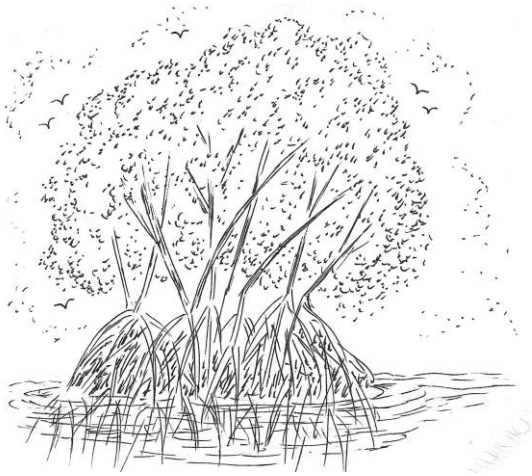
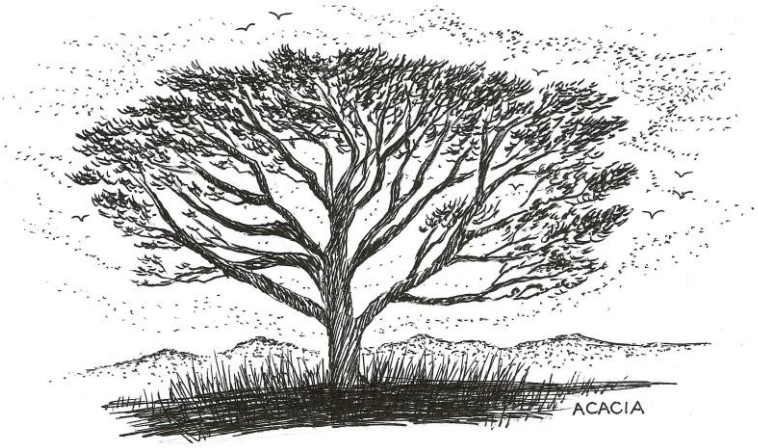
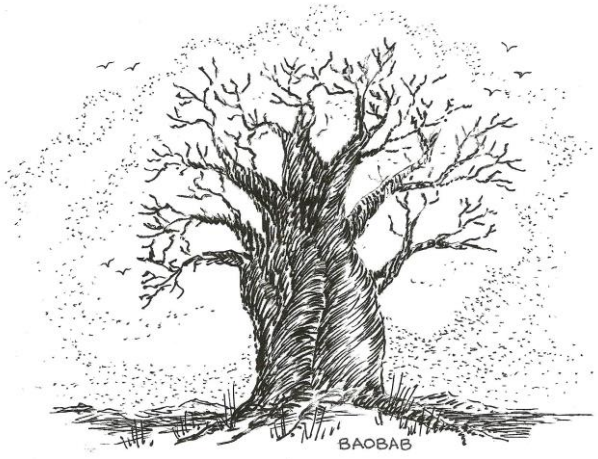
PLANT STUDY MANUAL







WRITTEN FOR

THE EAST AFRICAN WALDORF TEACHER DEVELOPMENT PROGRAM

BY

CATHERINE VAN ALPHEN

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Author's Acknowledgements

My journey through this Plant Study manual has been very exciting. I wish to acknowledge firstly the wonderful little book, *"The Living World of Plants"* by Gerbert Grohmann written for children that has been the basis for most of my information. I also wish to thank Beulah Reeler for her booklet of notes from Rudolf Steiner and other sources. I wish to thank my friend Priscilla Sydow who helped me with the inspirational drawing of the "Dance of Life". Many thanks go to Peter van Alphen for advice and editing.

Catherine van Alphen

Editor's Acknowledgements

Whilst every effort is made to acknowledge the work of others included in this manual, in some cases it has not been possible to trace the authors of poems or other material, handed down from teacher to teacher. I ask that any information regarding authorship is passed on to me, on peterva@mweb.co.za, so that authors may be acknowledged for their work in subsequent editions/printings.

This manual is indebted to the Waldorf tradition of teaching according to the principles of Rudolf Steiner (1861 – 1925), as developed by many generations of teachers.

Peter van Alphen

The East African Waldorf/Steiner Teacher Development Programme

The East African teacher development programme was started by the late Adeline Mlai, a Tanzanian, in Dar-es-Salaam in 1997. Adeline recognised the developmental value of Waldorf education and invited Peter van Alphen and Ann Sharfman, teacher educators with experience working in African settings in Cape Town, South Africa, to start a teacher development programme in Dar-es-Salaam. This programme was set up for teachers from Tanzania, Uganda and Kenya.

After the first year, difficulties securing the funds for continuing the programme were experienced, and in 1999 the programme was relocated to Nairobi, Kenya, as a more central venue for the three countries. The Rudolf Steiner School in Mbagathi was able to secure funding for its continuation, and in the eleven years that followed an ever-increasing number of teachers from East African countries joined the programme.

Our grateful thanks go to Zukunfsstiftung Entwicklungshilfe (GLS Bank, Bochum, Germany) and Freunde der Erziehungskunst Rudolf Steiners (Berlin, Germany), Sanduko a Ndege (Vejle, Denmark), Internationaal Hulpfonds (Amsterdam, Netherlands), Acacia (Basel, Switzerland), Stichting Helias (Netherlands), Iona Stichting (Amsterdam, Netherlands) and International

Association of Steiner/Waldorf Early Childhood Education (IASWECE, international) for their continued support of the programme from 1999.

About this Manual

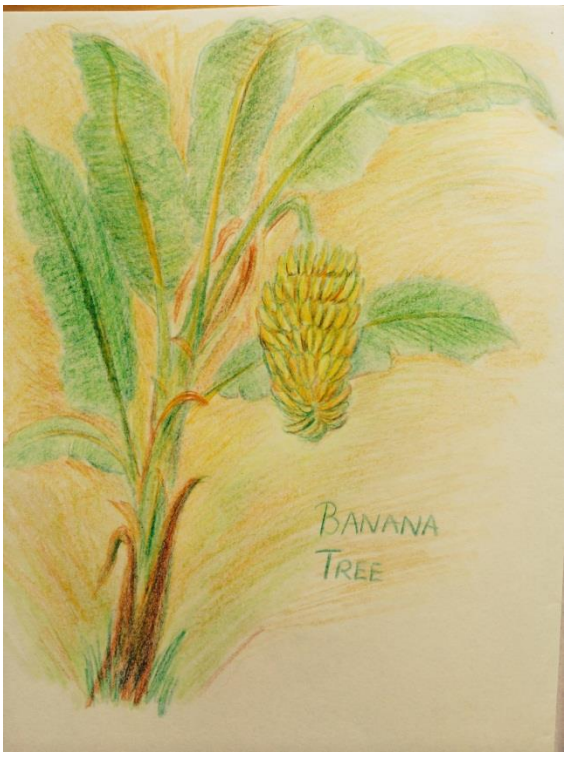
The manuals in this series answer the need for teachers (or student-teachers) to have notes on the modules they attend. This manual is written for Primary School teachers attending the module on Plant Study as suggested by Steiner for its introduction in Grade 5 (age 11 years) and as suggested by the author for its continuation in relation to Geography in Grade 6 (age 12 years).

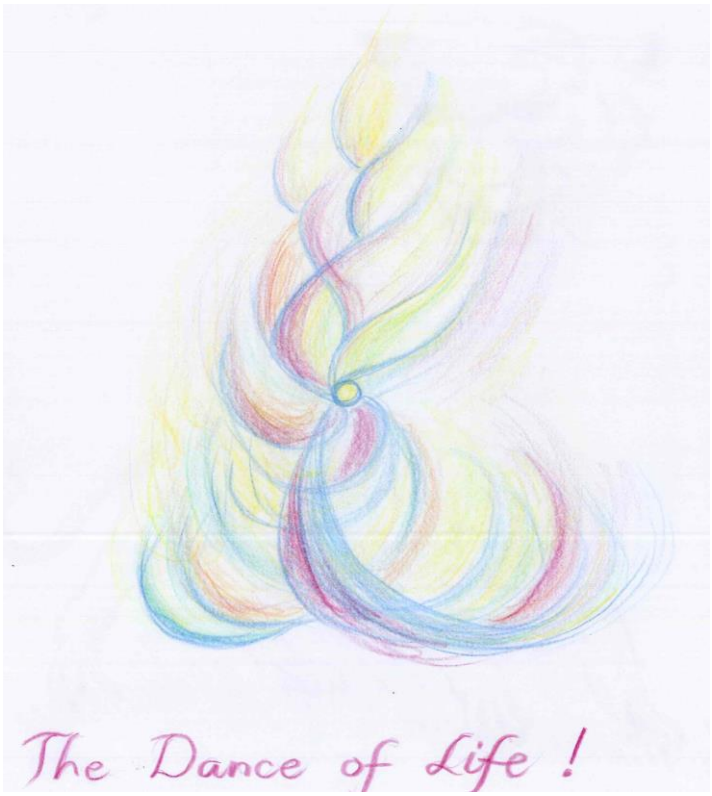
Teachers wishing to use this manual are asked to first study the manual on Child Development, so that everything written here can be seen in the light of a broader understanding.

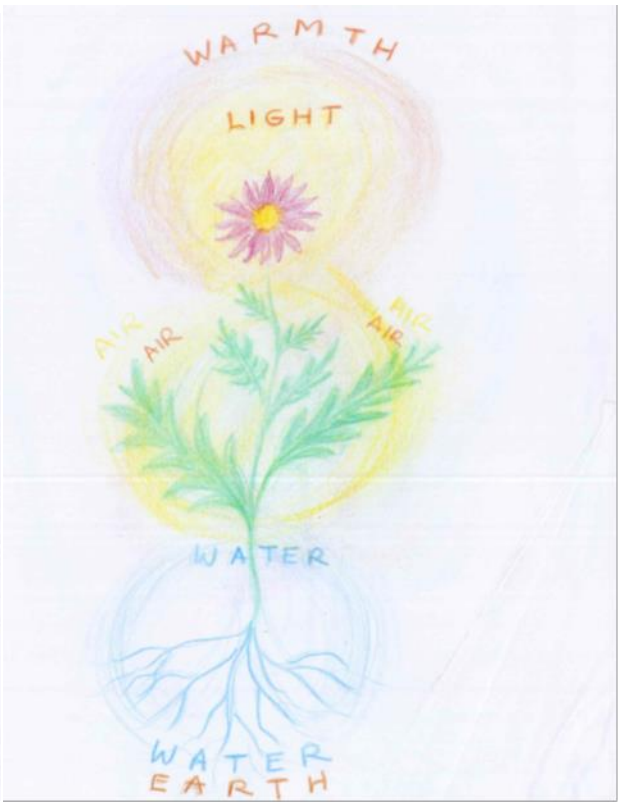
It is written to assist teachers new to Waldorf Education to see examples of how the educational principles given by Rudolf Steiner can be applied in daily teaching. Everything written here needs to be seen as possible examples, rather than "this is the way we teach the Plant Study curriculum in Waldorf Schools." Every teacher needs to adapt the suggestions given here according to the children in his or her class, their cultural background, the local environment, etc., so that the needs of the children are served, rather than following an imported curriculum.

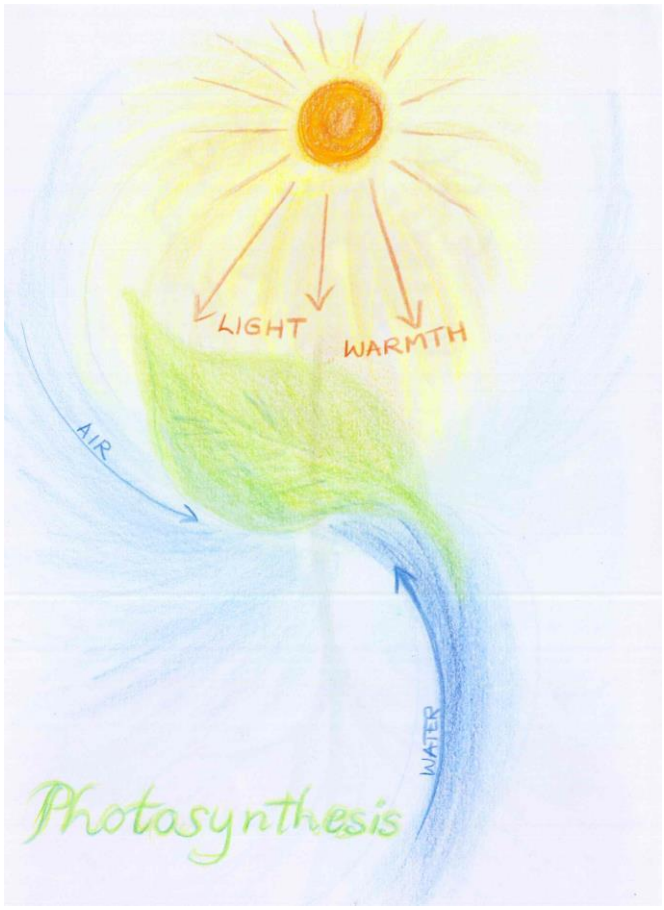
This manual is intended to be handed out at the end of the module for revision and further study. The suggestion is that participants study together in groups in their respective schools.

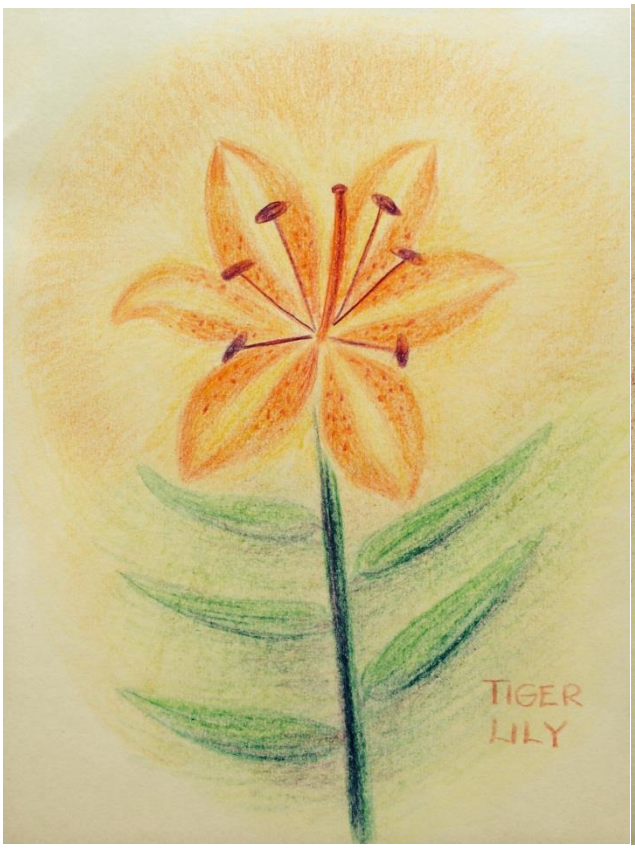
Although written specifically for teachers in East African countries, we trust that the material provided will be useful in Steiner/Waldorf training programmes in many countries around the world. Comments and suggestions are welcomed, and can be sent to Peter van Alphen on peterva@mweb.co.za.

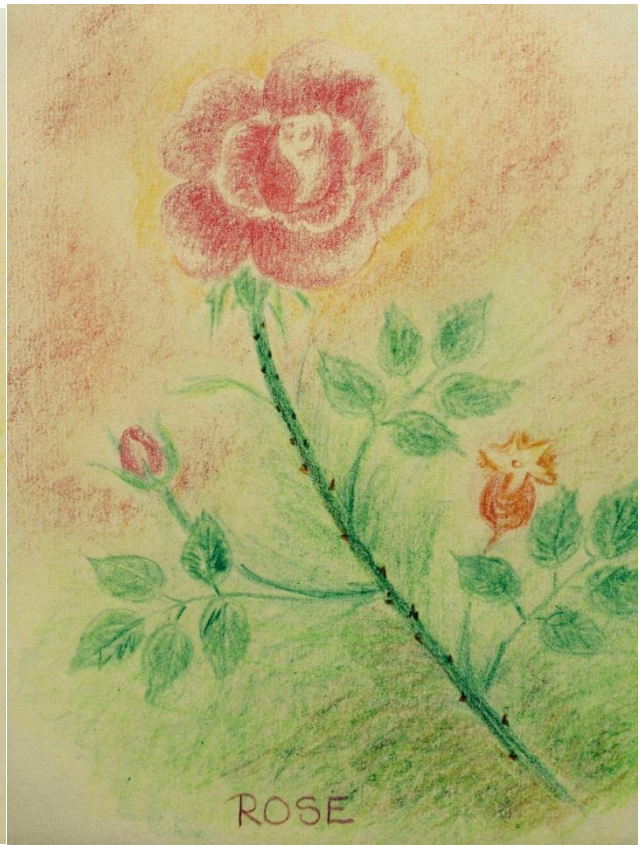












INDEX

SECTION 1: SUGGESTED USE OF THIS MANUAL

When to Teach Plant Study

This manual gives a full overview and content of Plant Study in the Waldorf primary school. Rudolf Steiner suggested that when children are turning 11, which is Waldorf Grade 5, the children would begin an intensive study of the plant world. However, plant study continues in the years that follow a teacher, linked to Geography.

How the teacher arranges his main lesson blocks on plant study is his or her responsibility, for much will depend on the children in the class. This includes their knowledge of the language of instruction used in the school, and other factors unique to their situation.

A Whole World Study in a Local Setting

The Plant Study main lessons span a wider geographical area than the children's own local area. They now have to see the world as a whole! This means that the teacher needs to have a wall map of the world hanging in the class (this should in any case be there permanently from Grade 5 onwards). Ideally this wall map is a climatic map of the world, as explanations of where certain plants can be found need to be explained in terms of the climate in different parts of the world.

It is important for the teacher to find local equivalents[1] in his or her area. The teacher is asked to read and digest the information given in this manual, and then question which local plants or trees are the same in nature as those described here. These local examples will be different in different countries or even areas.

Time of Year for Plant Study

The planning of *when in the year* one does Plant Study is most important. One has to choose a season when plants are growing, as there need to be many walks to look at plants growing in their natural environment.

Preparation for Plant Study – Living plants

Live plants in the classroom: the teacher needs to prepare the classroom before teaching plant study. A variety of live plants in pots, which the children can observe, and which they have to water regularly, need to be placed in the classroom. These can be used by the teacher to demonstrate, and for the children to draw from observation during main lesson and/or art lessons. Bringing the plant world into the classroom avoids a too theoretical way of studying plants.

[1] Equivalents = of the same value; in this case = similar plants that can be found locally

Live specimens of mushrooms, lichen, moss, ferns, pine needles and pine cones, etc are needed when teaching the evolutionary ladder, and so the teacher needs to find specimens – or their local equivalents – so the children can see the actual plants.

Preparation for giving lessons

Teachers can use the themes in this manual for preparing their lessons. This manual does not only provide the content of what is to be taught, but also suggestions such as getting the children to participate in class discussions, allowing them to contribute their own information, ideas and experiences. The teacher can arrange outside observations, which will also be discussed in terms of how to prepare a class for these.

Integrating the Arts into teaching Plant Study

Teaching a main lesson is not just the imparting of knowledge: we need the children to *experience* the nature and 'being' of plants. In order to do this, we need to use the arts to deepen children's experience of what they are learning. Section 4 of this manual gives suggestions of how this can be done.

Every time we prepare to teach an aspect of plant study, we need to ask ourselves, "what artistic activity can I involve the children in, to make this aspect of knowledge have deeper meaning and so the children can experience a connection with what they are learning?"

For this purpose, in the Arts section at the back of this manual (Section 4), I have included movement exercises and dances for teachers to use with the children during the Plant Study main lesson. The children are also most sensitively aware of beauty, and so I have also included drawings and paintings to show the interaction of the plant processes with the cosmos. I hope these examples will inspire and encourage teachers to use and expand their own ideas.

Suggested Arrangement of Plant Study main lesson blocks

Here follows a possible arrangement of main lessons, assuming a reasonable language ability is already established. However, this is only a suggestion, to help teachers (or a school curriculum as a whole) in finding a structure for their main lesson blocks, but they must not see this as 'the way it has to be done', but rather adapt their programme according to the needs and circumstances of the children they are teaching.

The suggested outlines below refer to the sub-headings in Section 2:

Class 5 (4 week main lesson block, i.e. 20 days)

THE FLOWERING PLANT (see Section 3 for an example of how to plan main lessons on the Flowering Plant as outlined here):

1. The plant as child of earth and sun; the four elements
2. The water of life; the secret life of the plant; drawing of the whole plant showing expansion and contraction in each part
3. Seed, roots and stem
4. Leaves: shapes, breathing, photosynthesis, water cycle
5. Development of the flower; structure and functions of each part of the flower
6. The relationship between flowers and insects; fertilisation and development of seeds
7. Wind pollination; the gifts plants give us; what can we give back to the plants?

EVOLUTIONARY LADDER OF PLANT KINGDOM

8. Mushrooms
9. Algae
10. Moss
11. Ferns
12. Conifers
13. The Lily
14. The Lily continued
15. The Rose
16. The Rose continued
17. Deciduous Trees
18. Deciduous Trees continued
19. Revision and completion of drawings
20. Test of knowledge on Plant Study

Classes 6 and 7

LOCAL PLANTS AND PLANTS OF THE WORLD

How one continues Plant Study will depend very much on how each school develops its curriculum, especially in relation to the teaching of Geography. If a school's curriculum studies its own continent, for example Africa, one can start with the shape of the continent, its mountains and plateaus which give rise to its major rivers and lakes. Having done this, one would study the plant life of Africa's different climatic regions, starting with a study of local or regional plants, and then moving from the equator north and south to look at the plants growing in the different climatic regions of Africa. In this case, the teacher can refer to the Equatorial Rainforests, the Savannah Grasslands, the Deserts, and the Mediterranean climatic zones of Africa, both north and south of the equator.

Then, when world geography is learnt, starting with the continents and oceans, the major mountains, rivers and lakes, the climatic regions can be described by studying the plants in each climatic region (or 'zone'). It may be, for example, that world geography is studied in Class 7. In this case, one would see how the climatic zones circle the world, and introduce the children to going further north and south, into the Temperate Woodlands, the Coniferous Forests and the Tundra of the polar regions.

There are further possibilities, if there is time and space in the curriculum, to study plants and trees that provide our food: the different grains, the fruit trees and the vegetables. These are very worthwhile to include, bringing understanding of our relationship to nature, and the reverence towards it that we need to feel for making our existence both possible and pleasurable on earth.

SECTION 2: PLANT STUDY

A GRACE

The plant seeds are quickened in the night of the earth,
The green leaves are sprouting through the power of the air
And all fruits are ripened in the might of the sun.
So quickens the soul in the shrine of the heart,
So blossoms Spirit-power in the light of the world,
So ripens Man's strength in the glory of God.

Rudolf Steiner

THE PLANT AS THE CHILD OF EARTH AND SUN

Every morning the sun wakens the earth with its warmth and light. As the darkness begins to soften, the birds burst forth to sing their joy for the new day. At the touch of the sunbeams, every plant and flower and tree lights up to reveal their true colours. In the sun's warmth they stretch out their leaves and open their flowers. Insects, animals and human beings also wake up and begin their daily activities.

The warmth and light of the sun carry a power that draws the plant upward to unfold its leaves. The flowers blossom and later fruit and seeds will ripen through the sun's loving warmth. Water and air flow through the plant, carrying nourishment and energy to every cell. They also weave the connection between sun and earth.

Could anything grow without the sun? No. Why? The earth would be too cold for anything to live on it. The sun is like a great warm heart, filled with love that gives life to everything on earth.

Even the moon and stars, wind and rain, work together to help the Earth. They interact like a family. That is why they have often been given names like Father Sun, Mother Earth, Sister Rain and Brother Wind.

So all four elements: earth, water, air and fire play their part. And as we learn about this wonderful world of nature, we come to realise that not one of them can survive without the others; we are inter-dependent in more ways than we think!

Let the children discuss the many ways in which the sun affects the earth, the seasons, the plants, animals and human beings who live on the earth.

THE FOUR KINGDOMS OF NATURE

See colour drawing of the four elements on page 5

This great, wonderful earth is home to all things, supporting life in all its forms. But what do we know about the earth and how does she support us? (Let the children discuss these questions[2].) The chief characteristic of the mineral kingdom are the rocks: whether round and smooth or rough and rugged, mountains and rocks have clear forms and they are also very heavy.

What can the rocks and mountains do? Rocks can do nothing on their own. They lie peacefully on the ground unless moved by wind, water or volcanic activity. And it is this very strength and stability that is needed for all living things to live in safety. Soil comes from rocks that break up into fine particles, or are eroded by wind and water. They allow the plants to grow, because they contain minerals that give the plants their structure. Soil is a mixture of the dust created by rocks and the organic matter left behind by dying plants, animal droppings, etc.

And how do the plants differ from the rocks, and what do they have in common? Plants have a physical form like the rocks but they are alive, so they can grow and produce leaves, flowers and fruit. Plants respond to the changing weather, drinking up water from the soil, and ripening their fruit in the sunlight. They cannot move around, as they are rooted in the earth, but they are a source of food for insects, birds, animals and human beings. We could not live without them! Plants are able to breathe, grow, and make their own food. If they get damaged, they can heal themselves and they can make seeds to reproduce their species for the next season.

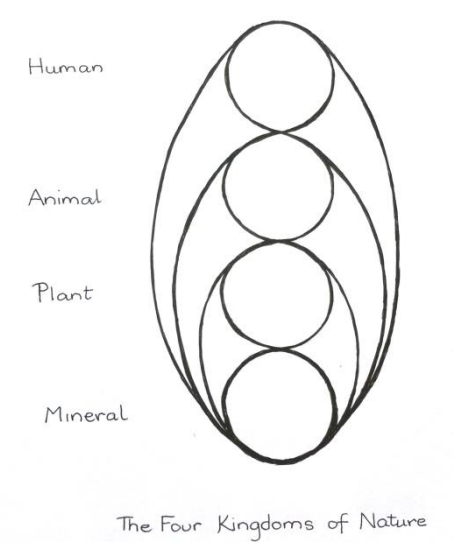
Animals have a physical shape like the rocks, but they are alive and can do all things that plants can, except make their own food. But what can animals do that plants cannot? Animals have legs and can move around in their environment. Even birds and fish, insects and reptiles can do the same in their own way. Animals also respond to the environment but differently from plants. We learned in Class 4 that animals have sense-organs and instincts that tell them about the environment and whether there is food or danger nearby. They can feel anger, fear, hunger and love and make sounds that express these feelings. But animals walk four-footed, their backs horizontal like the plains on the earth and they belong to the particular environment in which they live.

Human beings have gifts that animals do not have. What gifts are these? They can speak and think, and move freely on two legs, freed from the earth by their uprightness. Human beings are conscious of themselves and therefore can remember the past and imagine the future. They are creative, able to make choices and to change the environment and themselves. What a responsibility we humans have to use these gifts to

[2] What follows are guiding thoughts to the questions the teacher raises. The idea is to get the children to think for themselves and come up with their own answers as often as possible . The teacher can participate in the conversation, adding key thoughts that the children do not mention, to guide them in looking at nature in a holistic way.

create a place on earth for all these kingdoms to live in peace and harmony!

ELEMENT	MINERAL	PLANT	ANIMAL	HUMAN
Fire				Conscious Thought
Air			Senses and Feelings----------	
Water		Life Energy----------		
Earth	Physical Form ----------			



In this diagram we can see that each kingdom has the gifts of the previous ones but brings some new quality or gift in their own development. Only human beings are self-conscious through the power of thinking.

THE DANCE OF LIFE

See colour drawing on page 5 of the Dance of Life.

All things that are alive can breathe, move and grow: plants, animals and human beings. This life of breath connects every living thing and we all breathe the same air that circulates in the atmosphere around the earth.

As we breathe in, we take into ourselves all that is around us: weather, nature, the feelings of other people, the atmosphere or energy of the place we are in, so that we can feel at one with the whole world. We also breathe in the divine light and love of the spiritual world, whether we are conscious of it or not. (That is why we usually feel so happy and relaxed when out in nature.)

As we breathe out, our feelings flow out into the world. So there is a constant interchange between us and the world around us: even with the plants, animals and people we meet.

We are never quite the same as we were yesterday because our experiences of the day before have altered us. We have learnt things, gained and lost things, done things and grown wiser in the process. Our words and deeds, our thoughts and feelings have also influenced everyone around us. Life is an ever-flowing dance of interchange, growth and

becoming!

Now the plant world that we are going to study is even more connected to the weather around it than we are, because it breathes in and experiences the weather all the time. (We protect ourselves from the weather by living in houses and wearing clothes.) The plant does not have feelings as we do, but it is always responding sensitively to the environment.

The whole environment of the plant - through the qualities of the four elements (earth, water, air and fire) - affects the growth of the plant. The warmth and light of the sun, the cooling rain, the fresh air and the nourishing earth are all needed by the plant, but too much of any of these can become a drought, a flood or a storm that could destroy the plant and the earth in which it is growing.

However, the weather changes all the time and brings new life. The plant revives, a broken branch sends forth new shoots, seeds spring up after a fire and so the 'Dance of Life'[3] goes on.

The Dance of Life[4]

Streaming, swirling, round and round,
The flow of the pattern
Is swept by the sound.
Gracefully whirling all around,
The space is formed,
The shape is bound.
Out of the feeling,
Soft or strong,
A form emerges in joy of the song.
Out of the energy,
Dancing with mirth,
All creation comes to birth.

