. Remove the cover and the mushroom caps after a day. A fine impression of the gills would have formed by the discharged spores sticking onto the damp paper.



Spore prints can be preserved by drying and, if possible, covering with a fine spray of clear varnish. The colour and details of the prints would vary from mushroom to mushroom. Build up a reference spore print collection from readily available mushrooms and use these to identify any new finds.

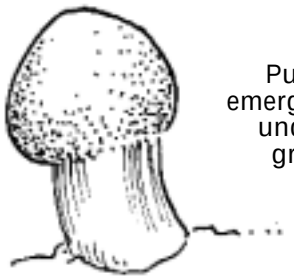
Bracket fungi and puffballs

Mushroom like growth are often found on many dead or living trees. But these *bracket fungi* differ from the mushrooms in that there is no stalk and the cap like structure is only a part circle very firmly attached to the wood directly. These grow in rows or one above the other like shelves. While these fruiting bodies remain outside the tree, often for years, mycelia keep growing inside destroying the wood. The older bracket fungi become woody and hard and growth rings can be seen on them.



Woody bracket fungi showing growth rings.

Puffballs are also fruiting bodies that jut out of the ground as soft, generally white, round bodies without any stalk. Spores contained inside the puffballs come out when it dries up and splits. Young puffballs are generally edible and have no harmful effects.



Puff ball emerging from under the ground.

Microbes at work - decomposition

All living organisms draw their nutrition from the environment and produce waste materials as a byproduct of the living process. Ultimately when they die, their dead remains add even more to the waste. If all these refuge and waste were to keep on accumulating, a time would come when no further life would be possible on the earth. These wastes would have a toxic effect on other living things. Even more importantly, essential inorganic substances required for life would be exhausted.

Materials like carbondioxide, nitrates and phosphates would remain bound or fixed in the waste and would not be available to others in a usable form. This will particularly hamper the work producers and no food will be available to support other life.

Fortunately for us, a group of living organisms work on all waste materials, including the lifeless remains, and break these down into simpler inorganic forms. These recycled substances are then used by the producers again for preparing food. These organisms are called the **decomposers** and they play a role that is only next in importance to that of the producers.

A variety of organisms, both large and small, take part in the process of degrading waste materials. Large scavengers like crow, vulture, jackal, crab breakdown the dead remains into smaller fragments. Worms and insects turn these into even smaller particles. But it is the microorganisms, especially bacteria and fungi, that digest all remnants into their chemically simplest and reusable form.

Bacteria and fungi work under different environmental conditions. While most baceria are killed in high concentrations of salt and sugar, many fungi thrive under such conditions. Many fungi also tolerate acidic enviroments and can grow even in oil-rich pickles. One speciality many bacteria have over fungi is the ability to grow in the absence of oxygen. On the other hand, most fungi can grow without liquid water as they can absorb enough moisture from the air.

Fungi play a particularly important role in breaking down plant residues. Most animal refuge and dead bodies get decomposed in days or weeks. But the trunk of a dead tree may require years to get back into the soil. Enzyme cellulase released by the fungi helps in breaking down the woody plants. Initial softening of the wood through the action of fungi-released cellulase also helps other insects in attacking a dead plant. Only fungi can breakdown lignin, a major constituent of wood that acts as a tough binder.

Cowdung

Fungal growth on dead matter helps in their decomposition.

Wood

Such aggressive metabolic properties make fungi very important as decomposers and key members of practically all terrestrial ecosystems. Thus the tiniest of living organisms, the microbes, play a major role in sustaining all other forms of life by cleaning up the wastes and keeping the basic nutrients in continuous circulation.

10. Soil

The non-living basis for life

In the simplest sense soil can be viewed as a non-living mixture of various chemical components. To the geologist, soil is degraded rock which has been transformed chemically to some extent and with which some other materials have gotten mixed. Chemists view it somewhat more generously as an innert but more active substance. Berzelius considers soil as "the chemical laboratory of nature in whose bosom various chemical decomposition and synthesis reactions take place in a hidden manner." Even the biologists look at soil as a non-living component of nature. They, however, credit it with playing an important life-supporting role by interacting with other ecological factors.

Thus the general overall view of soil has been that it is the layer of fine material that covers the land mass of the earth and provides a firm base for plants and animals to grow upon. It plays a special role in relation to plant life by acting as a penetrable solid foundation for their anchoring. It also serves as a reservoir for water and other nutrients vital for plant growth and absorbs the waste materials coming from the growing plants. Interestingly, plants also play a role in the formation and preservation of soil. Roots of the plants help in breaking up the rocks, loosen and expose the deeper layers of soil to water and air. Plants also make the soil suitable for life processes by adding humus to it and provide a protective layer on the surface which prevents rain and wind from carrying away the topsoil.

The living soil

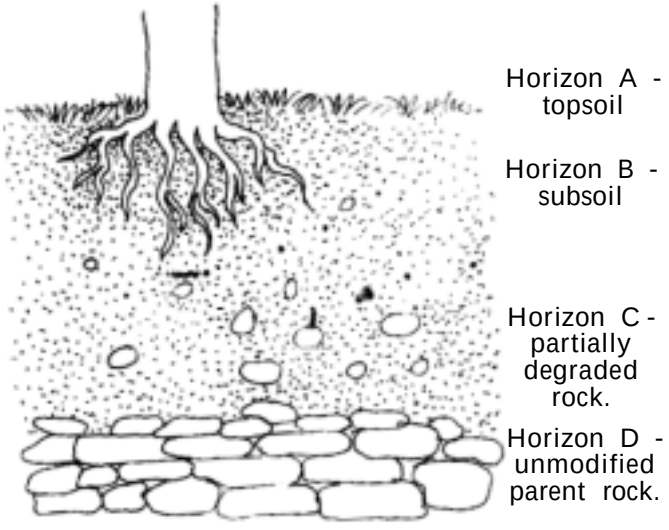
If we look at the top layer of soil closely we will find it to be a living place for many types of living organisms. These would be interacting among themselves, with the living and dead plant material in the soil as well as with the soil itself modifying it in many ways. In view of such interactions the soil-dwelling life forms are considered as integral components of the soil and the soil is seen as a major ecosystem which serves to link the inorganic, organic and the living worlds together.

