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Inquiry-Based Science Education Activities:

The INQUIRE Lesson Plans

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SEVENTH FRAMEWORK PROGRAMME

Contents

Why do flowers have different colours?

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Age of students: 9-14 years

Anticipated time: 3 units each of 45 min

Summary

Using prior knowledge (morphology of flowers, pollination, pollinators), students reflect and discuss in small groups possible reasons why flowers could have different colours. They test their hypothesis by means of observations and an autonomously designed experiment.

Learning outcomes

Scientific research of a question/problem/phenomenon (Hypothesis, Experiment, Results, Discussion)

- Autonomous design of an experiment to prove a hypothesis
- Enhance prior knowledge (morphology of flowers, pollination, pollinators)
- Perception of colours by insects
- Correlation of the flower colour and insects colour perception

Competences:

- Scientific knowledge: Colour of flowers , Perception of colours by insects, Flower-Ecology
- Skills:

1. Students learn / experience the scientific approach to address scientific questions/problems/phenomena
2. Students can link their observations and their learnt knowledge with the overall question “Why do flowers have different colours?”
3. Improvement to social skills
4. Working in groups
5. Sharing and articulating opinions
6. Encouraging an interest in biodiversity

Curriculum content: Primary to secondary grade (age 9-14); Biology courses.

Prior learning: Basic writing and reading skills; knowledge of terms, function and morphology of flowers, pollinators, pollination, nectar.

Overview of activities

Based on IBSE, students can develop an approach to the overall question “Why do flowers have different colours?” using the resources of the botanical garden (outside areas, glasshouses, equipment, scientist’s knowledge).

Guidelines for Teachers

Implementing the lesson

Referring to their prior knowledge (morphology of flowers, pollination, pollinators), ask the students to reflect on, and discuss in small groups, possible reasons why flowers could have different colours. They should develop a hypothesis and test it through observation and through an experiment that they should design and implement themselves. At the end of the session, the supervising educator should provide theoretical input about the perception of colours by insects.

List of activities and instructions on how to implement them

1. Using prior knowledge, students reflect and discuss in small groups possible reasons why flowers could have different colours. They discuss the question in small groups and record their agreed hypothesis on Worksheet 1
2. Each hypothesis is presented to the full class and discussed. Several methods for testing these hypotheses are presented by the supervising educator (Contacting experts, research through literature/internet, observations etc.)
3. The observation method is chosen for this activity. The students, in small groups, observe various flowers and the insects / animals that visit them in the Botanic Garden.
   The results are recorded on Worksheet 2.1.
4. The findings are discussed with the class and listed on the blackboard. Pollinators are recorded separately.
5. The educator explains how scientists work, focussing on the reproducibility of experiments. Afterwards students, in their groups, think about a way to repeat their experiment with a reproducible standard design. For this purpose the students can use different resources (e.g. nectar substitutes with different sugar-concentrations; different coloured paper etc. To make artificial flowers – see resource list).
6. In small groups, students set up their experiment and observe which insects visit their artificial flowers. They record their results on Worksheet 2.2 and compare it with Worksheet 2.1. The educator then will summarize the results of the different groups.
7. Students discuss whether the results falsify or verify their hypothesis.
8. Students are provided with theoretical input about the perception of colours by insects. A box with UV-radiation is used to illustrate the effect.

Assessment

Through presentation of each hypothesis and the plenary discussion

Resources

Student materials and worksheets:

- Blank paper, pencil or pen
- Worksheets (see below)
- Resources for the experiment: Magnifying glasses; paper of different colours -yellow, red, white, purple, blue, black; honey; sugar; Petri dishes; a balance; flour; aromatic oils; chronograph

Literature:

- Dieter Hess (1983): Die Blüte, Ulmer Verlag
- http://www.nabu-gifhorn.de/Mitgliederzeitung/MZ_2010/MZ%202010-19%20Wie%20Insekten%20sehen.htm
- http://www.scinexx.de/wissen-aktuell-11395-2010-03-19.html

Similar Experiments:

- http://www.jugend-verein.de/viewtopic.php?f=53&t=240
- http://saw.lernnetz.de/projekte/farbensehen/farbensehenbienen.htm

Worksheet 1

Why do flowers have different colours?
Observation report

Place:
Date:
Team of Scientists:
Reflect on ‘Why do flowers have different colours?’
Write down your ideas!

What experiment could you do to test your ideas?

Worksheet 2.1 – Outdoor-observations

Why do flowers have different colours?

Observation report

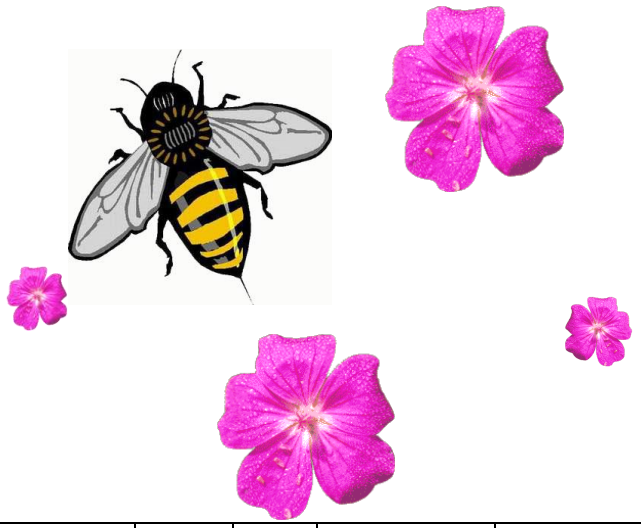
Place:
Date:
Team of Scientists:

Flower Colour	Honey Bee	Wild Bee	Beetle	Bumblebee	Ant	Fly	Butterfly	Other

Worksheet 2.2 – Observation of your own experiment

Why do flowers have different colours?

Observation report



Place:
Date:
Team of Scientists:

Flower Colour	Honey Bee	Wild Bee	Beetle	Bumblebee	Ant	Fly	Butterfly	Other

Should we have a new ski run?

Institute: MUSE - Museo delle Scienze, Trento, Italy

Developed by: Costantino Bonomi, Serena Dorigotti.

Grade level/age group: Secondary school (10-13 years old)

Duration: 3 hours

Summary

This activity simulates a 'real life' situation, where there is a clash between plant conservation and economic development. Students take on the roles of citizens of a ski resort in an alpine valley where new plans for ski slopes threaten an area rich in biodiversity. The issues to debate are: 'Will the new ski run negatively affect the biodiversity and economy of the valley? Will it be sustainable in the long run?'.

Students have to investigate the consequences of this development on the environment, collecting data on the species occurring in the different areas of the valley (specifically labelled) and browse through supporting reference material provided to find solid scientific and economic evidence to either support, stop or alter the plans for the new ski slope.

Learning outcomes

Participants will develop the ability to discuss complex problems; examining pros and cons, actively researching data and supporting evidence to back up their claims, and structuring them into a sensible argument. This activity should improve the students' ability to resolve complex problems, aiming to help them understand the complexities of decision making processes within a community and accept that one often has to make compromises. It will teach them that extinction is a problem linked to human actions, but that humans can also help conserve and protect threatened species.

Curriculum links

The activity addresses biodiversity and its conservation, offering opportunities to consider economic issues; it relates to Personal, Social, Health and Economic (PSHE) education.

Lesson outline

Preparation

It is essential that the teacher or the botanic garden educator surveys the botanical garden or the outdoor area where this activity is going to take place to identify the different zones where the activity unfolds. In particular the following zones should be clearly marked: the village, the existing ski run, the natural park (that includes a peat bog, a species rich meadow and pastureland) and the forest. In each natural habitat, the labels in Appendix 1 need to be placed according to the area they belong to (this is marked with a small capital letter on each label; with the following key: T = peat bog; B = woodland; P = ski run meadows; N = species

rich meadows and pastureland). Apart from Latin / common names, these labels also include essential information about each plant, specifying whether it is a threatened species (red with the red-list logo), a medicinal species (green, with the chemist's symbol) or a species good for milk production (blue, with a happy cow symbol); a white label with no symbol indicates a common species with no designated use.

The characters cards (in Appendix 2) need to be printed in advance and possibly assigned to each student one day in advance of the activity so that they can read them before the activity takes place and start to think about the role that is assigned to them. Particularly critical is the role of the Mayor. This role should be assigned to a student who is a natural leader within the class, who is able to encourage participation from all his/her class mates.
Any supporting / reference material (provide appropriate resources for an alpine area) also needs to be printed; 4 copies put into 4 folders, each labelled with the following interest groups in the village: Agriculture, Environment, Tourism, Services.

Introduction

Explain to the students that they will be playing a role game where each one of them will play the role of an important people in an alpine tourist resort. The resort is famous for both winter skiing and summer hikes and is close to a natural park with a rich and unspoilt countryside.

Set the scene for the story as follows:
The village in which the story is set is located at 1.200 meters altitude, in a beautiful and peaceful area. The surrounding area is of particular interest from a natural and environmental point of view as it is rich in forests, streams, lakes and alpine meadows and a lot of endangered species grow there. All these habitats and species need to be protected, which is why part of the area is designated as a Natural Park.

The main and most profitable economic activities for the population of the village are those connected to tourism. A lot of ski tourists arrive in winter; the village has a ski lift infrastructure and a famous long ski run. There are many hotels that also host tourists during the summer. Summer tourists mostly come to enjoy the countryside and green landscape of the mountain region; they also visit the Natural Park and do a lot of hiking.

Take some time to introduce the alpine village and the different habitats, explaining where the major hotels are located, the farms, the ski slope, and the forest, the natural park with the peat bog, the pastureland and species rich meadows. Re-iterate that during this game each student will take on the role of a villager; the mayor, the hotel managers, the farmers, the local traders and businessmen, the ski instructors, the builders, the forest rangers and environmental researchers, the local media and so on. The individual roles are all described in detail on the cards that are distributed (Appendix 2).

Introduce the proposal from a local construction manager to build a new ski run for the area to increase tourism and enhance the economy. The site he is suggesting for the run is, in part, within the National Park - passing through the peat bog and the species rich meadows and pastureland. Every member of the community will have his/her opinion about the benefits and problems that would arise from the project going ahead and many have particular interests to defend. Some people will find it difficult to decide whether to support the project or not, and many people start to argue about the project development.

The (IBSE) questions that the community members are now called to answer are:

‘Will the new ski run badly affect the biodiversity and economy of the valley?’ and ‘Will the new ski run, if built, be sustainable in the long term?’

Each interest group will need to think about secondary preliminary questions to answer before focusing on the final one i.e. for those in Tourism- ‘Will my guests increase?’; for Agriculture – ‘Will I sell more quality products without affecting the production cycle?’; for Environment - ‘Will species and habitats survive?’; for Services- ‘Will we be able to support the needs of the local community?’.

During this introduction phase, the teacher/botanic garden educator should make appropriate links to pre-existing knowledge (if any), particularly the information related to nature conservation, species extinction, climate change, sustainable development, economic growth and human wellbeing, PSHE education.

List of activities and instructions

1. Give each student a card that describes their role (Appendix 2), possibly one day before the activity so that they can begin to empathise with the character. Consider the ability level needed for each role e.g. the mayor, the builder of ski runs, the botanist, and assign roles accordingly (5minutes).
2. Each student writes their character name on a sticky label and wears it during the role-play at the beginning of the role play, they present their characters, explaining what jobs they do to their classmates. Students should be told not to take their own personal opinions about the issue into consideration; they must stay within ‘role’ and give only the opinions of their ‘character’. (10min.).
3. Set the scene of the play, as explained in the introduction, making sure to illustrate the location of the different zones and to put forward very clearly the questions to be investigated (5min.).
4. Ask each character to group into the relevant interest groups in the society: Agriculture, Environment, Tourism, Services. Let students choose for themselves the group they think they belong to, however make sure this is appropriate (5min.).
4. Hand over, to each of the four groups, one folder with the supporting /reference material (identical for each group) that also contains the specific question relevant for their interest group and give them time to look through the material (5min.).
5. The mayor should make an announcement that a public consultation will be held, to hear the different opinions on the new development project. The Mayor should ask each interest group to discuss their opinions in their group and collect data / research information relevant to support their opinion. Students can directly survey biodiversity collection data, using the labels placed in the different zones by a local university that organised a summer school there in previous years. They may also refer to the supporting and reference material produced by the same university in previous years and which is available in their folder (30min for research).
6. The Mayor convenes the meeting where every role player sets out their case ‘for’ or ‘against’ the ski slope, grouping into ‘Pro’ and ‘Con’. The Mayor must maintain law and order and must allow all representatives opportunities to speak. (30 min. for debate/ discussion). The role of the Mayor is critical to ensure that every community member or group has the opportunity to express their view. He/she should also summarise all the points from the discussion. At the end the Mayor should propose a quick show of hands in favour of the proposal or any optional suggestion recommended.