3 Explanation of the poem and painting on the 'Dance of Life' can be found in Section 3 on the Arts.

4 Song by Catherine van Alphen. © Catherine van Alphen

THE SECRET LIFE OF THE PLANT

When we look at a plant, it is either unfolding in its upward growth or beginning to die down. This shows us that the plant's life has stages of growth and decay. In fact we can never see the *whole cycle* of a plant's life at any one time; we can only see *a part* of the cycle, at the moment in time that we observe the plant. Most of the plant's life is hidden from view.

When we look at a seed, it has hidden within it the whole plant, which still has to be born! In looking at growing stem and leaves, the flower is not there yet. The fruit of the plant can only be seen towards the end of the cycle.

What part of the plant is always hidden? It is the roots that spread out underground. And so, the plant is in continual change, and we can never see the every stage at the same time! So the plant has many secrets for us to discover. We can look forward to new stages of growth and beauty every day in the life of the plant, especially if we water and care for our plants and gardens!

THE WATER OF LIFE

Plants, animals and human beings all need water to survive and they cannot live without it for very long. It is truly the 'Water of Life'. All living things contain water or liquid in every cell of their bodies.

What is so magical about water? It contains energy; the energy of life forces that create and sustain the bodies of all living things. [For the teacher: these life forces are also called the 'etheric' life forces. It is not necessary for children to know the name 'etheric' as the word 'life forces' gives a clear understanding of the meaning of this energy].

This energy or life force in water allows the plant to grow. We cannot see these life forces in the plant although we can see *the effect* of this power working in the growth of the plant. These life forces work invisibly, surrounding the plant and penetrating every cell with life and energy. This is the real secret life of the plant.

What other aspects of the plant are invisible? The plant can breathe and absorb water and mineral salts from the soil. The plant can also make its own food and reproduce itself by making seeds. All these invisible processes will be explored and discussed in the story of the journey of the seed as it grows into a complete plant.

A further secret is hidden in the seed. How does each seed know exactly what kind of plant it will become? The life forces hold the plan (or ‘pattern’ or ‘blueprint’) of each plant so that an acorn can only become an oak tree and a kernel of wheat can only become a wheat plant. So we may understand that the plant world is full of secrets that are revealed as we observe and experience the eternal 'becoming' of the plant world in the Dance of Life.

THE LIFE CYCLE OF THE PLANT

Let us follow the journey from the seed to the full flowering plant, and look at how the plant grows

The Seed

Imagine a tiny seed, sleeping deep inside Mother Earth through the dry months of the year. The soil forms a snug blanket around the baby seed, holding it safely in the darkness until it is ready to grow, just as a baby lives in the darkness of its mother's womb (body) until it is ready to be born. And what will awaken the tiny seed, what does it need to make it grow?

The first rains! Soaking rains make the soil moist, bringing life to the seed! The soil surrounds the seed with water, and the thirsty seed begins to suck it up into itself, just like a baby sucking milk from its mother.

At the same time, the gentle radiance of Father Sun's rays begins to stroke the earth with warmth and light at the beginning of the growing season. The little seed feels the warmth and begins to stir.

You can see a tiny dot on the side of a bean or pea seed and this is a tiny opening like a mouth where the seed absorbs the nourishment from the soil. It begins to swell up and grow.

Root and Shoot

The little seed is like a tiny house. As the seed grows, the little seed coat around it cracks open like a small door. And what will come out of the little door? First a little root appears. It is so small, we call it a “rootlet”. This tiny white rootlet curls outwards, twisting and turning in a spiral movement as it grows downwards, deeper into the darkness of the soil.

Very soon, a tiny little plant comes out! It has two seed leaves which are full of food for the new little plant to use. These seed leaves are like two storage rooms of the little house!

The little shoot turns and grows in the other direction compared to the root – upwards towards the light and warmth of Father Sun. At some point the little shoot will reach the surface of the earth and although it is so small and soft, it wriggles round in a spiral movement until it pushes through the soil and suddenly it bursts out into the beautiful sunshine! It is like a small child, wriggling and rolling until at a certain moment it stands upright! What a wonderful moment!

The Roots

The root continues to dive down, slowly growing stronger as it explores the soil of the earth around it like a little corkscrew. What do the roots do? Like fingers, they grasp everything, holding on tightly to soil, stones, rocks and whatever is available. This keeps

the tiny plant securely anchored in the earth and supports it to grow upward.

The little root grows bigger and sends out more and more little roots in every direction and on all these roots are tiny root hairs.

What are the roots looking for? Food and water! The soil is full of nourishment, like a mother feeding its child. The little plant needs nourishment from Mother Earth. The soil contains compost (organic matter) and mineral salts and the root hairs are able to suck up water, organic matter and mineral salts from the earth. All this becomes sap which this nourishes the whole plant.

In the firm, dark earth the roots become hardened and strong. Plants with short roots like vegetables can easily be pulled out of the earth, but it is very difficult to pull a plant out of the earth when it has been growing for some time. One can be amazed at how many roots and root hairs are growing under the soil on one plant!

At the end of each root is a root cap, which makes it possible for the root to dig into the soil. The root cap is like a metal spade that has to be hard enough to break its way into the soil. The root pushes the root cap from behind, just like the spade's handle gives force to the blade of the spade. But there is a difference: the root spirals its way into the soil, giving it enormous strength to break through the hardest parts of the earth.

The Stem

As the shoot grows, the seed coat falls away and the little seed leaves are getting smaller and smaller as they feed the tiny plant, which grows bigger and bigger.

The shoot gently spirals upwards and becomes the stem of the little plant. The stem is much softer than the roots that live in the hard, dark earth, for it lives in the elements of water and air. So we can see how stems are flexible, swaying in the breezes around the plant.

But the stem will grow fatter and stronger each year as the plant gets bigger and needs more support. It has the task of holding the plant upright so that it does not fall over when the wind blows. What part of the human being supports us to stand upright? Our trunk and the strong but supple spine inside us!

The stem is also like a pathway from the roots to the leaves. Inside the stem, the plant forms hundreds of tiny tubes that carry the liquids from the roots to the leaves and all over the plant. The stem is kept very busy transporting water and food to the whole plant.

In the centre of the stem is the hardest part, which holds the plant upright. We call this part the "core" of the stem, and can see how like our bones this part is! Around the core are the many tiny tubes, which are very busy transporting sap all the time, from the roots to the leaves, and from the leaves to where foodstuff is stored or needed. And then, there is the outer "skin" of the stem, which protects the stem from getting hurt: in trees this skin gets really hard, and we call it "bark".

The Leaves

The stem first grows two tiny leaves but soon branches out with more and more branches and leaves as it grows into a proper plant. Every plant creates its own shape of leaf and so leaves have many different shapes. They may be broad or narrow, pointed or rounded in shape. We can notice that the leaves are flowing in shape, some parts like the leaf blade expanding outwards to the sunlight and other parts contracting inwards to form the strong narrow stalk or the pointed end of the leaf. In fact all parts of the plant are contracting or expanding, sometimes both at the same time! How can that be? [5]

Leaves feel different too: some are hard, others are soft, hairy or waxy, etc. But all leaves have a waterproof cover like a roof, as one can see when rain water runs off a leaf. It runs down the ridges and drops down to give moisture to the thirsty roots.

Breathing

All leaves reach out to the fresh air and the warmth of the sun. Underneath the leaves are tiny openings called stomata that allow the plant to breathe. So the leaves are like little lungs that breathe in the air for the plant. The breathing process of the plant supports the life of animals and human beings in an amazing way.

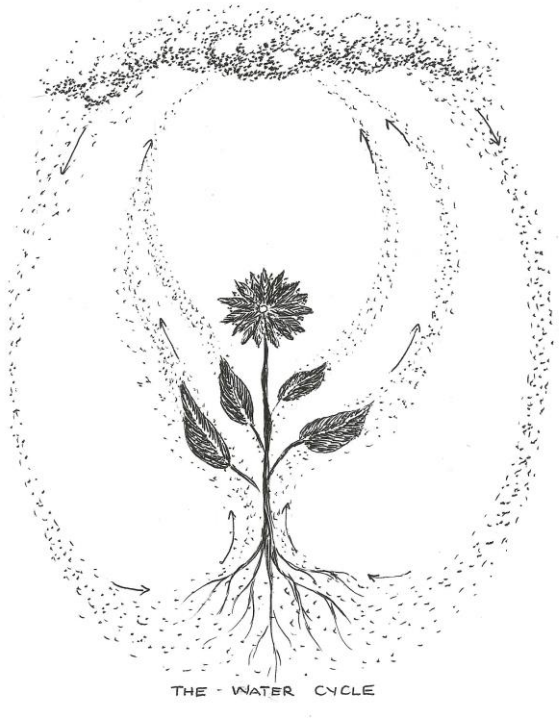
Human beings and animals breathe in oxygen from the air in order to stay alive, and then breathe out carbon dioxide as waste air. Plants, on the other hand, breathe in carbon dioxide and breathe out oxygen. So they are constantly supplying us with fresh cool air filled with moisture!

When we walk in a forest, we feel cool and we think it is because of the shade of the trees. It is also because of the fresh, moist air breathed out by the trees. So human beings are more dependent on and connected to the plants than we realise.

5 See chapter on expansion and contraction in the plant.

The Water Cycle

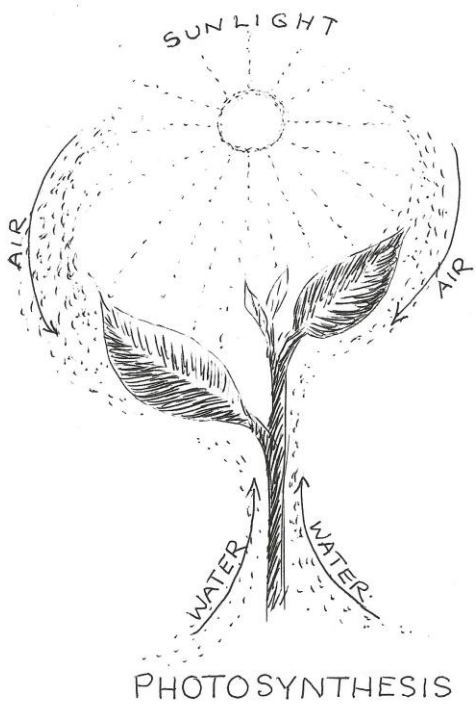
The warmth of the sun draws the moisture up from the roots. It flows through the plant and out of these tiny stomata in the leaves into the air. This moisture rises high into the atmosphere and transforms to form clouds. These clouds cool the earth in the forms of dew, mist and fog. They will also eventually bring rain. The secret work of the root hairs that gather the moisture from the earth, nourishes not only the plant, but the whole planet in a wonderful Water Cycle.



Into the roots and up through the stem,
Out of the leaves and into the air;
Clouds in the sky, gathering rain,
Down it falls to the earth again!

Photosynthesis

See the colour drawing of Photosynthesis on page 5 of this manual.



How does the plant make its food? From below the plant draws up the sap containing water and mineral salts. From its surroundings, the plant absorbs carbon dioxide from the air. The sunlight is able to penetrate the waterproof covering of the leaves and using the water, minerals and carbon dioxide, it makes a very special substance inside the leaf called chlorophyll, which gives the plant its green colour.

The creation of food is the work of Father Sun, Mother Earth and the plant - the Child of Sun and Earth - together. Without the heat and the light of the Father Sun, no food can be made! But equally, without the water, minerals and air of Mother Earth, food could also not be made! And, of course, without the plant - the Child of Sun and Earth - food could not be made, and nothing on earth could live!

From chlorophyll we also get a 'sugar' that is essential for the growth of the plant. One could truly say that the leaves are like little kitchens that process these different substances, in order to make food for the plant.[6]

6 Poem, song and dance for photosynthesis can be found in Section 3 of this manual.

After the food is made in the leaves it is sent to all parts of the plant. Some of it will travel back down to the lower parts of the plant, just under the bark or outer covering of the stem, where it is stored and looks like a layer of soft damp jelly.

This food not only nourishes the plant but will provide food for animals, insects and human beings, thus supporting all life on earth. So the leaves have three important processes working through them all at the same time: breathing, the water cycle and food-making or photosynthesis!

The Flower

The plant unfolds many leaves until it is full of green growth. But at a certain point the leaves become smaller in size and suddenly we notice at the end of a stem, a small round bud appears.

The bud looks as if it is just some smaller leaves wrapped into a little ball. But this contraction into the *bud* is the beginning of something completely new! It is the experience of the element of warmth, the warmth of the sun!

As the bud grows in size the tight green leaves, called the *calyx*, open out. Inside these leaves, are the *petals*, unfolding in an explosion of colour and radiating outwards like the sun. It is as if the light and warmth of the sun has touched the inner leaves with magic and transformed them into wonderful and beautiful shapes and colours.

The petals spiral open to show the *heart* of the flower: this is the centre of the flower! We see a *crown* of slender stamens in a ring surrounding a central pistil. Many flowers have golden centres, like little suns. Every flower is different in scent and colour, shape and design, but most of them display the joyful welcoming qualities of the warmth and light of the sunshine. Most flowers open in the light of day and close at night when the darkness brings peace and rest.

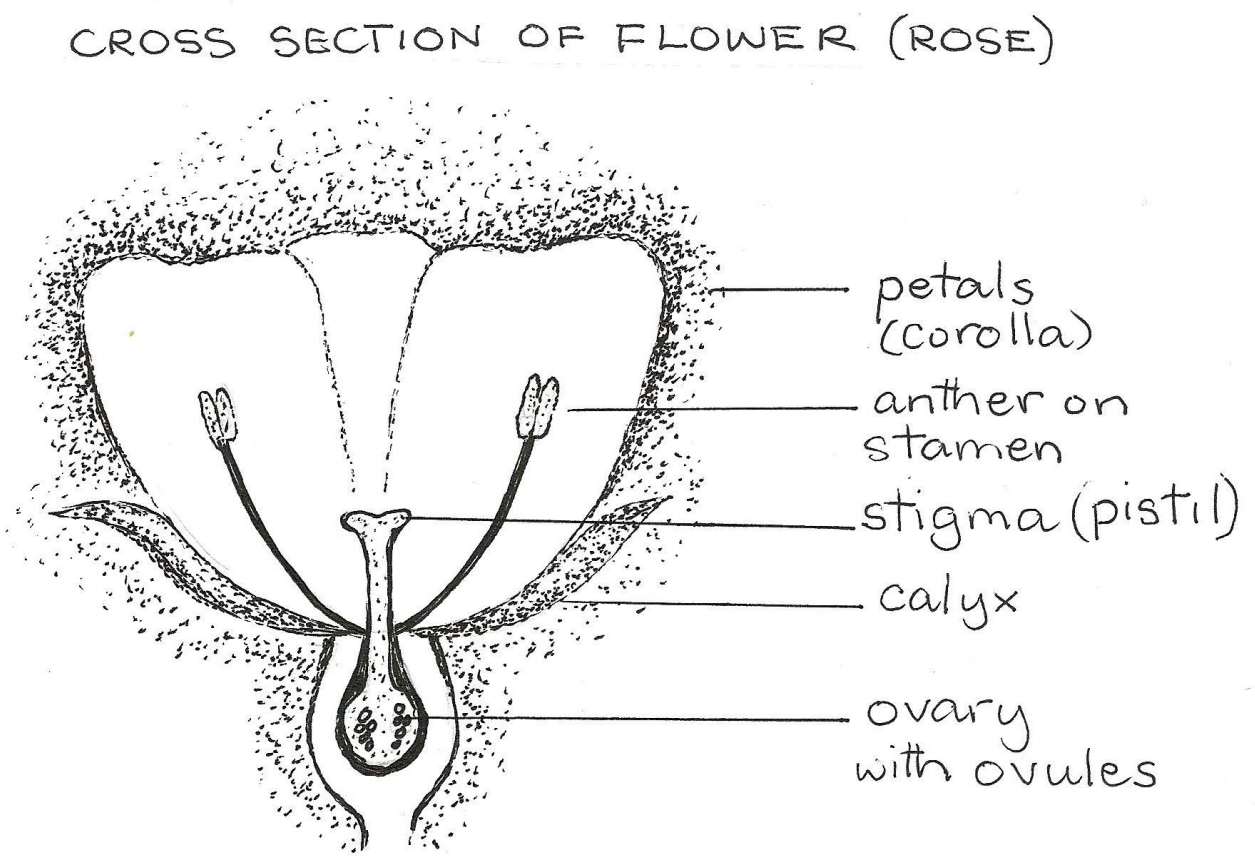
Even the sap of the plant is sweetened by the warmth of the sun, forming *nectar*, like honey, in the base of the flower. And streaming forth from the flower is its scent or fragrance, floating in the air around the plant.

Contained in its shape is the form of a star, sometimes a five or six-pointed star, as if it fell from the heavens into the heart of the flower. No wonder people give flowers to those whom they love!

But the flower has not been given such beauty just for people to enjoy and admire! Its lovely colours, its shape and delicate scent are created for a very specific purpose. The plant must reproduce itself by making seeds before it comes to the end of its cycle of growth when it will wither and die. So the flower attracts insects that will seek the sweet nectar that it produces in the deepest part of the flower.

Let us look more closely at the parts of the flower.

1. The Calyx is the group of small green leaves that surround and protect the bud.
2. The Corolla is the beautiful arrangement of coloured and scented petals.
3. The Pistil stands in the centre of the flower. At the base of the pistil is the ovary or seed box containing the ovules that will develop into seeds. A long tube or stalk rises up from the ovary and projects out into the centre of the flower. This is called the Style, which has a little sticky "cap" called the Stigma.
4. The Stamens are fine, delicate filaments that surround the pistil like a crown. They are connected to the petals and may be coloured in a similar way. On top of each stamen is the Anther that produces golden pollen



The Fruit

After pollination, the petals of the flower wither and die. The ovary begins to swell and grow as the ovules develop into seeds in the warmth of the sun. In some plants a fruit develops around the ovary to attract animals to eat the fruit, thereby swallowing the seeds. The seeds are not digested, but find their way back to the earth when the animal makes its droppings. Other plants form seed-pods, which dry out and then burst open, scattering their seeds.

The plant dies down, but the seeds fall to the earth where Mother Earth will cover them with a blanket of dead leaves and soil. The seeds will lie in the earth and wait until they are ready to begin the journey of the plant cycle all over again.

FLOWERS AND INSECTS

Every flower has beautiful colours and patterns in its petals to attract an insect. It also sends out a lovely scent to tell the insect where it may be hidden among the other flowers. Flowers are just like girls who have put on their pretty dresses for a party and they may even be wearing perfume!

The insect will come to suck the sweet nectar hidden in the depths of the petals. It flies around from flower to flower almost as if it is dancing for joy! The flower gives its nectar to the insect, but what does the insect do for the flower in return?

As the insect flies in to find the nectar hidden in the heart of the flower, it brings golden pollen from other flowers of the same kind. Because pollen is sticky, it got stuck to the insect's legs or body while visiting other flowers.

This ripe golden pollen is brushed off on to the sticky ***pistil*** in the centre of the flower as the insect searches for the delicious nectar below. The pollen travels down the style and pollinates the ovules in the ovary, so that they may grow into seeds that will be able to grow into new plants.

When the insect has drunk the sweet nectar at the bottom of the flower, it makes its way back up the flower, brushing against the pollen on the ***stamens*** of this flower. If the pollen is ripe, it will be sticky and the insect then carries it away to pollinate other flowers.

And now we discover a most amazing connection! The insect may be a honey bee, a bumble bee or a butterfly, or even another insect like an ant. Bees go to many flowers but some flowers will only have one special insect. It is as if the insect and the flower were made exactly for each other.

FLOWER AND BUTTERFLY

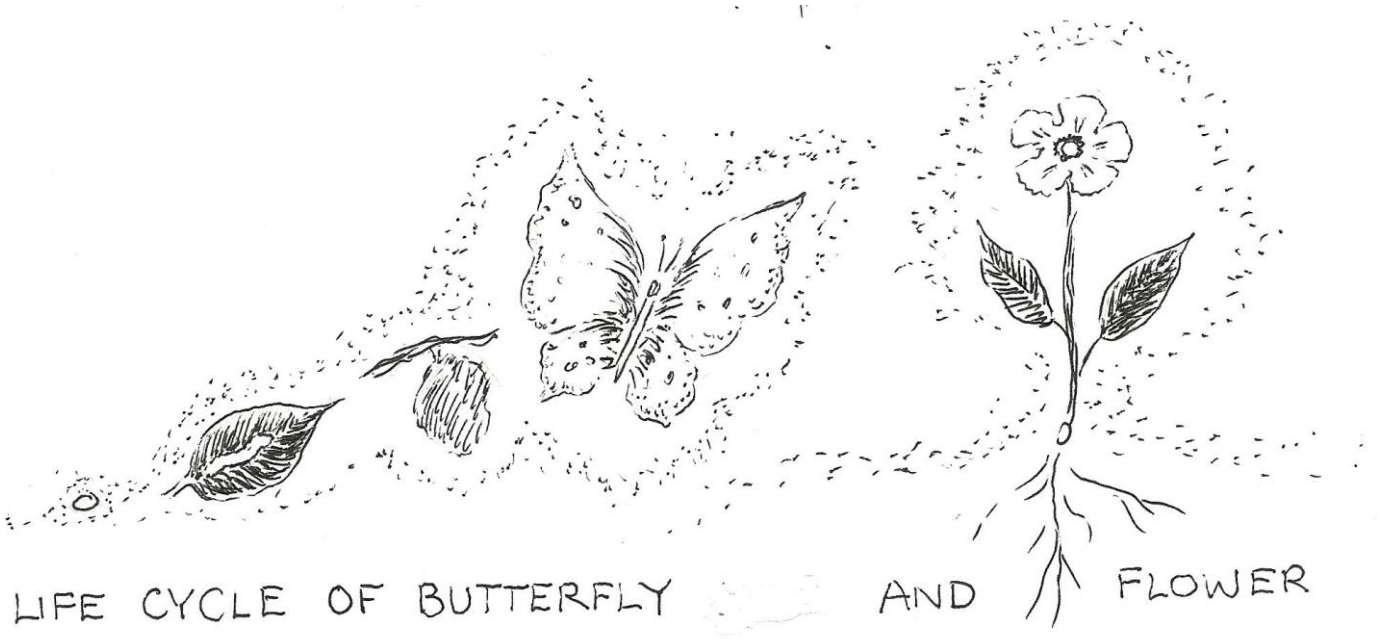
The flower and the butterfly even look like each other! Let us compare them. The children can begin by discussing the similarities and differences of the flower and the butterfly[7].

We can see that the colourful, scented petals are like the wings of the butterfly. Did you know that the colours of the silky butterfly wings are created by a fine dust, like pollen, and that they too are scented? This dust is very delicate and one must avoid touching the wings as they are easily damaged.

What about the feelers of the insect? What part of the flower is similar to this? The stamens of the flower look like the feelers or antennae of the insect and they are reaching out for the insect in the same way that the feelers are looking for the flower. The butterfly does not actually "see" the flower, but senses it with its feelers.

[7] As before, what follows are guiding thoughts to the questions the teacher raises. The idea is to get the children to think for themselves and come up with their own answers as often as possible. The teacher can participate in the conversation, adding key thoughts that the children do not mention, to guide them in looking at nature in a holistic way.

The life cycles of the flower and the butterfly are also similar in an amazing way. Let us compare them:



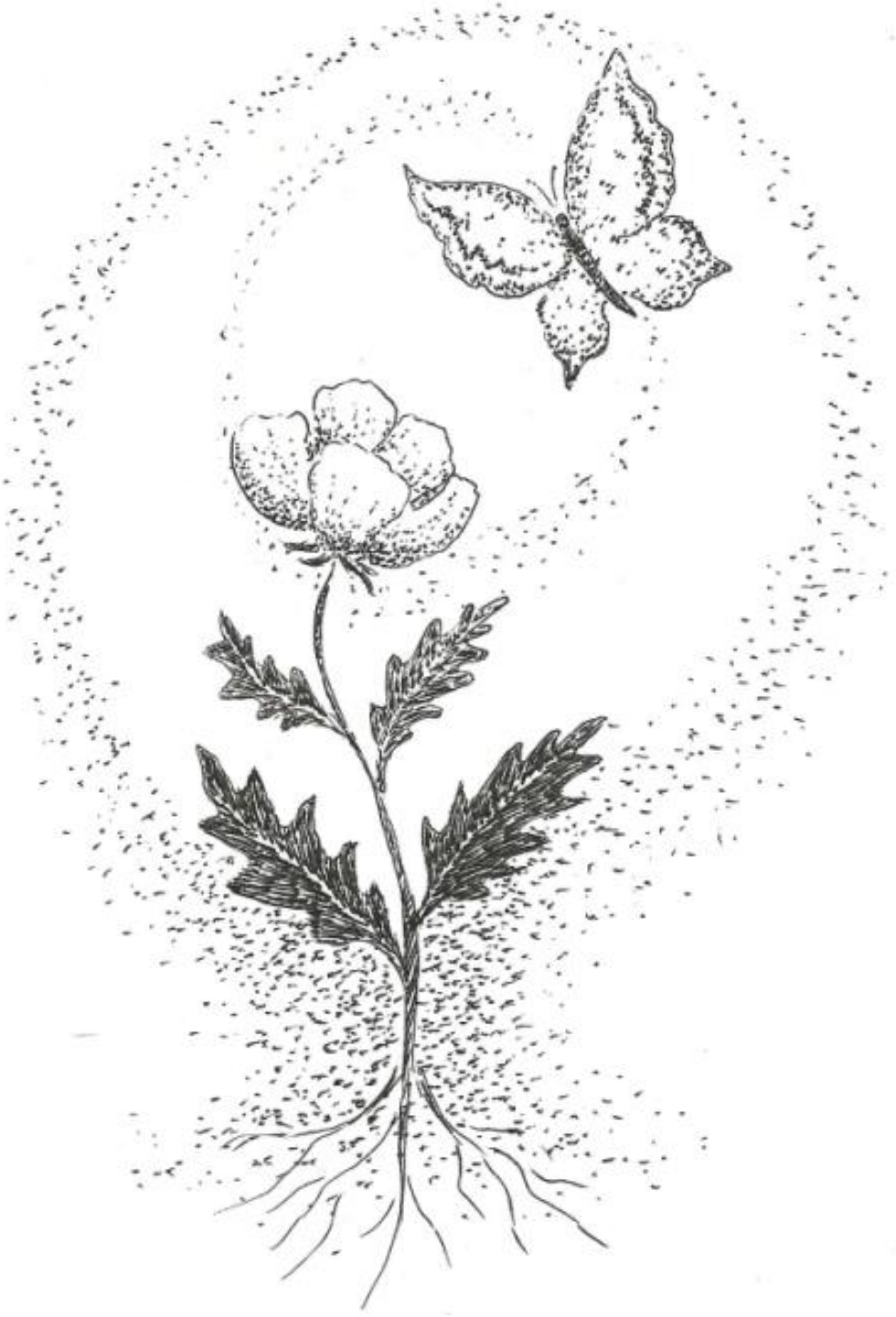
The new plant begins with a tiny seed whereas the butterfly lays an egg. The seed sprouts a tiny shoot and root while the egg hatches into a little larva or worm, which looks similar to the root. Neither root nor worm look anything like the plant or the butterfly they will eventually become. Both of them must grow considerably for some time. The worm feeds on the leaves of plants and grows large and fat. It may be insignificant or colourful, depending on the worm.

At a certain point, the growth forces of the leafy plant will form a small round bud. The worm stops growing and creates a chrysalis or cocoon around it. Something is about to happen to both bud and chrysalis! The magical change from green leaf to colourful flower is as dramatic as the delicate butterfly with its fluttering wings emerging from the chrysalis!

Plant	Insect
Seed	Egg
Root	Larva or worm
Bud	Chrysalis or cocoon
Flower	Butterfly

There is a lovely poem by Rudolf Steiner that describes this:

Behold the flower,
It is the butterfly held captive by the earth!
Behold the butterfly,
It is the flower set free to the heavens!



THE CONNECTION BETWEEN PLANT AND EARTH

In the story of creation from the Norse Tales in Grade 4, there is a mighty giant whose body is transformed into the earth when he dies. His bones become the rocks and mountains, his veins become rivers, his breath becomes the air and the wind, his eyes become the sun and moon, his skin becomes the soil and his hair becomes the plants growing out of the earth.

In this way the earth is pictured as a living being. Children need to learn about the plants in their relationship to a living earth instead of as isolated specimens. And so we always speak about plants in their relationship to the earth, so they see the interconnections.

What is the main colour that is found in nature? It is the colour GREEN. How do you feel when you see the green grass in the fields and the green leaves on the trees? Happy? Relaxed? Alive? How many children immediately want to play games on the grass or climb the trees or lie down in the green fields?

Imagine places where there are no trees, grass or flowers. Where can we see them? In dry areas and deserts nothing grows or else there are just small clumps of dry grass and trees with few leaves. We also find poor areas in cities with blocks of flats, tarmac roads and concrete pavements. The only colours are in signs advertising things to sell. We call these cities 'concrete jungles'. How do we feel in these places? Sad? Lonely? Tense? Dead?

That is why nowadays city planners create spaces for parks, while many streets have trees planted along the pavements and flowers in the centre of the roundabouts. Even people in poor areas are encouraged to plant trees and grow flowers and vegetables in their gardens. What effect do plants have on the environment and the people? It makes the places more beautiful. It makes people happier. They feel empowered and want to improve their lives and their surroundings!