If we examine some soil closely, we will find that it is made up mostly of mineral particles. We will find it to contains small amount of organic material that come from decaying plant and animal residues. Air and water are also present in the soil filling up the space between the particles. A smaller amount of water exists in a form bound chemically to the inorganic components. As noted above a wide variety of living organisms are found in most soils. Some of these organisms are bacteria, fungi, protozoa, insects and many tiny animals as we have seen earlier.

Soil at different depths

When digging a pit in the ground we might have noticed that the soil from different depths look and feel different. These might appear as distinct layers, each coloured somewhat differently, stacked vertically along the walls of the pit. Soil scientists call these layers, which differ from one another in their physical-chemical and biological characteristics, as *horizons* and have standard designations for them. The whole stack of these horizons are refered to as the *soil profile*.

The nature and thickness of each layer or horizon, and hence the overall soil profile, can vary widely from place to place. Still a generalised picture, which is useful for understanding the soil structures, can be drawn up. The generalised soil profile displays, as shown below, four distinct regions: horizon A - topsoil, horizon B - subsoil, horizon C - partially degraded rock and horizon D - unmodified parent rock.



A generalised soil profile

The topsoil starts with a thin covering of decaying plant residues and other organic litter. The layer of soil just under this is very rich in humus and has a dark colour because of it. This layer and the layer of litter above it are rich in microorganisms and tiny animals. The lower part of the topsoil does not have much organic material but has a high concentration of soluble minerals.

The region below the topsoil is subsoil which consists of fine particles as the layer above it, but these grains are packed quite densely. It does not have any organic matter and is also poor in living organisms. Soluble minerals that are washed down from the topsoil with percolating rain water accumulate in this region.

On an average the loose topsoil layer extends down to a depth of about 15 centimetres and the subsoil to about 90 centimetres. But these depths are highly variable from place to place. Formation of well developed soil capable of supporting life is an extremely slow process. It may require upto 20,000 years for the parent rock to come to the stage of topsoil. However, it can be lost, washed away by rain water or blown away by wind very rapidly, if the ground has no vegetation cover.

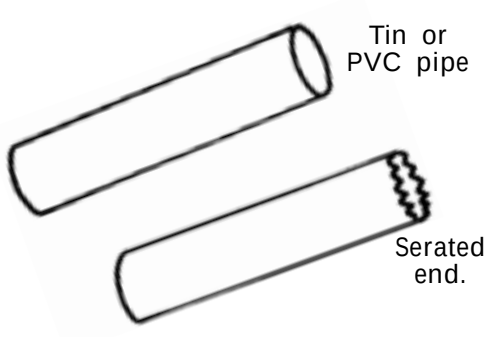
Determining a soil profile

A. Inside a pit:

* Find an open level area which has not been disturbed for a long time. Mark a spot on it away from any large trees and free from any thick roots. Sweep the surface very lightly to remove any twigs and other large and loose debris.
* Dig a pit keeping at least one side straight. Make it as deep as possible - professionals go down to a depth of six feet. Keep the dug up soil from different depths separately on the ground.
* Examine the excavated soil for any differences in colour, lumpiness, roughness etc. Try to see if different layers are visible on the wall of the pit. Can you make out the layers like the litter, humus-rich and plain topsoils, compact subsoil etc.? Note the thickness of each layer and draw up a soil profile for the area.

B. With a soil corer: Another method can be used for examining the soil profile of a swampy area.

* Take a tin cylinder open at both ends. An empty round talcum powder tin can be used for this or a longer tube can be made by rolling and welding together the edges of a thin galvanised iron ('tin') sheet. Thin walled sewerage pipe made from rigid PVC can also be used. Sharpening the walls of

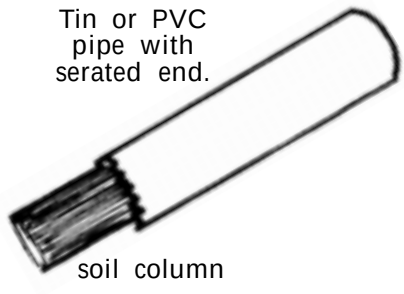


the lower end of the cylinder or cutting small teeth on it will be helpful in collecting soil samples from greater depths.

* Apply a coating of oil or grease on the inner side of this soil cutting tube and press it down into the soft soil. Turning the tube while pushing will help cutting in to harder soil. Let it sink down as much as possible, rock it sideways in all directions and pull it out straight up. The tube should come out along with the soil inside it.

* Push out the column of soil gently onto a flat horizontal surface. Tapping the cylinder wall gently or allowing the soil to dry out a bit would help in removing the soil column inside.

* Examine the soil column for different zones and note the profile. It can be dried and kept as a permanent record.

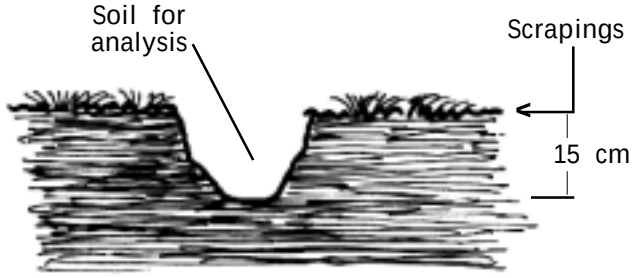


Collecting a soil sample

Different methods are used to collect soil samples for different purposes. A major variable among these methods is the depth from which the soil collection is made. For our work here we will make a collection of the topsoil layer from different places.