7. Because of the complex issues discussed, the mayor declares a citizen's referendum in which every character will have a vote. Before any vote is made, each group has to develop marketing or promotional materials (e.g. posters or leaflets) to persuade the citizens to vote for their cause. These posters / leaflets should be distributed and the citizens should have time to read them. If it has not already been suggested during the original debate, the teacher / educator should offer the option of an alternative route for the ski slope that might save biodiversity and grant economic development for the future, even though at extra cost (30 min. for poster development /distribution and second vote).
8. If no agreement is reached, a secret ballot is taken. The result of the ballot is read out by the Mayor. In the case of a split decision, the Mayor has a final vote (10 min.).

This is a guided IBSE activity, where a likely outcome is expected but should not be steered by the teacher. Good reference material is provided and plant labels are placed in the different zones beforehand, however students can decide what data or information they want to use and decide independently and how to present it in order to support their final position (pro or con) .

The structure of this activity can be analysed according to the 5 E model, where the 'Engage' stage is represented by the alpine outdoor setting and the different specific personal roles assigned to each student; the 'Explore' stage is the data collecting phase, examining plant labels in the different zones and examining the reference material provided and/or searching for further material; the 'Elaborate' stage is where the students decide their position on the ski run and then prepare the supporting material and appropriate evidence to justify it; the 'Explain' stage is represented by the posters, leaflets and speeches given during the public consultation. The 'Evaluation' stage can be carried out in the Plenary.

Plenary.

A final plenary is advisable, where the students can step out of their roles and express their own personal opinion. The teacher / educator can facilitate a structured discussion or a two-step discussion, first in small groups and then in a plenary, to find out whether the student's personal opinion differs from the opinion of the role they played. They can also discuss their personal views on the outcome of the public confrontation and what they think of democracy and majority voting in general, highlighting the link to PSHE education.

Assessment.

In this activity the teacher / educator can evaluate the poster and leaflets each group produce to support their position in the public consultation and campaign, considering the social and communication skills demonstrated by the students, the underlying critical reasoning and the soundness of reasoning and the appropriateness of the evidence provided to support their position. If the plenary is preceded by a small group discussion, the reports of the small groups to the plenary can also be used for evaluation purposes evaluating independent thinking and argumentation skills. During the public debate observation of students can also be carried out to evaluate their reasoning and articulation skills and their engagement.

Background information

During the role game, students are encouraged to speak and to justify their arguments for and against the ski run construction. They should argue from the point of view of their character, using some of the points listed. They can also add in their own valid points and reasoning, providing it is 'in character'. Characters should propose solutions, taking into account the economic and the environmental aspects, according to their interests.
Further key information on the use of role play games in education can be found in the following selected literature.

- Andersen R. (2008), The use of educational role playing games in education. Master thesis in ICT and learning: Høgskolen Stord/Haugesund.
- Blatner A, (2002), Role Playing in Education.
- McFarlane, A., Sparrowhawk A., Heald Y (2007), Report on the educational use of games.

Re the impact of climate change on alpine skiing, the economics of winter tourism, its long term sustainability, species and nature conservation, teachers / educators can refer to the supporting and reference material (please provide appropriate resources for an alpine area). If wished, extra materials can be researched by the students if you feel it would be useful for them to have further background knowledge to the skiing industry, work of National Parks or mountain tourism.

Resources and worksheets

- Labels with the information on plants occurring in the alpine valley (Appendix 1).
- Character cards giving description of character and their views (Appendix 2).
- 4 copies of the supporting material (provide appropriate resources for an alpine area); each set of resources into 4 separate folders bearing the name of the 4 interest groups. Each interest group should also have their secondary questions to answer i.e. for those in Tourism- 'Will my guests increase?'; for Agriculture – 'Will I sell more quality products without affecting the production cycle?'; for Environment - 'Will species and habitats survive?' ; for Services- 'Will we be able to support the needs of the local community?'.
- Sketch map / drawing / photo to illustrate the project
- Large sheets of paper for students to make into posters / leaflets
- Coloured pens / pencils / paints / stickers / images to illustrate posters
- Sticky label for each character

Appendix 1- Labels.

MUD SEDGE *Carex limosa*	**BROAD LEAVED BOG-COTTON** *Eriophorum latifolium*
HARE'S TAIL COTTONGRASS *Eriophorum vaginatum*	**BOGBEAN** *Menyanthes trifoliata*
NARROW LEAVED OLIVE WILLOW *Salix rosmarinifolia*	**WILLOW GENTIAN** *Gentiana asclepiadea*
SMOOTH BLACK SEDGE *Carex fusca*	**PURPLE MOOR GRASS** *Molinia caerulea*
SIBERIAN IRIS *Iris sibirica*	**GREAT SUNDEW** *Drosera longifolia* #

NORWAY SPRUCE *Picea abies*	**SIVER FIR** *Abies alba*
MYRTLE *Vaccinium myrtillus* 	**GREEN FLOWERED WINTERGREEN** *Pyrola clorantha*
TWINFLOWER *Linnea borealis*	**PERENNIAL RYEGRASS** *Lolium perenne*
TIMOTHY GRASS *Phleum pratense*	**COCK'S FOOT** *Dactylis glomerata* 
ALSIKE CLOVER *Trifolium hybridum*	**GREATER PLANTAIN** *Plantago major*
SCENTLESS MAYWEED *Matricaria inodora*	**TUFTED HAIR-GRASS** *Deschampsia caespitosa*

RIBWORT PLANTAIN *Plantago lancolata* 	**YARROW** *Achillea millefolium*  
COMMON BENT *Agrostis tenuis* 	**SWEET VERNAL GRASS** *Anthoxantum odoratum* 
ARNICA *Arnica montana*  	**BEARDED BELLFLOWER** *Campanula barbata* 
CUMIN *Carum carvi*  	**PERENNIAL CORNFLOWER** *Centaurea montana*  
GERMAN GREENWEED *Genista germanica* 	**STEMLESS GENTIAN** *Gentiana kochiana* 
YELLOW GENTIAN *Gentiana lutea* 	**ALPINE AVENS** *Geum montanum* 

COMMON ROCK-ROSE *Helianthemum nummularium*	**IMPERFORATE ST. JOHN'SWORT** *Hypericum maculatum*
OX-EYE DAISY *Leucanthemum vulgare*	**TIGER LILY** *Lilium bulbiferum*
TURK'S CAP LILY *Lilium martagon*	**ST BRUNO'S LILY** *Paradisia liliastrum*
CRESTED LOUSEWORT *Pedicularis comosa*	**PASQUE FLOWER** *Pulsatilla alpina*
GLOBE FLOWER *Trollius europaeus*	**PURPLE FLOWERED SCABIOUS** *Knautia baldensis*
PHEASANT'S EYE DAFFODIL *Narcissus poeticus*	**SWEET WILLIAM** *Dianthus barbatus*

WOODLAND TULIP *Tulipa sylvestris* 	**MOUNTAIN PASQUE FLOWER** *Pulsatilla montana*  
EYEBRIGHT *Euphrasia officinalis* 	**ALPINE CLOVER** *Trifolium alpinum* 

Appendix 2 Character cards

Character list (22 – if more than 22 students, some characters can be duplicated; if less, some of the duplicated characters can be removed):

1. Ski run builder
2. Wildlife ranger
3. Forestry officer
4. Farmer 1
5. Farmer 2
6. Farmer 3
7. Hotel manager 1
8. Hotel manager 2
9. Hotel manager 3
10. Field Study Centre Manager
11. Ski instructor 1
12. Ski instructor 2
13. Mayor
14. Environmental journalist
15. Newspaper journalist
16. Shopkeeper 1
17. Shopkeeper 2
18. Doctor
19. Vet
20. Barman
21. Science teacher
22. Botanist

1. Ski Run Builder **Character description**	After graduating in accountancy you have worked for many years in the construction industry, building ski runs. You enjoy your job and want to do something more for your local area. You believe that cooperation and consultation with local people gets better results. For this reason you were happy when some of your colleagues asked you to join the project which will develop the local skiing area. Your group proposes the building of a new ski run near to the existing one so as to be able to use existing nearby electrical structures and reduce costs. The only problem is that the new slope will be close to the National Park. You already know that there will be many difficulties, but you believe in this project because the economy needs tourism. You will try and make a really good presentation at the public meeting.	
Objectives	You want to build a new ski run. There are 2 different areas in which the new ski run could be built but you will spend less if you build the ski run inside the National Park because this area is close to the existing ski run. To build the ski run in the alternative area (which will cost more), the resort will need to attract high numbers of skiers.	
For the development.	PRO	You want to spend as little money as possible; therefore you need to build close to the pre-existing ski run even though it is in the National Park. You can make money by selling the wood from the woodland cleared to build the new ski run.
Risk	The decreasing number of tourists in winter due to Climate Change.	

2. Wildlife ranger **Character description**	Your work consists of patrolling and protecting the area inside the National Park. You do not approve of the project to build the new ski run because you think that it will damage natural habitats and the endangered species which live there. You firmly believe that protecting habitats and mountain environments is extremely important and a responsibility for everyone. You have been fascinated by nature since you were a child and you studied biology at University to understand the relationships between different organisms. You love your work because it gives you the opportunity to live in the most beautiful and precious environments of your area and you are proud to be a ranger. For all these reasons you are really worried about the effects of the new ski run on the natural environment in the Park. In your opinion there could be an alternative solution that does not cause so much damage to the most vulnerable environments.	
Objectives	To protect the endangered species that live in the National Park. To ensure that the environment is not damaged in such a way that will reduce the number of tourists visiting the National Park in the summer.	
Against the development.	PRO	Although you are against the development, if it goes ahead it will provide the opportunity to educate more tourists to respect nature.
	CON	Vulnerable habitats will be destroyed and endangered species could disappear.
Risk	The number of tourists visiting the Natural Park could decrease during summer.	

3. Forestery officer **Character description**	You have been interested in nature since you were a child. When you finished secondary school, you decided to become a forest ranger and now live in the forest, close to nature. You want to help protect nature. Your duties are to manage the growth of the forest, and to look after activities that take place in the forest such as hunting and fishing. You think that the building of a new ski run will be dangerous because many trees will be felled. You know that the roots of trees anchor the soil in place and removing them could cause landslides. You remember a disaster that happened 2 years ago as a result of tree felling and do not want this to happen again in your valley.	
Objectives	To prevent tree felling and resulting landslides.	
Against the development.	CON	To preserve nature and ensure minimal damage by humans by humans.
Risk	The decreasing number of tourists visiting the National Park.	

4. Farmer 1 **Character description**	You are the President of the Local Farmers Association. You do not approve the building of the new ski run because you have seen the proposed plans are very close to your farm which will reduce the area available for grazing. You obtained permission to graze your cows in the meadows inside the National Park and many people appreciate the high quality of your cheese and milk. You think that if farmers have to give up part of their pasture, the village council must provide an alternative area for farmers to graze their cows.	
Objectives	To guarantee sufficient pasture in which to graze your cows.	
Against the development.	CON	You believe that the pasture inside the National Park makes really good milk and cheese because it has a wide variety of plant species in it. If you are forced to move the cows the milk and cheese might not taste as good. Tourists who usually buy the milk and cheese during the summer may not visit due to the new ski run.
Risk	Summer tourists may not visit to buy your milk and cheese.	