Why are some areas of a country without plants while other places are crowded out with plant life? What do plants need to grow? Water, sun, fresh air and fertile soil. Even the driest places like semi-deserts can become carpeted with flowers after a good downpour of rain.

The plant cannot survive without the earth's soil and water to sustain it and the earth is dry and lifeless without the plant world. The plant grows on the earth in the same way as hair grows on our heads. But plants cannot grow anywhere; each species needs a particular soil and climate just as each person grows hair that is typical of them alone. They are inseparable, belonging together.

How do the earth and the plants help each other? The earth looks happy and beautiful when it is covered with trees and flowers. The earth anchors the plant so that it can grow upward towards the sun without falling over. It also supplies water and mineral salts to

feed the plant.

Plants feed animals and human beings, as well as providing us will many other gifts. Plants give their bodies back to the earth after they die, and these rot and become compost which improves the quality of the soil. Trees give cooling shade and attract rain to the area in which they grow. This also improves the land. (The children may have more answers.)

FOR THE TEACHER

The realisation that the plant belongs to the earth brings a sense of comfort and joy to children. Why is this?

Rudolf Steiner asks us to imagine the soul of a child preparing to enter the physical world before birth. He or she needs to "absorb something which is not yet mineral but which is on the way to becoming mineral, namely the etheric element."[8] These life forces are strongly present in the relationship between the plant world and the earth, and before birth the child receives the picture of this connection between the plants and the earth. When the child hears about this relationship from teacher or parents, it affirms what he or she already knows.

The plant, growing out of and supported by the earth, enlivens and beautifies the earth. This is similar to the soul of the human being that enlivens and beautifies the human body. Thus we may say that the plant world is like the ***soul*** of the earth.

Rudolf Steiner presents an interesting image. He suggests that the plants in summer (the rainy season in East Africa) are in an expanded state, growing outside the earth in the warmth of the sun. He compares the plants in summer to the consciousness of the human being that leaves the body during sleep, waking up to the spiritual world. Thus the earth is asleep in summer while the plants, like dreams, are growing in the sunlight.

By contrast, the earth wakes up in winter (the dry season in East Africa) when the plants die down and rest within her just as we awake in the morning when our thoughts return to our body.

This idea also shows us that the plant is not just a child of the earth and sun; it is like the dreaming of the earth, the thoughts and feelings or the soul of the earth. This is the way that the teacher can present the Plant Study main lesson, allowing the children to experience the soul qualities of the plant, because the plant is the soul of the earth.

8 Rudolf Steiner, *Kingdom of Childhood,*

THE SOUL OF THE PLANT WORLD

FOR THE TEACHER

How can we best present the plant to children in order to demonstrate its soul qualities?

The teacher can use *poetic imagery* to describe all aspects of the plant. For example, the palm tree has a strong straight trunk covered with rough bark like armour on a proud and mighty warrior. Its long, sharp-pointed leaves seem like rows of spears or a spiky headdress waving in the sunlight!

The teacher needs to perceive the *character* of the plant out of an observation of its different qualities. Then he or she can present it in an imaginative way, expressing its temperament, essential characteristics and moral quality. This does not mean being sentimental and giving the plant all kinds of human feelings like feeling 'sorry for itself' or 'upset' by the weather. The plant is unconscious of itself and never reacts emotionally. It merely responds to the surrounding elements.

How can we learn to perceive the true essence of a plant?

The German writer, artist, biologist and scientist, Johann von Goethe put forward a method of observing the plant to assist people to develop sensitivity in their perceptions. He said that one can look at the outer form which he called the 'Phenomenon'. Then one needs to learn to sense the *inner essence* or *being* of the plant which he called the 'Noumenon'. In this method of observation there are three steps:

1. Describe the outer phenomena in detail to develop a clear picture of the plant.

2. Observe your instinctive feelings about the plant: do you like this plant or does it irritate you, etc.? Put these feelings aside.

3. Now try to sense the *natural inner qualities* of the plant. Can you characterize it as if it were human? Can you sense a moral quality?

It is important not to become sentimental about flowers and plants as we lose sight of their true character. If we feel that a little flower is 'sweet', we have missed its essential being or 'Noumenon'. If we do not like the jasmine flower because we find the scent is overpowering, that is our feeling, not the quality of jasmine. That is why Goethe's method asks us to observe our own feelings and put them aside.

It takes practice to sense the Noumenon of a plant, but that is the aim of this method of observation. Some people are good at sensing the Noumenon but find observation of the Phenomenon more difficult. We need to learn to be able to observe both the outer form or Phenomenon and the inner quality or Noumenon clearly. As teachers we *do not* talk about the Noumenon to the children, but we use the inspiration of the Noumenon *when we describe* the plants to children in an imaginative way.

Both teachers and children can learn to enhance their sensitivity so that feelings become a reliable and perceptive sense-organ, assisting the faculties of observation and thinking.

By 'moral', we must remember that the plant unconsciously expresses the natural quality of its being. If we look at a rose bush with strong woody stems barbed with thorns, serrated leaves grouped in five leaflets of deep green tinged with reddish purple, and deep red scented flowers, we may sense that the rose has a powerful presence. She demands to be treated with respect and honour as befits a queen among flowering plants. No one picks roses without cutting them carefully to avoid the thorns and then arranging them to display their beauty in an elegant vase! So the Noumenon of that particular type of rose is a 'queen'.

GOETHE'S THEORY ON THE METAMORPHOSIS OF PLANTS

FOR THE TEACHER

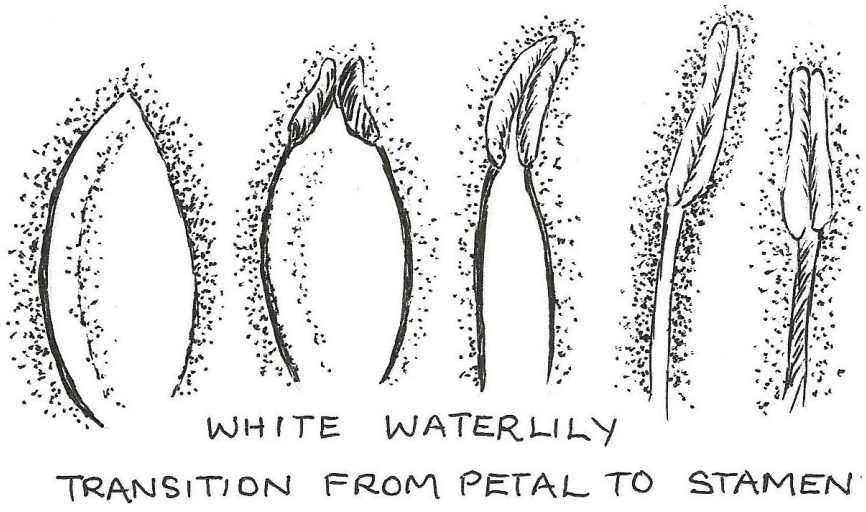
Johann von Goethe (1749-1832) said that “Life is a process of growth and becoming, not an object”.[9] When he observed the plant, he “experienced the plant dynamically”[10] in its continual unfolding from seed to flower, through growth and decay. He felt that the archetypal[11] plant should be seen as a “doing”, not a “being”,[12] as it is continually in process. Rather than analysing the different parts of the plant in order to study it, Goethe presented a holistic view[13] of the plant in constant interplay with the surrounding elements.

Goethe did not see the plant as something that was *actively* choosing to grow, but as *passively* responding to the forces of the elements. Growth could also be seen as a 'conversation' between the plant and the cosmos. In Goethe, Rudolf Steiner found a scientist who could view the plant, not as a separate organism but in a continual relationship with the whole of creation!

Goethe expressed further ideas in his study of plants. He noticed that the different parts of the plant are not joined together like parts of a car, but seem to evolve and develop out

9 Henri Bortoft, The Wholeness of Nature, 1996, Lindisferne Books, N.Y., P 271
10 Ditto, P275
11 Archetypal Plant = the original plant from which all other plants emerge
12 Ditto p 270
13 Holistic view = see things as a whole (not plants as separate things, but as interconnected with their environment)

of each other. Goethe used the term ***metamorphosis*** to describe how the parts of the plant changed and developed from one form to the next. He said that the plant was actually "all leaf", meaning that the basic form of the plant was the leaf and all other parts evolved out of it.



For example, the petals of the flower are similar to the leaves but have changed shape and colour because they are now needed for a different purpose. Similarly the forms of the stem, root, stamens and pistil that are long and thin are really rolled up leaf forms. In certain plants and flowers the transformation from one form to another can be clearly seen e.g. grasses, grains and bamboo have leaves that unfold from the stem. One can see this metamorphosis in the Lily family most easily because they are softer, more filled with water and therefore adapt more quickly.

Goethe's[14] scientific experiments were not taken seriously during his lifetime. This was because of a new form of thinking had spread in Europe after 1650 CE. A new *analytical* approach to scientific thinking was introduced by Isaac Newton (1642-1727), which became the basis for scientific development for the next centuries till about 1900 CE. This analytical approach has dominated the education of children in schools since that time, which we know needs to be changed, on the one hand, to a more child-friendly approach, and on the other hand to a deeper way of looking at nature, as started by Goethe.

Since the Renaissance[15], science had begun to explore the outer world through the vehicle of objective thinking. The aim of science at this time was the development of logical, linear thought and clarity of observation through the senses. This approach led to the scientific ideas presented in the physics of Isaac Newton and the theory of evolution of the species by Charles Darwin. In the same way that science focussed on the world of the senses, so psychology explored the soul to discover its secrets.

With the birth of quantum physics around 1900, the scientific viewpoint on the world shifted. Matter was no longer seen as a variety of separate solid objects to be observed, touched, weighed and measured in order to be understood. Physical matter was now considered to be made up of particles or waves of energy of varying density in continual interaction with one another. Things that previously were considered fixed and certain were now merely possibilities that could change according to other factors.

[14] Johann Wolfgang von Goethe, 1749 –1832

[15] Renaissance = the awakening of Europe, 1450 – 1600

Alongside quantum physics came new ideas based on holistic thinking. One example is the hologram where the whole picture of an object is revealed in all its parts. We see this today in the use of fingerprints, hair or the iris of the eye to show the unique qualities of each individual person.

The viewpoint of the world as being one whole is not new: it is found in ancient religions and cultures, especially those of India and China. But now, people realise that when one looks at the outer world through the experience of the senses, the incredible variety of form in all the kingdoms of nature becomes visible, and it is difficult to experience the *oneness* of creation at the same time.

It is only when one closes one's eyes and steps back into the inner experience that one can become aware of the sense of the whole, the connection between all living things. This state is known as *'active absence'*. "We step into active absence when we do not try to be aware of the whole but open ourselves to be moved by the whole."[16]

Though we cannot see the whole life cycle of the plant at any one time, we are able to visualise the complete process in our imagination. By holding this image of the complete plant in our minds and simultaneously following the growth of the plant in nature, we come to a greater understanding of the plant's unfolding through the different seasons. So both the experiential observation through the senses and the imaginative picturing and are needed to complete our study of the plant.

This use of analytical observation and holistic imagining combines the strengths of both left and right sides of the brain and is an essential approach for holistic thinking. Goethe expressed this truth by saying, "my perception itself is a thinking and my thinking is a perception."[17]

Rudolf Steiner recognised that Goethe was using his feeling imagination to enable him to perceive the *movement* of the whole plant life cycle and this experience guided his thinking to a holistic vision of the plant.

These ideas are not to be discussed intellectually with the children but are for the development of the teacher's knowledge and understanding. They can be presented artistically through drawing and movement, so that the children can experience the principle of the metamorphic unfolding of the plant.

16 Henri Bortoft, The Wholeness of Nature, 1996. p 13

17 Henri Bortoft, The Wholeness of Nature, 1996 p 309

THE POLARITIES OF THE ELEMENTS

FOR DISCUSSIONS WITH CHILDREN

Goethe wrote that the plant grows by responding to the elements. How do we observe this?

Let us first look at the elements of earth and sun[18]. The seed, as it germinates sends a little rootlet downwards into the earth. How does the rootlet sense which way to go? The earth has a force that holds and draws the rootlet downwards. We notice that everything that is dropped falls down to earth, whether it is a stone, a feather or an apple. We call that force *gravity* or weight.

On the other hand, there is the opposite force. The little shoot grows upwards towards the light of the sun. All plants grow upwards unless their stems are too weak. We call this force *levity* or lightness. The opposing pull between the Earth and the Sun creates the vertical or upright position that gives strength and balance to the growth of the young plant.

The warmth of the sun (the element of fire, or heat) also creates expansion and growth in the plant, which we see in the opening of leaves and lengthening of stems and branches. However the downward pull of the earth causes the plant to contract and strengthen the base of the plant. The bark becomes tougher and stronger through the earth element that helps the plant to stand upright and be anchored in the earth.

The plant is also influenced by the element of water. How does water flow? It flows in ripples and waves in the rivers and seas. Water has a pulse, flowing up and down in waves, taking water to every part of the plant. This flow can be seen expanding and contracting in all the shapes of the plant from seed to fruit

The element of air also creates waves in the curly clouds of the sky. The wind blows in different directions, fast and slow, wildly and gently. We breathe air in and out and so does the plant. We can feel our chests expand and contract as we breathe. This breathing in and out, expanding and contracting, belongs to the many opposites of life.

What other opposites do we find in our daily lives? We see light and darkness in the contrasting forces of day and night. Every living thing needs a time for growth and a time for rest. This pattern of expansion and contraction may also be observed in the seasons of the year.

THE SEASONS IN THE TROPICAL ZONES

The seasons are not the same in different parts of the earth, and so whatever is written

[18] The sun is the element of “fire”, which includes light and heat

here needs to be adapted to local conditions where the children live.

Generally there are four seasons in the tropical zones of the earth: a long rainy season followed by a dry season and a shorter rainy season followed again by a dry season. Generally this means there are two growth seasons in each year, during the months of rain, and two ripening and harvesting seasons in between at the beginning of the dry seasons.

In rainy seasons we see tremendous expansion of new growth, whereas in dry seasons everything contracts into an almost lifeless condition, awaiting the new wave of growth when the rains return.

THE SEASONS IN THE TEMPERATE ZONES

It is not necessary to show children how the angle of the earth's axis causes the different seasons in the temperate zones at this stage of their learning. Child developmentally they are only ready for this, at the earliest, in Grade 7 (the year they turn 13). However, a teacher could give a *descriptive* introduction to the seasons in the temperate zones of the earth. One would have to explain, for children living in the tropical zone, that the temperate zones lie midway between the tropical zone (the middle of the earth, where it is hottest) and the polar zones (where it is coldest). The use of a globe of the world will make this very clear to the children.

What changes can we observe in **springtime** that tell us summer is on its way? We notice that the sun rises earlier each day and sets later each evening. The sun shines down from higher in the sky at midday. How would this affect the warmth of the sun? The more vertical and direct the rays of the sun, the hotter it gets. That is why the countries close to the equator are far hotter than those closer to the poles. Thus the days get longer and warmer as the season moves from **spring into summer**. As the days lengthen, so the nights grow shorter and less cold. The expansion of warmth and light during the day is stronger in the summer months than the contraction of darkness and cold during the night.

The opposite is experienced as summer changes to **autumn** and then to **winter**. What changes do we notice? The days are contracting, growing shorter and colder as the sun rises later and sets earlier each day. The sun is lower in the sky at noon and gives less warmth. The leaves on the trees change colours and fall to the ground, deprived[19] of the life-giving warmth of the sun. Nights get longer and longer (expanding). They are cold, rain and snow fall from the sky. Winter is on its way.

So we may compare the experience of expansion and contraction of temperatures through the different seasons to the changing temperatures of day and night, as follows:

19 Deprived = not receiving

“Each season corresponds to a different time of the day or night.

Winter is like night
Spring is like morning
Summer is like noon
Autumn is like evening.”

This can also be connected to the development of the plant. The seed of the plant lives in darkness, like night or winter; the young plant is like morning or spring; the fully grown plant with flowers is like the midday of summer and the old plant with fruit and seeds is like an evening or autumn.

WHAT THE LEAVES SAID[20]

The leaves said, it's spring and here are we
Opening and stretching on every tree;
The leaves said, it's summer, each bird has a nest
We make the shadow where they can rest;
The leaves said, it's autumn, aren't we all gay
Scarlet and golden and russet were they;
The leaves said, it's winter, weary are we,
And they lay down and slept right under the tree. (Anonymous)

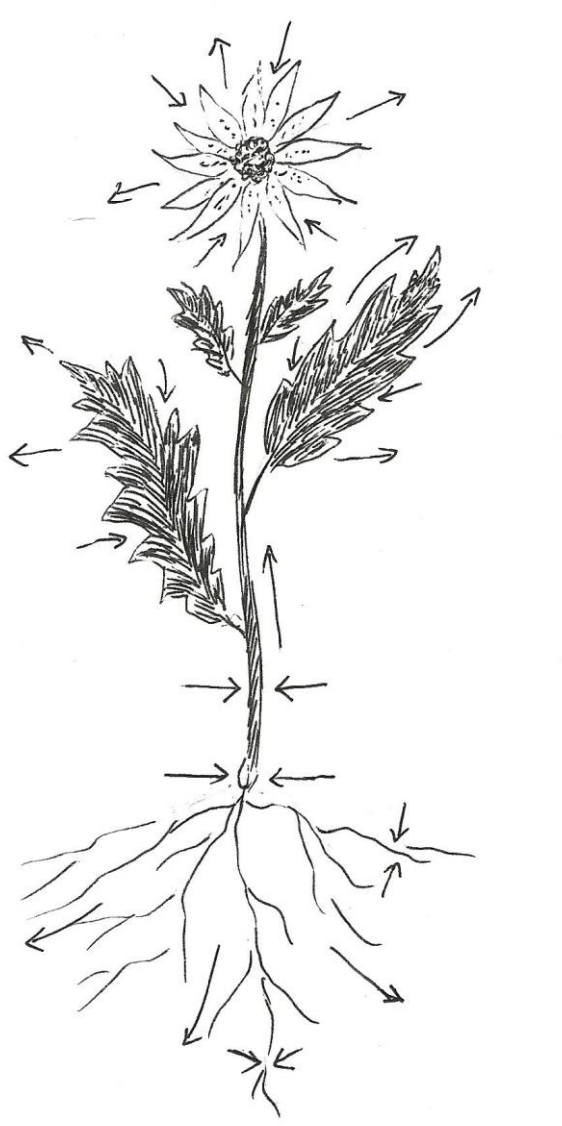
20 Song from Assembly Song Book by Peter van Alphen p 46

EXPANSION AND CONTRACTION

See colour drawing on page 5 of this manual.

We can observe the invisible polarity of expansion and contraction in the elements surrounding the plant: the upward pull of the sun and the downward holding of the earth.

If we see how the pulse of water and air flows in waves, we are also looking at expansion and contraction of energy through these two elements. Water and air also flow through the plant. If the plant has so much water flowing through it all the time and the life forces in water have a pulse in their flow, it is natural to expect to see a similar expansion and contraction in the form of the plant. If we look at the diagram of a flowering plant, we can see very easily where the form is expanded and where it is contracted.



EXPANSION & CONTRACTION

The teacher draws a picture on the board of a plant with roots, stem, leaves, bud, flower and fruit/pod. He or she does not put in any writing or arrows to explain the diagram as yet. The teacher can then ask the children to say where they see that the plant is expanded and where it is contracted?

They will soon get the idea that the roots are expanded, the stem is contracted, the leaves are expanded, the bud is contracted, the flower expanded and the pod is contracted.

Then the teacher can ask if anyone has some other ideas? If the children do not come up with the idea themselves, ask them if there are any places on the plant where it is expanded and contracted at the same time?

They should begin to notice that the roots are expanded in length, but contracted in size as they become finer and finer. The stem is contracted in width to give strength to the uprightness of the plant, but expands in length as the plant grows. The leaf is contracted where it joins the stem, then it expands for the leaf blade and contracts towards the point or end of the leaf.

In fact the entire plant breathes between expansion and contraction, creating the beautiful

shapes of the plant world.

PATTERNS OF THE PLANT WORLD

All the shapes of the plant show flowing movements that expand and contract. Why are these forms shaped like this? This is because the water or liquid inside the plant flows in a similar way. The water gives *elasticity* (flexibility) so that plants can sway in the breeze or grow in different directions.

The expanding energy enables different parts of the plant to *grow longer or bigger* while the contracting energy *consolidates the growth*, making sure that the plant is strong enough for the next burst of growth.

All forms of life show these flowing watery patterns, indicating the presence of water inside them and also the presence of the life forces. Even an old dead tree will have these flowing patterns in its trunk and branches long after the life force has left the tree.

What other patterns can be seen in the plant world?

The teacher should take the children outside and let them look at dandelions in the grass. There they will see a large and beautiful *spiral* of leaves. Let the children look for other spirals in the garden and see how many different plants have spirals in their flowers, leaves, trunks and even fruits and seeds. The teacher may have to point out the way leaves spiral round a stem and how a tree trunk twists round in a spiral motion.

Why do plants have spirals? If the children can observe a sunflower growing, they will notice how the sunflower turns to follow the sun. The truth is that all plant growth is in a spiral motion. Spirals are like coiled springs of energy. The plant grows upward, attracted by the sun, and as the sun appears to be moving, so the plant turns to follow the sunlight. In fact the sun is not moving; it is the earth spinning on its axis, like a joyful dance, that makes the sun appear to be moving. Nevertheless all plant life turns to follow the sun, just like the sunflower. And if the children see the head of the golden sunflower they will see the most beautiful *double spiral* of seeds! Where else can the children find this double spiral form? Let them find other examples.

In Grade 6 or 7, an amazing diagram can be built up if the teacher brings (or lets the children dig up) dandelions (or a similar plant) so that each desk has one. The children are given A3 drawing paper and 'press-stick'.[21] The teacher explains that the children are to remove one leaf at a time, starting at the base of the stem. Each leaf is arranged side by side in an arc or spiral on the paper in the order that they grow on the stem of the dandelion. The teacher must go round and check that every child is doing the exercise correctly. When the children have arranged all the leaves correctly, they will stick the leaves down so that they do not fall off the paper. The children place all their pieces of paper in an area on the floor or on several tables pushed together so that it creates a

21 A type of sticky that will enable the leaves to be stuck to the paper for a short time. e.g. Blu-Tac

display.

The teacher asks the children what they observe about the leaves:

- The leaves vary in size from small in the beginning, growing larger and then tapering off, becoming smaller at the end.
- The leaves begin roundish in shape, becoming more indented as they get larger and even more indented as they get smaller again,
- The leaves may change colour, being yellowish to start with, turning a brighter, deeper green in the middle and having the freshest green in the youngest leaves.
- Other changes may be noted according to the season or if another plant is chosen for this exercise.

Other patterns will be found in the growth of trees and flowers, in fact each plant develops patterns that belong to their species based on the flowing patterns found in water and the life forces.

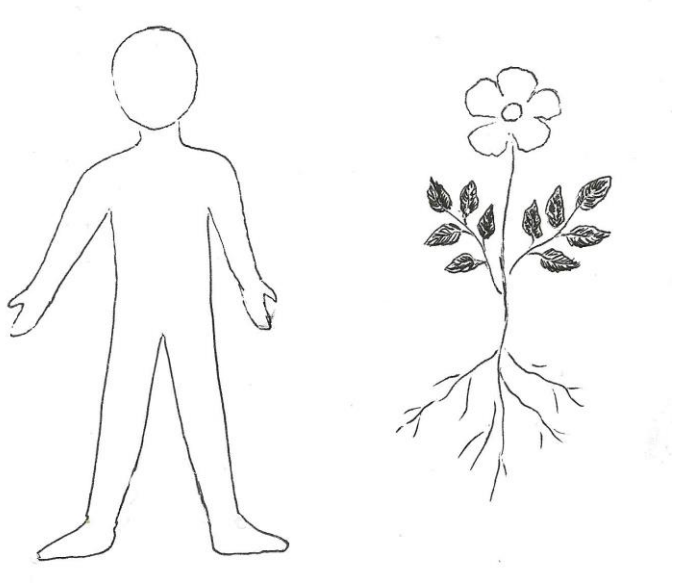
THE COMPARISON OF THE PLANT AND THE HUMAN BEING

The children need to have studied the life cycle of the complete plant and its various functions before attempting to compare the plant and the human being. It is important to allow the children to discover the connection between the plant and the human being *for themselves* as it is not what immediately comes to mind. It is part of the secret life of the plant.

The teacher needs to bring about a class discussion, guiding the discussion so that the children, as far as possible, think for themselves and come up with their own ideas. He or she can begin by drawing a human being and a plant side-by-side and of equal size on the board, and then ask, “What do you think is similar and what is different between the plant and the human being?”

It is important not to correct the children immediately when they give their ideas, but to allow them to see that *different answers* are possible and that the true connection is not so obvious.

So the first question is, “What is similar about the stem of the plant and the human being?” One answer is that both grow upright. Another answer is that the stem is like the spine of the human being. “What is different between the stem and the spine?” The stem is on the outside but the spine is on the inside. The stem is hollow and carries water and air to parts of the plant while the spine is hard and made of bone. Both stem and spine support the plant or human being to stand upright; both are flexible. By now the children will begin to see how to proceed.



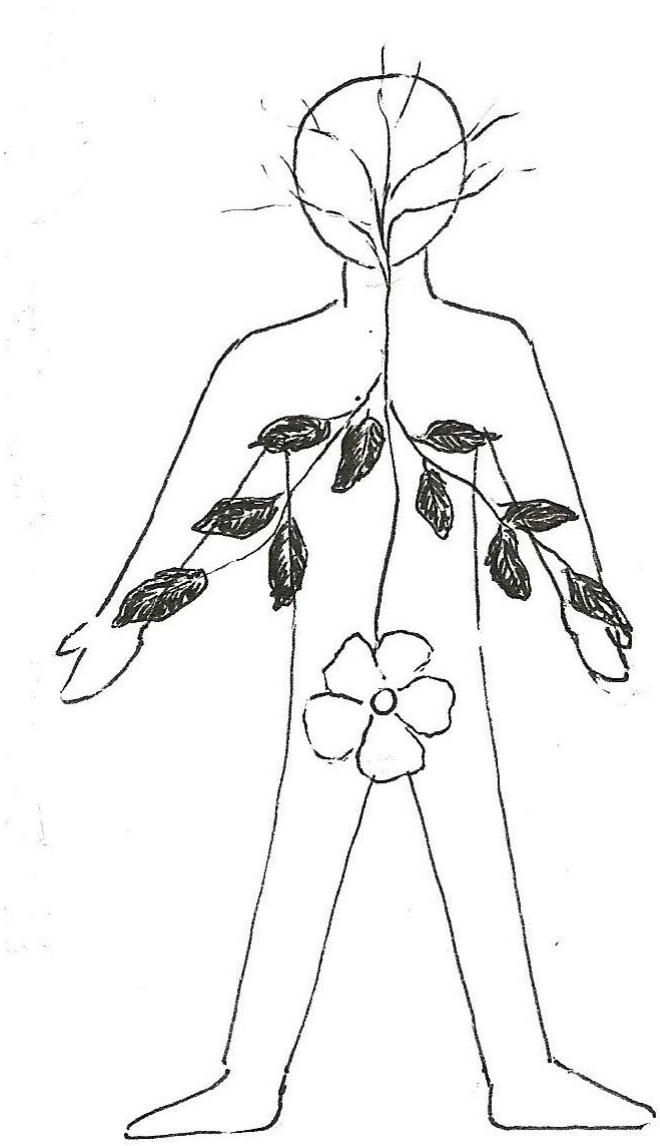
A child may say that the leaves are like hands, so the teacher should ask , “In what ways are leaves like hands?” The shape of a hand is a bit like a leaf. Our hands can do lots of work, but what is the work of the leaves? The leaves make the food for the plant so the leaves are like little kitchens. Our hands can cook food in our kitchens at home but we cannot make food like the plant can. Where do the leaves make the food? Inside the leaves. We prepare the food outside of our bodies.

Look at the roots. What do they do? They grow outwards in all directions underground to hold the plant firmly in the soil. Are they like our feet? No. Why not? We move around on our feet and the plant cannot. The roots also drink up water and mineral salts from the soil. What part of the human being takes in food and water? The head and the mouth. Is there any part of the head that reaches out in every direction like the roots? Our eyes are always looking everywhere around us. Our ears listen and our noses smell whatever is around us. These are our senses!

What about our thoughts? Our thoughts also explore the world of ideas and think about everything we experience. We even talk about 'root hairs'. So roots are like the hairs on our heads or our senses that reach out to experience the world or our thoughts that go everywhere!

Suddenly we begin to see that the connection between the plant and the human being is deeper and more complex than we thought in the beginning. The teacher can draw lines between the two drawings on the board. The lines between the stem and the spine, the leaves and the hands are easy. But now we can see that there is a line between the roots and the head of the human being. These two are opposite each other!

What about the flower? One child may say that the flower is like the head of the human being. We often speak about 'flower heads' or the 'pretty faces' of the flowers. However, this is not the only answer, so the teacher can say, “Yes, have you any other ideas?” We have just seen that the roots are like the head, so what is similar in the human being to the flower? What does the flower do? It attracts insects to pollinate it so that it can make seeds for new plants. And where does a mother carry her baby before it is born? In her womb. So the places for the reproductive areas of the human being are hidden away, while the place for the plant to reproduce itself is out in the open! Here we see more opposites between plant and human being! Now the teacher can draw a line between the flower and the area of reproduction in the human being.