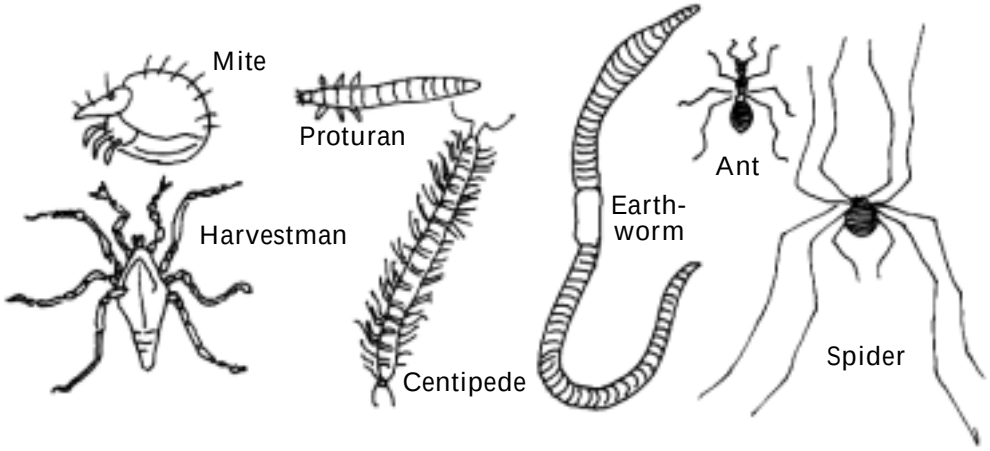
* Mark out a small clear patch and remove any large and loose debris from the top.

* Scrape out the layer of leaf litter and compacted humus till the harder surface of true soil is exposed. Save the collected scrapings in a plastic bag and examine it for living organisms as described earlier under *tiny animals* (p.66-67).



* Dig down to about 15 centimetres, mix the excavated soil well and keep about a kilogram of the mixed soil for further examination. While digging out and mixing the soil note if it is coming out as loose grains, crumbly lumps or hard clods. If the soil is moist, note its stickiness.

* Spread out the soil on a clean hard surface and break up the clumps by rolling a piece of iron pipe over it. Leave the loose soil spread out in shade till it is dry.
* Sieve the soil sample through a piece of mosquito net cloth or a screen with 1-2 mm openings. Discard the larger material retained on the screen and save the finer sievings for further studies.
* Soil samples collected from different types of places, e.g. garden, river bank, grazing fields etc., should be processed separately as above. The fine material from each can be compared to explore the variations among them.



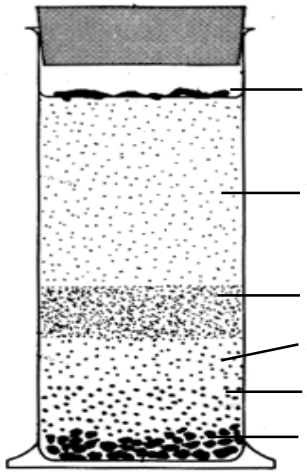
A selection of organisms found in the soil - total mass of soil organisms can be upto 200g per square metre of soils in very fertile grasslands.

Soil composition

* Take a tall jar or bottle with tight-fitting lid/stopper and clear smooth sides. Plastic kitchen jar of 500 ml capacity, jam bottle or a tall squash bottle will all serve the purpose.
* Fill the bottle to about 1/4th capacity with fine soil collected above and add water to the top.
* Close the container tightly and disperse the soil in the water completely by turning it up and down and shaking well. Leave the bottle standing upright on a level surface for a few hours.
* Take a close look at the soil that has settled down under the water. You can notice that it has formed several distinct layers. Some fine material could be found suspended in the water layer. There would also be something floating on the water surface.

The size of the grains and the colour in each layer would be different. The thickness of each of the settled layer would vary from sample to sample reflecting the relative proportion of the components in the soil sample.

This sedimentation process separates the the basic components of the soil quite effectively and gives us an idea of their relative proportion in a given sample. These basic components are classified according to their grain sizes details of which are given in the figure below.



Separation of soil components through sedimentation

Mineral Component of soil

Clay, silt and sand together constitute the inorganic or mineral part of the soil. These are all derived through a progressive degradation of the parent rock. These differ from each other in the size of their particles as well as in some other physical and chemical properties.

Because of their larger size individual sand grains can be seen with the naked eye. These sand grains are basically rock fragments and hence feel very rough when rubbed between fingers. Sand particles do not stick to each other even when wet. Particles of silt and clay are too small to be seen individually with the naked eye. Dry powder of silt and clay feel smooth between fingers. When wet, only clay feels sticky.

Magnified grains of sand.

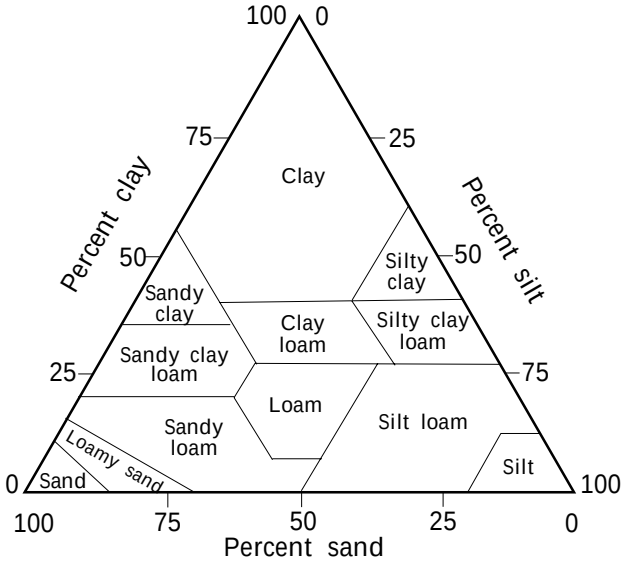
Clay, with the smallest particle size, forms a sticky mass when mixed with water. The sticky clay can be worked into various shapes which become quite hard on drying. The smallest clay particles form a colloidal suspension in water. These do not settle out even when left standing for a long time. During rainy season water appears translucent to opaque and light yellow or milky because of this colloidal clay. Such 'muddy' water can be cleared up by adding some coagulants like alum or some plant materials like moringa seeds.