5. Farmer 2 **Character description**	You inherited your father's farm, which you are now managing. You are member of the local farmers' consortium because you think that the association with the other local farmers helps to obtain fair prices and allows you to share knowledge and expertise with other farmers. As a consortium you are united, and will try and convince the businessman not to build the ski run inside the National Park.	
Objectives	To guarantee sufficient pasture in which to graze your cows.	
Against the development.	CON	You believe that the pasture inside the National Park makes really good milk and cheese because it has a wide variety of plant species in it. If you are forced to move the cows the milk and cheese might not taste as good.
	CON	Tourists who usually buy the milk and cheese during the summer may not visit due to the new ski run.
Risk	Summer tourists may not visit to buy your milk and cheese.	

6. Farmer 3 **Character description**	For many years you have managed your parent's farm, where you grow crop plants. Your father insisted that you attend college, where you graduated in Agricultural Sciences. You have worked hard to obtain certification as an organic farm and have been farming in this way for 4 years. You joined a consortium of farmers because you believe that working with others can help you to produce high-quality products and could make it easier to sell yours. You know that the new ski run would be situated alongside your farm. If you run an organic farm, you are not allowed to use any chemicals on your plants or in your soil. You are worried that chemicals used on the new ski run could contaminate your soil, which would ruin the many years of work you have carried out gaining certification as an organic farmer. You are also worried that the ski run could damage your plants. You know that tourism is important for the economy of your country and that a ski run will help to attract holiday makers. However, you believe that another way could be found to build the ski run without damaging the landscape and local agriculture. You will try to find out about better alternatives.	
Objectives	To guarantee that the ski run will not put at risk the organic certification of your farm or the crops grown.	
Against the development.	CON	Chemicals and soil remodelling used on the ski run could damage crops and ruin the farm's organic certification.
Risk	Losing organic certification and obtaining low prices for crops.	
7. Hotel manager 1 **Character description**	At University you studied Economy and for many years you worked for the tourist board, promoting the local area. Last year you opened a small hotel in the countryside, from which there is no access to the skiing area at present. In the past you have tried to organise special events to encourage tourists to visit the area near your hotel, but they were not successful in attracting people, who were mainly interested in skiing. Your employees are people who live in the area, who come to work during the high season (summer), but you are unable to offer them year-round employment as there are too few tourists at other times of year. You are frustrated by the economic situation of your country and wish that you were able to attract tourists throughout the year. The new ski run in the National Park would be close to your hotel. You think that the new ski run will help to encourage more tourists to visit your hotel and the area around it throughout the year.	
Objectives	Attracting tourists throughout the year so it is possible to provide full-time employment in the hotel for local people. Ensuring that the business doesn't go bankrupt.	
Choice: For the development.	PRO	The ski run will help to attract greater numbers of tourists throughout the year.
Risk	Those against the ski run (environmentalists and farmers) might say bad things about people supporting of the ski run to newspapers, which could discourage tourists from using your hotel.	

8. Hotel manager 2 **Character description**	You have owned a hotel in the countryside for many years but there are insufficient numbers of tourists to keep the hotel open all year round. Business is bad and you have been considering closing down the hotel to work in another job. If the new ski run is built you will not have to do this as there will be more visitors to the area. You will be happy to see a project that injects new life into the economy of the area so that local people are able to make enough money to survive. For these reasons you are in favour of the new ski run.	
Objectives	Attracting tourists throughout the year so it is possible to provide full-time employment in the hotel for local people. Ensuring that the business doesn't go bankrupt.	
Choice: For the development.	PRO	The ski run will help to attract greater numbers of tourists throughout the year.
Risk	Those against the ski run (environmentalists and farmers) might say bad things about people supporting of the ski run to newspapers, which could discourage tourists from using your hotel.	

9. Hotel manager 3 **Character description**	You began work as a waiter in a country hotel, but your dream was to buy and manage your own hotel. In order to achieve your dream, you have saved and borrowed money, and have bought one hotel close to the original ski run. You are very satisfied with your hotel, because buying it was hard work and your business is doing well. You have heard about the plans for the new ski run and you and your colleagues are happy because it will stimulate tourism, bringing more visitors into the area.	
Objectives	Attracting tourists throughout the year so it is possible to provide full-time employment in the hotel for local people. Ensuring that the business doesn't go bankrupt.	
Choice: For the development.	PRO	The ski run will help to attract greater numbers of tourists throughout the year.
Risk	Those against the ski run (environmentalists and farmers) might say bad things about people supporting of the ski run to newspapers, which could discourage tourists from using your hotel.	

10. Field study centre manager **Character description**	For many years you managed a farm that produced plant crops, which you have now passed on to your sons. You now manage a field study centre, situated in the National Park. You love your job because you are surrounded by nature and have the opportunity to work with passionate students and researchers who are studying the protected area and the species that live in it. You know about the project to build a new ski run in the National Park are you are worried that its construction could be dangerous for the species that live in the park, many of which are at risk of extinction. You also think the increased number of people visiting the National Park as a result of the increase in tourism could cause damage to the endangered species. Your experience as a farmer and your ties with the local area make you pessimistic about the ski run project and its impact on local endangered species. However you do understand that a ski run could be of benefit to the local economy and would be interested in finding a different site for the project.	
Objectives	You want to protect the National Park. If the ski run goes ahead, habitats will be damaged and many endangered species will die. The scientists and students will no longer visit the field study centre because the organisms they have come to study are no longer there.	
Against the development	CON	The new ski run will damage many endangered species. The students and scientists will no longer visit the field study centre and your job is under threat.
	PRO	The ski run will benefit the local economy, businesses will make more money. If the ski run were built in an alternative place it is possible that you might support the project.
Risk	You could lose your job because the scientists no longer visit. Many endangered species could die.	

11. Ski instructor 1 **Character description**	You studied sport science at University and enjoy all kinds of sport. For many years you have worked as a ski instructor in the local resort. You would like to make more money but as the resort is small, there are not enough tourists during winter to have a secure job and make enough money. Because of this, you have been considering moving to a larger resort, but your manager says that he is obtaining approval to build a new ski run which will mean you are able to make more income. You hope that the plan will be approved and the new slope will attract a lot of tourists so that you are able to make more money and live in the village where you have been born and your family live.	
Objectives	Make more money and stay living close to family and friends.	
Choice: For the development.	PRO	Increased number of tourists.
Risk	That the project is not approved.	

12. Ski instructor 2 **Character description**	Ever since you were a child you dreamed of being a ski instructor for 3 reasons: You love sport, you like working outdoors and because you can work for half the year as a ski instructor and spend the other half working at the seaside as an entertainer in the tourist villages. Unfortunately there isn't much work to do as a ski instructor during the winter because it is a small resort with few visitors. This means you are forced to do other jobs such as cleaning- which you hate. You are happy about the plans for the new ski run and you hope they are approved so that you are able to achieve your dream of becoming a ski instructor.	
Objectives	Make more money and stay living close to family and friends.	
Choice: For the development.	PRO	Increased number of tourists.
Risk	That the project is not approved.	

13. Mayor **Character description**	4 years ago you were elected mayor of the nearest town and its surrounding countryside. People voted for you because you showed that you believe in the social and economic development in the local area while caring for the environment. You have a degree in natural sciences and you love all kinds of sport. You spend most of your free time with your family, walking and climbing in the mountains or skiing. Since you were elected you have never had any great problems to resolve. However, recently you have had complaints from hotel managers, shopkeepers and ski instructors about decreases in the number of tourists to the area. A project has been proposed to build a ski run close to the pre-existing one. However the proposed area is inside the National Park. You think that the project offers an opportunity to attract tourism to the local area and will improve the economy meaning local people can make more money, but you know it will be hard to convince all people to support the plans. You know that from environmental reports and surveys the area proposed for the ski run is rich in endangered species but you also know that is you want to stimulate tourism that it is necessary to accept building projects that will attract more visitors. You must win the support of local people and of the press who will help win support for the project. You have decided to organise an open meeting during which you will hear about the needs and the problems of all the people in the area. At the beginning of the meeting you will make a 5 minute presentation, introducing the project. You will also mediate the discussion during the meeting. At the end of the meeting you will try to reach a decision, which will be a compromise between all parties taking part in the meeting.
Objectives	To promote tourism, this will help the area's economy to improve. To ensure disputes do not arise during the meeting and to find a solution to the problem taking into account environmental and economic constraints.

14. Environmental journalist **Character description**	You are a writer for a famous scientific journal. At University you studied Biology and after you graduated, attended a course in scientific journalism. You worked as a science writer on the main daily paper and specialist reviews. You are well informed about many science topics but you particularly enjoy writing about natural pollution. At the moment, you are writing a book about climate change and its influence on the environment. You are happy to write about news linked to your local area and you have contacts with a university colleague who is working as a botanic researcher on the flora of the park. You think that it would be good to use the researcher's data to publish an article explaining what could happen to the precious plant and animal species that live in the park if the ski run project goes ahead. The publicity generated could help prevent environmental disasters in the future.	
Objectives	To have exciting new stories for the journal.	
Against the development.	CON	You are campaigning to preserve the natural world
Risk	Losing your job because you publish inaccurate stories.	

15. Newspaper Journalist **Character description**	You are a journalist and have worked for the local daily paper for 20 years You are famous in the local area as an unbiased reporter because you do not take sides when you write your articles. You have heard about the plan for the new ski run, and you think that it would be good to boost the economy of the local area. You also enjoy skiing in your spare time. You have not heard the details about the project so during the open meeting you will try to gather more information. You will write an article which will explain all sides of the story. You aren't an expert in Natural Sciences, but you are determined to present the facts to the local people.	
Objectives	To have a good story for the local newspaper. To present the facts about the development in the article produced.	
Choice: Undecided, slightly favours the development.	PRO	The project will improve the economy for your own area.
Risk	Adding confusion to the problem.	

16. Shopkeeper 1 **Character description**	You have a shop in the centre of the village that sell sports equipments for skiing, but your business has been poor for the last few years. You have decided to sell your shop before it goes out of business but you would have liked to have passed it on to your sons in future. You have put off making your final decision until the outcome of the ski run project is known. You are hoping that the project is approved, because a new ski run will boost the local economy and you will be able to keep your shop open.	
Objectives	To keep your shop open.	
For the development.	PRO	You would be able to keep your business running profitably, which could be passed onto your sons once they are old enough.
Risk	The project will not be approved and your business will be difficult to sell.	

17. Shopkeeper 2 **Character description**	For 7 years you have been selling speciality products in your store that are made by local farmers, but you would like to stock many more products and you have many new ideas. You are in favour of the changes because you can see the advantages of attracting more tourists to the region. The restructuring of your store will be a good investment if the project is approved and more tourists come to buy the products that you sell. However having discussed the project with your suppliers there is a problem: the project doesn't have the support of the farmers' consortium which supplies you with specialty cheeses. You think that this project can help to resolve the economic problems of the area, but you accept that you need more information and everyone needs to express their views.	
Objectives	Expand your business and make more money.	
For the development.	PRO	There will be more tourists to whom you can sell your products.
Risk	If the farmers consortium finds out you are supporting the project, they may refuse to supply you with their products.	

18. Doctor **Character description**	You have worked as a doctor for 15 years and you know the people who live in the area very well. You care about the health of the people and you think the reason they are so healthy is that the get a lot of exercise and have a healthy lifestyle. Many people cycle to work and at the weekends, many people visit the National Park to take long walks and relax. You have heard about the plans to build a new ski slope inside the National Park and you are afraid that this will destroy environment and the scenery, making people less enthusiastic about visiting. You are against the project but you also recognise that it offers many benefits to local people.	
Objectives	To ensure the community lives healthily.	
Against the development.	CON	If the ski run is built, the National Park will be fragmented and you are worried people will no longer want to visit.
	PRO	There will be more jobs and the economy will improve in the area.
Risk	That some of your patients may fall out with you over any decision you make.	