If the teacher now draws a picture of the human being and places the plant upside-down inside the person, we can see more connections. Now the head and the roots are in the same place and this is the coolest place. The flower is the warmest part of the plant and is placed in our warmest area, that of reproduction.

Can we find more opposites between the plant and the human being? We have seen several examples of parts that are on the outside of the plant being compared to what is inside the human being, and the opposite as well. What about our breathing? The plant also breathes but in an opposite way to the human being. The human being breathes in Oxygen and breathes out Carbon Dioxide while the plant breathes in Carbon Dioxide and breathes out Oxygen. In this way we see how plants work together with human beings, each giving the other what they need.

The plant kingdom has an endless supply of gifts for the world. Let the children collect all the ideas. Not only do they offer food, their vegetables, fruits, spices and herbs, but the wood is used for furniture and many other uses. Medicines are made from all parts of different plants and we enjoy the shade of trees in parks and gardens. The plant gives freely, without knowing what they give, while human beings have to learn to give consciously.

What about our feelings which are inside the human being? What is outside of the plant that is similar to our feelings? The fragrance of the plant!

Rudolf Steiner has said that the fragrance of the plant is the most spiritual part of it. Yet the plant is quite unconscious of its beauty, while we are self-conscious and are always trying to make ourselves look more beautiful. Yet what is more beautiful than a joyful, happy smile? Those people who are kind and good and helpful to others develop beauty of heart. Just as the plant shows us beauty on the outside, so we need to cultivate and show beauty from the inside!

THE EVOLUTION OF THE PLANT KINGDOM

The flowering plants are called the 'complete plants' because they develop all the parts of the plant during their life cycle, i.e. seed, root, stem, leaf, flower and fruit. However, there are many species of plants that look quite different from the flowering plants we have studied so far. These plants arose as the earliest plant forms of creation and do not have all the parts of the plant, often specialising in one particular part and leaving others out.

Yet in many cases one can see how these incomplete plants sensed the next step towards becoming a complete plant and they tried to imitate it in some way. In each case they were held back because they specialised in one particular aspect of the plant. An example may be seen in the fern that has remained in the sphere of the leaf, yet creates flowery forms in its leaves.

Every country has its own forms of these basic plant species. It is best for the teacher to look for local examples to observe and draw with the children as well as using this manual for the essential information.

THE MUSHROOM

See the colour drawing of the mushroom on page 6 of this manual.

The Mushroom is the baby of the plant kingdom and belongs to a plant family known as Fungi. They grow in the shade of trees and undergrowth, hidden from the light of the sun.
Without sunlight, mushrooms cannot develop proper stems or leaves. Like babies, they cannot stand up properly as they have no roots to hold on to the earth, but lie snuggled up in the blanket of Mother Earth, as if asleep. Again like babies, they do not make their own food but suck up moisture and nourishment from decaying soil and roots, or from the trees on which many of them grow.

Mushrooms develop in two phases. The tiny spores[22] or seeds grow into threadlike filaments and become a tangled mass like a woven blanket which is called a mycelium. This mycelium grows close to the surface of the earth in damp shady places.

When it rains, up come many little mushrooms, popping out of the mycelium blanket and growing up above the surface of the soil. They even look as if they are wearing a baby's bonnet or little hat to shade their faces. Sometimes the hat is creamy in colour, but some mushrooms have strong orange, yellow, purple or red colours and spots to decorate them.

Mushrooms are similar to flowers, but they open *downwards* while flowers mostly open *upwards* to the light of the sun. The colours are very different, being dark and often dirty as they do not like the sunshine.

Mushrooms also do not smell like fresh flowers. They may smell spicy but some of them even stink.

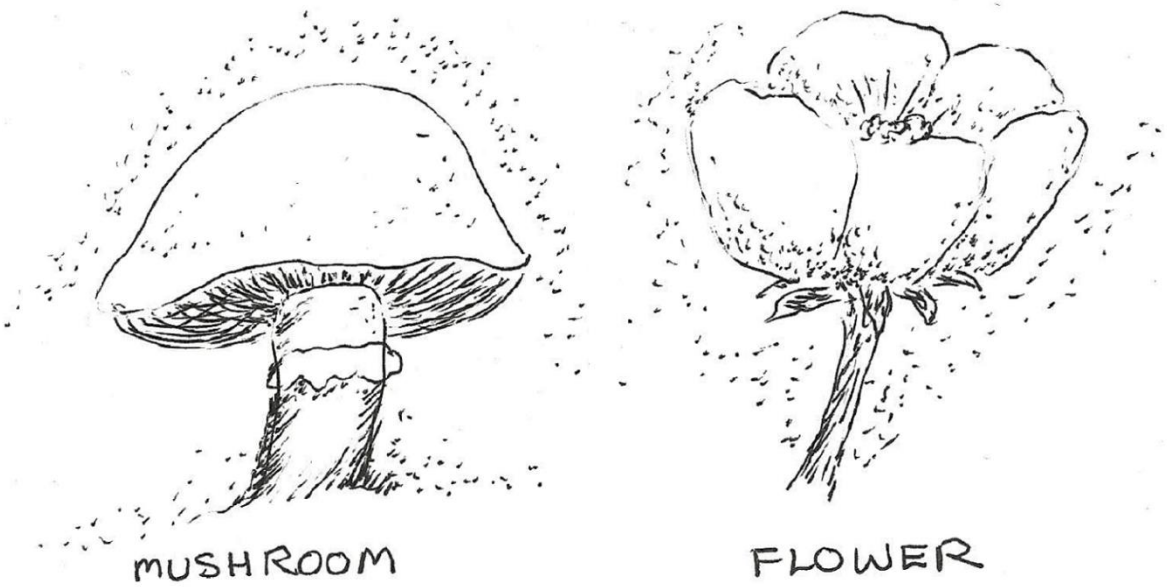
As the mushroom grows bigger, the hat often turns upward. One can see the stalk with a white ruff around it like a collar, and under the little hat are the gills, looking just like the pages of a book. These gills may have pretty pink, cream or brown colours. If the gills are snowy white, it is usually a poisonous mushroom.

Hidden inside the gills are the spores. When the mushroom ripens, the gills open up and a shower of tiny spores float down to the earth below. These spores are like fine pollen but they are also like seeds as they will sprout into threads for the mycelium blanket. So we see that the spores are a combination of pollen and seed.

The mushroom is a child of the moon and the night. Why do we say this? In which way

[22] Spores = small, single cells that can grow into a new plant, without needing to go through the process of pollination. Spores can withstand drought and heat over long periods of time (even years). Fungi, algae and mosses produce spores as a means of reproduction.

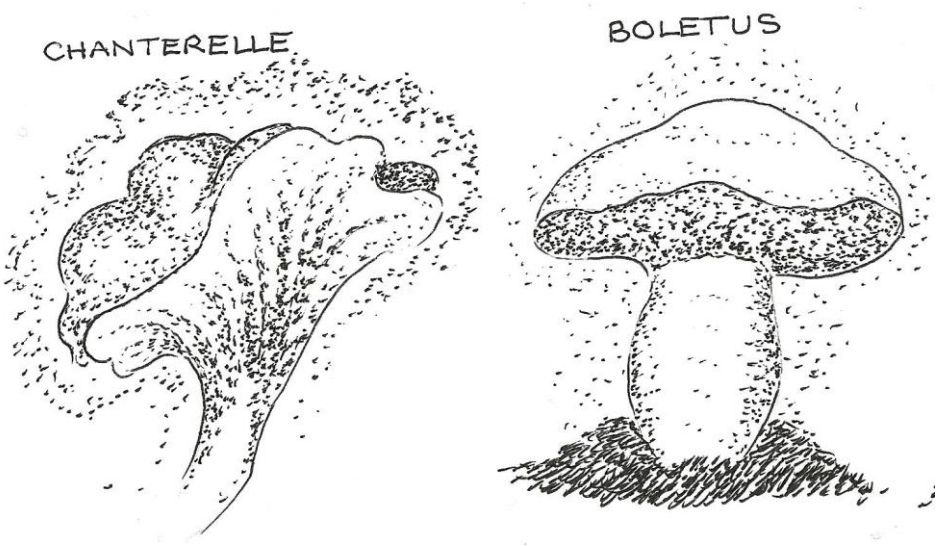
does the mushroom look like a moon? Where does the mushroom live?



Mushrooms are like flowers and fruit combined, especially as some of them can be eaten without being cooked. However, with their strange colours, they suggest a touch of magic and it is not surprising that certain varieties are inedible[23] or even poisonous and other types give people bad dreams or hallucinations. It is wise to be very careful and make sure that one is eating a kind of mushroom that is safely edible.

Edible mushrooms are cultivated and sold to restaurants and these fungi are beneficial, being healthy for human beings.

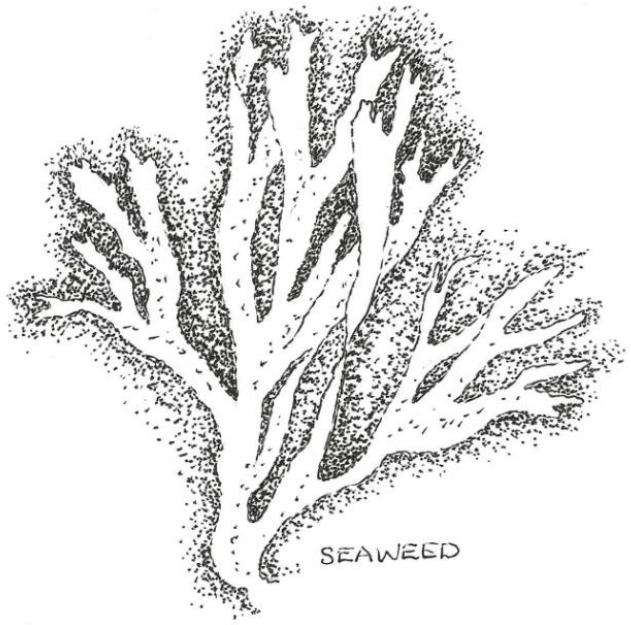
There are thousands of varieties of mushrooms or fungi, many of which do not look at all like the simple mushroom. Many look like strange sponges growing out of the trees they live on. Mushrooms belong to a shady mysterious underworld of their own.



[23] Inedible = cannot be eaten; edible = can be eaten

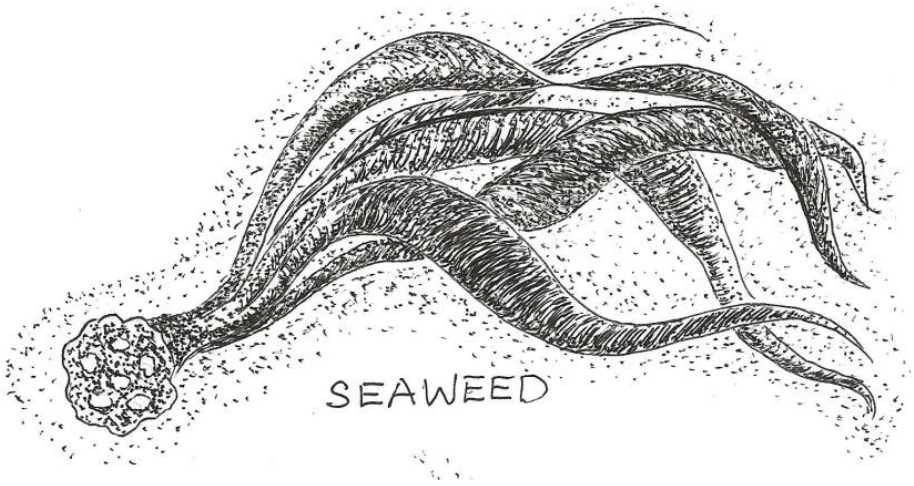
ALGAE

In the dreamy underworld of the sea and the rock pools along the seashore, we find magical landscapes, as if out of a fairy tale. Towering rocks seem like ancient mountains with their deep caves in which strange creatures dwell. Instead of mountain people with their animals, there are bright fishes flashing swiftly through the currents of the sea, waving their shiny fins and tails like colourful flags in the wind.



And everywhere are floating, swaying forests and grasses, tossed to and fro in the tides of the sea. These are the seaweeds, belonging to the Algae family. Some look like lettuce, others like palms or mossy banks of emerald green. Some seaweeds are green, others red, purple or brown. In warm seas, algae are very colourful!

Some seaweed is fine and delicate, others have great lengths of branches and leaves. They have no roots, only discs with suckers to hold on to rocks. When the sea rages in a storm, the seaweeds are torn loose. They are swept around in tangled heaps like huge islands until they drift ashore and collapse on the beaches. Here they will die in the heat of the sun as, like fishes, they cannot live out of water. Seaweeds are usually collected and ground to powder when dry as they make an excellent natural fertiliser for growing plants.



Because algae have no roots, they are not grounded in the earth and therefore they can make no flowers. However, algae are developed from the sunlight shining through the movement of the water. This gives them their *flowing leafy forms* and their green colouring. Algae have chlorophyll and are able to make their own food through photosynthesis. Therefore it is also food for many fishes and sea creatures.

"Almost all plant forms found on the surface of the earth occur once more in the algae stage."[24] This tells us that plant-life began in the sea and as the land rose and waters subsided, the algae adapted to life in the rivers and lakes and ultimately transformed to

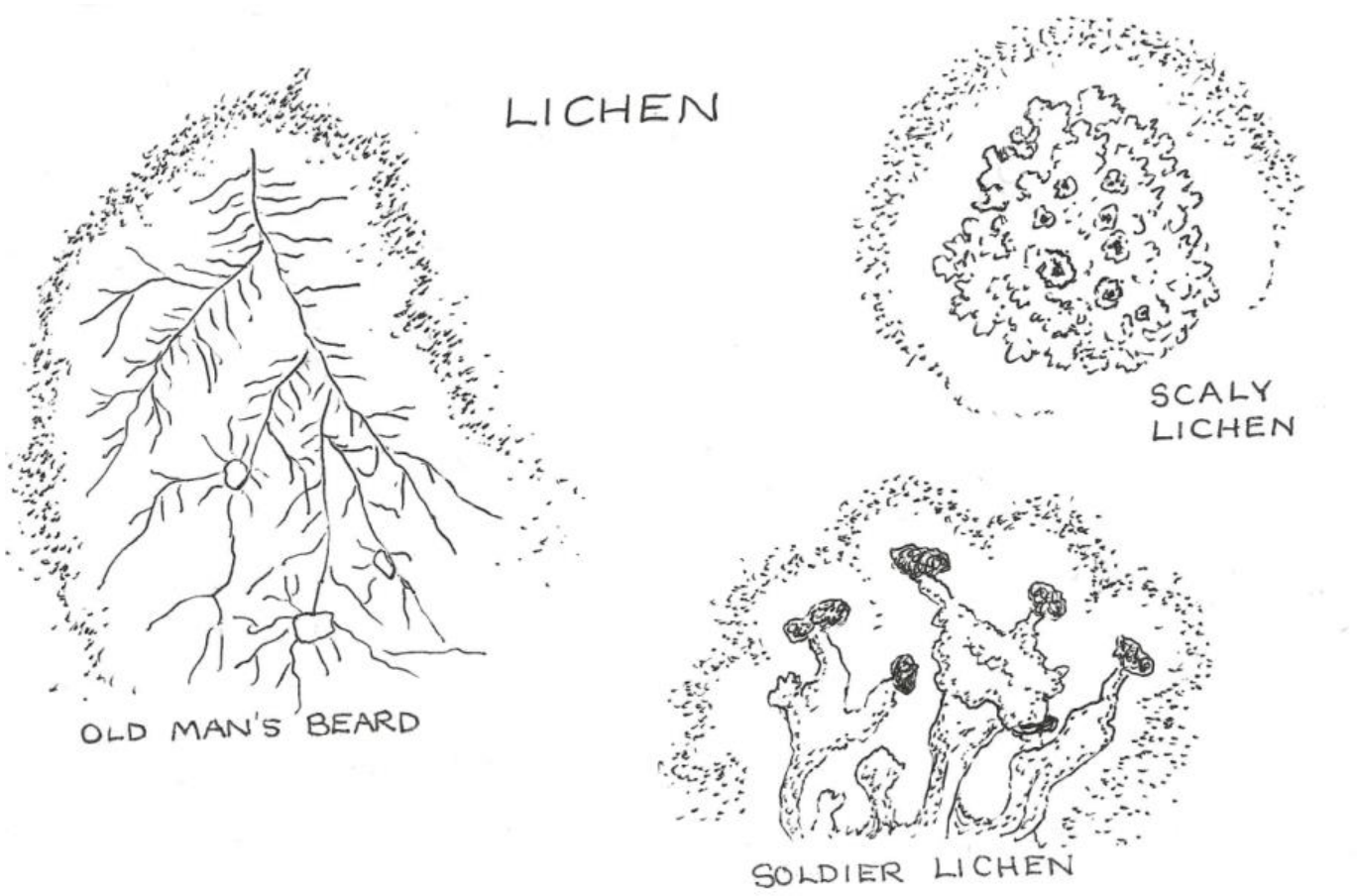
24 Gerbert Gromann, The Living World of Plants, Page 35

become plants on land.

Algae that grow in ponds and rivers are threadlike and slimy to touch. They lie like a soft green veil over a pool or along the bottom of a ditch, even on underwater rocks and stones. The individual algae plants are too tiny to be seen without a magnifying glass or microscope; if you were to use one of these, you would see many thousands of little algae all clustered together.

LICHEN

One can often see a soft greenish growth on the bark of the trunk and branches of a tree. This is a very ancient plant, called Lichen[25] and there are many different varieties.



Lichen is *all leaf* and some varieties have curly scales that look like leaves. This is the 'leafy' type. Sometimes lichen has long threadlike hairs that hang down from the branches, and this variety is called “Old Man's Beard”. Lichen may also appear as a fine crust on the bark of the tree with yellow or orange colours as well as green. This is the 'crusty' type. Then there are lichen that seem to grow little branches and these are the 'shrubby' type.

Lichen also grows far north in Alaska, Finland and Russia, beyond the timber line, where

25 Pronounced 'lie-ken' or lich (rich) -en

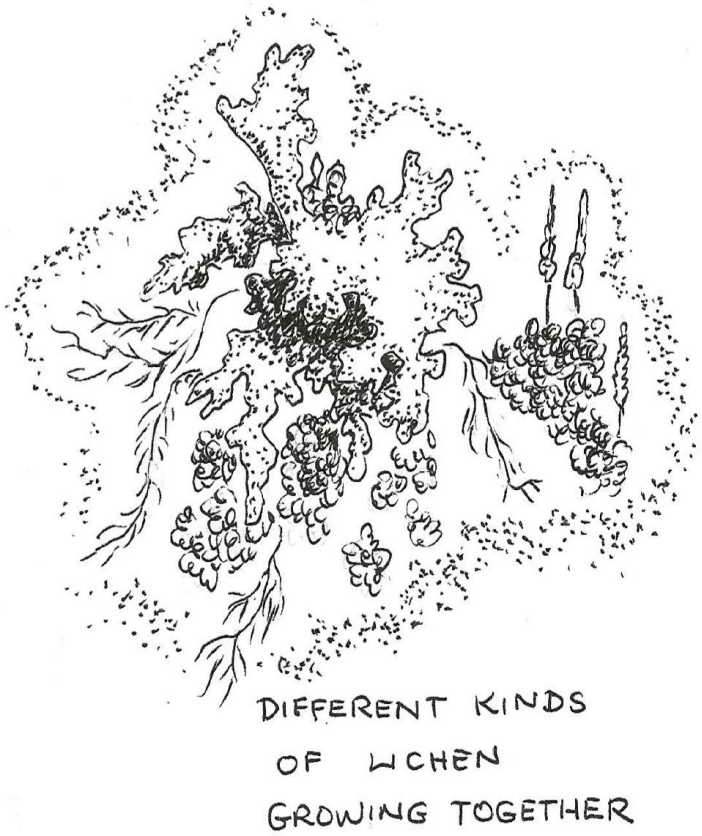
little else is able to survive. They cover wide areas like a cushion and are important as they serve as food for the reindeer. One variety even looks like the antlers of the reindeer.

Lichen is also found in the hottest and driest places. It grows on rocks out on the open mountainside. Being exposed to the weather, it will dry out in the heat of summer and fade to a soft grey colour. Surprisingly, it does not die, but patiently waits for months or even years if there is a drought, until rain or dew bring enough moisture. Then it sucks up the water like a sponge and swells up to grow strong and leafy again.

Lichen has no roots, but clings to rocks or bark using fine sucking threads. It also has no stalks, flowers or fruits.

Lichen is generally made up of two different plants that live together, supporting each other in a process called 'symbiosis'. These two plants are fungi and algae, who are like an old Grandfather and Grandmother who have been married for so long, that they feel that they have always been together.

It is as if, at breakfast, Grandfather says: “Shall I fetch some water?” Grandmother answers: “Yes please, and then I shall prepare breakfast.” At lunch time, Grandfather says: “Shall I chop wood and make the fire for you?” And Grandmother says: “Yes please and I shall cook the meal.” At dinner time Grandfather says: “Shall I set the table and prepare the room?” And Grandmother answers: “Yes please and I shall cook the dinner.” And so they continue day after day, helping each other and living happily ever after.[26]



DIFFERENT KINDS OF LICHEN GROWING TOGETHER

The fungi part of lichen is like the Grandfather, that cannot make its own food but absorbs water and helps to break down rotting wood. The fungi provide the structures for the algae part of the plant to live and work. The green algae are like the Grandmother that has the ability to make its own food through the process of photosynthesis, but needs the protective structure of the fungi. And together these two become the lichen plant.

Lichen reproduce in two ways. The fungi part of the lichen produces a structure that develops spores. Often these structures are a bright red or yellow colour, reminding one of the mushrooms. When their spores are scattered, each spore

26 From a nature story by Eileen Parker

finds another algae and together they create a new 'Grandfather and Grandmother' lichen.

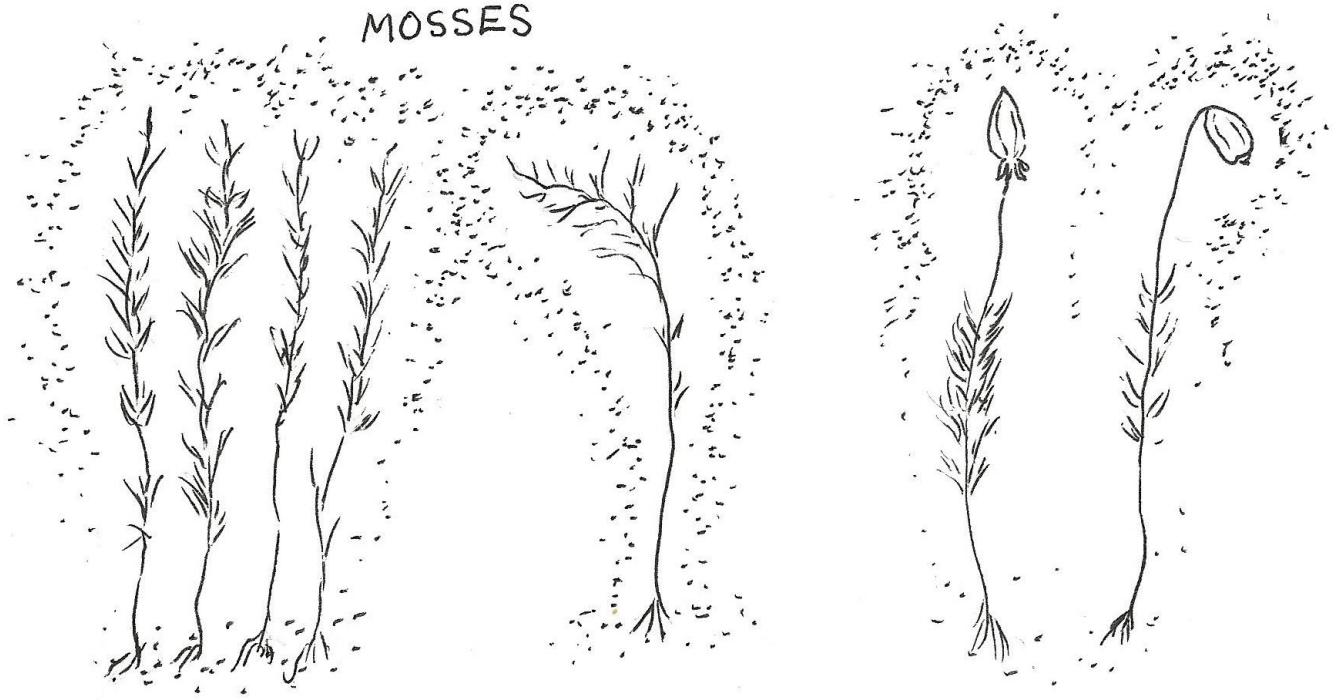
Another way for the lichen to reproduce occurs when pieces of lichen fall off the rock or tree trunk. These fragments may be carried great distances by wind or water and then they take hold of a log or branch and create a new lichen colony.

Unlike mushrooms that grow best in the dark, lichen needs to have sunlight to create its own food using photosynthesis. Often different kinds of lichen can be found together.

MOSS

If you have damp shady corners around the outside of your house or a dripping tap in the garden, you should find a beautiful green carpet growing on the bricks or in the soil there. It also grows on the trunks and branches of trees if there is plenty of shade and water. This soft, spongy carpet is the moss plant family. Mosses always grow wherever it is damp, soaking up every drop of water they can, which is why they are such a beautiful green colour.

If you were suddenly able to shrink to the size of an ant, you could visit this miniature emerald green forest, the world of the moss plant. It would be like visiting a tropical forest where everything grows so abundantly and quickly because of all the water. Some mosses look like primeval forest growth, others like palm trees, but all so tiny, you would never know unless you explored it for yourself. And what a variety of moss plants there are!



If you pull one moss plant away from its family, you will be amazed at how delicate the forms are. Mosses are more advanced than algae that can only grow in water.

The moss plant begins life when the spore germinates, growing a little stem with little leaves carrying the green chlorophyll that makes their food. The mosses grow closely

together, for they cannot stand on their own. They have no roots, only little threads that pull away from soil or rock very easily.

When the time comes for reproduction, the stem becomes longer and at the top of the stem a little seed-pod develops, covered with a tiny pointed cap. Mosses would like to make flowers but they are only able to make the seed-pod, so no petals are present. The cap falls off when the spores are ripe. The seed-pod (or spore-capsule) containing the spores has a lid that springs open to scatter the spores when the weather is dry. These tiny spores will sprout into new little moss plants.

Mosses are important in the life of the forest as they suck up excess water like a sponge after it has rained, storing it for trees and other plants. Bog Moss grows in very wet places in Europe where it can be dangerous to walk. People cut up the Bog Moss into bricks called peat. They dry it to be used as wood or charcoal for their fires.

Various mosses produce different forms. Tree Mosses have little stems that make them look like tiny trees with fine, needle-like leaves on them. Twig Mosses look like tiny branches lying on the ground, with leaves like bristles of a hair brush. Liverwort Mosses lie flat with small leafy branches that spread over the ground, while Bog Moss produces a kind of 'imitation' flower on top.

THE FAMILY OF FERNS

See the colour drawing of ferns on page 6 of this manual.

In ancient times the world was very different from what it is today. There was an age when the sun was hardly seen. It was hidden in swirling mists that covered the earth in watery veils. Rain soaked the ground, creating soggy marshes and swamps. Floods of water washed mud and clay down from higher places and there was very little solid ground.

No human being walked the earth at this time. Only pre-historic creatures, that could live both in water and on land, could survive in these swamps. These were amphibians, among whose descendants are lizards and frogs.

What else was there in this land of mist and water? There grew the family of water-loving plants known as the Ferns. Can you imagine a whole world covered with plants that belonged to the fern family? Even the palm trees of today originated among the ferns. With so much water and a hot tropical climate, they grew into huge forests with long waving fronds growing out of massive tree trunks. Some ferns were like vines that clung to the tops of the tree ferns.

It was a lush green world as none of these ferns had flowers. Some ferns did not even have leaves, only long, green, jointed stems and branches. These were called Horsetails. Without flowers, there were no bees or butterflies, only dragonflies and grasshoppers and other long thin jointed insects that looked rather like the horsetail ferns.

In this hot, wet, tropical climate everything grew very fast and the trunks rotted in the watery marshes and the Horsetails and Tree Ferns fell into the swamps. They were soon covered with layers of mud and clay.

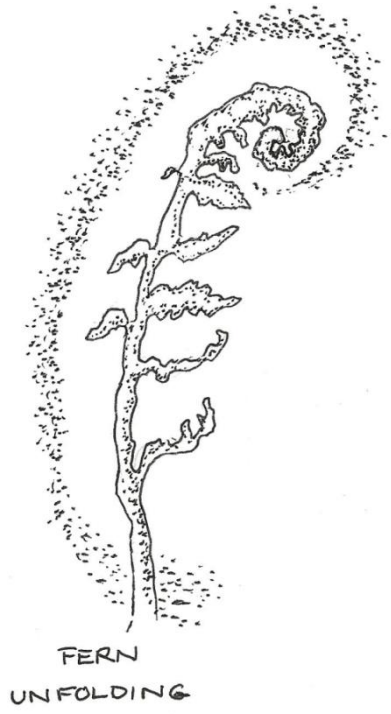
After a time, the climate changed suddenly from hot to cold and an ice age set in. The water drained out of the marshes and the earth began to freeze over. The layers of soil pressed down their heavy weight and squeezed out all the moisture from the marshes. Mountains and dry land appeared. Eventually the earth became solid. Deep under the earth, the fern forests were changed into a totally new substance, coal. This became known as the Carboniferous Age when fossil fuels were created.