Soil texture

Different soils contain the three basic mineral components - sand, silt and clay - in different proportions. The relative amounts of these determine the physical characteristics and other properties of any soil. The soil property that reflects this proportion directly is known as the *soil texture*. Based on this property soils can be divided into three broad groups or *textural classes* called sands, loams and clays. In the sand group of soils sand particles constitute over 70% and clay particles less than 15% of the bulk. The clays contain about 40% or more of clay particles. The loams cover a wide range of composition, the ideal loam being a mixture of about equal amounts of sand, silt and clay. Loamy soils have a porous crumb structure combining the advantages of pure sand and clay. Such combinations also overcome many of the disadvantages which the pure soil types suffer from.

A large number of subgroups have been designated to describe all soil types containing any combination of the three basic constituents.

Subgroups with compositions intermediate to the major classes have names like *sandy-clay, silty-loam, loamy-sand* etc. A typical triangular map is used to show the relationship between the soil classes and their composition.



Triangular map of soil textural classes.

Determining soil texture

Soil scientists use very fine sieves with openings of defined sizes to separate the sand particles from clay and silt first. Then they estimate the amounts of the latter two through sedimentation and calculate the overall composition.

One can, however, get an idea of the soil texture through a simple 'feel' method. This method, which requires some experience, is good enough to be used by the soil scientists in the field.

Finding soil texural class by its 'feel'

a. Take a pinch of the dry soil sample between the thumb and forefinger. Rub the soil gently between the finger tips and note how smooth or rough it feels. Compare its feel with that of sand and fine clay.

b. Make a stiff dough of the soil sample with water. Rub a bit of the wet soil between the fingers as above and note how it feels.

* Slip the forefinger downward on the thumb smearing the wet soil uniformly. How does the soil smear on the thumb look? Like a slick and shiny layer? Like grainy bits? Or something in between the two?

* Press the soil smeared finger tips hard and separate them slowly. Note if the wet soil feels sticky or not.

c. Take a small ball of the soil dough between the fingers and squeeze the finger tips hard on it. Does the soil come out as a thin and smooth ribbon? Or as a grainy ribbon or only as crumbs?

d. Roll the soil dough into small balls. What happens when the wet balls are pressed with a finger? Do they deform easily, i.e., show good plasticity? How easily do the balls fall apart?

* Do the balls keep their shape when dry? How hard are the dry balls?

* Match the feel and look of the soil rubbings and other observations for each of the soil samples with the table below to get an idea of their textural classes.

The table below lists the characteristics of pure sand and clay along with that of loam - the most commonly occuring soil type. The overall texture of any soil is determined mostly by the proportion of sand and clay in it. An ideal loam has characteristics intermediate to sand and clay. But these would shift towards whichever component occurs in a larger proportion. Thus a sandy-loam would be more sandlike while a clay loam would resemble the clay more.

Characteristics of different soil types

	Characteristics fl	Soil type		
		Sand	Loam	Clay
1.	Appearance to naked eye	Grains easily visible	Some grains can be seen	Grains cannot be seen
2.	'Feel' (Dry)	Rough	Moderately smooth	Smooth
3.	'Feel' (Wet)	Rough, not sticky	moderately smooth & sticky	Slippery & sticky
4.	Smear on the thumb	Coarse & grainy	Less grainy	Smooth & shiny
5.	Nature of the soil ribbon	Does not form ribbon	grainy and short	Smooth and long
6.	Strength of wet balls	Very weak	Break easily	Do not break
7.	Plasticity	Brittle	Somewhat plastic	Very plastic
8.	Stability of dry balls	Fall apart on drying	Moderately stable	Very hard and stable

Soil structure and porosity

Soil texture reflects mainly the proportion of the constituent mineral particles of different sizes. But soil also contains varying amounts of organic matter. The proportion of such organic matter is usually low, amounting to about 5% or less. But it affects to a large extent the way the soil particles aggregate or stick to one another. This determines the size and packing of the soil particles and the space left between them. In other words, the mineral particles and the organic matter together determine the soil structure.

The gaps between the soil particles are an important part of the soil structure. In a loose top soil this *pore space* can be upto half of the soil volume. When the soil is just moist, about half the pore space or 25% of the soil volume is filled with water and the other half with air. This water is often called the soil solution since various salts are dissolved in it.

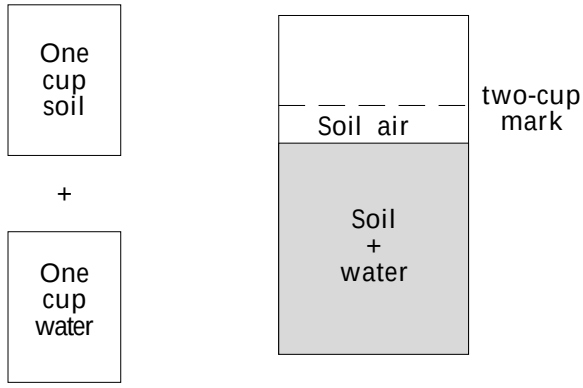
Thus the overall soil composition is taken as - mineral skeleton (50-60%), organic matter (upto 10%), water (25-35%) and air (15-25%).

This is an ideal condition for plant growth since the roots can get all the basic materials from the soil itself.

Water content of any soil can vary with the external supply. During flooding all the soil pore space gets filled with water leaving no room for air. Under very dry conditions practically all water is lost from the soil and the pores contain only air. Neither of these conditions is good for growing plants.

How much air is there in the soil?

* Take a wide mouthed plastic jar (500 ml capacity). Pour into it a cup of water and mark the level. Add another cup of water and put a second mark. Empty and dry the jar.
* Place a cup of a soil sample in the jar and tap lightly to pack the soil. It should come upto the first mark. Add a cup of water to it and stir gently with a stick. Air bubbles can be seen rising through the water.
* When the soil is fully mixed with water note the level of the water in the jar. Note how far below the two-cup mark is the new level. This difference indicates the amount of displaceable air in the soil sample. Compare the air content of a sandy soil with that of a clay soil.