19. Vet **Character description**	You have always been fascinated by the animals living in your local area, so at university, you studied veterinary science. You often work within the local area, and some of your clients are part of the consortium of farmers opposed to the ski run. You are concerned that the project will force farmers to graze their cattle on lower pastures and this could cause the cows to suffer, as the temperatures in the valley are much higher than in the hills. You are even more worried that the ski run project will cause farmers to go out of business as there is not enough pasture which will mean that you will have fewer clients.	
Objectives	To ensure the health of the cows and other animals living in the park	
Against the development.	CON	Farmers might be forced to change jobs as there is not enough pasture for their animals to graze, meaning you will have fewer clients. Other wild and endangered species living in the park could suffer because of the development.
Risk	If a compromise is not reached many farmers could stop farming	

20. Barman **Character description**	You like your job because you are very sociable and it gives you pleasure to speak to so many different people from day to day. There are many people who have told you their opinions about the ski run, but you find it difficult to understand the opinions of all the people you have spoken to. Some people are against the proposal because they want to protect the environment and the habitats in the National Park, while others are in favour of the project because it will improve the local economy and they stand to make money. You are in favour of the project because you will have more customers which will improve your business.	
Objectives	Attract more customers and make more money.	
Choice: Undecided, slightly favours the development.	PRO	The ski run will help tourism in the area grow so you have more customers.
Risk	Many people will be dissatisfied if the project is approved. If they find out that you support the project they may stop visiting your bar and you will lose friends.	

21. Science teacher **Character description**	You have taught science for many years at the local secondary school and you know many of the families of your students. You know that many people's jobs are linked to tourism, farming and the ski runs, and so you find it difficult to decide whether to support the project. You know that if the project is approved the economy will improve and many of the children you teach will have good jobs to go to when they have finished school.	
Objectives	To educate children about science, including the environment and nature.	
Choice: Undecided, slightly favours the development.	PRO	To offer better job opportunities for many local young people
Risk	The environment will be damaged.	

22. Botanist **Character description**	For many years you have worked at the local Science Museum, researching the flora of the local area. Part of your job includes teaching school children about the environment and ecology of the mountains. You and your colleagues have proposed a project to protect and preserve the National Park. You are fighting for the approval of your project, but there is competition from another project to build a ski system in an area of the park you are trying to protect. You are starting to become frustrated because you have seen this kind of project be approved in the past. You think that everyone is out to get as much money as they can without considering nature. The area that has been proposed for the new ski run has lots of endangered and endemic species. You do not know what will happen to these plants if the building project goes ahead. You have made a report which outlines the impact the ski run project will have on the threatened plants in the area. Your report states that the only acceptable option is for the new ski run to be built outside the National Park area where the damage to threatened species cannot occur. You also know that this option would also satisfy the needs of farmers traders and hotel managers, Obviously the cost of building the project will be higher at the second site, but to your mind this is a good compromise.	
Objectives	Protect the National Park and its endangered species.	
Against the development.	CON	If the building project goes ahead many endangered plants will die. If a different location is selected you will support it
Risk	Nobody will listen and approve your proposal and the plants will die.	

Chocolate Choice Challenge

Institute: Royal Botanic Gardens Kew
Lesson developed by Sue Hunt

Objective

To make young people reflect on how their choice has a great effect on other people, their environment and that it also can play a part in reducing the planet's energy usage.
This is done by tasting chocolate!

Student outcomes

All students tasted different types of chocolate and chose which they would buy based upon the available information.
All students reflected on what was important to them and others when buying chocolate.
Some students understood that 'Greening' or moving towards a sustainable planet is down to personal **choice** and **action** based upon the information they have or want to find out.
Some students grasped that the rich have greater choice than poor!
Some students understood the use of consumer power.

Summary

Students must think about buying a bar of chocolate. What do they base this purchase on? Is there anything that would influence their decision?

Information on each of the chocolates is given one at a time to build up their knowledge and therefore put them in a better position to make an informed decision.

1. They first choose which chocolate they would like to have through tasting a number of different chocolates.
2. Information on the cost of the chocolate is given and they are asked if this would make a difference to their choice. This is the monetary aspect of the purchase. Their budget would affect this choice.
3. The next information is given on whether the chocolate is organically produced, to see if care for the environment will make them reflect on which chocolate they would choose.
4. The last bit of information is on the effect the chocolate production has on people. Is the chocolate Fair trade i.e. is it produced in an ethical manner where the people involved are treated fairly, with consideration?
5. Finally they reflect on their choice – which chocolate would they buy based upon having all the information?

The Challenge is more effective with children over the age of 9, young people and adults, who can grasp this concept. It can be undertaken individually or as a group - either way, each student has their own chocolates to taste.

Guidelines for teachers

Teacher introduction:

“You are a college student with very little money to spend.

You really fancy a bar of chocolate. You have a range in front of you and you need to make a choice of which to buy.

You will make your decision based on taste and background information.

You will need to taste more than once so do not eat all your chocolate right away”.

List of activities

Step 1

Taste all the chocolates and decide which chocolate you would buy.

What have you chosen and why?

Step 2

In envelope 1 is the price of each chocolate.

Place the prices next to the chocolates.

Has this made a difference to your choice?

Taste again if need be.

Choose the chocolate you would buy if cost was considered as a criterion.

Write the name of the chocolate down in the ‘Profit’ section o the worksheet.

Think about what you have chosen and why. Is your choice different knowing the price and the amount of money you have?

Step 3

Open envelope 2. It contains planet facts or use of the terminology ORGANIC about the chocolate.

Which chocolate would you buy now?

Taste again if need be.

Write the name of the chocolate down in the ‘Planet’ section of the worksheet.

Think about what you have chosen and why. Is your choice different knowing the facts about organic chocolate?

Step 4

Open envelope 3. It contains people facts or use of the terminology Fair trade about the chocolate.

Which chocolate would you buy now?

Taste again if need be.

Write the name of the chocolate down in the 'People' section of the worksheet. Think about what you have chosen and why. Is your choice different knowing the facts about Fair trade chocolate?

Step 5

Discussion

Were your choices the same after finding out information about the chocolates' price, and production in relation to planet and people?

Considering all the information which would be your final choice and why?

Write this down where all circles overlap (if you are using the Venn Diagram worksheet) or in the 'Final' box (if you are using the table worksheet).

Has this further information and thought altered your decision?

How much do you care about people and the planet in your daily choices?

Did you need to compromise to make your decision? Should you need to compromise?

Did you realise your choice was so important?

This 'choice' power is there with every purchase you make.

Can you think of anything else that may affect your decision (e.g. carbon footprint)?

Plenary Statement……..

Our personal choices as well as business decisions come down to a balance of choice based on PEOPLE PLANET AND PROFIT. It is called the Triple Bottom Line, where we consider SOCIAL, ENVIRONMENTAL and ECONOMIC implications to our decisions.

You do this every time you buy something, often without thinking. You place different emphasis on the People, Planet, Profit choices, often without knowing all the information. It is your choice whether you find out the facts before each purchase or work decision in the future.

Your Choice Matters! It impacts on people and the planet. We have collective consumer power.

Health and Safety

- Ensure that there are no issues or risks because of students' allergies, dislikes or religious beliefs
- All chocolate types marked as A, B, C, D etc. should be placed on paper plates
- Handle chocolate with food serving gloves.
- Store chocolate in cool conditions.
- Store food stuffs in rodent proof containers.

Resources

1. Minimum 3 different types of chocolate
   ORGANIC,
   FAIR TRADE,
   Neither of the above but LOW COST.

Either all milk or dark chocolate so there is an easy comparison
Examples
A – Economy range supermarket chocolate e.g. Sainsbury's: 30p/Not organic /Not Fair trade
B – Cadbury: £1.79/Not organic /70% Fair trade
B – Lindt: £1.89/ Not organic / Not Fair trade
D – Green & Blacks £1.89 / Organic and Fair trade

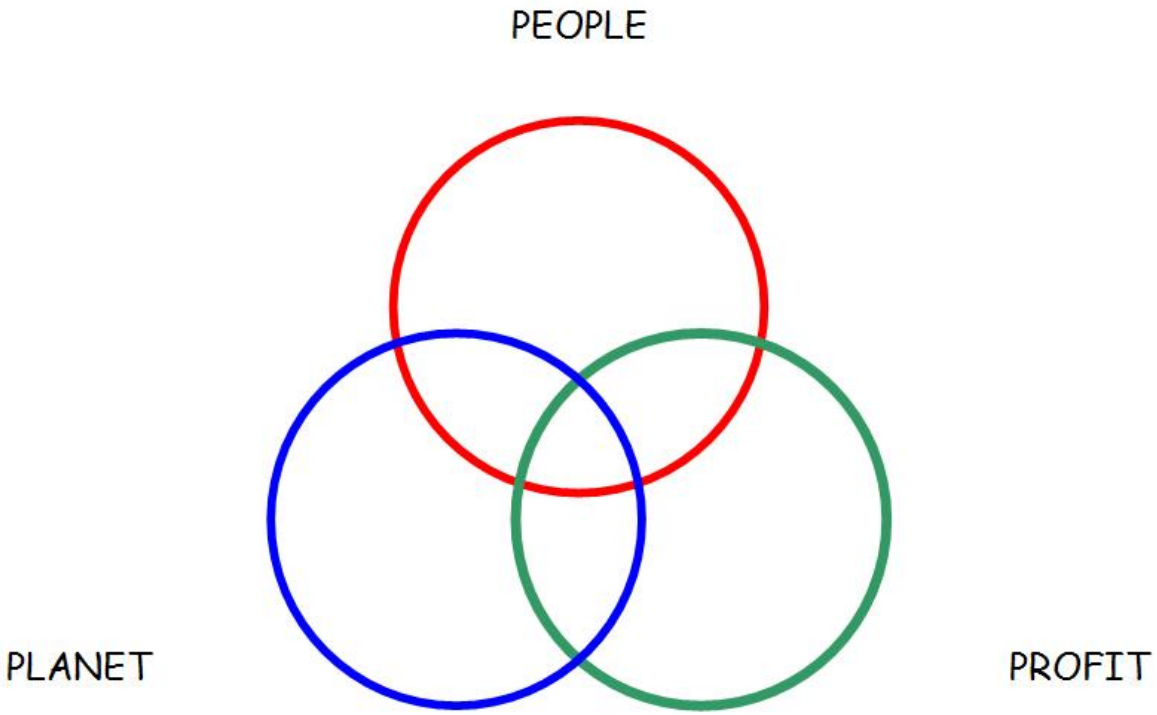
2. Paper Plate divided into A, B and C sections (depending on how many different types of chocolate you are using). Different chocolates in each section. Or paper cups labeled A, B, C etc. (depending on how many different types of chocolate you are using). Provide enough chunks of each chocolate for the students to taste.

3. 1 serviette per student divided into sections: A, B,C etc.

4. Worksheet either Venn Diagram or the table for older students.

5. Information envelopes
   Envelope 1: labels with information about the price of the chocolates
   Envelope 2: Information about organic farming and what organic means e.g. http://www.soilassociation.org/whatisorganic/organicfarming .Information about which of the chocolate samples are organic
   Envelope 3: Information about Fair trade products and what Fair trade means e.g. http://www.fairtrade.org.uk/ Information about which of the chocolate samples are Fair trade

The People-Planet-Profit Chocolate Challenge – Venn Diagram worksheet



The Triple Bottom Line of decision making – Social, Environmental and Economic

The Chocolate Choice Challenge table worksheet

You are a student with very little money to spend. You really fancy a bar of chocolate. You have a range of bars to choose from A, B, C etc.

Step 1
Taste all the chocolates and decide which chocolate you would buy based on taste.
Write down your choice in the table.

Step 2
Open envelope 1 and find out the price of each chocolate.
Does this information make a difference to your choice?
Write down your choice in the table.

Step 3
Open envelope 2. It contains Information about organic farming and what organic means.
Does this information make a difference to your choice?
Write down your choice in the table.

Step 4
Open envelope 3. It contains information about Fair trade products and what Fair trade means.
Does this information make a difference to your choice?
Write down your choice in the table.

Step 5
Considering all the information which would be your final choice and why?
If you are in a group you now have to come to a collective decision about which bar of chocolate you would buy.
You need to consider people, planet and profit.

Step 1 Choice Taste	
Step 2 Choice Profit	
Step 3 Choice Planet	
Step 4 Choice People	
Step 5 Choice Final	
Your Group's Final Choice	

So, choosing a bar of chocolate can be quite complex. Every time you buy something you have a choice.
Always think about people, planet and profit if you care about your futures.