Today there are so many kinds of plants everywhere that we can scarcely imagine a world where ferns once covered the entire earth. There are still three groups of plants in the fern family. Most familiar are the beautiful green ferns with their tiny delicate feathery fronds that grow in shady forests and damp areas. Every country has its beautiful ferns, especially the areas where there is plenty of water.

Then there are the Horsetails or Equisetums and the third group is known as the Club Mosses.

FERNS

Deep in the shady woods, where the wood-soil is soft and moist, the fern plants grow. In the winter of cold countries, nothing can be seen except brown rotting leaves, as the plant dies down. This will form compost and enrich the soil for the new growth in the spring. Underneath the soil the long *rootstock* of the fern lies sleeping.



This rootstock is really an underground stem lying horizontally with small thin roots reaching into the soil to drink up all the moisture they can. When the growing season begins, some strange shapes push their way through the earth and leaves, looking like brown scaly knobs.

As they grow taller, they begin to unroll and show that they are leaves rolled up in a tight spiral like a snail shell. They grow quite tall and inside are very fine and delicate. Each leaf or *frond* has a midrib, like a feather, called a *rachis*. On both sides of the rachis are more little spirals that unfurl[27] to form more leaflets. These too may be divided again and again, for the fern spends all its energy in making beautiful fronds because it has no flowers. The fern is similar to the ancient Greeks of Athens who loved to create beauty in all forms!

[27] Unfurl = a beautiful word meaning 'to unfold'

And now the forest floor is filled with the graceful green ferns, unfolding and swaying like dancers in the cool shadows under the trees. They grow best beside the streams and waterfalls.

One sees the unfolding of the fern best in the tall *tree ferns* where the leaf spirals are large and clearly visible. Some of these ferns have fronds growing outwards in a whorl[28] so that they look almost like petals of a huge flower.

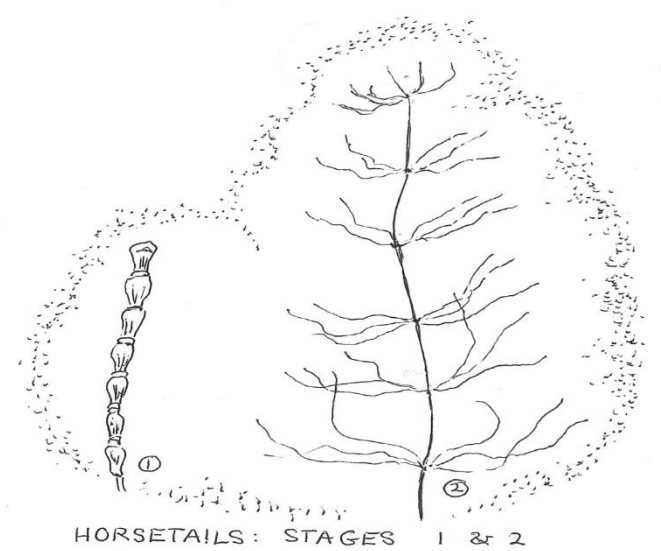
Ferns are ***leaf-plants*** and therefore their leaves are only able to imitate the parts of the flower that evolved from the leaves, i.e. the corolla or petals and the stamens.

A young fern is completely curled up, as if hanging over towards the earth. As it unfolds, it gradually uncurls until it is fully upright, showing itself as a fully grown fern. Spores are found on the *underside* of each frond, like the mushrooms. This shows that they have not made the connection to the sun like the flowering plants, that lift their flowers to the light and where the sun-filled golden pollen is carried from flower to flower by butterflies and bees.

In summer, if one looks underneath a fern frond, one may see little brown patterns like dots, stripes or a crusty brown area. These are the spores of the fern, tiny and fine, like dust. The ferns reproduce in a similar way to the mushrooms, lichen and mosses. The spores fall off into the damp ground and they sprout and grow immediately. So ferns become a dense mass in a short time, living tightly side-by-side.

In the evolution of plants, the fern was the first plant after the moss and algae to grow upright, like a young child learning to stand up and to say “I” for the first time. The ferns do not run around of course, but their light feathery leaves seem to dance in the breeze with the carefree quality of a young and playful child.

THE HORSETAILS



If you have ever touched a horse's tail and felt how wiry and stiff the hairs are, you will understand why these plants are called horsetails. Also they look like the long hairs of a horse's tail. In early times, huge forests of giant horsetails grew on the earth looking as if a whirlwind had just blown all their leaves away, leaving the tall naked trunks and thin twigs behind!

The horsetail plant is like a skeleton but instead of bones joined together, it is made up of sections of stems. It has roots and likes to grow in sandy and stony soil, rather

[28] Whorl = leaves that grow in a spiral

like a Spartan soldier, trained to survive in harsh surroundings. Unlike the graceful fern with its delicate fronds, the horsetail cannot make any leaves at all.

Like other incomplete plants (mushroom and moss), the horsetails develop in two different stages. First they produce thin brown stalks without any branches (see drawing 1). These stalks carry the spore cone. After these hard stalks have scattered the spores and died down, up spring the green stalks with branches, looking like proper horsetails (see drawing 2), but without any spore cone. Underneath the ground lies the rootstock from which both kinds of stalks develop. However, it can take years for the horsetails to reproduce new plants.

The speciality of the horsetail is the way it is divided mathematically both in the stems and twigs. If you observe the horsetail, it has nodes at equal distances all the way up the stem. At each node side branches spring out, radiating in all directions in the shape of a star. “Were the Horsetail a flowering plant, the side-shoots would become petals or stamens.”[29] The horsetail looks as if it would like to make a flower at the node but it cannot. It just keeps on growing more horsetails.

The horsetails produce spores but in a different way to the ferns. Being *'stem-plants'* instead of 'leaf-plants' like the fern, they “imitate only that part of the flowers that comes from the stem – namely pistil and ovary.”[30] At the end of the horsetail you will see something looking like a pine cone. This little cone is quite supple and if you bend it you can see little white cases containing spores hiding inside.

We shall see how the horsetail plants assist the next stage of plant evolution, namely, the cone-bearing trees.

THE CONIFEROUS TREES (CONE-BEARING)

The cone-bearing trees were the earliest *trees* to be found on earth. They were found at the end of the Carboniferous Age in the early forms of cycads, ginkgo and firs. After the water-loving tree ferns, the speciality of these trees was that they were drier, stronger and therefore more hardy, being less dependent on water.

We see how aspects of the horsetails (studied above) are noticeable in the conifers e.g. the little horsetail cone containing the spores developed into a proper pine cone, and the hardy quality is seen in the strong bark and trunk of the conifers. The fine threads of the horsetails are similar to the needle-like leaves of the pine trees

The home of these cone-bearing trees is in the far northern countries of Canada, Alaska, Scandinavia, Russia and North China, and they also grow well in southern parts of New Zealand and South America. However, they grow in most parts of the world where

29 Grohmann, The Plant., page 45
30 ditto

winters are cold. Cone-bearing trees are also called *evergreen trees* as they do not lose their leaves in winter. We can often see them growing in lonely places on rocky mountains, standing like soldiers on guard, or marching in huge armies across the slopes of hills and valleys.

The fir, spruce, redwood, pine, cedar and cypress trees are the best known of the many coniferous trees. They are tall and hardy, often achieving a great size and age. They survive well in the ice and snow. The oldest known tree in the world is a pine tree that is 4700 years old.

THE PINE TREE

If one walks in a pine forest, there is a stillness about these trees that is very peaceful. The trunk of the pine tree stretches far up into the sky. There is an old legend that the starry archer of the heavens[31] shot an arrow into the sky and it fell to earth. Here it landed on a mountain slope and entered the ground with its tip reaching upwards to the sky. It grew roots and branches and became a pine tree.[32]

But the bark of the pine tree is not smooth like an arrow. The pine tree has a hard, scaly bark like the armour of a soldier. The tree develops very slowly and this brings about a hardening that protects it against extremes of climate change. The rough bark prevents too much evaporation of water in the heat of summer and also helps the pine survive the icy temperatures of frost, ice and snow in winter.

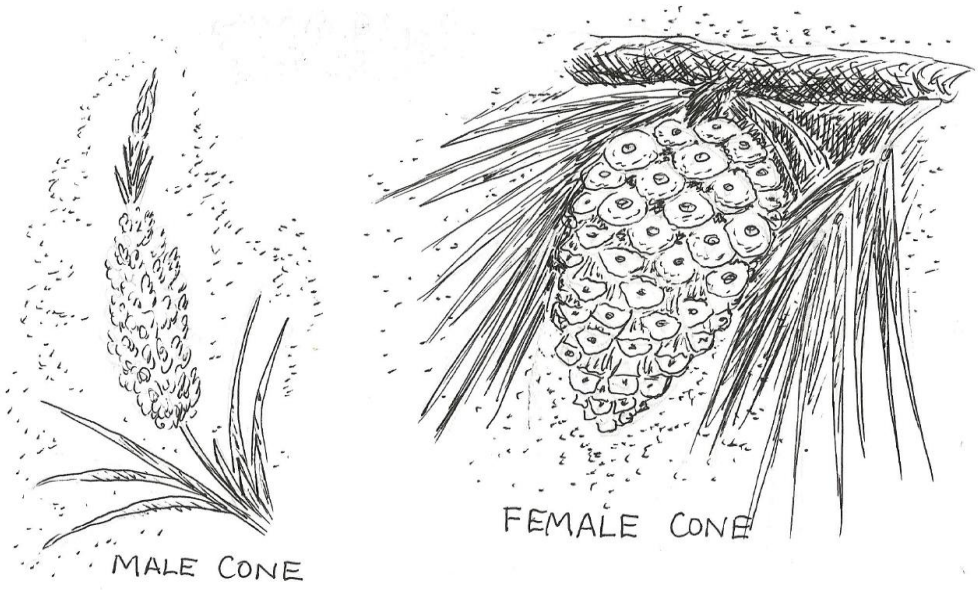
Most pine trees have great branches reaching out on all sides from a central trunk, giving a noble impression especially when the needles are fresh and green. The branches with their thin needles droop downwards, allowing most of the weight of the winter snow to slide off on to the ground. Some snow remains and the trees look lovely, especially when the sun sparkles on their snowy branches. When the snow has disappeared, the branches and needles lift up again.

Pine trees are densely covered in long, thin needles or triangular leaves that are hard and rough to touch. The needles usually come in three's, held together with a tiny stalk. In spring the new needles are fresh and green but they turn dark green as they get older. They remain on the tree for several years, which is why it is called *evergreen*. Around the base of the tree are many needles dropped from the branches. Very little else grows under a pine tree as the soil is too acid.

In spring time the pine produces two types of cone. The 'male' cone grows at the ends of the branches and looks like a golden candle standing upwards. As the cone matures, the firm 'candle' becomes soft and fluffy with yellow pollen. As there are no proper flowers, the pine tree does not attract insects for fertilization. This pollen is blown away by the wind when it is ripe and it drifts across to the female cones of other pine trees.

[31] The constellation of Sagittarius: half horse, half human shooting an arrow into the heavens

32 Isabel Wyatt, The Seven Year Old Wonder Book, "The Tree that Dreamt a Flower."



One can immediately smell the scent of the golden resin that is found on the small, dark green “female” cones when young. These cones often take a long time to ripen, even a couple of years in some species. The pollen lands on the sticky cone and there it will fertilize the seeds inside.

After fertilization, the female cone grows larger as the seeds develop. When the seeds ripen, the cone expands. Under each scale on the cone lie two seeds, each with a paper-like wing. When they fall out, they twirl in the air and carried away by the wind. Some will land on the earth close to the pine tree while others will be carried further away. The seeds sprout easily and the new saplings shoot up quickly; this why some pine forests are quite dense, with trees growing close together.

One can find hard brown pine cones with their beautiful double spiral patterns lying on the ground near the tree. If one comes at the right time one may open the cones and crack the seeds. Inside are delicious pine nuts. But the pine tree protects its nuts well and it is hard work to gather a few pine nuts.

The coniferous trees were the first to create seeds instead of spores and so they really belong to the flowering plants. However, they develop so slowly that what might have been a flower became a hard woody cone looking a bit like a flower. The cone is actually both flower and fruit as it holds the seeds inside it.

THE FLOWERING PLANTS

The final stage of the evolution of the plant kingdom is found in the full flowering plants: this is the stage in which *every part* of the plant is now fully present. In this final stage, we will study the Lily and the Rose, as key examples of the two main categories of the fully developed plants: the monocotyledons and the dicotyledons. This stage includes the deciduous and flowering trees, also belonging to the final stage of the evolution of the plant world.

THE LILY AND THE ROSE

For the Teacher

There are two main families of flowering plants to which many different plant species belong. The Lily is a beautiful example of the group of plants known as monocotyledons (mono = one) or plants with one seed leaf (when the seed germinates, one leaf appears; this is a seed-leaf, different from the leaves that grow afterwards). The monocotyledon family includes all the grasses, grains, bamboos, sugar cane, palms, bananas, gingers, onions, garlic, and flowering plants belonging to the lily family (cannas, irises, arum lilies, snowdrops, crocuses, daffodils, amaryllis, tulips and many wild flowers!) It would be very good to have a few live plants of the lily family in the classroom

The Rose represents the group of plants known as the dicotyledons (di = two) which have seeds that split into two halves as the plant germinates, producing two seed-leaves. The dicotyledon family includes trees such as the baobab, acacia, mangrove, Australian eucalyptus, European beech and oak trees, fruit trees and the rose family. Beans would be good to soak in cotton wool or wetted toilet paper to germinate. This will enable children can observe all the stages of growth, including the two half-seeds and two seed-leaves. Once the bean plants grow further, they will be able to see how the new leaves are different from the seed-leaves.

These two plant families are so different, even opposite to each other in character, that naturally the forms of their roots, leaves, flowers, etc. are also very different. The teacher needs to use his or her discretion whether to use the actual examples of each as described below, or to find equivalent plants.

For the Children:

THE LILY

See the colour drawing of the Tiger Lily on page 6 of this manual.

In the beginning of the growing season, we eagerly wait for the first flowers that burst forth after the dry season. (In temperate climates, we will speak of “In springtime” and “after the cold winter”) These are generally the many varieties of the lily family (see list

above).

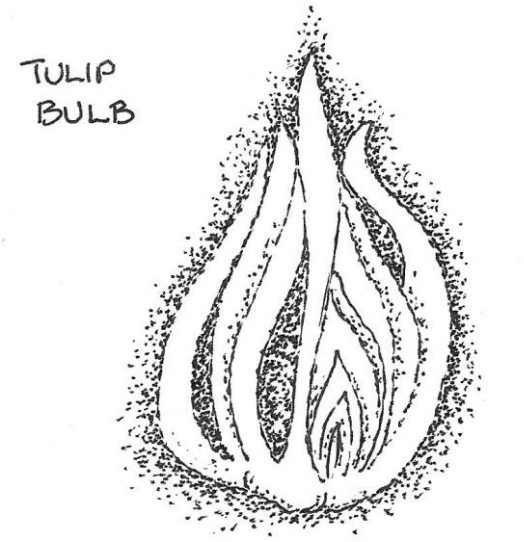
Lilies spring up swiftly from the soil with long straight leaves and long soft green stems. A little bud forms at the end of the stem and often the six colourful petals open in a trumpet with a strong and lovely scent that seems to announce to everyone the message that "Spring has come again!"

They bloom in clusters of glorious colour for about a month to six weeks and then suddenly they die away. Sometimes they are called 'angel flowers' as they seem to fly in and then fly away again all too soon. They will not bloom again until the following season.

In Medieval pictures when the angel announces to Mary that she will be the mother of Jesus, the angel often carries a lily. The lily represents purity and also an angelic messenger.

THE TULIP

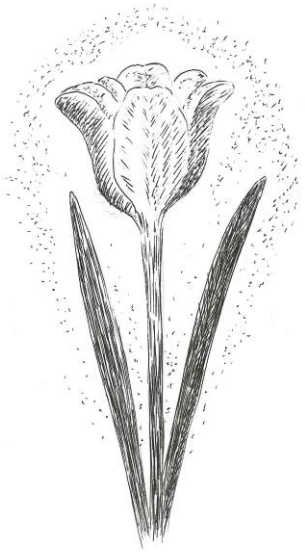
If we observe a tulip, we will learn the special characteristics of this lovely flower. In the earth we will discover a bulb which has been planted several months, even a year beforehand. It looks just like an onion and if you cut it downwards in half, you will see the soft fleshy layers. These layers will grow upwards and become leaves, stems and buds. Even the flower is hidden in the bulb, but very tiny and undeveloped, waiting for the right time to grow. So the whole plant is formed out of the layers of leaves that grow out of the bulb.



Goethe said that the plant is "all leaf" and here in the tulip or other bulb plants we can see quite clearly what he means: that every part of the plant unfolds out of the *leaf form* seen in the bulb. The stem is really leaves that have been rolled up tightly, the leaves and petals are the *leaf form* spread out.

Underneath the bulb are short white roots, showing that the lily family has a short life span. Because of these short roots, they are relatively easily dug up and transplanted and this is also why the lilies make good pot plants. If they have been growing for many years and the bulbs have multiplied, the roots may have become all knotted together. Then it is not so easy to dig them up; but one can pull the bulbs apart from each other, and many tulips can be planted to beautify the house or the garden.

As the tulip begins to grow in the rainy season (or springtime in temperate climates), it first sends up soft, green leaves with straight lines or veins running down the blade of each leaf. These veins run alongside each other and so they are called 'parallel-veined' leaves. The leaves have no proper stalks, they just open out into the narrow leaf shape. There is no branching of the stems; each flower will have its own long thin stem growing



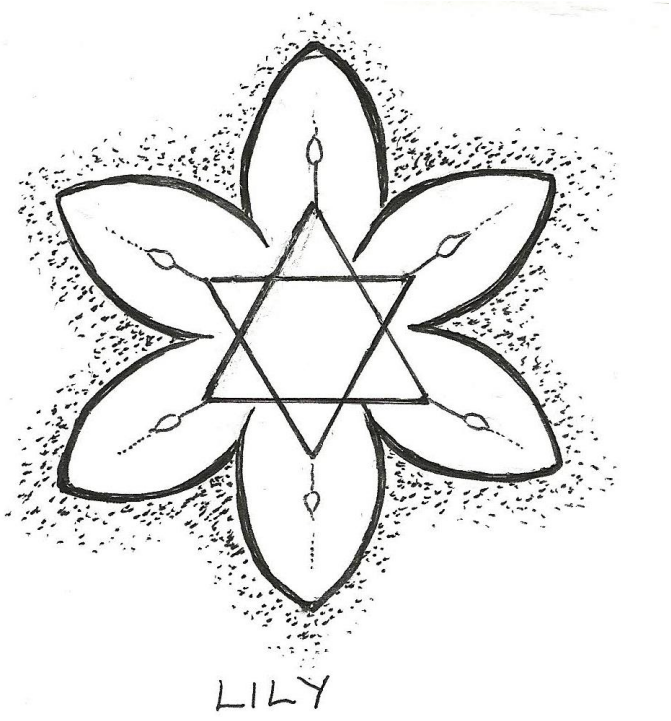
up from the bulb and ending in a bud.

There is no green calyx to protect the flower, the leaves of the bud are first green and then quickly change colour into the vibrant red, orange, golden, purple or mixed colours of the many tulip varieties. So the calyx and the corolla are the same leaves changing colour! Sometimes the tips of the tulip leaves hint at the colour of the flower and sometimes the petals of the flower still keep a touch of green. The tulip is in such a hurry to make the most of the flowering season that it does not spend time developing different parts of the plant!

If you look into the centre of the open tulip flower, you will see three petals, each with a stamen, forming a triangle. On the inside of these are three more petals with stamens, forming another triangle. If we draw the flower and put in the two triangles, we can see that the triangles are interlaced and form a double triangle or six-pointed star. (This is also known as the Star of David from the Jewish tradition.)

If we observe different lily plants, we see that the arum lily has one petal, some wild flowers have three petals and the tulip, tiger lily and most other lilies have six petals. Even the water lily has multiples of three petals and stamens.

The pattern of three or six can also be seen if one cuts the pistil of the tulip crosswise with a knife. There we see six undeveloped seeds waiting to be fertilised.



The Lily Family (monocotyledons)
The plants that belong to the lily family, can easily be recognised by their bulbs or short roots, their long straight leaves and their three or six-petalled flowers.

However, there are many other plants that belong to this group. The green grass that grows in fields and gardens also has straight leaves and short roots. The various reeds by the rivers and ponds, although different in many ways from the green grass, also have long straight leaves and long, hollow, jointed stems.

We can see similar characteristics in the bamboo and sugar cane, also the banana plants and the many varieties of palm trees.

Another group of plants belonging to the lily family or monocotyledons is the grain family: wheat, barley, rye, maize, millet, rice and sorghum[33].

Teachers may choose to create another main lesson in Grade 6 to study these grains that are of such service to human beings.

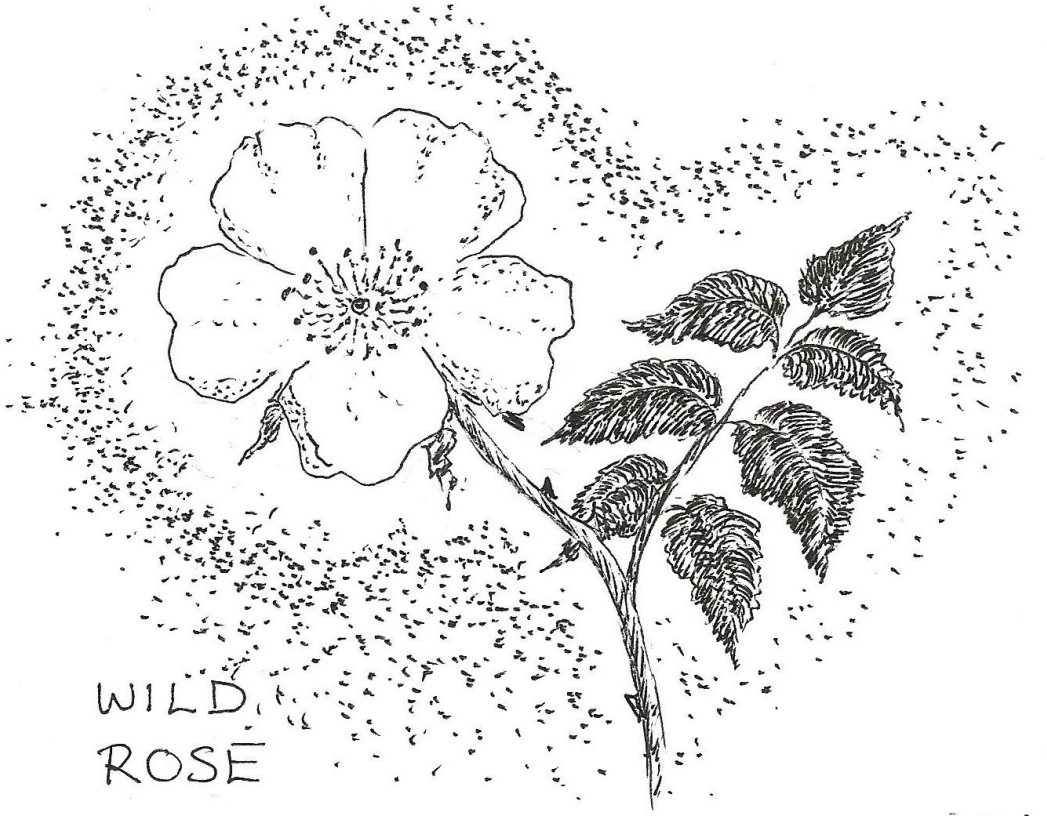
THE ROSE

See the colour drawing of the rose on page 6 of this manual.

The rose is a queen among the flowers, beloved in all countries of the world for her beauty and fragrance. She grows on sturdy bushes that live for many years. There are wild roses that grow in hedges along the roads and fields. They vary from having simple flowers with five petals to the many-petalled spiral form. Many different colours and scents have been developed over the centuries.

The Roots
The rose has a strong 'tap' or 'main' root that grows deep into the soil, becoming thicker, stronger and more woody every year. This root holds the plant firmly in the soil so that it cannot be easily pulled out. It also sucks up water from the soil. Roses need a lot of water which is why they like to grow in fertile, clay soil. The tap-root branches out underground far and wide to gather the nourishment it needs from the soil, just like the queen taking control of her kingdom!

33 Sorghum = a grain widely grown for food, fodder and other purposes in rural Africa, S. America and Asia.



The Stem

The stem of the rose is soft and green to begin with, but steadily becomes stronger, straighter and more woody with age, sometimes with a reddish or brownish colour. The stems of some roses have a reddish or purple colour when young and become more green or brown later on. Sharp thorns develop, arranged in a spiral pattern up the stem, to protect the plant against animals that might eat her or human beings who would try to pick her lovely flowers. Even a queen has her guards to protect her!

The Leaves

The leaves are quite different from the lily family. Each rose leaf grows out of a *node* or *growing point* on the stem. At first a little stalk appears and this unfolds into a number of leaflets with delicate serrated edges like a little saw. The rose leaf may be divided into three, five or seven leaflets, depending on the kind of rose bush. These also grow spirally on the stem.

The leaflets have a different shape too. From the stalk, the leaf-blade expands like a little hand reaching out to the sunlight and it tapers off to a point at the end. The leaf-blade has a ridge down the middle and several smaller ridges branching out sideways to create a net of veins over the leaf-blade. These leaves are known as 'net-veined'. The rose bush has many branches of leaves and leaflets and at the end of the branch, the leaflets become smaller and suddenly a tiny bud appears.

The Flower

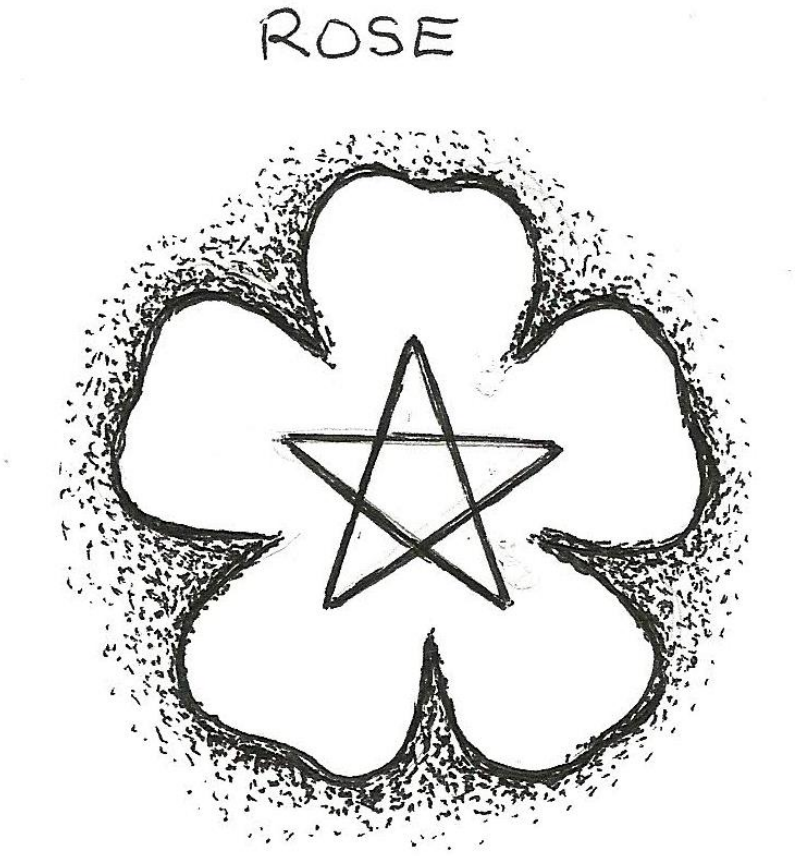
As the bud swells, we notice the calyx with its five slender leaflets that enclose the bud to protect it. Eventually they peel back to reveal a beautiful set of petals, neatly rolled up in a spiral whirl. The petals are often red or pink, but there can be many shades of colour,

from a delicate white or pink to yellows, oranges and the deepest blood-red. Because the rose is known as *the flower of the heart*, it only has the warm colours and we do not find blue petals naturally. In more recent years, a purple colour has been cultivated. The petals are in multiples of five.

As the rose opens, the spiral shape is clearly seen and in the heart lies a crown of golden stamens. Even the stamens are in multiples of five. The general shape of the rose shows a five sided pentagram. So we could draw a five-pointed star in the middle of the flower.

Roses are pollinated by bees and after the bee has flown away, the petals will begin to die down. The base of the rose flower becomes fat and is known as a 'rose-hip'. This is the fruit of the rose and inside are the seeds.

However, roses are not usually grown from seed in cultivated gardens. Rose gardeners choose a strong, sturdy plant called the 'stock' and they will graft[34] the type of rose they are cultivating on to this 'stock' plant. Gardeners are continually developing new kinds of roses to improve the colour, the shape and the scent of the rose. Through the ages different fashions have been favoured and so styles of roses keep changing.