Precise measurements of air content can be obtained if one uses a graduated measuring cylinder for this work.

Soil contains water

* Put some soil in an old tin container and cover the tin fully with a glass plate. Warm the tin gently. Water vapour driven off from the soil can be seen to condense on the glass cover.

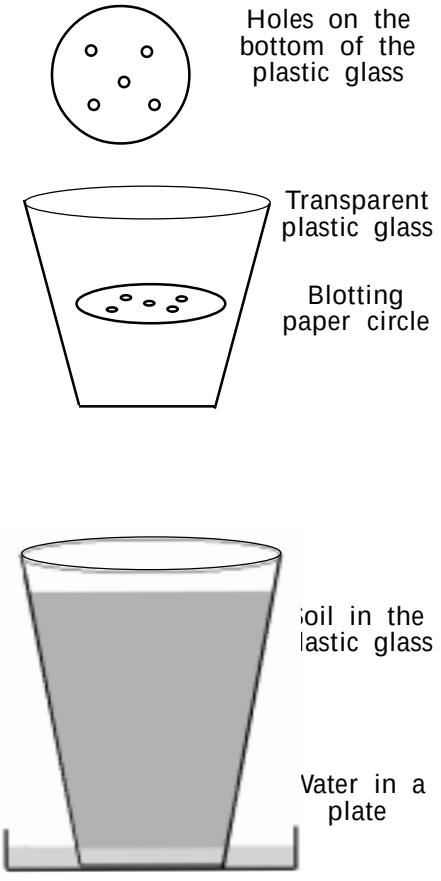
The dynamic soil-water.

The amount of water in any soil can change according to the surrounding conditions. The rate at which water passes through the soil particles (*permeability*) and the maximum amount of water the soil can retain (*water*

holding capacity) are two important properties of soil. These soil properties are also determined by the size of the soil granules and hence by the pore space.

Permeability and water holding capacity of soil

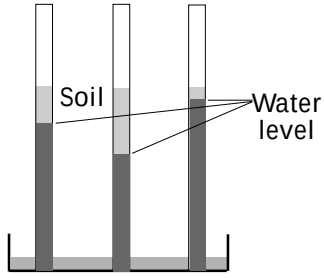
* Take a transparent plastic glass and make a few holes on its bottom with a hot iron nail. Place a blotting paper circle inside the glass to just cover the entire bottom. Fill the glass with soil sample - the blotting paper will prevent the loose soil from escaping through the holes.
* Stand the soil-filled glass on a plate and add a glass (same size as that holding the soil) of water to the plate.
* Water will rise through the blotting paper and the soil. This can be seen from the darker colour of the wet soil. After some time the soil in the glass would become uniformly wet and the water would reach the top.
* Do this with several soil samples side by side and note for each the time taken for the water to reach the top and the amount of water remaining in the plate below when the soil has become fully wet.



The time taken for water to reach the top is indicative of the permeability of the soil sample. Faster the water comes to the top, greater the permeability of the soil. It also means that the soil will allow water to drain out faster. A slow rising water line will indicate slow drainage and greater danger of water logging in that soil.

The amount of water left behind in the plate after the soil is completely soaked tells us about how much water is being taken up and held by the soil. The lesser the amount of water remaining in the plate, greater the water holding capacity of the soil sample.

If we use very tall glasses filled with soil, we may notice that water rises to a certain height and stops. This height will be different for different types of soil. This tells us from what depth can the soil draw water up and is known as its *capillarity*. In actual practice determination of soil capillarity is better done with tall transparent tubes of 1 to 2 cm diameter. Lower end of the tubes can be plugged with cotton and the tube filled with soil. The soil-filled tubes can be made to stand vertically, with appropriate support, in a container of water. The final levels can be noted after water has stopped rising or after a fixed period of time.



Water rises to different levels in tubes with different soils.

It may be noticed from these activities that sandy soils allow water to rise up faster (greater permeability) but hold less water (lower water holding capacity) This is because their larger particles leave larger pores but the total volume of pore space is less. Clays, on the other hand, have finer particles. This results in smaller pores but larger total pore space. Hence water moves slowly in such soils but more water is retained by them. Also because of the smaller pores, clays show greater capillarity and can draw water up from greater depths.

Soil fertility

The most important role of soil is in relation to its ability to support plant growth. This property of soils - soil fertility - is controlled by their content of organic matter. The soluble mineral salts present in the soil also contribute to some extent to a soil's fertility.

As we saw above, the organic components of soil determine its interactions with air and water. By altering the structure of a soil the organic matter helps in making it suitable for different types of plants and crops. Organic matter in the soil also helps directly by providing valuable nutrients required for plant growth.

In this way, after their death the living organisms make their contribution to the soil's ability for supporting new life. And it is in this link role that soil proves to be one of the most important factors for the living world.

Worksheet guide to studying soils

1. Place and season of study:
2. Type of location: Big city / small town / rural area / wilderness / forest.
3. Collection of soil samples and field characteristics:
   a. Place of collection: Road side / rice field / sandy patch / river bank / sea shore / rocky area / near a pond / manure pit / high land / other.
   b. Mode of collection: Topsoil scrapings / digging a shallow ditch / from a deep hole / with a soil corer / other.
   c. Ground condition during collection: Dry / very dry / moist / wet / water logged / muddy / any other.
   d. Soil condition: Hard / easy to dig; came out as hard clods / crumbly lumps / loose soil.
   e. Litter layer on the soil: Deep / thin / mostly dry leaves / partly degraded / fully degraded.
   f. Soil profile: How many layers are noticeable? At what depths? Make a sketch of the profile.
   g. Living organisms:
      i. in the litter layer: Many / few; what were the most common?
      ii. in the soil: Many / few; what were the most common?
4. Physical characteristics of the processed samples:
   a. Colour: Light / dark; black / brown / red / yellow / off-white.
   b. Appearance under magnifier: Coarse grains / fine grains / powder / grains mixed with powder.
   c. Feel of the dry soil: Hard / soft; rough / smooth; grainy / powdery.
   d. Feel of the wet soil: Rough / smooth / slick; sticky / not sticky.
   e. Behaviour of soil dough: Forms long / brittle / no ribbon when pressed; Forms good / poor / no balls when rolled; On drying the balls become hard / crumbly / fall apart.
5. Interaction with air and water.
   a. How much air the soil contains: About 10 / 25 / 50 %
   b. How fast does water reach the top - time (permeability - high / low)?
   c. How much water does the soil take up - percentage of soil volume (water holding capacity - high / low)?