Decomposition Challenge

Institute: Royal Botanic Gardens Kew

Developed by: Sue Hunt

Duration: 20 minutes

Age group: Key stage 3 or 4

Summary

Students engage with live or images of a fresh fruit and the same fruit but mouldy.

They are asked to estimate the age of both fruits. After a brief discussion of their age the students state the mouldy fruit is older than the fresh one. They are informed at this point that both fruits are the same age and asked how this could be. They work in pairs/threes/fours to rationalise how this situation could arise and each group in turn offers an hypothesis on how this discrepancy could be. After each explained hypothesis the students are told this is not the case and are given a little more information. They reflect once more to alter their hypothesis.

Learning outcomes

Students will use prior scientific knowledge, problem solving and communication in small and large groups to explain how two pieces of fruit of the same age can look so different/be at different stages of decomposition. They share their hypothesis with the class to move forward their learning to develop all the factors which affecting the rate of decomposition.

Students relate this knowledge to real life scenarios of shelf life and storage conditions of supermarket fresh foods.

Competencies

Knowledge: Students will undertake a problem solving activity which will tease out the factors affecting the rate of decomposition

Skills: Students will develop the following skills; problem solving, hypothesis generating, communication in small and large groups, negotiating a consensus statement,

Social Learning: Students will develop social skills as they work as a team to develop a hypothesis.

Curriculum content

This lesson supplements and supports the *How Science Works* aspect of both KS3 and KS 4 and the delivery of the factors which affect the rate of decomposition.

Lesson Outline

1. Teachers introduce the two pieces of fruit and ask the students groups to give an estimation of the age of the two pieces of fruit.
   (H&S considerations – instruct not to remove the cling film if using fresh and mouldy fruit.)
2. Ask each student group what have they estimated with no explanation. Most student groups will state the mouldy one is older. If a group says they are the same age, come back to them at the end of this round and say they are right – the strawberries/lemons are the same age.
3. The students are asked to discuss in their groups for 1 minute how this is possible and come to a consensus hypothesis.
4. After this time a group is asked to give their hypothesis on how this difference in the same age fruit is possible. They must explain why the fruits would differ with their different condition.
5. After each explanation of the hypothesis the group is told that their explanation was sound science, however both pieces of fruit had not been subjected to that approach.
6. Another group is asked until all the factors affecting the rate of decomposition have been stated except one:

   One kept in the heat, one kept in the fridge (cold), one kept moist, one kept dry, one irradiated, one vacuum packed, one bruised, one given ripening hormones, one sprayed with fungicide/pesticide.
7. After each group has given presentations, they can have the opportunity to reply to anything the other group may have said. The order must be maintained, either by the teacher or (ideally) by a nominated student.

Plenary and Assessment

Teachers provide IBSE open question.
Knowing these facts how can they be used to:

- Increase the shelf life of fruit in a supermarket.
- Define storage conditions when transporting fruit across the world.
- Design a composter.
- Design a leaflet to instruct the public about recycling plant material.

Assessment

Exam questions about decomposition.

Resources

Fresh strawberry and a mouldy strawberry OR Images of a fresh and mouldy piece of fruit e.g. lemons.

(Mouldy fruit should be kept in a container, such as a 100 ml glass beaker, with Clingfilm to prevent spore inhalation and health problems. Students should be advised not to remove the cover due to mould spore contamination. The fresh fruit should also be in the same sealed container for direct comparison.






Ecological Inquiry

Institute: Royal Botanic Gardens Kew

Developed by: Sue Hunt

Introduction

This outdoor student activity shows how, using a single question set within a scenario and with limited resources, students draw out the required knowledge necessary for developing a methodology and understanding of fieldwork sampling sufficient for examination at 16 and 18 year old level. This activity has also been successful at teaching simple field study techniques with students as young as 11 years old.

The activity is an inquiry based, outdoor format which gives the basis of how to gather data needed to assess impact on species abundance brought about by climate change or other environmental pressures. A follow-on activity takes the learning from uniform sampling techniques to non uniform sampling methods.

Curriculum background

Field sampling techniques are taught in the English biology strand of the GCSE science award at 16 years and for Advanced level assessments at 18 year old prior to University entry. There are specific knowledge outcomes and practical abilities required for the examinations. Each student must be able to describe, explain and apply specific field study knowledge using correct scientific methodology, terminology and calculations. In some instances this knowledge is used in a practical assessment.

The specific knowledge of how to undertake a field study of an area with relatively uniform distribution of a plant species is the basis of the required knowledge.

Activity overview

Besides learning through inquiry, the activity also demonstrates how the facilitator uses:

- A scenario with a real life reason to engage students.
- Practical outdoor delivery of field sampling in everyday locations.
- Low cost equipment easily sourced.
- Limited basic resources to limit the scope of the investigation to the desired learning outcome.
- Time constraint to focus the activity.
- Low teacher involvement.
- Peer learning support.
- Assessment mark scheme as the activity objective.
- ‘How science works.’
- Considerations of precise, accurate and reliable data.
- Little or no prior knowledge requirement.

Outline of Activities

Field sampling isn't only for balmy sunny days! The practical, outdoor student activity takes place in all weathers, so students must be dressed appropriately for the weather of the day. Work in students groups of 3 or 4 if possible.

Students are taken to a large square or rectangular area covered in uniform vegetation which contains an abundance of the specific plant X. The area is so large and the abundance of the species is so great that students are unable to count each one. The plant species can be chosen dependent on your own local resources and time of year, but it is not described to the students and only referred to as plant X.

Introduction

Hand out Student Question Sheet 1 and explain.

"Today we are undertaking a study of a specific plant X to understand the effect of increased visitor use of this popular picnic spot on its numbers (abundance). We need to know the number of plant Xs for baseline data analysis in this area." Describe the limits of the area under study, but do not state the size.

"Your task is to determine, as accurately as you can, the number (abundance) of plant X in this area."

"Your group will be asked to explain how you undertook this study as well as the number of plants in the specified area.

Please ask for any further information your group may need. There is only a small amount of equipment which can be used, which includes string and a metre rule.

Student's Expected Learning Progression

Most students in their groups realize quite quickly that they need to be able to identify/recognize the plant species they must count. They will ask, "What is the plant species and how do I recognize it?" When this question is asked, students are provided with the plant species name and identification sheet.

Most students in their groups will conclude the number of plants in such a large sized area is too large to count. They consider undertaking smaller areas as representative of the number. They ask for equipment equivalent to a quadrat, but there is only string, a scissors and a meter rule. They ask for some string. They are only given the string if they state how much they require. They have now devised simple sampling equipment – a basic quadrat.

Groups consider how many samples they will take and where they will sample in such a large uniform area. Most students rationalize they must undertake a random sampling method at a large number of locations to give a fair representation of the number of plants in the area.

Students undertake their species sample count.

They realize they cannot state how many plants there are as they do not know the size of the area under study. They ask for a large measure, but there is only the meter rule. Groups work out that they can pace the length and breadth of the area and measure their pace (step) to calculate the area under study.

This concludes the practical data gathering.

During this time the teacher moves around each group facilitating to ensure progress is made. Teachers can ask questions but not provide solutions if groups are struggling. E.g. How do you know what plant X looks like? Is your string sampling area a good size?

Data Analysis

Student groups calculate the area under study.
They average the number of plants per sample area.
They calculate how many plants in the area studied.

The results are collected and displayed on a board/large piece of paper.

Discussion

Compare results. Are group results similar? How similar are they? In the UK students must know the difference between reliable, precise, accurate?

The compilation of different groups' data allows students to consider the reliability of their results and how to increase reliability by pooling data and averaging, which is equivalent to repeating the investigation. Differences between terminologies can be brought out such as the distinction between reliable, accurate and precise data.

Each group describes their methodology for determining the abundance of Plant X. Bullet points are put on a sheet. A simplistic example of a field sampling mark scheme by a UK examination board is provided below, which might offer useful data that could be collated for discussion as part of the activity.

Mark awarded at AS (17 year olds) from OCR and AQA Awarding Bodies	**Mark scheme statements to award a assessment mark**
1 Mark	Uniform area studied.
1 Mark	Area of known size.
1 Mark	Identification sheet is needed to identify the species under study.
1 Mark	Sample area using quadrat.
1 Mark	Quadrat of appropriate size e.g. 0.25 m^2
1 Mark	Random sampling method used or statement of how to generate random sampling numbers.
1 Mark	Repeat for reliable results.
1 Mark	Statement of averaging data.
1 Mark	Calculation shown with appropriately correct answer.

Continuation Student Sampling Exercise for a Non Uniform Area

Scenario 2 allows students to consider and describe the methodology for a line transect. On completion they use their methodology to develop a mark scheme for assessing a non uniform area.

Resources

Location

A large area up to the size of a football field (90m x 120m) of low growing uniform vegetation, such as a lawned area, playing field or meadow. The site does not have to be a natural area but can be a managed location.

Species

The location must have an abundance of a particular common species relatively evenly distributed, such as:

- *Hyacinthoides non-scripta*
- *Taraxicum officinale*
- *Bellis perennis*
- *Plantago major*
- *Trifolium repens*

Student Question Sheet 1

Scenario 1

RBG Kew (or other botanical institution) is undertaking a study of a specific plant X to understand the effect of increased visitor use of this popular picnic spot on its numbers (abundance). We need to know the number of plant Xs in this area for baseline data analysis.

Your task is to determine, as accurately as you can, the number (abundance) of plant X in this area.

You will be asked to explain how you undertook this study and the number of plants in the specified area.

Equipment

- One scissors
- Ball of string
- Meter rule
- Pencil, paper and clipboard or weather writer for each group.
- Plant X identity sheet comprising of the plant image and botanical description. One for each group.
- One large sheet and marker to compile results
- Undercover space for introduction and plenary needed if wet.
- Calculators

Scenario 2

RBG Kew (or other botanical institution) is undertaking a study of a specific plant X to understand the effect on tree planting upon its numbers. We need to know the distribution (number over a specific area) of plant species X going from uncovered high light intensity regions to low light intensity regions under a tree canopy.

Your task is to determine, as accurately as you can, the distribution of plant species from the trunk of a densely foliaged tree to 10 meters out.

You will be expected to describe the method used to obtain your data and your results. You must use your data to substantiate your results description.

Please ask for any further information or equipment you may need.

By Land, Sea and Air.

Institute: Agencia Estatal Consejo Superior de Investigaciones Cientificas & Universidad de Alcala
Developed by: Marina Ferrer Canal, María Bellet Serrano,
Blanca Olivé de la Puente & Alicia Fernández Rodríguez

Grade level: 5th and 6th Primary Education

1st and 2nd Compulsory Secondary Education

Duration: 2 hours

Materials:
(for each group of 4 students)

- A collection of different fruits and seeds
- A washing bowl full of water
- A cuddly toy or piece of animal fur
- A fan
- Field notebook (Appendix 1)
- Concept maps (Appendices 2 and 3)

Learning outcomes

- Observation
- Critical thinking
- Teamwork
- Hypothesis development
- Experimentation
- Discussion

Key words

Fruits, seeds, dispersal

Aims:

- To reflect on the role of fruits and seeds.
- To identify the different dispersal mechanisms.
- To understand the importance of fruit and seed dispersal.

Summary:

Using inquiry-based learning, students will reflect on fruit and seed dispersal. In order to do so, they should collect samples of fruits and seeds in the Botanic Garden and classify them according to their dispersal mechanisms.

Curriculum links:

REAL DECRETO 1513/2006, de 7 de diciembre, por el que se establecen las enseñanzas mínimas de la Educación primaria. (Establishes the syllabus for primary education).

Natural, social and cultural knowledge – 5th and 6th Primary Education (ages 10 -12)

- Block 2. Diversity of living organisms.
  - Plant structure and physiology.
  - Use of plants and animals identification guides.
  - Observation and recording process associated with living beings. Oral and written communication of results.
  - Finding information about living beings and their living conditions.
  - Accuracy and precision of the animal and plant observation.pollination, nectar.