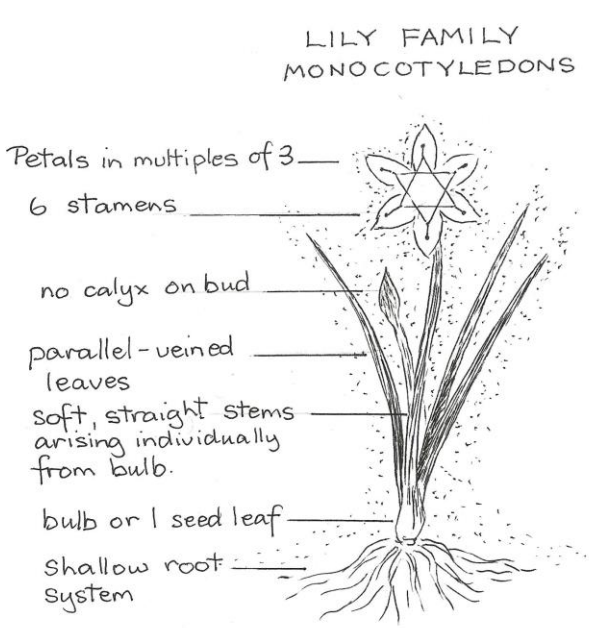


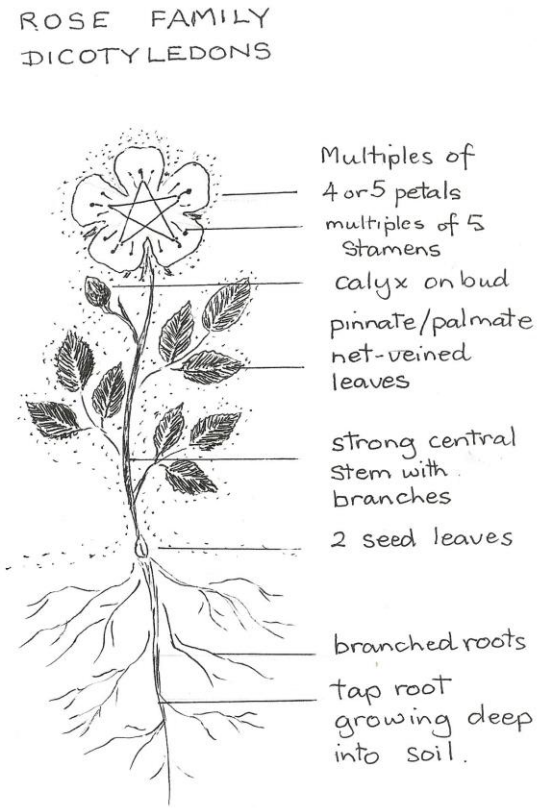
[34] Graft = to bring together two varieties of plant by cutting the one's upper part into the stem of another. Once this is done, the new plant is firmly tied to the stem of the host plant so that they grow together as a new variety.

The Rose Family

The family of the rose can be recognised by their long tap-roots, strong branching stems and net-veined leaves as well as flowers with petals in multiples of five or four.

The fruit trees, like the apple, pear, plum and peach, belong to the rose family. The teacher may choose to study the apple tree instead of the rose. One can clearly see the net-veined leaves and five petals in the flower. If one cuts the fruit of the apple cross-wise, one may see the five-pointed star in the arrangement of the seeds in the fruit. (See the section on Plants of the World for information on the apple tree.)

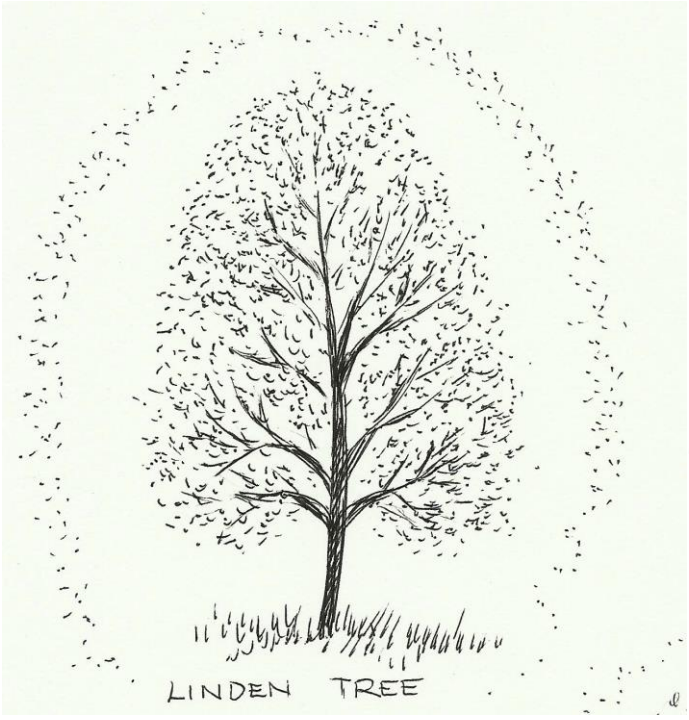


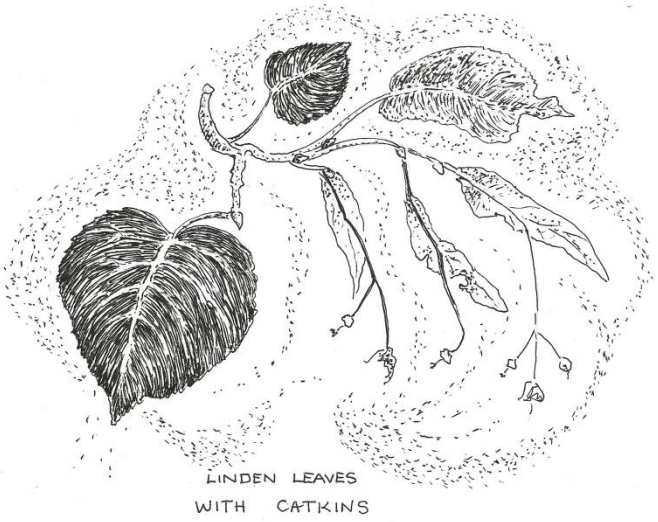


DECIDUOUS TREES

Closer to the warmth of the Equator than the cold coniferous forests, lies the climatic belt of the Temperate Woodlands. Across the great plains of Europe, America, Asia and Africa we find beautiful forests of deciduous trees with their airy spreading branches and lush green leaves. In Africa, the temperate woodlands are found in the west of South Africa (KwaZulu-Natal and Eastern Cape provinces), and in Swaziland. These woodland areas have a temperate climate as they are not in the tropical regions of Africa, and have the four seasons in each year: spring, summer, autumn and winter.

Deciduous trees are lovely in the way they change with all the seasons. Let us look at a European tree: in springtime, their naked branches begin to shimmer with green as the buds slowly unfold into catkins or early blossom, followed by delicate leaves. As spring yields to the growing warmth of summer, the leaves spread out like small hands of all shades of green, stretching up to the sunlight and air. Each tree develops its own character and style: stately or graceful, slender or powerful. Summer is the time of rich beauty as the deciduous trees achieve their full height and splendour.



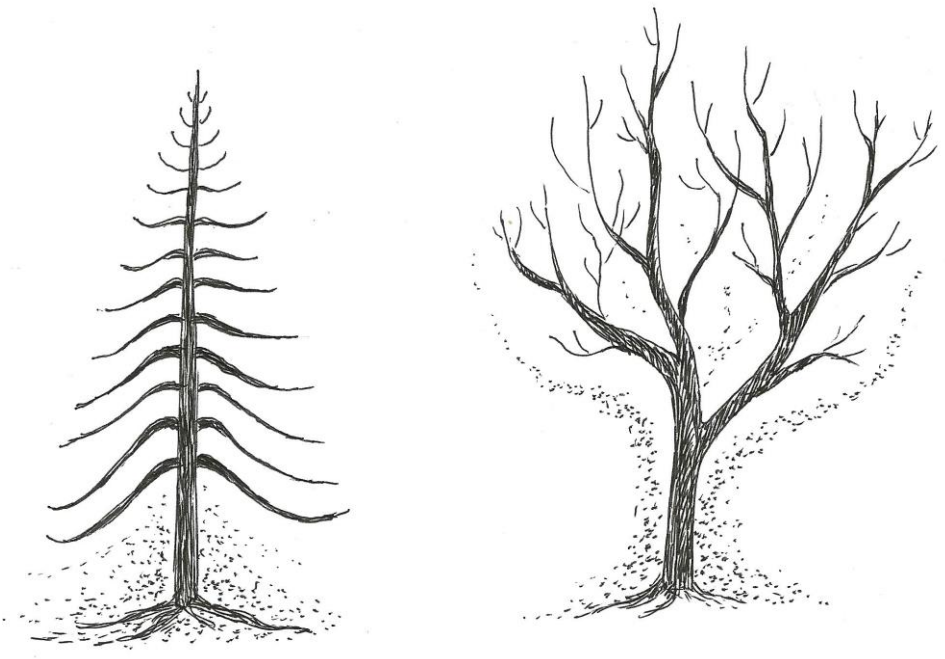


Then, as the cooling breezes of autumn swirl around, the deciduous trees begin to change colour, turning yellow, brown or flame colours. Eventually the leaves die and fall, creating multi-coloured carpets on the ground. The winter is cold, leaving the trees with bare branches lifted up to the grey sky; their leaves are gone, mingled with the earth to

form *humus*[35] for future growth of the tree in the following spring.

If we compare them to the conifers we can see that their shape is quite different. The conifer has a tall straight trunk with a pointed tip and branches that spread on all sides. This gives a triangular shape to the tree as a whole. But the deciduous tree has branches like many arms reaching up towards the sun, so that its broad green leaves can take in as much sunlight as possible. These trees often have a rounded or oval crown[36] and their branches stretch far out on all sides.

Here follows a diagram to compare the basic structure of conifers (left) and deciduous (right) trees:



A tree is not merely large plant, it is actually like a family of plants all joined together. It is as if the tree is a group of plants raised up together - the strong, wide girth[37] of the trunk raises these 'joined' plants together, ensuring that all the branches and leaves will be properly fed. Then when the tree bursts into leaf in the spring, it is as if it were a "meadow " in the sky!

In order to support the height and breadth of the tree's growth, the trunk takes in earth forces that harden it, like the roots. We can feel this in the rough or smooth bark, and how the trunk cannot be moved, it is so firm and strong. When the tree becomes old and dies, it crumbles and returns to the earth element, looking just like soil again.

[35] Humus = organic matter (leaves, etc) that has decomposed, becoming nutrients that can be taken up by the trees again in the next season of growth. The leaves have played their role on the tree, making foodstuff for the tree through photosynthesis, and so they die and are returned to the soil, to be used again when the new season begins.

[36] Crown = the 'head' of the tree

37Girth= measurement or size around the trunk

PLANTS OF THE WORLD

What causes the Differences in Plants across the World?

Around the world we find plants and trees of all kinds growing in different landscapes and climates. What causes them to adapt to the different geographical climatic zones? There are main two factors that cause these differences.

Firstly, all plants grow according to the warmth of the sun. At the Equator and the tropics, one finds that the sun shines down vertically from dawn to dusk, and its powerful life forces and intense heat cause tremendous plant growth. In these countries there is little variation in the seasons as the sun's heat is constant.

As one travels north or south of the Equator, the rays of the sun shine less directly overhead[38]. The sun crosses the sky in an arc[39] which is higher in summer and lower in winter, but never directly overhead. Because of the slant of the sun's rays, the life forces are less strong and the climate is not as hot as in the tropics. Here people experience spring, summer, autumn and winter as the sun's warmth varies from one season to the next.

When one travels to the polar regions, the arc of the sun's rays is so low that one experiences extreme cold, ice and snow. These are the lands where it is always cold and both summer and winter last for many months. Summer here is not warm but continuously light and the North and South Pole are known as the “lands of the midnight sun”. These changes in climate influence the type of plant growth that is found in each area.

Secondly, the amount of rain or river water that is available affects the type of plant growth in that region. Swampy places have lush growth while in desert regions, the hot, dry weather can be quite extreme. In the desert, vegetation may be reduced to a few hardy plants or only bare sand and rocks. Here the contrast of day and night brings about an extreme change in temperature: burning heat during the day and icy cold nights. Only those plants suited to such a climate will be found there.

Thus the polarities of heat and cold, wet and dry create different climates with corresponding vegetation. We find tropical flowers in the jungle, succulents in semi-desert areas and *Alpine*[40] flowers in high mountains. Each plant grows, nurtured not only by the earth but by all the elements in its surroundings and this brings about the variety and beauty of the plant world.

[38] Parts of the earth beyond the Tropics of Cancer and Capricorn (this knowledge can be presented to the students in their Astronomy lessons later)

[39] Arc = a bow shape from east to west, at an angle from mid-heaven

[40] Alpine = the name of flowering plants in high altitudes across the world, given by scientists who first studied these in the Alp mountains of Europe.

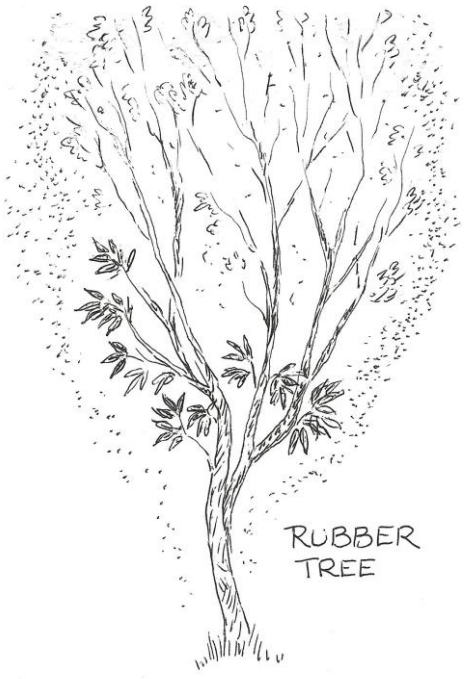
EQUATORIAL RAINFORESTS

Along the Equator, where there is plenty of rain and water, we find the *Rainforests*: huge areas of dense forest and teeming wild undergrowth. Trees grow to great heights of 50 - 60 metres, stretching their branches heavenwards to reach the sunlight, where they create huge leafy canopies[41] in the sky. Far below, the plant undergrowth is thick and tangled. Rope-like lianas[42] twist themselves round trunks and branches while chattering monkeys swing from tree to tree. Brilliant flowers and large colourful insects light up the gloomy darkness while long sinuous[43] snakes hide in the depths of the dense forest.

The most exotic flowers of the tropics are the orchids with their stiff waxy flowers in electric colours. They are almost 'animal-like', with markings like eyes and sensuous shapes that are amazing, attractive and uncanny.

Every day the overwhelming heat builds up from the vertical rays of the sun. Intense humidity[44] makes human beings feel sticky with sweat, heavy, lazy and lethargic. Clouds gather overhead and eventually burst with an ear-splitting thunderstorm and torrential rain that pours down almost every afternoon.

This daily downpour of rain and the tremendous heat causes rapid plant growth of all kinds. Therefore, we can call these trees the giants of the earth's forests. Among the many varieties of broad-leaved, hardwood[45] trees, of great beauty, living close together are mahogany, ebony, rose-wood, ironwood and the rubber tree.



THE RUBBER TREE

The rubber tree grows naturally in the Equatorial Rainforests of South America, India, Thailand, Indonesia and Malaysia. It enjoys steady all-year rainfall and intense tropical heat of 20-35 degrees Celsius, and is protected from strong winds by being surrounded by other trees that protect it.

The rubber tree grows up to 60 metres high with a long, slender trunk and branches. Its bright green leaves have a clear mid-rib, and usually spring in groups of three from the end of a twig. It does not seem to have any flowers, but inside the nut or fruit of the rubber tree are tiny stamens that show it to be a combination of flower and fruit.

41 Canopy = a roof-like covering

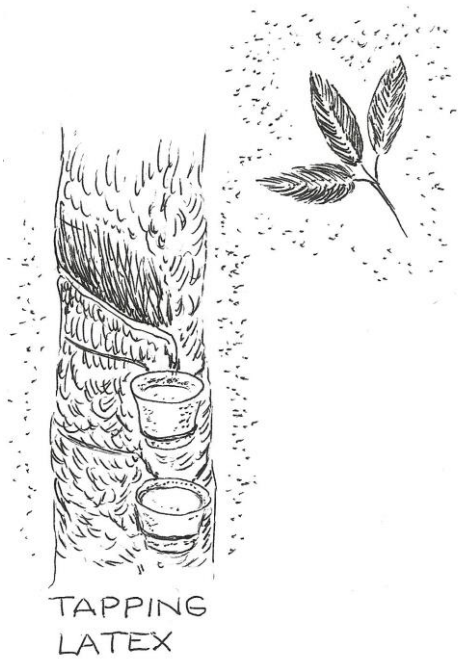
42 Liana = a plant that looks like a rope growing around trunks and branches in the forest

43 Sinuous = the flowing shape of the snake as it moves

44 Humidity = amount of moisture in the air; intense humidity = air that is heavily laiden with moisture.

45 Hardwood = the trunks of these trees are very hard, making strong furniture that will not damage easily.

The bark is a soft brown and slightly rough and it yields a sticky, milky-coloured sap when cut or damaged. This sap or gum is the source of the rubber trade as it is a stretchy, flexible and waterproof substance, also called latex that is used in many, many ways.



Collecting the gum is known as 'tapping'; this takes away the sap that the tree needs for itself, to maintain itself and grow further. Tapping is done every 2 or 3 days in order to allow the trees to recover and grow back again.

Although methods vary greatly, generally the tappers (or workers) make several spiral cuts in the bark of the tree, each about 25 cm long, taking care not to cut into the wood underneath the bark. As the trees spiral to the right as they grow, the tappers cut spirally from the left to catch the greatest number of tubes in the bark and thus collect the most gum. They attach a galvanised[46] spout to the tree and this allows the gum to drip into an aluminium or plastic cup, which is also attached to the tree.

The gum soon begins to coagulate (or harden), so the tappers have to collect the gum before this happens. The gum is transferred to a special tank and is later placed inside a Flexibag. The bags are placed inside a large container that carries 21 tons of liquid latex and then it is transported to be processed.

Rubber tree seeds have been transplanted to many other tropical countries and they are now cultivated in plantations. This makes it much easier for the trees to be cared for and rubber to be tapped regularly. In the deep rainforests, rubber trees are surrounded by tangled undergrowth and many varieties of trees, making it difficult for tappers to get to them. Transporting the rubber is also difficult once it has been collected.

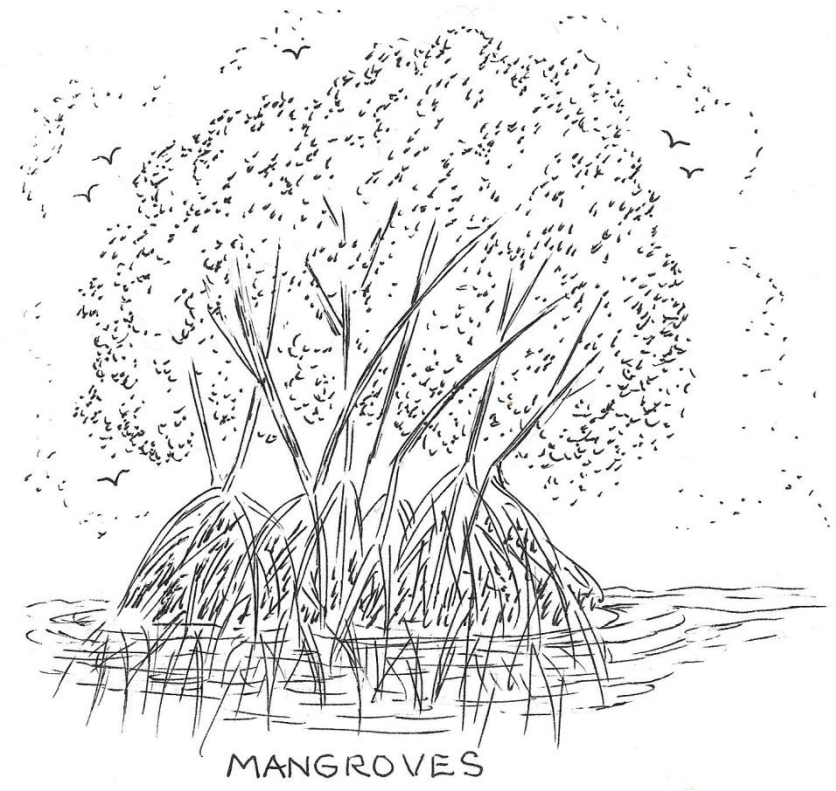
Let the children discuss in groups why there are so many difficulties working in the rainforests. They can also discover how many uses for rubber they can think of! Then they will realise how useful and valuable the rubber tree is!

All plants have gifts for humankind, which they give freely and unconsciously. Like a person giving blood to help others in hospital or like the cow that produces milk for many people to drink, so the rubber tree freely gives its milky sap or gum for the service of humankind.

46 Galvanised = metal that has been treated

MANGROVES

Along the coast and river banks in the Equatorial Forests, grow trees known as Mangroves. Mangroves grow in tight, tangled groups or families. Many slender trunks shoot up from one clump of soil, each with clusters of leaves on top. They often look like little islands of trees growing in the mouth of a river. They are easily recognised by the huge tangle of long roots that form a barricade or fence around their trunks. Sometimes they look as if they are growing on stilts[47]!



Mangroves manage to survive in water of differing tide levels. Their roots are very strong and give support for the trunks of the trees in the soft soil close to the water. Mangroves are like amphibians as some roots grow on the land and some in the water and they have a specialised filter system to keep most of the salt from the sea from killing the plant. The tangled network of roots also hold the soil and prevent it from being eroded away and washed out to sea.

Mangroves are very friendly and sociable as they are home to many creatures. Birds of all kinds nest in their green leafy canopy, especially the noisy and brightly-coloured macaws of the parrot family. Fish come to lay eggs in the net of their roots and many shellfish and oysters live there too. Crocodiles and snakes of the tropics come to hunt for food among their roots, as well as all kinds of monkeys, deer and other animals. Bats and bees look for nectar from their flowers. There are even tree-climbing crabs that live in their branches.

There are many kinds of mangroves: three of them being the red mangroves, white mangroves and black mangroves. Each of these has tiny flowers with four or five cream or white petals like little stars on a spike at the end of a branch or between the stem and leaf-blade. Many of the mangroves reproduce differently from ordinary plants. The black mangroves have long pods like beans and the seeds germinate on the plant inside the pod. Eventually the pods will drop and many of them are transported by water like little boats. The pods must come to land where they turn vertical as they need time to grow and root themselves in soil in order to become new mangrove plants. Because they have

[47] Stilts = poles which raise houses above the ground; also poles with steps on them for a person to place their feet on so they can walk raised above the ground.

already germinated they can immediately create their own food through photosynthesis. Other mangroves have adapted in slightly different ways to ensure their seeds will create new plants.

Red and black mangroves produce strange roots that run horizontally through the mud and then grow upwards towards the sky. These strange roots are called 'snorkel' roots as they have tiny pores to allow the plant to take in air as most of the roots are underwater. The mangroves struggle to get sufficient gases from the air and these 'snorkel' roots store air for use when the roots are submerged in the water. They also collect mineral nutrients from the air as the poor soil struggles to supply their needs.

Mangroves have changed and adapted to all kinds of environmental difficulties. They have often been cut back to make way for building development, dams, factories, etc., but countries like Bangladesh have cultivated them, recognising the importance of mangroves in protecting the coastline and the environment.

THE SAVANNAH GRASSLANDS

THE *ACACIA* TREE

Further from the Equator or higher above sea level, one finds the grasslands of the tropics. In Africa they are known as the savannah grasslands. Dotted all over these vast grassy plains one can see many dark green trees called acacia trees. They have long, airy, slender branches reaching outwards and their topmost twigs form a flat top like an umbrella. They can grow to a mighty 18m high with a crown that spreads over 36m across.

Acacia trees have small feathery leaves and fine, sweet-scented flowers. Even in the dry season when the long grass has turned yellow, the green of the acacia brings life to the

savannah. In times of severe drought the acacia sheds first its leaves and then its bark that has a cork or waxy covering and in this way it can minimise water loss. Some acacias have deep roots while others spread their roots wide to search for water in the dry season.

Like the image of the sheltering umbrella, the acacia cares for many animals that depend on it for food and survival. To protect itself against attack from wild animals that eat the bark and leaves, acacia trees grow sharp hooked or pointed thorns. The tall giraffe can reach to the topmost branches and grasp the greenest shoots with its long tongue. The acacia has an acid substance in its leaves and sharp thorns growing in a conical shape to protect the youngest shoots at the growing point. The giraffe produces a liquid saliva that reduces the acidity but even so it has to avoid the thorns. The gerenuk (a small antelope with long legs and neck) can stretch up to 8 feet to nibble the leaves while the tiny dik-dik (buck) feeds on the lowest branches. Goats, sheep, cattle and camels also feed on the acacia leaves. The acacia has a juicy fruit like a pea pod, sometimes twisted into a spiral. When it falls to the ground it is quickly eaten by animals.

Weaver birds make nests in the branches. On one type of acacia, a hollow egg-shaped ball grows at the base of a pair of thorns. A small ant makes its home in this ball and also eats the nectar at the base of the leaves. When animals come to eat the leaves, the ants swarm out and attack them. In this way the acacia and the ant protect each other.

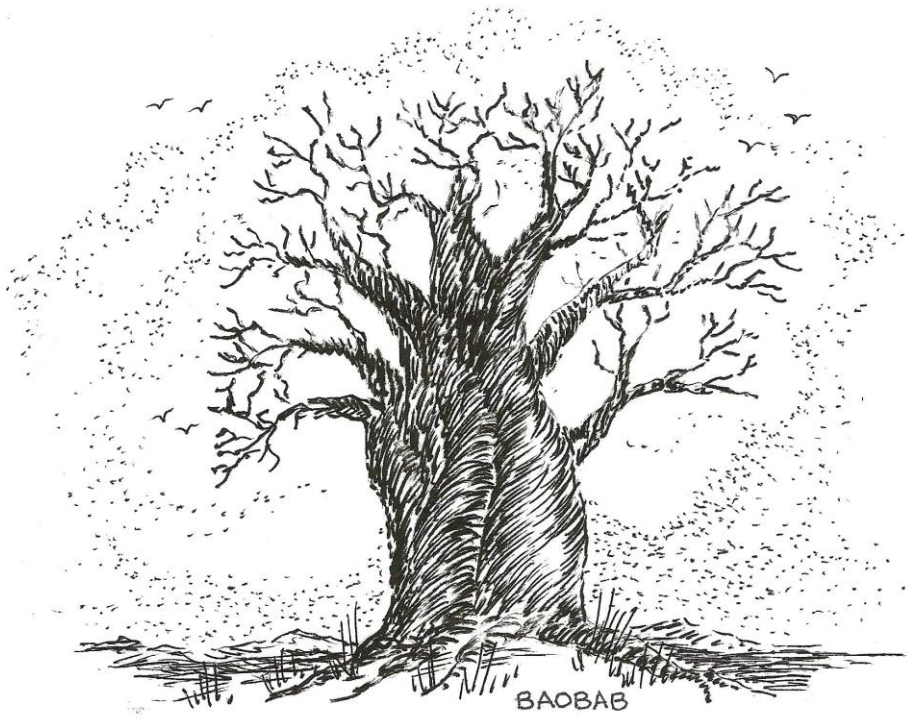
The acacia also provides human beings with commercial substances like gum arabic that is used in many industrial products and tannin used for tanning hides. It also has medicinal qualities.

THE BAOBAB TREE

One of the strangest trees growing on the dry savannah grasslands is the great baobab tree. At full size it looks like a large African Mama with twisted spiky branches like arms and hands sticking up into the air. It has a huge gnarled trunk, with a girth of about 14 metres across and can grow up to 25 metres high. Baobabs can last for more than 1000 years!

Young baobab trees have slim straight trunks but these begin to twist and get fat as it grows older. Twice a year during the rains, the baobab puts out small green leaves and soft flowers but as the heat builds up these die and fall off so most people see the baobab without any leaves.

There is a San legend about the origin of the baobab tree. Once the Great Spirit asked all the human beings and animals to plant trees on the earth. He had given all the trees away except one, when along came the hyena and complained that he had been forgotten. So the Great Spirit gave the hyena the last remaining tree which was the baobab. Because the hyena was careless or grumpy, he did not look what he was doing and planted the baobab upside down. That is why the baobab looks as if it has its roots in the air.



African people look up to the old baobab trees with reverence, calling them individual names all starting with Um which means Mother. The many varieties have other names such as Monkey Bread Tree, Sour Gourd Tree and Cream of Tartar Tree. Just like a mother who always has food for her children in the kitchen, the baobab tree is full of gifts and many uses. Not only is the wood used for furniture and timber, medicinal remedies are extracted from the bark and roots. Many baobab trees also have edible fruits. The baobab is truly a mother among trees in Africa.