11. Living together

Ecology - the science of nature

The most remarkable thing about nature is *togetherness*. Things, whether living or non-living, do not convey a sense of naturalness in isolation. A beautiful tree is just that. But a group of trees, beautiful and plain, large and small, would form anything from a garden to a forest. There would be noticeable interactions - both co-operation and competition - among the plants there. And there will be more. Any wooded area would automatically attract other living things. These would range from microbes and tiny creatures to large animals, and even man. All of them together would become quite a remarkable natural whole. Components of this whole could be of very diverse, even opposing, characters. Yet they would exist together. Even more, they would sustain and enhance the unified whole by interacting among themselves in all possible ways. Each of them would influence its surroundings in many ways. But taken together their impact would be much more magnified. Such profound impact of things together is the very essence of nature.

In other words, nature is a reflection of the process of *living together*. And the study of such natural togetherness is called the science of ecology. In a literal sense it means the *science of the living place*. Functionally also, ecology keeps the living place - the *habitat* - as its focus. It studies the habitat along with all the organisms, materials and happenings within it. All these components are studied together as a conceptual whole called the *ecosystem*. In practical terms an ecosystem is defined as *a basic functional unit comprising of all living organisms, their physical environment and all interactions taking place within and among them in a specific unit of space*.

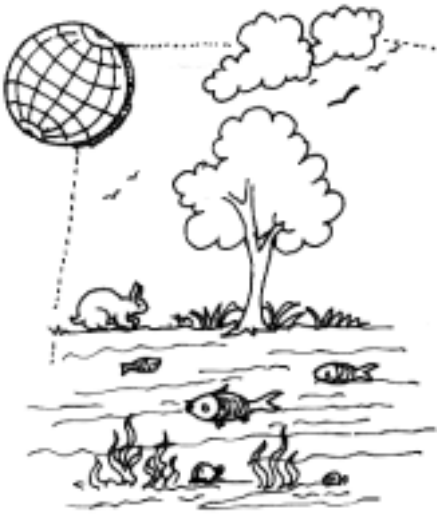
Ecosystems - building blocks of nature

An ecosystem may be very large or quite small. It can be a forest, an ocean or a small compost pit or an aquarium. To be a true ecosystem the unit should be able to support all life within it in a reasonably self-sustained manner. Also all material in an ecosystem must be used in

a cyclic way. Thus, what one gives off into the system should be converted back by others into a form usable ultimately by the first organism. For example, the carbondioxide we breath out into the air is converted by the plants back to oxygen we need.

Keeping these conditions in mind, we can find many ecosystems of different sizes and types around us. An ecosystem may be connected with many others around it in some way or the other and several of them together can form yet another larger ecosystem. Finally, all ecosystems on earth can be seen to be connected to one another. And together they form the *biosphere* - the largest ecosystem of which all earthlings are a part.

Interestingly, the biosphere, the only part of the earth which supports all life, is only an insignificant fraction of our planet's bulk. It extends only a few hundred metres below and a few kilometres above the sea level. All life on earth is limited to this thin shell around the globe consisting of the upper parts of land surfaces and of the oceans and the lower atmosphere. While the availability of sun's radiation decides the lowest depths where life can be found, the upper height is dictated by the availability of the other life supporting factors like oxygen.

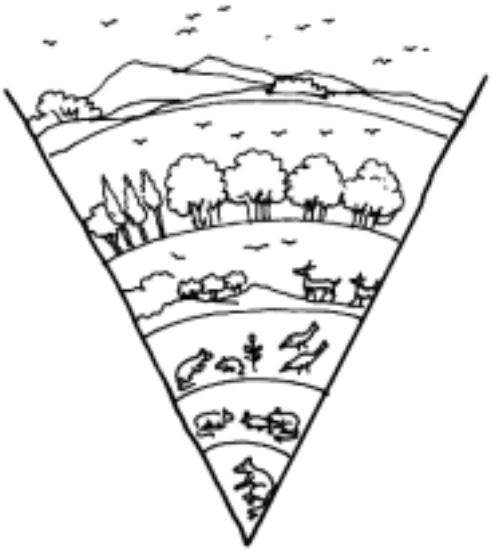


Biosphere - the thin shell of life around the earth.

Components of an ecosystem

The life supporting factors like air, water, soil, minerals, sunlight are the nonliving constituents (*abiotic factors*) of any ecosystem. Living organisms (*biotic component*) form its other essential part. These two components of the ecosystem are linked through two important processes. These are: 1. the flow of energy through the components of the ecosystem and 2. the cycling of nutrients within the ecosystem. An example of the first is the sun's energy captured by the plants and stored as chemical energy (food). This is taken up by the plant eaters, who again pass it on to the meat eaters. The second is exemplified by the drawing of soil nutrients by a growing plant. When the plant dies it degrades into the soil, thereby returning to the soil the nutrients it had taken in.

The wholeness of nature is too complex to be appreciated fully when looked at in its entirety. Hence a more manageable approach has been to study it in smaller, self-contained, units as ecosystems at various levels of organisation. Studying even smaller units independently is also possible within an ecosystem. These common ecological units are: *individual* (a single organism), *population* (a group of the same organism), *community* (populations of different organisms living together) and, finally, the *ecosystem* where many different communities co-exist in a characteristic way.