REAL DECRETO 1631/2006, de 29 de diciembre, por el que se establecen las enseñanzas mínimas correspondientes a la Educación Secundaria Obligatoria. (Establishes the syllabus for compulsory secondary education).

Natural Sciences – 1st Compulsory Secondary Education (12-13 years old)

- Block 1. Common content.
  - Basic steps of the scientific method: approach a problem, discussion, construct a hypothesis, doing an experiment, etc. to understand natural phenomena and solve problems.
  - Interpretation and use of data and information about nature.
  - Recognition of the role of scientific knowledge in technological development and in life.
  - Proper use of materials and laboratory instruments and respect for safety standards.
- Block 4. Living things and diversity.
  - Characteristics of living things. Interpretation of its vital functions.
  - Simple keys to identify living things.
  - Assessment of the importance of biodiversity. The problems arising from its loss.

Natural Sciences – 2nd Compulsory Secondary Education (13-14 years old)

- Block 1. Common content.
  - Basic steps of the scientific method: approach a problem, discussion, construct a hypothesis, doing an experiment, etc. to understand natural phenomena and solve problems.
  - Interpretation and use of scientific to form their own opinions.
  - Recognition of the importance of scientific knowledge to make decisions about objects and oneself.
  - Proper use of materials and laboratory instruments and respect for safety standards.
- Block 5. Life in action.
  - Sexual and asexual reproduction.
  - Observation and description of life cycles of animals and plants.

Prior knowledge:

- Plants with flowers (Angiosperms)
- Parts of the flower
- Concept of fruit
- Parts of the fruit
- Concept of seed

Lesson outline:

Divide the students into groups of 4. Consider the composition of the groups, mixing students with different skills. Alternatively distribute roles: 1 coordinator, 1 speaker, 1 note-taker and 1 responsible for the resources.

Establishment of the initial question

1. Every inquiry-based activity should start with an initial question or problem to be solved. In this case, we will ask them: **How do plants move?** If they don´t know the answer, guide them a little bit more by asking**: How is it possible to find the same plant in different places?**

Hypothesis formulation

2. During a brainstorming session students should express their views. Encourage everyone to participate and share their ideas with the rest of the class.
3. Encourage students to test their hypothesis: **How could you prove it?**

Experimentation

4. Provide the students with a map of the garden. In the map they can note down where they have collected the material they will need for the experiment. Students go for a walk around the Botanic Garden and collect samples of fruits and seeds found on the ground. Encourage them to take notes and/or draw those fruits that are on trees or shrubs (try to avoid damaging any plants).
5. Students are taken to a table area outdoors where they can test their hypothesis. They are asked to classify the fruits and seeds according to their dispersal mechanisms. They will be provided with:
   - A washing bowl full of water (do they float?)
   - A cuddly toy or piece of animal fur (do they stick to fur?)
   - A fan (are they carried in the wind?)
6. Students should try out various tests and note their observations in their field notebook to gather evidence.

Presentation

7. A member of each group explains the group findings to the rest of the class. Students can discuss the outcomes and decide whether they are correct.
   NB The study of the dispersal mechanisms could be done in different ways, dependent on the visiting class:

   1. Placing the fruits and seeds in Appendix 2 or 3 depending on their age and knowledge.
   2. Creating an individual or group concept map showing mechanisms.

Plenary

8. At the end of the activity, students should reflect on the importance of fruit and seed dispersal.

Assessment:

- Competency-based assessment:

  This is carried out by teacher observation and oral communication between the student and teacher, using the following criteria:
  - Evidence of good discussion and critical reasoning.
  - Participation and ability to communicate.
- Learning outcomes assessment:

  This is carried out through teacher observation, class discussion or a simple test.

A useful assessment tool is the field notebook; the results of the field notebook (Appendix 1) will help you recognise a) if the students understand the function of fruits and seeds b) if they can identify different dispersal mechanisms and c) if they recognise the importance of fruit and seed dispersal. You could also use the concept maps provided (Appendices 2 and 3) or those that the students make.

Background information

Definition of fruit: Fruits are the structures of flowering plants (Angiosperms) that develop after fertilization. Fruits contain seeds and the main aim of the fruit is to protect protection and support seed dispersal.

Definition of seed: The seed is the embryo of a new plant. Seeds are found inside the fruits and, in optimum conditions, they will germinate and produce new plants.

Fruit and seed dispersal: Fruits have a need to disperse seeds and extend the area for growth of the new plant (i.e. find space and good conditions in which to grow without too much competition from other plants). To do this, fruits have a range of dispersal mechanisms:

- Wind: seeds can be very small or have appendices such as wings, parachutes or tufts of hair so that the wind carries them.
- Animals: animals are responsible for voluntarily or involuntarily seed dispersal, either because they stick to their fur /coat or by ingestion and subsequent deposition (many fruits can be eaten without damaging the seeds).
- Water: fruits are dispersed by the rain or are swept away by water currents.
- Self-dispersal: some plants explode when they are ripe or can shake their seeds out acting like pepper-pots.

Importance of fruits:
Many fruits &seeds can be the source of useful products including: textile fibres (cotton seeds), pharmaceuticals or herbal products (poppy) and dyes (fruits of the walnut, mulberry, etc.). However, the fundamental importance of fruits is their value as food for humans and animals. There are hundreds of plants used for human consumption, but only a few plant species provide the majority of our food that we consume directly and these are mainly fruits and seeds

Resources

Bebbington A., Bebbington, J. A guide to fruit and seed dispersal. *Field Studies Council: Bringing Environmental Understanding to All.*

Leins, P., Erbar, C. “Flower and Fruit. Morphology, Ontogeny, Phylogeny, Function and Ecology”. 2010. *Schweizerbart Science Publishers.* ISBN 978-3-510-65261-7.

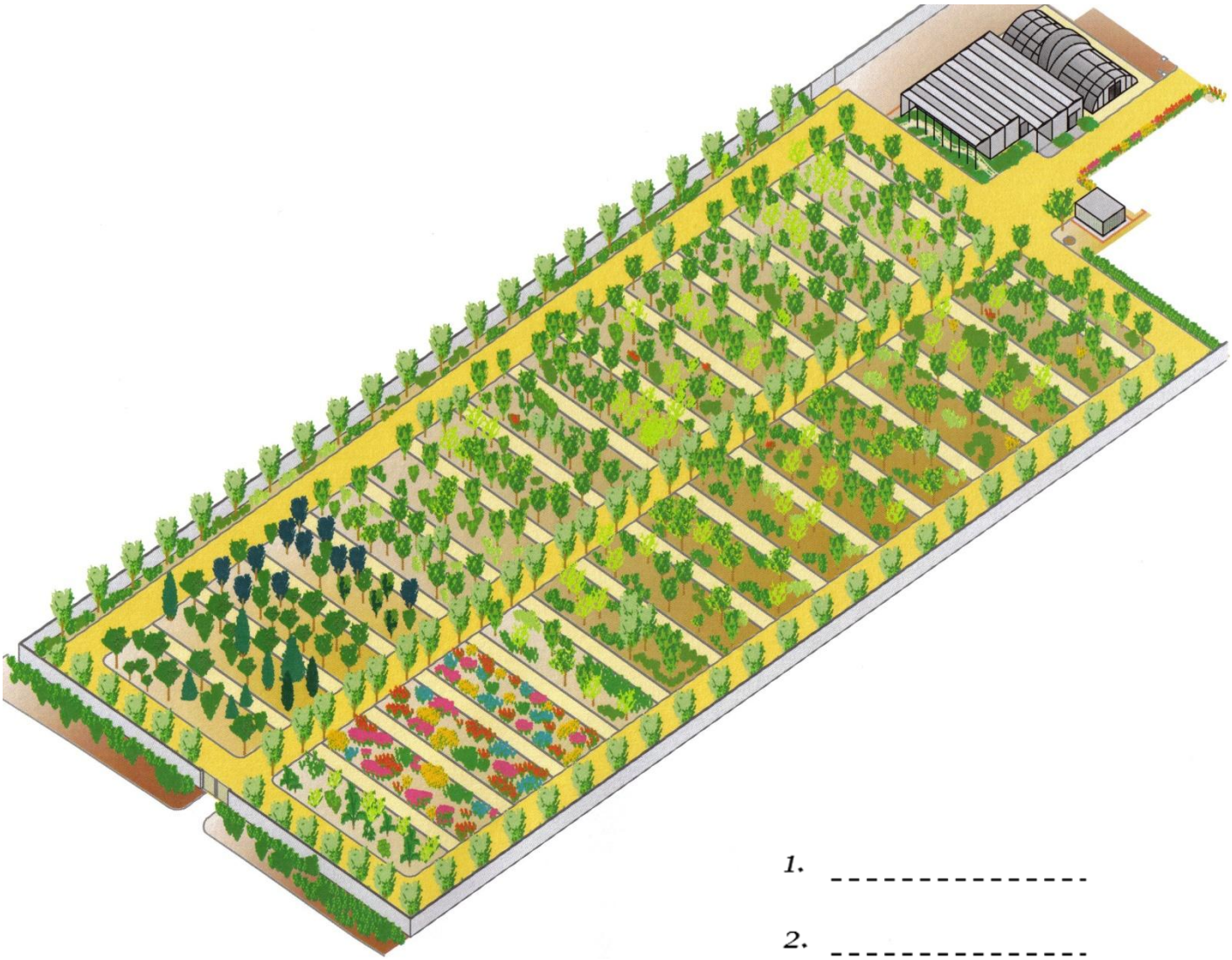
http://www.exploringnature.org/

Appendix 1. Field notebook

1. Our hypothesis is:

2. How can we test it?

3. Where did you pick the material?



1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

4. What dispersal mechanisms have you observed?

Mechanism	Example (name of the plant)	Drawing of the fruit or seed

5. Why are fruits important to plants?

6. Why are fruits important to us?

Hummingbird seeks Bromeliad

Institute University of Bremen

Lesson developed by: Doris Elster, Sonja Eilers

Class level:

Lower secondary school

Time required

Approximately 30 minutes

Material:

- Flower models of four different bromeliads:
- *Tillandsia fasciculata*
- *Aechmea fasciata*
- *Aechmea nudicaulis*
- *Hohenbergia penduliflora*

(See images on pages 6-7)

Curry powder

Hummingbird cards

Straws of different lengths

Labels to tie onto straws

Fruit juice (as nectar)

Overview:

Students will investigate in depth 'flowers and their pollinators'. They establish hypotheses, design and conduct their own experiments and analyze their findings.

Students draw conclusions, on the basis of their experimental models, about the correlation between the beak lengths of the hummingbird species, the corolla tube length of the 4 flowers and transport of pollen.

Learning Outcomes:

Students…Discover how the concept of ecological niches can be demonstrated by correlation of beak length and corolla tube length

1. Understand that the transport of pollen and the subsequent pollination of flowers is an unintended result of foraging animals
2. Understand how flower sustainability can be supported

Teacher notes

You will need to make the flower models representing the 4 bromeliad species ahead of time; alternatively you could get the students to make them. The curry powder is used as 'pollen' and is dusted over the anthers so that it can be picked up by the student 'pollinators'. The bird name tags should be tied onto the different length straws to indicate correct 'length of beak – short, medium or long.

Outline of activities

Nectar is the main food source of most hummingbirds. With the extremely long beak and specialised tongue hummingbirds are able to extract nectar from the bottom of different flowers.

Question: Why do certain hummingbird species visit particular bromeliads?

Hypothesis:

_____

Materials:

Flower models: *Tillandsia fasciculata, Aechmea fasciata, Aechmea nudicaulis, Hohenbergia penduliflora*

Curry powder

Hummingbird cards

Straws of different lengths short / medium /long

Fruit juice

Experiment:

1. Each student should select a hummingbird species card. In the following experiment you take the role of a hummingbird foraging for food. Fly to different flowers, using an appropriate straw to represent their bird species beak length, and try to obtain some nectar.
2. Note your observations.

_____

_____

_____

_____

_____

_____

_____

3. Note the differences between, and comment on, the 'representative model' you are using in the experiment and the real-life situation (see table 1).

Tab. 1: Model and reality.