THE DESERT

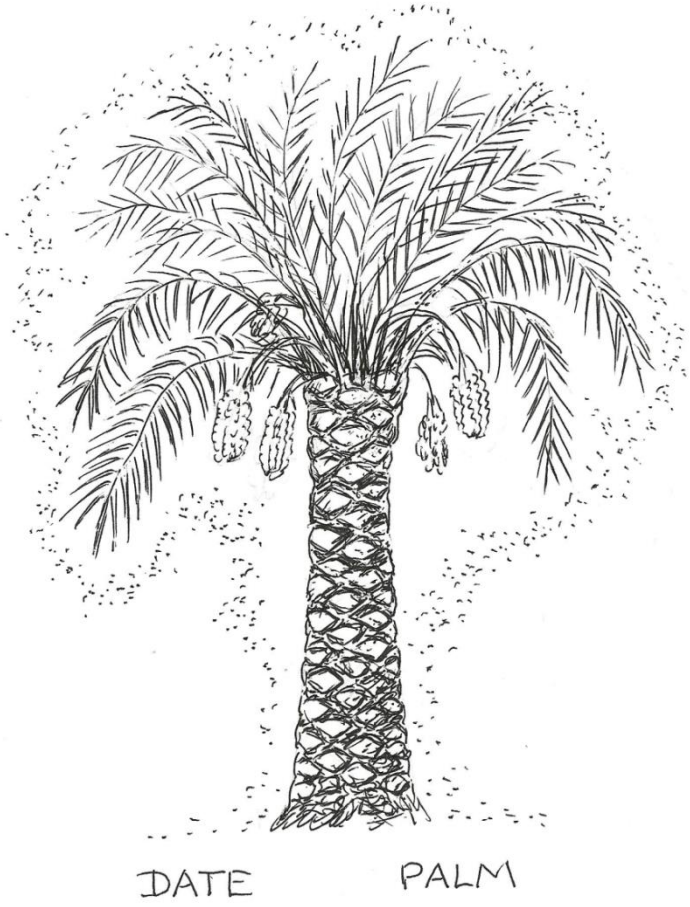
As soon as the abundance of water found in the Equatorial Forests is no longer available, the climate changes radically. The heat of the sun blazes down, drying up the soil and the semi-desert and desert are created where a few hardy grasses, thorn bushes and cacti are left in the bare land of rocks and sand. Human beings have played their part in creating deserts by thoughtlessly cutting down trees for their own use, not realising that the roots of trees hold the layers of soil together. Trees also attract rain through the evaporation of moisture through their leaves.

THE DATE PALM

One tree has become the sole[48] survivor of this arid land: the palm tree. Although many varieties of palm trees grow all over Africa, the date palm is the tree of the desert. Date palms grow in groups or groves, wherever there is water deep below the surface of the sandy wastes. Tribes like the Berbers of North Africa dig wells there and create an oasis

[48] Sole survivor = the only survivor

where they can live, irrigating the land to grow food. Camel traders come to water their camels at the well before moving on to their next destination.



The date palm has a tall, strong, straight trunk with long feathery leaves. It stands in the desert like a proud warrior, well able to survive the climate. The new leaves grow in a crown, like a spiky headdress from the centre of the top of the trunk. Each leaf has a long midrib with thin sharp leaves on either side like a huge feather. The long, pointed leaves create shade, letting thin shafts of sunlight through like a blind on a window. They sway joyfully in the breeze. In some countries the palm tree is said to be waving its branches in praise of God!

The trunk has thick bark, which may be slightly scarred from old leaves that have fallen off. In some varieties of palm the bark is smooth, in others it is rough. The trunk can be slender when young but grows into a solid pillar with age. High at the top of the trunk the flowers grow on long branched stalks, generally protected by a spathe.[49] Both male and female flowers grow on the same tree but usually in different seasons. The flowers are pollinated by the wind, often in the early morning when the palm trees are covered in a mist of pollen.

The sweet juicy dates develop in clusters on the stalks, each with a small hard pip in the centre. When they ripen, the young men and boys gather them from the trees. They tie a rope between their ankles and climb up the trunk, using the rope as a rung on a ladder. They also have a rope around the trunk and their waists to prevent them from falling. In the cloth around their waists is a sharp knife which they use to cut the stalks full of ripe fruit. These fall to the ground to be collected by other boys waiting below.

Palm trees are evergreen; some varieties, like the date palm, have leaves shaped like feathers, while others have fan-shaped leaves. The coconut palm is also found in the desert. Palms mostly belong to tropical countries.

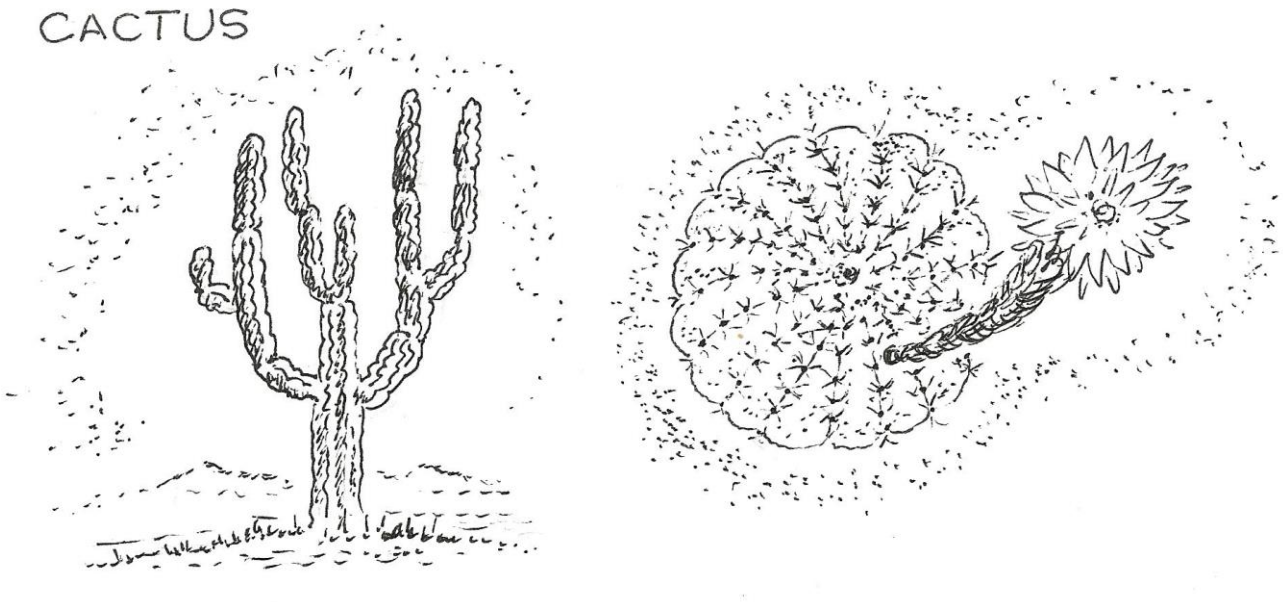
49 Spathe: a broad leaf like a shield that protects the flowers

THE CACTUS PLANT

In the dry semi-desert and desert regions of the world where there is very little plant-life, we may see some of the strangest looking plants. They have large, fat juicy stems full of prickly thorns or *spines*. These plants are called succulents.[50]

The most well-known of the succulent family is the cactus of which there are many varieties. Most recognisable is the tall cactus with many long arms reaching up to the sky (see first drawing below). It can grow to height of 19m. The smallest cactus is 1cm in diameter at maturity. Many cacti (or cactuses) grow in a round globe shape (see second drawing below, looking at the globe-shaped cactus from above: note the stalk on which a cactus flower appears), but there are a wide variety of shapes and sizes.

The cactus survives in these dry regions because it has adapted to store and conserve water. It has a shallow[51] root-system that extends far out on all sides to absorb any rain or dew that might fall. The stems have become greatly swollen to hold as much juice as possible. They are ribbed with ridges that allow the stem to expand quickly whenever there is rain or to contract if there is severe drought. The ridges also provide shade that reduces evaporation.[52]



Because the stems are green in colour, they carry out photosynthesis to feed the plant. The cactus takes in carbon dioxide by night and keeps it for day-time to use in the process of photosynthesis.

The cactus has no proper leaves, as they have contracted to become thin spines. Each spine grows out of a node called an areole (or reduced branch). The spines are like needles sticking out of the stem and protect the cactus on all sides like a barbed wire

50 Succulent: juicy

51 Shallow = not deep, staying near to the surface

52 Evaporation: loss of water from the plant due to the sun's heat

fence. This prevents many animals from eating the juicy stem and destroying the cactus. The spines also trap the air keeping it cool next to the stems. This also reduces evaporation of water from the plant.

The cactus has another way to reduce loss of water. It has a special mechanism whereby it only transpires water by night and not in the heat of the day.

So we see that the cactus is very able to defend itself against attack from the heat of the sun or the animals in the area. But there is another side to the prickly cactus!

The growing season is very short after the rain has fallen, if there is any at all. Then we may see the miracle of the cactus flower. Out of the areole there grows a bud that opens into a trumpet shape with many petals and beautiful colours. It does not last long, sometimes only a day or two. In that short time the cactus becomes a glorious beauty, but after the flowers die it will be a long time before they may be seen again.

THE MEDITERRANEAN LANDS

Beyond the desert we find a climate that takes its name from the countries that surround the Mediterranean Sea. Although this climate may be found north and south of the Equator, these countries are in the same latitudes as the Mediterranean countries and often on the west coast of a continent, e.g. Western Cape province in South Africa, a part of Chile in South America and California in the United States of America.

Unlike the tropics, the climate of the Mediterranean lands experiences the different seasons of spring, summer, autumn and winter. The summers tend to be dry and hot while the winters are cold and rainy. Spring and autumn are often the most pleasant seasons. Because of the long, dry summers, the trees are not very tall and need to be hardy to withstand drought. Such a tree is the olive tree.

OLIVE TREE

Its silvery green leaves are thin and oblong (see drawing below), the upper side being a dark 'olive' green and the underside a soft grey-green colour. The olive tree is a small, hardy, evergreen tree or shrub that flourishes in the dry climate of the Mediterranean lands. Its trunk is often twisted, looking as if it has strong muscles, and one could imagine this humble tree as a worker, offering many gifts to human beings. It has a rough scaly bark with a scented resin[53].

The flowers of the olive tree are small, white and feathery, springing from the axils between the leaves and the trunk. The fruit looks like a grape and is very hard. Both green and purple/black olives are grown. They are extremely sour and go through a long process of being soaked in brine (salt water) and other methods before they become the popular food they are, eaten daily all around the Mediterranean and abroad. This simple little tree also produces a rich oil, used in cooking all over the world.

[53] Resin = thick and sticky secretion by plants, that harden with time; used for making incense, frankincense and myrrh, perfumes, and to get substances to bind together.

The olive tree was said to have been the gift of the goddess Athena to the city of Athens when she became its patron. In ancient Greece, the oil was used to anoint kings when they were crowned. Athletes were also rubbed with olive oil before the Olympic Games. The olive leaf is a symbol of peace and abundance.

The olive groves in the Mediterranean are very ancient, some of them as old as 1200 years. The wood is used for making furniture. When olive branches are used in fires, they burn longer than other woods and contain more energy.

Olive trees have been found in a fossil bed in Macedonia (near to Greece). Some fossilised leaves were found on the volcanic island of Santorini (a Greek island), dated 37000 years old.

THE PROTEA

In the Southern Hemisphere, particularly the Western Cape in South Africa is a family of plants called proteas. The name comes from the Greek God Proteus who could change himself into many different shapes. This is because the protea family also has a great variety of shapes and sizes.

The proteas are hardy bushes or shrubs that grow naturally over the mountains and valleys of the Western Cape. They have adapted themselves to survive growing in poor soil with severe lack of water over the long hot summer months. Their strong, hard roots, leaves and flowers give a feeling that they are like tough, old people who are not affected by the blazing summer sun!

Proteas have many shallow roots growing out on all sides to drink up any moisture. The stem is hard and woody, even scaly like a snake. The leaves are smooth and hard, often a dark green with a red edge to each leaf to ward off the heat of the sun. The leaves overlap each other, giving shade to those below to reduce water evaporation. Sometimes the leaves are hairy, trapping the air to keep the leaf cool. Many proteas have long oblong leaves but there are a variety of different shapes, each one adapted in its own way to conserving water.

Most proteas flower at the end of the winter rains or in early springtime. Often they have

a bud like a cone that opens up into a densely compacted[54] head of many flowers. The petals that surround the cone are hard, stiff and often waxy, looking like leaves that have changed colour to become part of the flower. The petals generally range from yellow and orange to red in colour. The flowers last for a long time, sometimes up to a month. They can also be dried successfully.

The flowers produce a strong, honey-smelling nectar that attracts a great variety of insects, as well as lizards, mice and birds. Sunbirds and sugarbirds cluster round to drink the nectar and play a part in pollination or distribution of the seeds.

Fires easily occur over the hot, dry summer and many of the proteas are completely destroyed in bush fires. But they have mechanisms for survival, often re-sprouting from the roots or re-seeding themselves. The hard seed-shells crack open in the heat and ash of the fires and the following winter and spring - when the rains begin again - will see a new generation of protea plants on the hillside.

THE TEMPERATE WOODLANDS

North of the Mediterranean Lands – Northern Europe, and the equivalent areas in North America and middle Asia – and, in the Southern Hemisphere, further south - lie the Temperate Woodlands. Here we find the home of the broad-leaved deciduous trees: oak, ash, beech, birch, plane, poplar, willow, maple and many others. On these fertile lands, well-watered by rainy seasons and many rivers, we find the most magnificent gardens, parks and forests of the world.

THE BIRCH TREE

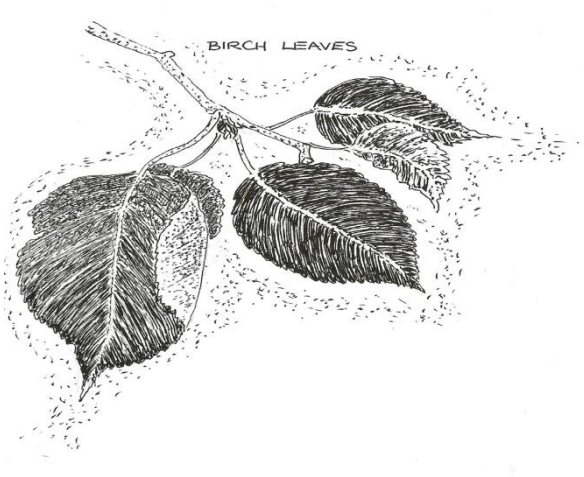
The birch tree is a pretty tree rather like a dainty lady. She has a slender trunk with a white or creamy bark on which one can see dark blackish scars. Her twigs and branches sway gracefully in the breeze as if she is dancing joyfully. Her leaves are small and light green in springtime but in autumn they turn a lovely golden yellow. Each leaf is shaped like a triangle with a sharp point at the end. Both in colour and movement the birch tree seems to be filled with light and air.

In spring the birch has catkins of two kinds, both on the same twigs. The catkins[55]

[54] Compacted = squashed closely together

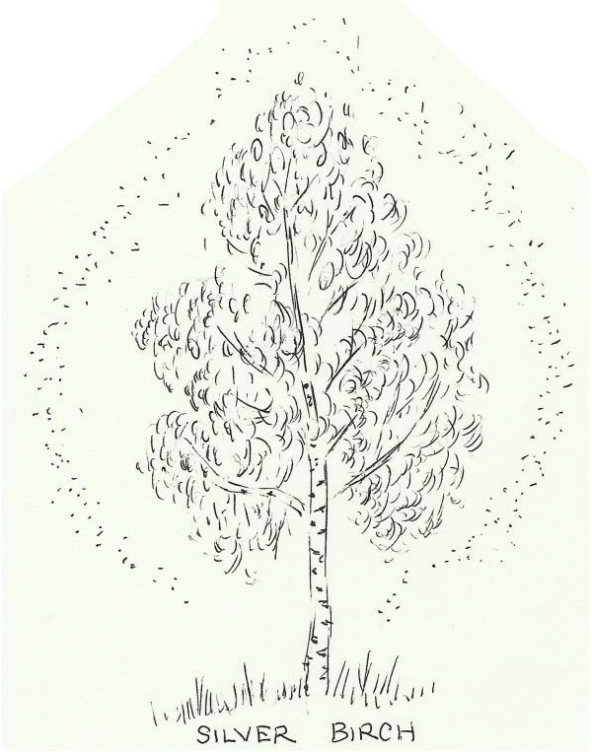
[55] Catkin = a cluster of flowers that hangs (sometimes stands up straight) from certain trees, looking like the tail of a kitten. It is the reproductive part of the tree

carrying pollen hang down softly while the catkins bearing fruit and seeds are much smaller and stand up at first. These catkins become heavier and droop downwards when the seeds ripen. The fruit- catkins have no scent as they are pollinated by the wind that wafts the pollen over them. When the ripe catkins open, the little seeds look like beetles with two paper wings that carry them away on the breath of the wind.



The birch tree always looks at its best when young and especially when the morning sunlight shines through its leaves. In old age, it loses its gracefulness and fresh youthful quality and the wood rots easily. If we observe an oak, however, we see that it comes to its fullness and strength after many years, living on to a great age. It often looks most magnificent towards sunset.

The birch tree is very healthy, having no insect enemies. It also can resist both frost and drought in spite of looking so delicate. Although it has no scent in its catkins, it has scent in other parts of the tree and the leaves are aromatic[56]. The sap too is rich in sugar and oil which has been used by tribes living in the northern lands when food is scarce, making the bark into bread. The birch sap is also used as medicine, restoring sick people to health or using it for health-giving drinks.



The wood of the birch tree is used as timber, while the bark is peeled off and softened like leather to make many useful things, even straps and shoes. Long ago babies were laid in cradles made from the flexible branches of the birch tree. Birch timber is used in the making of certain musical instruments due to its fine resonance.

THE APPLE TREE

All over the world we find many varieties of the well-loved apple tree. The apple has been cultivated for its fruit and grows on a short sturdy trunk with a crown wider than it is high. It is so lovely to see an apple orchard in blossom with its flowers like a cloud of pink across the valley. They bloom in early spring as the buds have been prepared in the previous season. No leaves appear at this time and the delicate flower is like a princess in her pretty pink dress. Like the rose, the apple blossom has five petals and a five-pointed green calyx. The pistil is inferior (or inside) the apple blossom and after the

[56] Aromatic = has a sweet scent or fragrance

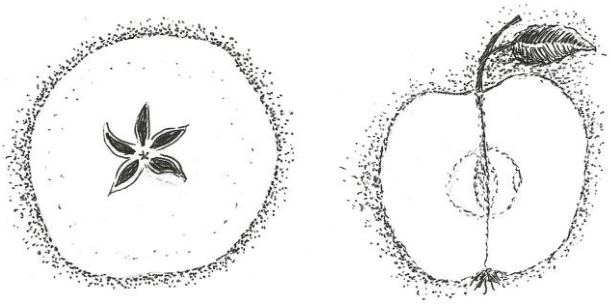
insects have drank the nectar and left pollen from other apple flowers on the stamens, the petals fall, and the pistil begins to swell and form the fruit. When the apple is ripe you will see the remains of the calyx and stamens underneath the fruit.

The apple tree has a rich abundance of sap that results in much nectar in its blossom for the bees, as well as a great harvest of sweet and juicy fruit. The rose, however, although delicate and scented, has no nectar for the bees, only its rich pollen.

The apple tree has simple leaves that appear after the petals have fallen to the ground. So the leaves are more connected to the fruit than to the flowers. The rose, however, has compound leaves, showing that she puts her energy into the formation of her fine and delicate beauty, while the apple tree is concerned with the useful business of producing fruit.

The apple tree grows between sun and earth. In spring the sunlight invites the blossoms to open upon the strong branches and trunk into which the earth sends her energy. The warmth of the sun fills the earth in summer so that the apples may grow full and round as if bursting with life and energy. Then the sun ripens the apples so that they become rosy-cheeked and sun-kissed! A round apple is a picture of a small earth.

If one cuts the fruit of the apple through crosswise, one may see a five-pointed star where the seeds are placed in the core (see first diagram below). Here again we see the connection between the apple and the rose. The second diagram is a cut from top to bottom: note the seed-house in the centre and the left-over stamens at the bottom end of the apple.



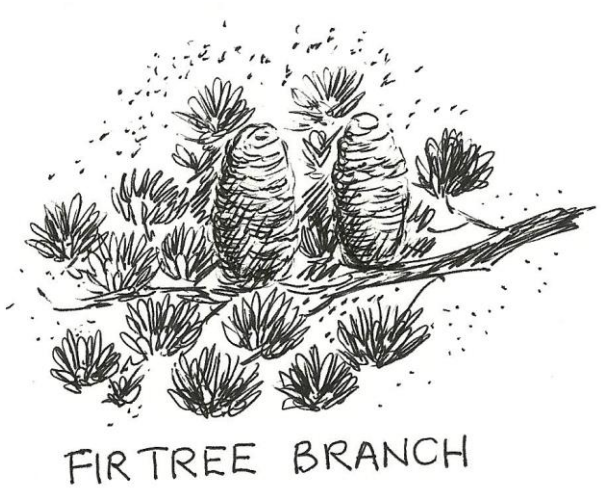
The rose and the apple tree are like the parents of a large family. The rose is the mother in her beauty and delicate forms, while the apple is like the father, going out to work to provide food for the family. Other members of this family are the pear, peach, plum,

cherry, and quince, producing fruit like their father, while the raspberry and blackberry are more like their mother with their long thorny branches like the wild rose. The strawberry is also a child in the rose family. The wild apple is the Crab Apple tree with fruit too acid to eat unless made into a jelly.

"Both plants are unthinkable without man and belong to him as much as do the domestic animals. The rose refreshes the soul; the apple, the body."[57]

THE CONIFEROUS FORESTS

Further north and south of the Temperate Woodlands lie the cold lands where the coniferous forests grow (often called the Coniferous climatic region). These forests grow in the far north of Europe (Norway, Sweden, Finland) and in the northern parts of Russia and Canada. As we have spoken about the pine tree before, we can now study the Fir tree.



The fir tree is like the pine tree in its solemn majesty. Its smooth grey trunk grows straight upward to the sky. Looking down from above, its stiff strong branches ray outwards like a star with the branches below fitting exactly in between the ones above.

The fir tree is evergreen, carrying its needles in bunches that are attached to little twigs with a base like a small suction cup. The needles are shorter than those of the pine tree, rather like stiff bristles. The needles remain green all year round and do not fall off for several years. Among them grow the fir cones that are upright and cylindrical in shape. These cones take over a year to ripen.

There are many types of fir but their wood is not considered good timber, so it is used in building construction or pulp for making plywood. Fir trees are often grown for Christmas trees as they are so festive.

TUNDRA

North and south of the coniferous forest belts lie the cold Tundra regions (in the north: see the northern-most parts of Canada, Greenland, Norway and Russia and the permanently frozen Arctic Ocean; in the south: see the southern-most tip of South America and Antarctica), where very little grows except dwarf shrubs, sedges[58], grasses, mosses and lichens. It is too cold for trees to grow and fierce winds blow over the area. The ground is permanently frozen. Reindeer and a few smaller animals roam these regions, but there is very little human life, the climate is so harsh. The tundra climate may be also be found in high Alpine mountainside.

57 Gerbert Grohmann, The Living World of Plants, p23

[58] Sedges = grass-like plants that grow in wet areas; some of these have adapted to living in the tundra.

SECTION 3: DEVELOPING THE MAIN LESSON

CHILD DEVELOPMENT

The child in Grade 5, aged around 10 turning11 in this year, has grown into his or her body and is experiencing a time of physical well-being. The years of struggle in Grade 3 and 4 are past and the children feel more secure in their own resources and are ready for greater challenges.

The physical body is now relatively well-proportioned and co-ordinated, giving strength and grace to their movements. They enjoy stretching their physical boundaries in games, athletics and sport. They are also eager to stretch their mental abilities and are full of curiosity, questioning and discussing ideas and attitudes about everything.

However, they still need plenty of imaginative input and they love to create beauty in their books, so it is important that the teacher sets high expectations so that this ideal of beauty and perfection can be satisfied.

The wide range of subjects given in Grade 5 is exciting but must not become intellectual, nor too easy: the teacher needs to provide rich content, ask interesting, deepening questions for them to try to find answers to and set engaging tasks.

Much of the subject matter invites artistic expression in all media: painting, music, poetry, drama and movement. It is essential that all the arts are developed as much as possible at this age before puberty – especially *emotional* puberty – sets in.

Grade 5 is known as the *heart* of the primary school and the teacher must make the most of their enthusiasm and determination. The skills achieved at this age will carry the children into the turbulent years that follow with a wonderful sense of self!

TEACHING AS A PATH OF DISCOVERY

We live in a wonderful world of plants: a beautiful world, an amazing world! As teachers we can say these words to the children in our schools, but they are mere words unless the children discover the wonder, fascination and secrets of the plant world for themselves.

How can teachers help to set children on this path of discovery?

In Grade 1 and 2, children live strongly in their feeling of sympathy[59] that gives them a sense of being at one with the world. Thus young children experience the plant and the wisdom of the growth processes of nature unconsciously. This force of sympathy gives the children the will to do things. It also stimulates their powers of fantasy and imagination, and the ability to create mental pictures. At this stage the teacher tells stories about Mother Earth and Father Sun that awaken the children to the working of the world around them.

After age 9, the children begin to differentiate themselves from their surroundings through the growing sense of antipathy[60] or separation. They learn to observe the world around them with greater awareness. By standing back from any object we see it more clearly. This helps to prepare children to cultivate the ability to think, to remember and to form concepts which are the gifts of antipathy. Although the children are ready to look at phenomena consciously, this does not yet mean intellectually. They still need to be presented with *imaginative pictures* in the mind, that describe what is happening e.g. that plants grow on the earth in the same way as hair grows on our heads.

The Teacher's Presentation

In Grade 5, when the teacher presents new material, the children are ready for more than stories. The teacher brings *images* to explain the scientific material to be taught, using *descriptive language* so that the children understand the concepts. Images can be expanded and this allows growth into deeper understanding, which develops mental flexibility in the children.

It is like *painting a picture* in the imagination of the children: the image speaks directly to the children, helping them to understand what they are learning in their own terms. For example, when we speak of the 'evolutionary ladder' of the plant kingdom, describing the simplest plants to the most complex ones, the image could be that of human development:

> "The mushrooms are the babies of the plant world", and so on through the ladder till we reach the flowering plants, which are "the fully grown adults of the plant world".

When the image fits the content well and the teacher presents the lesson, *richly describing* the details, colours and beauty in an imaginative and lively way, the children will be filled with wonder at the working of the plant world. It will seem like magic to them! In this way the material will become a *living experience* in their imaginations, helping them to understand and remember what is being taught.

59 Sympathy = feeling "with" (for example having a good feeling towards another person; feeling drawn towards (for example an activity); joining oneself with something.

60 Antipathy – feeling apart from

The Class Discussion

The children will have been listening for some time to the teacher's presentation of something new they are learning. They will have been 'breathing in' the rich pictures arising from the teacher's images and descriptions. This needs to be followed by a 'breathing out' in which the children speak about the topic. This alternation of 'breathing in' and 'breathing out' is very important, to keep a healthy balance between listening and speaking.

An important method to be used in the classroom is for the teacher to create *discussions* out of the material being taught and to develop the technique of using 'open questions'.

What is an 'open question'? It is a question that is open to having *more than one answer* e.g. what are the differences between a plant and a rock? It requires the teacher to allow children to express ideas and opinions without the teacher giving all the information or expecting certain fixed answers.

If the teacher hears a child say something unclear or not quite scientifically correct, he or she asks them further questions e.g. "What do you mean by ... ?" This allows children to expand their ideas and clarify their thinking and may even lead to further discussion with the rest of the class. In this way, both the individual and the class gain in understanding and the ability to express themselves clearly. The result is a glow of interest and energy between the classmates and the teacher, as they discover the plant world around them!

Observation out-of-doors

It is important for children to experience the plant world outside the classroom, and not just to learn about it in a theoretical way inside the classroom.

However, *how* we do this needs good planning. It does not work well to hold the lesson outside. Their attention is easily scattered, and there are so many plants to see, that it is hard to focus. Class discipline is also much more difficult outside. Many children, when presented with a plant, find that there is so much to see that they do not know what to look for. They also cannot easily look at a specimen and listen to the teacher at the same time.

So it is best for the teacher to begin in the classroom. He or she can present the specific plant by presenting it in descriptive pictures, bringing out the most characteristic details of the plant. This will stimulate their interest in the plant. The teacher also needs to describe this plant in terms of where it likes to grow, in sun or shade, plenty of water or very little - in other words describing the environment where the plant is growing. Finally, the teacher can pose two or three questions that the children need to find the answers to when they go outside to look at the plant.

When the class is outside, looking at the plant in its natural environment, the rich descriptions and the two or three questions will have aroused their interest, and they will

observe far better than if the teacher had to give the lesson outside, where the plant is growing.

“Tell me everything you can see about this plant,” is a good question for the teacher to ask. As far as possible, the teacher will ask interesting questions, rather than try to teach when outside.

The class can also be taken on one or more outings into nature or to a botanical garden. There the children can experience the plants *in nature itself*, where they can connect the pictures in their imaginations with reality before them.

It would not be good to give long explanations here. The children only need to be directed to what plants or parts of plants they should observe. When the children have been well prepared in lessons beforehand, they find the expedition very exciting, especially if the teacher sets a simple question paper to be filled in or gets them to draw some of the plants.

This need not stop the teacher from bringing plants into the classroom, both for giving explanations and for observation by the children, especially if observing them in their natural surroundings is not possible.