Common ecological units

An understanding of the smaller and locally existing ecosystems has helped in identifying some larger ecosystems on the earth. Each of these larger ecosystems covers a single geographic zone and occurs under the same climatic conditions. This unit is called a *biome.* Desert, tundra, tropical rainforest, mountain, grassland etc. are examples of such biomes. Since the life forms and living ways in each is very different from that of others, these are often called *life zones*.

The evolving ecosystem

An important thing about any ecosystem is its changing nature. Whether it is a small pond or the biosphere itself, subtle changes in its living as well as nonliving characteristics can be observed over a period of time. Usually these changes take place slowly and in a balanced way. But sudden and catastrophic changes can and do take place at times. As a result of all these the *ecosystem* evolves into newer forms.

For example, a large body of water may in time get invaded slowly by marsh plants. Gradually dead plant materials would accumulate and the filled up pond will become a swampy area. After a still longer period of time the ground may become firm enough to support large trees. This may give rise to a regular forest where the water-body first stood. The normal aquatic life would die out and other organisms which fit better into the emerging environmental conditions would appear. The course of

the changes might even be influenced by the newer inhabitants in some totally unexpected ways. Man's role in influencing the environment, particularly over the last few centuries, is now well appreciated.

Catastrophic changes like the eruption of a vulcano, severe flooding etc. can bring about abrupt environmental changes. Such events can leave a lasting impact on the flora and fauna over very wide areas. Changes may even take place on a global scale. Disappearance of dinosaurs due to the impact of a massive meteor on earth is a well known example of this.

Environment, both local and global, is being reshaped continuously in this way for centuries. On a still larger time scale - over millions of years - the planet earth has also changed many times over. It had evolved from a ball of molten rock to a planet covered by oceans and violent storms. And from that to one with land masses and simple life forms to the one we know today. Changes are taking place still. And with ever increasing human activity earth's future is heading in uncertain directions.

Ecology - hands on

The above is a greatly simplified overview of some aspects of ecology and ecosystems. It aims to bring out the fact that in nature everything is organised in many complex, interactive and mutually dependent ways. And that we can gain valuable insight into it by studying things individually and in progressively larger groupings. Continuing the study over a long period of time gives us a still better understanding of the system, especially an appreciation of its dynamic and evolving character.

In the course of our activities with nature so far, we have been looking at some of its isolated components or some processes for a short time only. We have also had on occasion watched individual organisms or even groups of them (population). There are also many examples of *mini-nature* within our easy reach and understanding where we can find both a diverse group of organisms living and working together. Such examples of natural systems are easy to observe and understand because of their small size and low complexity. We can also observe many changes taking place in a sequencial manner within such systems over a fairly short time span. In short, we too can make a study of these evolving ecosystems in our amateur ecological adventure. We can go even farther and build some models of these based on what we have done so far. A terrarium or an ecopond can be stocked with appropriate materials to mimic a land or water based ecosystem of our design.

The living world in a dung pat

Most of are familiar with cow dung, although with a general sense of dislike. But we also know of its important role as a rich manure and soil conditioner. It also serves many other useful purposes around the home, especially in rural areas. Let us now take a different look at it from a nature-explorer's point of view.

Normally, cow dung is expelled as a large glob of dark greenish-grey coloured semi-solid matter . As it hits the ground, it forms a mound with a flattened base and a rounded top. It is called a *dung pat* or a *cow pat*. The top surface of the pat has many dipressions and lines. When fresh, it also has a shiny surface. The dung inside a fresh pat is lighter in colour and has a uniformly granular appearance. There will be some variation in the appearance and consistency of the dung depending mostly on what the animal has eaten. Most interestingly, fresh cow dung has practically no smell.

A cowdung pat is shaped like a mound with a flat base and a rounded top.

The interior of a fresh pat is of lighter colour and is uniformly granular

Locate a few fresh dung pats on the ground in a somewhat out of the way place and watch them closely for a few days. Several kinds of insects will be found descending on the dung soon after it has been deposited. Among these will be different kinds of flies and dung beetles. Some flies, like the house fly and blow fly, would only lay eggs in the fresh dung. But the small yellow colored dung flies would settle in to live on the dung.

Dung beetles are roundish insects with hard, dark coloured, often shiny, wings. They are found in a large variety of species and in sizes ranging from one-half to three centimetres. Some of them shape bits of dung into perfect balls, often larger than their own size, and roll these away. They usually work in male-female pairs and one pulls the dung ball while the other pushes it. They bury the dung balls under the ground and use it as food and also for laying eggs in them. This way the

A pair of dung beetles rolling away a ball of dung.

young larvae would have plenty of food as soon as they hatch out of the eggs. There are other types of dung beetles which dig under the dung pat and feed and breed there itself.

In a few hours the dung surface appears dull and a hard crust starts to form on it. The pasty dung inside would now appear like a piece of sponge filled with blister-like pockets. It would also be giving off a strong smell. Both the pockets and the smell are due to the gases generated through the action of bacteria breaking down the organic matter in the dung. This process gives us the *gobar gas* (bio-gas) fuel rich in methane and the smell comes from sulphur compounds. By this time a large variety of microorganisms, invisible to our eyes, are decomposing the dung into simpler chemicals that will go back into the environment.

By the second day we can find several kinds of small worms wiggling about the dung. These are mostly the larvae of the insects which had laid their eggs in the fresh dung. Some of these would be slender threadlike and others stubby maggots without legs. The larvae would be feeding on the raw dung voraciously and would become pupae soon. They are in a hurry to complete their growth process before their foods in dung gets degraded further.

Insects and worms colonise the pat by day two.

In another day or two, three to four days after the dung was deposited, the dung surface would have dried up completely into a hard crust. It can be turned over in one piece like a turtle shell. We will find only a fraction of the dung mass under the shell and that too will be fairly dry and crumbly. All the smell would have disappeared too. Many tiny animals like earthworms, millipedes, beetles, ants, centipedes will be found there. Some of these would be preying on other smaller organisms thriving earlier. Some white ants may also be seen there by now.

The dung surface dries up to a hard crust with little dung remaining within.