Representative model	**Real-life situation**
Flower model	
Curry powder	
Straws	
Yourself as pollinator	

4. At these flowers I have been able to feed on nectar successfully:

_____

_____

5. I prefer this flower/these flowers for feeding on nectar because:

_____

_____

_____

_____

_____

Group discussion

6. Do all “hummingbirds” (students) with the same beak length prefer the same flower? Discuss your position and give reason for your choice. Note your results briefly.

_____
_____
_____
_____
_____

7. Which flower type with which corolla tube length has been preferred by which “hummingbird/s” (see table 2) to feed on nectar?

Tab. 2: Correlation between flower type, corolla tube length and hummingbird species.

Flower type	**Corolla tube length**	**Hummingbird species**
1. *Aechmea fasciata*	long	
2. *Aechmea nudicaulis*	long	
3. *Tillandsia fasciculata*	medium	
4. *Hohenbergia penduliflora*	short	

8. How can the results of the model experiment provide an explanation of the interrelationship between real bromeliad plants and real hummingbirds?

_____
_____
_____
_____
_____
_____

9. Given the results can you tell which hummingbird is most likely to feed on which bromeliad? (optional)

_____
_____
_____
_____
_____
_____

References

HESS, D.(1990). Die Blüte. Eine Einführung in Struktur und Funktion, Ökologie und Evolution der Blüten Mit Anleitungen zu einfachen Versuchen.[The Blossom. Instruction in structure, ecology and evolution of blossoms.] With guidelines of simple experiments] Stuttgart. Ulmer.


Archilochus colubris
Costa Rica) Brazil, Ecuador, Mexico


Station 2:
Lower montane rain Forests
Hummingbird seeks Bromeliad
New teaching methods concerning „Flowers and their pollinators"
Hummingbird seeks Bromeliad
Mellisuga helenae
(Bee Hummingbird)
Phaethornis longirostris
(long billed hermit)
Calypte costae
(Costas Hummingbird)

Project “Survival”

Institute: University of Sofia • St. Kliment Ohridski

Developed by: Ljuba Pencheva and Vera Djankova

Age Range: 9-14 years

Duration: 3 hours

Resources required: Role-play sheet (Appendix 1); short presentation to introduce key words; marker ropes or flags; books on botany; identification manuals ; CD on country flora; notebooks and pencils

Skills: Observation; group work; recording data; data analysis; discussion

Curriculum links: Humans and nature; Biodiversity

Cross –curricular activity: Geography**,** Writing

Overview:

This is a simulation that closely resembles an interesting real life situation. The activity encourages the students to work as a team of scientists to conduct research on plant species growing in a given area.

Learning Outcomes:

- Students can recognize and observe medicinal and food plant species in a given area.
- Students can recognize certain poisonous plant species.
- Students recall and recap on previous knowledge about biodiversity.
- Students understand how to use scientific literature to check / enhance their knowledge
- Students understand the terms ‘edible’, ‘healing’ (medicinal) and ‘poisonous’ plants and recognize the differences and similarities between these plants.
- Students are able to formulate questions.
- Students can organise and carry out research plans.

Objectives:

- That students and teachers recognise the diversity of species in the Botanic garden landscape
- To consider the role of plants both as food and for medicinal needs.

Preparation for the activity:

1. Split the students into groups of 4 and mark out one area per group for study within the botanic garden. Use flags or ropes to mark out the area for research.
2. Organize a resource library in the garden, with available books and / or electronic search engines on botany, plant identification and local flora
3. Designate one member of staff from the Botanic Garden to take on the role of a scientist who is studying in the ’library’, and of whom the children may ask questions. Explain to the students that each group may only pose up to 3 questions to the scientist.

Teaching sequence:

1. Explain to the children that they will act as if they are scientists reporting for a TV show about areas that might be useful for survival in a time of disaster. This will involve exploring various zones of the garden for suitability, recording edible, medicinal and poisonous plants. For a full explanation of the role play, please see Appendix *1*.
2. Via a short presentation or discussion review key points about plants (e.g. which are the plant parts we eat; about herbs, traditional spices etc.). Discuss poisonous plants, giving local examples.
3. Divide the children into groups of 4. Hand out a notebook and a pencil to each student, show each group the area they have to study, and repeat the rules. Remind the students what roles they are playing:
    - A researcher who looks for edible plants
    - A researcher who looks for medicinal plants
    - A researcher who looks for poisonous plants
    - A coordinator who a) collects the questions the three researchers might pose, b) checks for answers in the Library and / or asks the scientist
4. Allocate between 60 and 90 minutes for the research, monitoring the process and assisting the discussion when necessary.
5. Remind students that they can ask the scientist three questions. They need to decide within the group which questions are the most important to ask and which are the ones they can find an answer for themselves in the Library.
6. After the children have completed their research, encourage them to discuss within their groups what they have found and to briefly record their findings and observations in their notebooks.
7. Facilitate a plenary discussion for the full class; this should be held like a scientific meeting. The coordinators should report on the diversity of species they have found in their area, and to state whether they think their area could be suitable for human survival in a disaster.
8. The class should vote on which garden zone (territory) is the most suitable for the purposes of an eventual TV show. They should also select the best terrain for filming.

Teacher / Botanic Garden educator notes:

This activity is intended to make a direct connection between the plants in the environment and our everyday needs. The aim is for students to recall knowledge about biodiversity; the availability of labelled plants in the botanic garden will help, as students may know the names of several plant species but not be able to recognize them in nature.
In addition, children will have access to scientific literature to check and supplement their knowledge. It might be opportune to point out that they should have clean hands before using library books and electronic data sources – as scientists still handle research publications and resources with great respect.
Due to time constraints and shared books and data sources, encourage the children to think through what they need to research in the library, to make the most effective use of time and resources.

Notes on behavior:

When visiting locations where there are rare and endangered species, it is especially important that children's research does not impact negatively on their survival. Underline the significance of ethical behavior, and discuss how they should carry out the research without endangering the vegetation.

Supplementary activity:

Materials:

- Herb Spiral Chart (Appendix *2*)
- Planting schedule

As a follow on activity and once the students have collated their information on the plant species, ask them to prepare a list, continuing their research as appropriate, for a class project to construct a 'herb spiral' in their school grounds. Students should prepare a planting plan, selecting the species and justifying their selection.

Additional information: http://en.wikipedia.org/wiki/Permaculture

Appendix 1

Project “Survival”

Introduction:

This game provides an exciting context for the study of vegetation in a given area of the Botanic Garden. The students are additional made aware of the important role that scientists play in our lives and how they contribute to resolving a wide range of social issues.
The activity provides an opportunity for a dynamic transition from individual to group work, combined with the development of observation and literature research skills.
The focus of the research is edible, medicinal, and poisonous plants. This directly correlates with everyday life, and with people’s need for food, good health, and safety.

Instructions:

Tell the students that there is a TV film shoot planned, for a popular science show, on the opportunities for survival in different circumstances. One film section will be shot in the Botanic Garden. The concept is that there will be enough drinking water, but all the rest of the requirements needed to live e.g. food and medicines, should be sought in the wild.
Prior to the shooting of this film, it will be necessary for a team of scientists to study the available vegetation on the terrain and to write a report about it. In order for the study to be effective, scientists will need to work in groups of 4, each group being responsible for the research within a specified area.

Each team must find out:

- Are there any edible plants that people could use to feed themselves and survive on in case of a long stay? NB In their report, the scientists will need to give details about which parts of the plant/plants are edible and in which season they can be used.
- Are there any medicinal plants in their area? What could they be used for?
- Are there any poisonous plants? Which parts of the plant are dangerous?

Resources

1. ‘The Library in the Open’ is at the disposal of the scientists, where a representative of the team (a coordinator) can check out facts and make additional research to prepare his/her report.

It is important that the team are clear that the available resources in the Library are to be used by all scientists. In order to find the necessary information quickly, the team will need to prioritise their research

2. In the Library, the scientist (staff member of the Botanic garden), will co-operate to provide additional information about any species. This person will, however, be busy, and will not be able to answer more than 3 questions per group.

The team must formulate their questions effectively in order to optimize the information they can get.

Report:

Each team should record their observations and findings (1\2 -1 page) and provide additional data related to seasonality / any other information they feel may be important in terms of survival in their area. Ask the students to note the origin of the plant species. Students should reach a conclusion – grading the area – as to whether it is appropriate for human survival or not.

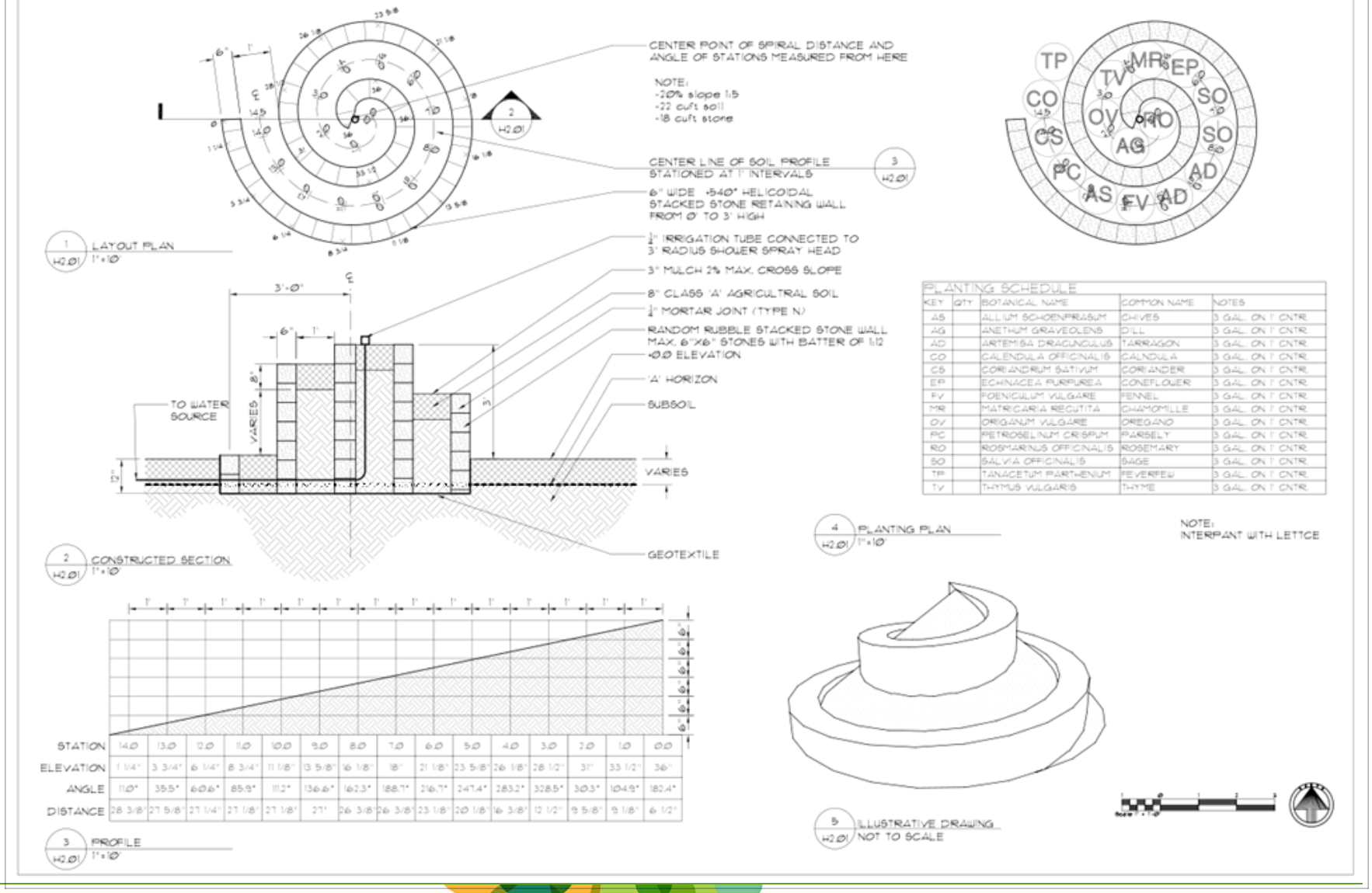
Plenary / Scientific meeting:

After preparing their reports – the coordinators of each team should present a summary on the group's research at the scientific meeting, which is attended by representatives from all teams. Students should agree on selection criteria for the most appropriate site (i.e. most edible plant species available, best balance between edible plant species and medicinal plants, lack of poisonous plants etc.).