AN EXAMPLE OF HOW TO STRUCTURE A MAIN LESSON

Theme: The Life Cycle of the Plant

An example of designing main lessons over SEVEN days

Day 1

Rhythmic Section	include: Song, Morning Verse and movement to connect the children to the lesson: Songs: own choice Speech exercise Poetry: Introduce poem/song "The Dance of Life" and/or other suitable poems. Movement: for several days practise expansion and contraction[61] introducing aspects such as cold and warmth, night and day, darkness and light, dry and rainy seasons (or winter and summer). Use hall or large space, if possible. On the return to the classroom, let the children pause outside for a moment and take several breaths of fresh air. Inside the classroom, when they have sat down, begin the next section of the lesson.
'Thinking' or Learning/Content Section	Discussion How did you feel breathing in the fresh air? Alive? Healthy? Cold? Warm? How did you feel when you breathed out again? Happy? Sad? Healthy? Sick? Did you feel connected to the weather and the world around you? (Someone may have said this.) Introducing new work The Plant as Child of Earth and Sun The Four Kingdoms of Nature: discuss the role of the four elements in the growth of the plant.
Work time (Will Section)	Work in Main Lesson Book It is very important that the teacher has prepared the PLANT STUDY heading and a drawing on the board for the outside cover before the children enter the classroom, to demonstrate what is expected. The illustration of the complete flowering plant in the four elements is a good choice. On the first page, a suitable verse can be written down, preferably the poem begun that morning. It is best that the children set out their first page carefully and do the writing before they illustrate or draw a picture. The teacher could encourage the children to imagine their own idea of the plant as well. The children should be given plenty of time and guidance to create a book of beauty. The front cover and the first page may take more than a day or two to complete beautifully.

61 See movement exercises in Section 4 of this manual.

Day 2

Rhythmic Section	Singing: Repeat songs from Day 1 Speech exercise Verse: Practise poem using lively expression Movement: ❖ Repeat exercise of contraction and expansion ❖ Mime the four elements
'Thinking' or Learning/Content Section	Recall Full recall of yesterday's lesson. Questions for discussion: Why do we say the plant is a child of earth and sun? What are the four elements? Why does the plant need the four elements? Do humans also need the four elements? What do we do if we lack one of them? Introducing new work The Water of Life. The Secret Life of the Plant: Introduce the whole plant, and the idea of the plant in a state of constant 'becoming' and that one cannot see the whole plant at one time. Discuss the idea of expansion and contraction in the plant and where it can be observed. Where can we see expansion and contraction in our weather? In plants? In humans? What causes expansion and contraction? How does it help the plant?
Work time (Will Section)	Work in Main Lesson Book The teacher will have prepared some notes from the beginning of yesterday's lesson for the children to write into their Main Lesson books. These notes should be imaginative and descriptive, but not too long. This can be followed by working on drawings started in Day 1.

Day 3

Rhythmic Section	Song: Repeat songs Poems: Repeat poems using lively expression Movement: - Mime the complete life cycle of the plant - Mime expansion and contraction in the plant forms - Teach 'Dance of Life'.
'Thinking' or Learning/Content Section	Recall Full recall of yesterday's lesson What is the magical element in water? Is it only in water? Where can we find it? What does it do for all living things? (Builds the body/form and also maintains and heals the body.) What did we say about the secret life of the plant? Do we see every part of the plant at all times? Where do we see expansion and contraction in the different parts of the plant? Introducing new work 'The Life Cycle of the Plant' (or The Story of the Plant from Seed to Flower): Describe the 'story' (first part) of the seed, roots and stem.
Work time (Will Section)	Work in Main Lesson Book Draw expansion and contraction in the different parts of the complete plant

Day 4

Rhythmic Section	Rhythmic Section: Repeat songs and poems Movement: exercise on water cycle. Repeat the 'Dance of Life' dance. - Repeat miming the complete life cycle of the plant - Repeat miming expansion and contraction in the plant forms - Repeat 'Dance of Life'.
'Thinking' or Learning/Content Section	Recall Full recall of yesterday's lesson The teacher asks the children to describe the growth of the seed, roots, and stem, discussing the images from the day before to make sure that the children live into the pictures and understand them. Introducing new work 'The Life Cycle of the Plant' (second part): Continue story of the plant, introducing the shapes of the leaves, followed by the functions of the leaves: the breathing of the plant, photosynthesis (the food-making process) in the leaves and the water cycle.
Work time (Will Section)	Work in Main Lesson Book Write notes on seed, roots and stem. Complete drawing of expansion and contraction in the whole plant.

Day 5

Rhythmic Section	Repeat songs and verses Mime water cycle: Use following verse if desired: 'Into the roots and up through the stem, Out of the leaves and into the sky. Clouds in the sky are gathering rain, Down it falls to the earth again.' (3x) Repeat 'Dance of Life' Teach 'Dance of Photosynthesis'.
'Thinking' or Learning/Content Section	<u>Recall</u> Full recall of yesterday's lesson Ask the children to discuss the three functions of the leaves with their neighbour in the desk. Then get them to describe one function at a time: a) breathing b) food-making /photosynthesis c) water cycle In what way does each function support all life on our planet? <u>Introducing new work</u> 'The Life Cycle of the Plant' (third part): Describe the development of the complete flower in connection to the warmth and light of the sun! Create a diagram of the parts of the flower, while describing them and their functions.
Work time (Will Section)	<u>Work in Main Lesson Book</u> Write down notes on the three functions of the leaves. Draw a picture of photosynthesis.

Day 6

Rhythmic Section	Repeat songs and verses Repeat miming water cycle: Use following verse if desired: 'Into the roots and up through the stem, Out of the leaves and into the sky. Clouds in the sky are gathering rain, Down it falls to the earth again.' (3x) Mime parts of the flower Repeat 'Dance of Photosynthesis'.
'Thinking' or Learning/Content Section	<u>Recall</u> Full recall of yesterday's lesson Get children to describe to each other the different parts of the flower and the function of each section. Then share with the class. <u>Introducing new work</u> 'The Life Cycle of the Plant' (fourth part): Describe the special relationship between flowers and insects. Teach them the poem of the 'Flower and the Butterfly'. Complete the story of the fertilization of the flower and the development of the seeds, showing how it all arises naturally from the warmth of the sun.
Work time (Will Section)	<u>Work in Main Lesson Book</u> Write notes on the structure and functions of the parts of the flower. Draw a picture/diagram of the flower showing the different parts clearly.

Day 7

Rhythmic Section	Repeat songs and verses Briefly repeat miming water cycle: Use following verse if desired: 'Into the roots and up through the stem, Out of the leaves and into the sky. Clouds in the sky are gathering rain, Down it falls to the earth again.' (3x) Repeat miming parts of the flower Repeat dances learned
'Thinking' or Learning/Content Section	<u>Recall</u> Full recall of yesterday's lesson Discuss relationship between flower and butterfly and how they help each other. Name other insects that bring about pollination <u>Introducing new work</u> 'The Life Cycle of the Plant' (fourth part completed): Briefly introduce wind pollination. Complete the story if necessary. Answer any questions that arise. Discuss the many gifts of plants to us. What can we give back to the plants?
Work time (Will Section)	<u>Work in Main Lesson Book</u> Write in last notes on the life cycle of the plant. Write in poem of Flower and Butterfly. Draw picture of the flower and the butterfly.

Day 8

Rhythmic Section	Go through all songs, verses/poems and dances learned thus far
'Thinking' or Learning/Content Section	<u>Recall</u> Full recall of yesterday's lesson Describe wind pollination; what gifts do the plants give us? What can we give back to the plants? <u>Introducing new work</u> New Section of Plant Study: The Evolutionary Ladder of the Plant Kingdom
Work time (Will Section)	<u>Work in Main Lesson Book</u> Write in last notes on the life cycle of the plant. Write in poem of Flower and Butterfly. Draw picture of the flower and the butterfly. Complete other drawings/decoration/borders to do with the Life Cycle of the Plant.

SECTION 4: THE ARTS

POEMS

by Catherine van Alphen

THE DANCE OF LIFE

Streaming, swirling, round and round,
The flow of the pattern
Is swept by the sound.
Gracefully whirling all around,
The space is formed,
The shape is bound.
Out of the feeling,
Soft or strong,
A form emerges in joy of the song.
Out of the energy,
Dancing with mirth,
All creation comes to birth.

THE GAME OF THE LEAVES (Photosynthesis)

1 There's a game we love to play
All together, every day;
All together everyone
Making food is so much fun!
Chorus: Photo- photo-photosynthesis,
That's the name of the game (2x)

2 Water comes from the earth below,
Mineral salts (but they don't show);
Air comes swirling all around,
Breathing in without a sound. Chorus

3 Making food needs chlorophyll
Chlorophyll green is our "magic pill".
That's the gift of the glowing sun,
We mix it all till the food is done! Chorus

MYSTERIOUS MUSHROOMS

Down in the dark wood, rotting leaf mould,
Softly decomposing,[62]transforms in ways of old
Into humble humus, the compost of the earth
Whose richness brings new life to birth.

Down in the damp soil, tiny threads appear,
Weave a tangled web, a blanket snug to wear;
Many baby mushrooms small
Are wrapped inside this woven shawl.

Moistened by the rain, the mushrooms swell and grow
Until their little hats above the ground do show.
Clustered all together near root or bark of tree,
Amazing spongy fungi are a magic family!

LICHEN
Grey-green lichen, dusty dry leaf,
Clinging to rough bark of tree;
Orange-gold lace on ancient rock
Of mountain mystery.
In heat -laden drought, the lichen shrinks,
Seeming to die away -
Sleeping, waiting many years
'Till rain returns someday.
Long-lived lichen, humble leaf,
Two plants bound together;
Feeding, working, each for the other
Through all kinds of weather.

MOSS
Emerald moss
Soft and spongy
Glistening with moisture;
Watery wonderland,
Miniature forest
Of fairy fantasy!

PINE TREES
Like soldiers they march over mountain and plain
Their coats of green needles are slanted like rain,
Their bark of rough scales like armour so strong
Their cone fists clenched to fight against wrong!

62 Breaking down into small particles

They stand to attention with heads held high,
Proudly upright against the sky,
Guarding the mountain castle together,
Bravely withstanding the harsh winter weather!

THE PALM TREE
Graceful palm tree, what do you show,
Waving your branches to and fro?
In praise of God I joyfully sway
And help mankind in every way.
Friendly palm tree, much we do
With all the gifts that come from you.

Juicy dates are good to eat,
Woven leaves make baskets neat.
Branch and fibre, trunk and seed,
Each fulfils a special need;
Your many uses help us live
And so to you our thanks we give.

THE OAK
Up stretch my branches into the sky,
Deep are my roots that hidden lie,
Mightier than all the trees am I.
Against the storm I bravely stand,
Protecting all on either hand
For I am guardian of the land.
Down on my leaves fall the sun's bright rays,
Far over many a field I gaze,
Knowing the earth and her wonderful ways

THE WATER LILY
Open, water lily slight,
Your bud unfold
With heart of gold, the sun's own light,
Your petals shining snowy-white,
Greet all whom you behold.

Gaze o'er the glistening pool,
So deep and cool
With friendly fishes flashing by
Or nibbling your green leaves that lie
Under a sunny sky.

MOVEMENT

1. Expansion and contraction exercise for cold and warmth, night and day, darkness and light, winter and summer. Use hall or large space.

   Children form a circle facing inwards. Step back until they have room to open their arms fully. All move in towards the centre of the circle, bringing arms to cross in front and bending over to make themselves feel cold, small and dark. Then all together, move out backwards, opening arms to feel warmth, space and light. Repeat exercise several times to fully experience all the above suggestions.

2. Mime growth of the plant from seed to leaves. Let the children find a space of their own in the room where they can see the teacher. Let them bend over, curling up small, but not lying on the ground. Children must imagine that they are a tiny seed. Teacher describes and demonstrates how the plant sucks up water and how the sun warms the seed in the earth. Children mime (act) how seed expands and begins to send out a tiny root. Root twists downwards. A tiny shoot emerges and grows upwards. Children mime how shoot grows in a spiral up towards the sun and puts out leaves on all sides. (3x)

3. Mime water cycle: Use following verse if desired.
   a. 'Into the roots and up through the stem,
   b. Out of the leaves and into the sky.
   c. Clouds in the sky are gathering rain,
   d. Down it falls to the earth again.' (3x)

THE DANCE OF LIFE

Melody is in waltz (3 beats to a bar) time. Group form a circle holding hands, right palm up and left palm down. They all face to the right.
A. R, L, turn full circle raising arms in 3 steps R L R, close L (2x)
B. Face centre of circle
R, L, (towards centre, swinging arms inward), R, L, (backwards, swinging arms back)
Skip side ways right: R, L, R, then sideways left: L, R, L, close R

Repeat A and B.
R = Right foot, L = Left foot, Underlined = long beat, no underline = short beat

DANCE OF PHOTOSYNTHESIS

Music: The Song of the Leaves

Groups of 4: children stand in couples, one couple facing the other. i.e. Sun and Air facing clockwise, Water and Plant facing anti-clockwise. Groups are arranged in a circle around the room. Couples hold hands. (optional)

A. Side R touch L, Side L touch R, Step forward R touch L, step backward L touch R.
Group extends Right hands on top of each other in the centre and form a wheel; they skip clockwise for 8 steps until back in original places.

B. Rights and Lefts around square for 8 beats:
Child takes R hand of opposite partner along the line of the square and skips past them in 2 steps. They turn, following line of the square to face a new partner, this time taking L hand as they pass in 2 steps. They turn again along line of square and meet their own partner with R hand, passing them in 2 steps and returning to own place. (Partner on right will be moving anti-clockwise, partner on left will be moving clockwise.)

C. Sun and Air couple hold hands and make an arch while the Water and Plant couple take hands and skip under the arch and on to meet new partners in 4 steps.

Repeat dance with new partners.

DRAWING

The drawings in this manual are intended for the use of the teacher to help them create clear blackboard drawings for the children. However, the teacher should use colour at all times to bring the drawings to life.

The use of dots around the different plants should be replaced by soft shading to enhance the beauty and the sense of life and energy present in plants. This shading is also intended to complete the picture from an artistic point of view. Teachers can demonstrate shading skills with the children if needed, and children should practice developing each picture to a high artistic standard.

Plant study is a wonderful opportunity for encouraging a sense of beauty in the children but it needs the enthusiasm of the teacher to bring about the regular discipline of taking great care and pride in one's drawings.

It is not always necessary for children to create full page drawings. Sometimes a smaller drawing is sufficient and will be easier for the children to complete in the main lesson time. Small is also beautiful!

Accuracy is also important when drawing plants. The angle of shading a leaf shows the ways it grows (shading must always follow the direction of growth). If the teacher has taught the children to only shade in one direction, now is the time to show them that shading can be done in many ways.

Also encourage the use of dark and light colours and a variety of tones in each colour. The children should also mix their colours e.g. darker and lighter greens or green, yellow

and blue together to create richer colours.

Look carefully at the drawings shown at the front of the book. They demonstrate the suggestions made here.

PAINTING

The most important thing about painting plants is the teacher's preparation! The teacher must practise the painting beforehand so that she or he can demonstrate what must be done successfully.

It is good to demonstrate how to begin the painting or how to use the brush for different effects. It is also good to leave your painting unfinished so that the children are inspired but have to use their own imagination to complete the painting.

PAINTING TECHNIQUE

By Grade 5, the children are expecting to be able to make more beautiful paintings than in earlier years. The following guidelines should have been taught to the children from Grade 3 or 4 but are essential for use in the plant study paintings of Grade 5.

The children need to learn how to paint using more detail as well as the flowing colours of earlier classes. The teacher should make sure that children are painting on GOOD QUALITY PAPER that holds the colour and the form of the paint. This does not mean buying the most expensive water-colour paper, but ensuring the best possible paper under the circumstances.

- The teacher MUST train the children to squeeze the water out of the brush after cleaning and before dipping into colour, otherwise the colours will run all over the page and the plant will be unrecognisable! If the children learn to paint more dry i.e. with less water on the page, they will have more control of the paint.

- Each child should have a clean cloth to dry off excess water on the page before starting to paint. They can also dry their brush on this cloth after squeezing out the water if they need it to be drier.

- The drier the brush, the darker the paint colour will be. It only needs to be damp, not sopping wet!

- Children need to be shown how to take only a small amount of paint rather than dipping the brush in deeply. They can then add a little water to spread the colour of make it paler. (Do not allow children to dip the brush in the paint and then in the water to make it paler as this is a waste of expensive paint!)

- When wanting to create shadows, or darker, more mixed colours, it is not necessary to wash the brush out every time

- The children need to learn how to turn the brush and use the narrow side of the brush for fine lines and strokes. They can experiment to discover different effects by making short strokes, dots, blobs, dashes, etc. These help to create texture in a painting, e.g. bark on a tree trunk.

- The children must learn to be more patient, allowing the paper to become drier before adding new colours. Some areas of the painting will have flowing and blended colours, others need more form and detail.

- The teacher needs to imagine where the painting should be dark and where it should be light. Every painting should flow between darkness and light.

- If you have a disaster, do not be afraid to repeat the painting!

COLOURS

It is easy to do every painting with just 3 primary colours: blue, yellow and red.

The obvious colours to use in painting plants when trying to create green are *Prussian blue* and *lemon yellow*. But also explore using the *golden yellow* with *blue* as this creates a darker olive green.

If possible, get hold of *Mauve* to produce a beautiful purple. The pure colour can be used for flowers (violet, iris), while stems, leaves and shadows can become richer if the mauve is combined with blue or green. Mauve mixed with red (carmine or vermillion) brings about interesting shades of purple and brown. Mauve and yellow combined also make brown.

EXAMPLES OF PAINTINGS

The Dance of Life

The first drawing in this manual is the “Dance of Life”. It may be drawn but it can also be a successful painting as it is all about swirling colour.

At first glance it seems as if the lines are whirling outwards like arms in a dance. Actually it is really about the life energy (etheric) swirling *inwards* to create the seed for new growth, for a new plant. (See if you can see the seed in the picture!) One could also imagine the energy flowing in both directions as the plant begins to develop!

Even animals and humans begin life as a minute seed shape and slowly develop the forms appropriate to their species. In the plant world however, these forms are not seen until the seed begins to germinate. In the animal and human, the forms develop inside the mother before birth and are completed during the life cycle after birth.

THE INCOMPLETE PLANTS

1. The mushroom with its strange dirty colours should be painted using *vermillion red*, *golden yellow* and *Prussian blue*. Paint the background using a blend of these three colours to make browns and purples and oranges. Leave the mushrooms white but make sure that you create them fairly big or they may be too small to decorate later when the paper is drier.

N.B. Lichen and moss are too small to paint successfully, it is easier to draw them.

2. Seaweeds are lovely to paint in *mauve* (purple), *Prussian blue* and *lemon yellow*. Create a wild, flowing sea with the long trailing leaves of the seaweeds. Mix the colours darker towards the bottom of the page and lighter towards the top of the page. Combined colours will make greens and browns of all shades.

3. Ferns need a fresh green from *lemon yellow* combined with *Prussian blue*. Add *mauve* to yellow for brown unfolding fern knobs. Keep the centre of the page a light yellow and change to light green and darker green as more ferns unfold towards the outer edge of the paper where the colours should be the darkest!

4. Pine trees are often solitary on tops of mountains and it is easier to paint one rather than a whole forest. Use *Prussian blue*, *lemon yellow* and *vermillion red*. Turn the page vertically (portrait) for a tall tree. Begin with an early morning mood of light blue sky blending softly into yellow as it meets the mountainside. Using blue, paint the mountain first, mixing red into it to create a brown/purple tone for the rocky slopes. When the paper is drier, paint the trunk and branches of the pine tree in blue, taking care to squeeze out the water before you take a small amount of paint. Do not rush! Take care that the paint does not run when painting branches and needles. Later, add yellow to make the needles green, especially on the side of the pine tree closest to the sun. Finally add a touch of red to the trunk of the pine tree.

FLOWERS AND TREES

5. The arum lily can be painted in *Prussian blue* and *lemon yellow* only. Begin with a dark blue at the bottom of the page (which is placed vertically, i.e. portrait), and create the long stems and flowing leaves. The blue is also surrounding the plant and becomes lighter as the plant grows up towards the sky. Leave the single petal of the arum lily white; one or two flowers, each with their own stem is enough on the page. Make sure the paper is not too wet by squeezing out the brush after cleaning. Add yellow to make leaves and stems green. When paper is nearly dry, add the yellow candle in the centre of the flower.

6. The tulip may be painted in a similar way, beginning at the bottom of the vertical page (portrait) with the stems and leaves. However, you need to have yellow as a background colour to the sky if the flower is yellow, orange or red. So make the blue or green pale and let it fade into the yellow without a hard line. Allow the page

to dry before painting the petals of the tulip flower. Add details, mixing colours to make green, adding other colours to stem and flower if needed.

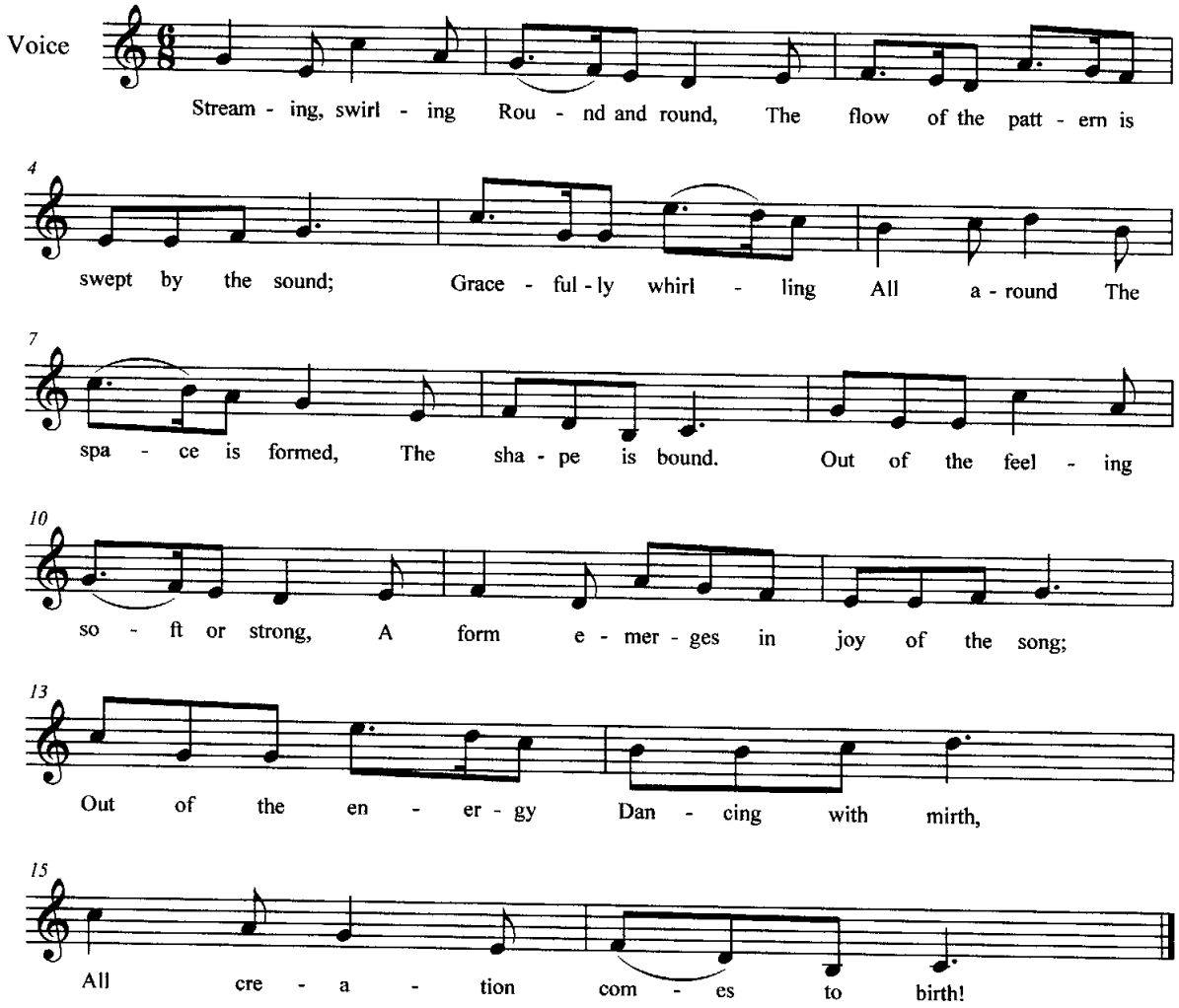
7. The rose is very difficult to paint, so I suggest that the teacher allows the children to paint their own imaginary flower in the style of a rose or dicotyledon plant. Turn the painting vertically (portrait) to give enough space for the flower. Colours needed are *Prussian blue*, *lemon yellow* and *carmine red*. Begin with dark colours at the bottom of the page, creating the broad green leaves or leaflets, surrounded by lighter green background. Let the light-green fade into a yellow or soft pink background. Allow page to become almost dry before painting the flower. Mix colours and add details.

   Children need to plan to leave enough space for the flower. If they want to have a yellow centre, they must also leave a space as the red is very strong. Show the children how to paint small petals to begin with as the paint often runs and makes the flower larger!

8. Paint imaginary or actual trees in changing seasons! How different is the acacia or euphorbia from the palm tree! Choose colours according to the moods of the trees or the seasons: fresh delicate spring/beginning of rain season colours, rich greens for summer/ height of rainy season, fiery reds and oranges for autumn/beginning of dry season, blues and purples for winter/height of dry season.

The Dance of Life

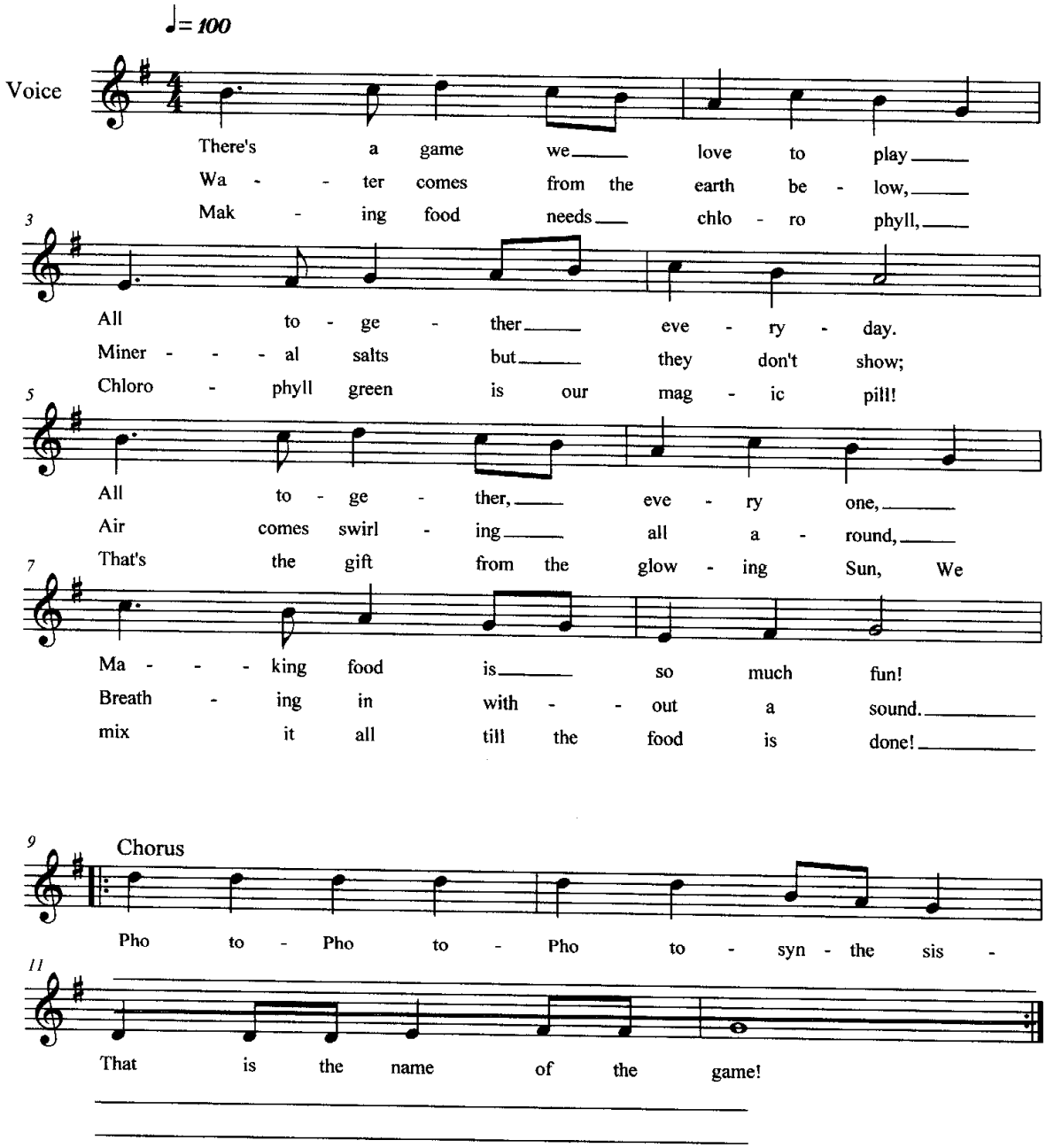
Catherine van Alphen



April 2012

The Song of the Leaves (Photosynthesis)

Catherine van Alphen



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