Degraded dung goes into the soil.

White ants would take over whatever remains of the pat after about a week from the start and mix it into the soil. This would complete the decomposition of the dung pat. But in the meantime it would have

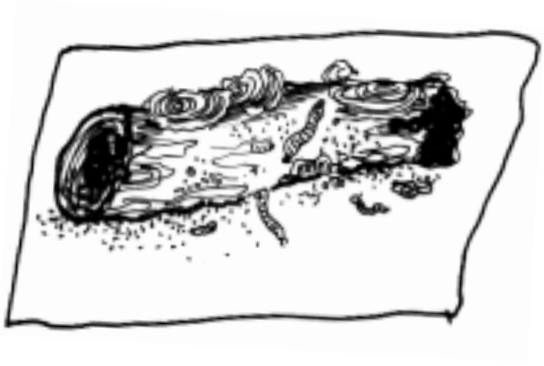
supported a variety of living things. And each of these would have thrived at a particular stage after the dung was deposited. At the same time, each one of these living organisms would have played a part in the decomposition of the dung itself.

The rate, sequence and the exact nature of changes in the dung pat would depend on external conditions like temperature, humidity, type of the ground it lies on etc. And each situation will present us with a new system to study. Thus by observing a 'lowly' dung pat only for about a week or so, we can get many interesting insights into an evolving miniature ecosystem.

Rotting log - life on a roll

A piece of dead wood lying around and rotting is not an unusual sight. If we go for our nature walk in an wooded area we can find many such pieces in different sizes and in various stages of decay. Let us collect a reasonably decayed piece and examine it carefully. Place the piece in a shallow tray and take a close look. We might see some fungi growing on it and may be a snail or millipede sticking to the outer surface. Patches of moss and even some small plants may also growing on it.

Tease it apart gently with a knife or any other pointed tool. The bark, by now sticking loosely, would come off easily. Some woodlice and other insects hiding under it may also spill out. The core wood would start crumbling if it is quite old and we will find ants, termites and other small insects inside. There may be other tiny creatures too there. On the whole, we will find the rotting log to be a living place for a wide variety of organisms.



A wide variety of living things can be found in a rotting log

This in itself is quite interesting. But would it not be even more excitng if we could follow the fate of a dead branch, a tree stump or a whole fallen tree from the start to end? Yes, we can do so without much difficulty. We would need access to a garden large enough to leave a log undisturbed in a corner for a long time. We can then watch it change

over a period of time and get a good idea about the decaying process and who ever takes part in it.

Another, perhaps easier, way would be to visit a large wooded area where many fallen trees in different states of decay can be found. We can explore the organisms and other factors on a number of such dead trees. Then by arranging them according to how long each appears to be lying around, we can get an idea about the decay sequence.

In general, we would find a sequence of events, especially in a damp wooded area, as follows:

Stage I

Snails, slugs and woodlice are usually the first arrivals at a freshly fallen log. They use it as a shelter and feed on the softer parts. Other carnivours like centipedes and ground spiders follow soon.

Stage I: Snails, slugs and woodlice are the first arrivals on a freshly fallen log.

Stage II

The log would have moss, fungi, grass and small weeds growing on it. Heat and moisture would have loosened the bark and many insects and other tiny animals would be crawling about it. Frogs, lizards and other animals can also be found on and around the log.

Stage II: Moss, fungi, grass and small weeds start growing on the log. The loosened bark has many insects.

Stage III

Action of wood boring beetles and other insects and of heat and moisture would have loosened the wood to a great extent. Larger animals scratching on it and birds probing for hidden insects and larvae would cause pieces of wood to break off. The crumbling wood would be infested with ants and termites which would soon break it down completely.

Stage III: Ants and termites break down the crumbling wood completely.

The exact course of events and the time scale would vary greatly depending on the climate and environment of the place. The size and qualities of the fallen tree or branch would also add to the variability. Still keeping track of an entire course of decay would definitely be very interesting and educating.

A similar course of events can be seen in the stump of a dead tree. Here an added dimension will be the changes in the woody roots that are buried in the soil.

A decaying stump of a dead tree supports a variety of life both above and under the ground.

And we move on . . .

Starting with simplest of activities with leaves we have come to watching the whole course of a fallen tree decomposing. In all these activities we have been working as amateur ecologists and students of science. We are learning the ways of science using nature as our study object. We are also developing an appreciation both for science, particularly its method, and nature. Thus initiated, we can hope to go on finding newer areas and approaches to study on our own.

After a nature walk

Sorting and analysing

. . . the nonliving

Displaying

. . . the living

Exploring Nature presents a series of simple activities relating to the living nature around us. The activities have been chosen to be interesting in themselves. When taken up as such, these activities should help in developing a habit for looking closely at things around and to bring about an appreciation for natural objects and processes. At the same time, enough background has been included to link the activities to broader concepts of science, particularly to that of biology and ecology. Children can use this book directly. But it aims to be more of a resource book for the adults interested in working with children.

Nikhil Mohan Pattnaik (Ph.D., Biochemistry, 1976) and Puspashree Pattnaik (M.Sc., Zology, 1979, B.Ed.) have been interested in *education*, especially at the primary stages, and *science appreciation*, particularly beyond the classroom. Their basic approach has been *learning with things around*, for which they have been developing ideas, programmes and materials over the last two decades. Srujanika, co-founded by them in 1983, has been the main academic forum for their work and has played an important role in creating resource persons and materials.

The authors and the Srujanika team have been involved with the writing / translating / editing / production of a number of books, mostly in Oriya language, published by themselves as well as others including the National Book Trust, India, and Vigyan Parasar. These include classics like Totto-chan, Divaswapna, Halden's My Friend Mr. Leaky and activity books on Sky-watching, Paper folding, Science toys, Plant spotting etc. *Bigyan Tarang*, a resource periodical linking Science, Education and Development, is being brought out by them since 1989 and plays a link role in their activities. Starting with the BJVJ 1987 they have also been involved with a number of broader programmes.