A debate should be held as to which territory is the most appropriate to recommend for the film shoot that is going to be dedicated to 'survival'.

NB There are no plants used in this activity that fall under the environmental legislation for this country. All activities are in compliance with the ethical guidelines of the INQUIRE project.

Appendix 2


CENTER POINT OF SPIRAL DISTANCE AND ANGLE OF STATIONS MEASURED FROM HERE
NOTE:
-20% slope 1:5
-22 cuft soil
-18 cuft stone
CENTER LINE OF SOIL PROFILE STATIONED AT 1' INTERVALS
6" WIDE -540° HELICOIDAL STACKED STONE RETAINING WALL FROM Ø' TO 3' HIGH
¾" IRRIGATION TUBE CONNECTED TO 3' RADIUS SHOWER SPRAY HEAD
3" MULCH 2% MAX. CROSS SLOPE
8" CLASS 'A' AGRICULTRAL SOIL
¾" MORTAR JOINT (TYPE N)
RANDOM RUBBLE STACKED STONE WALL MAX. 6"X6" STONES WITH BATTER OF 1:12
+ØØ ELEVATION
'A' HORIZON
SUBSOIL
VARIES
GEOTEXTILE
TO WATER SOURCE
VARIES
1 H2.Ø1 LAYOUT PLAN 1" = 1Ø
2 H2.Ø1 CONSTRUCTED SECTION 1" = 1Ø
3 H2.Ø1 PROFILE 1" = 1Ø
4 H2.Ø1 PLANTING PLAN 1" = 1Ø
5 H2.Ø1 ILLUSTRATIVE DRAWING NOT TO SCALE
NOTE:
INTERPANT WITH LETTCE
TP MR EP TV CO SO OV CS AG SO PC AD AS FV AD
PLANTING SCHEDULE
KEY | QTY | BOTANICAL NAME | COMMON NAME | NOTES
AS | | ALLIUM SCHOENPRASUM | CHIVES | 3 GAL. ON 1' CNTR.
AG | | ANETHUM GRAVEOLENS | D'LL | 3 GAL. ON 1' CNTR.
AD | | ARTEMISIA DRACUNCULUS | TARRAGON | 3 GAL. ON 1' CNTR.
CO | | CALENDULA OFFICINALIS | CALNDULA | 3 GAL. ON 1' CNTR.
CS | | CORIANDRUM SATIVUM | CORIANDER | 3 GAL. ON 1' CNTR.
EP | | ECHINACEA PURPUREA | CONEFLOUER | 3 GAL. ON 1' CNTR.
FV | | FOENICULUM VULGARE | FENNEL | 3 GAL. ON 1' CNTR.
MR | | MATRICARIA RECUTITA | CHAMOMILLE | 3 GAL. ON 1' CNTR.
OV | | ORIGANUM VULGARE | OREGANO | 3 GAL. ON 1' CNTR.
PC | | PETROSELINUM CRISPUM | PARSELY | 3 GAL. ON 1' CNTR.
RO | | ROSMARINUS OFFICINALIS | ROSEMARY | 3 GAL. ON 1' CNTR.
SO | | SALVIA OFFICINALIS | SAGE | 3 GAL. ON 1' CNTR.
TP | | TANACETUM PARTHENUM | FEVERFEW | 3 GAL. ON 1' CNTR.
TV | | THYMUS VULGARIS | THYME | 3 GAL. ON 1' CNTR.
STATION 14.Ø 13.Ø 12.Ø 11.Ø 10.Ø 9.Ø 8.Ø 7.Ø 6.Ø 5.Ø 4.Ø 3.Ø 2.Ø 1.Ø Ø.Ø
ELEVATION 1 1/4" 3 3/4" 6 1/4" 8 3/4" 11 1/8" 13 5/8" 16 1/8" 18" 21 1/8" 23 5/8" 26 1/8" 28 1/2" 31" 33 1/2" 36"
ANGLE 11.Ø° 35.5° 60.6° 85.9° 111.2° 136.6° 162.3° 188.7° 216.7° 247.4° 283.2° 328.5° 30.3° 104.9° 182.4°
DISTANCE 28 3/8" 27 5/8" 27 1/4" 27 1/8" 27 1/8" 27" 26 3/8" 26 3/8" 23 1/8" 20 1/8" 16 3/8" 12 1/2" 9 5/8" 9 1/8" 6 1/2"

PLANTING SCHEDULE				
KEY	QTY	Botanical name	Common name	Notes

Can you see the difference between wind pollinated and insect pollinated flowers?

Institute: National Botanic Garden of Belgium.

Lesson developed by: Jutta Kleber

Age of Students: 10 – 14 years

Duration: 1 hour

Summary

Pollination is a very effective factor in the evolution of plants and thereby an important cause of biodiversity.
When discovering the different ways in which indigenous plants are pollinated, insect and wind pollination will be the first items to be discussed. By observing flowers (either living or in images), children can make hypotheses on whether the flowers are wind or insect pollinated. This is an ideal starting point to discover features of wind and insect pollinated plants.

Learning outcomes

- Students know that most indigenous plants are pollinated either by the wind or by insects.
- Students can recognize a particular plant part as a flower (including cases where it doesn't look like a 'classical flower' e.g. a catkin).
- Students can describe the function of flowers in reproduction.
- Students are able to carefully observe various kinds of flowers.
- Students can describe the visual differences between insect and wind pollinated flowers.

Curriculum links

Primary school, 3rd grade (10-12 year old):

1. Students can observe using all their senses and can document their observations in a systematic way.
2. Students can, under guidance, test a hypothesis by investigating an observed natural phenomenon.
3. Students can discover similarities and dissimilarities in organisms or materials and classify them by using at least one criterion.

4. Students can illustrate that organisms are adapted to their environment.

Secondary school, 1st grade (12-14 year old):

1. Students can explain the functions of the following parts of plants: root, stem, leaf, and flower.
2. Students can illustrate with examples that organisms are adapted to their environment.
3. Students are able to carry out scientific research under guidance:
    a. Formulate a hypothesis, related to question for investigation.
    b. Collect and organise data, in order to classify, determine or come to a conclusion.

Lesson outline

Introduction

This activity is ideally introduced through a walk in nature or in a park, preferably in late winter and spring (to observe flowering trees) or spring and summer (to observe flowering herbaceous plants).
Ask the children to observe flowers. If possible, they may collect flowers. If it is not possible to collect flowers, provide pictures of plants flowering in this season or let the children take photographs of them or accurately draw them .
Discuss the following questions with the whole group:

- Can you explain what pollination is?
- Do you know how plants are pollinated?
- Do all plants have flowers? Do all trees have flowers?

Next, introduce the students to two symbols: one representing wind pollination and one representing insect pollination.
This activity is guided by the teacher.

Main activity

Divide the class into smaller groups of about 4 participants.
Give each group several of the flowers that were collected or the photographs of observed flowers.
Ask each group to discuss how they think each flower was pollinated. When the group has decided, the flower (or image) is classified under one of the two symbols (insect or wind).
This is an open activity without any interaction from the teacher.
The activity can be extended by letting the students research (using books or on line resources) the names of the collected plants and the method of pollination.

Plenary

The results of this classification activity are presented by each group, giving evidence for their classification, and results are discussed in a plenary session.

- Did all children have the same results?
- What errors were made and why?
- What can the students articulate about the features of wind versus insect pollinated plants?

Assessment

To assess the knowledge, following techniques can be used:

1. Let the children make a concept map about the features of wind versus insect pollinated plants.
2. Give each group a 'new' flower and observe if they can tell how it is pollinated ; check to see whether they use appropriate arguments to defend their opinion.

Background information

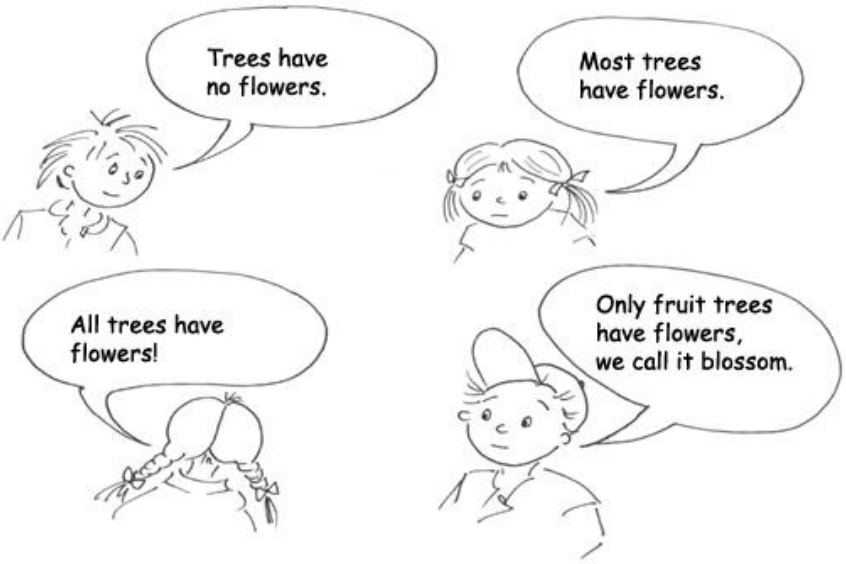
Some features of **insect pollinated flowers**:

- Flower features that attract insects:
    - Large, brightly colored petals. Attention: some flowers that don't look colorful to us do so to insects. That's because insects can see ultraviolet light.
    - Guide lines for insects to see where the nectoar is
    - A sweet scent.
- Usually a short stamen, with anthers firmly attached inside the flowers. Sticky pollen grains that cling to the insect's body. A sticky stigma, so the pollen grains remains in place.

Some features of **wind pollinated flowers**:

- Small and inconspicuous. Sometimes green or brown in color.
- They have no scent or nectaries (e.g. flowers of grass plants).
- The stamen usually has long filaments, with anthers that hang outside the flower. The stigma is large, branched and feathery. Pollen grains are produced in large amounts and are often smooth and light so that they can be carried away by the gentlest of wind currents.

Wind pollination is typical for grasses, gymnosperms that produce cones and many shrubs and trees that flower in winter and early spring.


Trees have no flowers.
Most trees have flowers.
All trees have flowers!
Only fruit trees have flowers, we call it blossom.

List of herbaceous flowers to classify

Horse Chestnut 	Common or Black Alder 
Apple 	Hazel 
Oak 	Lime 

Sweet Chestnut

Common Hornbeam

Willow

Wild Cherry

Silver Birch

Hybrid Black Poplar

Ash	Norway Spruce
	
Wych Elm	**Common Beech**
	

Pollination vector:

Wind: (11)

Common alder, hazel, oak, sweet chestnut, hornbeam, silver birch, hybrid black poplar, ash, beech, Norway spruce, wych elm,

Insect: (5)

Horse chestnut, apple, lime, willow, wild cherry,

List of tree flowers to classify

Greater Plantain 	Ragweed 
Mugwort 	Crested Dog's-tail 
Cornflower 	Rosebay Willowherb 

Rape 	White Melilot 
Bindweed 	Heather 
Helenium/ Sneezeweed 	Ox-Eye Daisy 

Timothy Grass

Purple Loosestrife

Dog Rose

Marjoram

Pollination vector:

Wind: (4)

Greater Plantain, Ragweed, Mugwort, Timothy grass

Insect: (12)

Crested Dog's-tail, Rape, Cornflower, Rosebay Willowherb*, White Melilot, Bindweed,* Heather, Helenium/ *Sneezeweed, Ox-eye daisy, P*urple Loosestrife, Dog Rose, Marjoram

Plants and Climate

Why have most Cacti no leaves and Spanish Moss no roots?

Does the shape of plants have something to do with the climate or other abiotic based characteristics?

Institute: Schulbiologisches Zentrum, Hannover (SBZH)

Developed by:: Jörg Ledderbogen, Anke Malethan, Ingo Mennerich

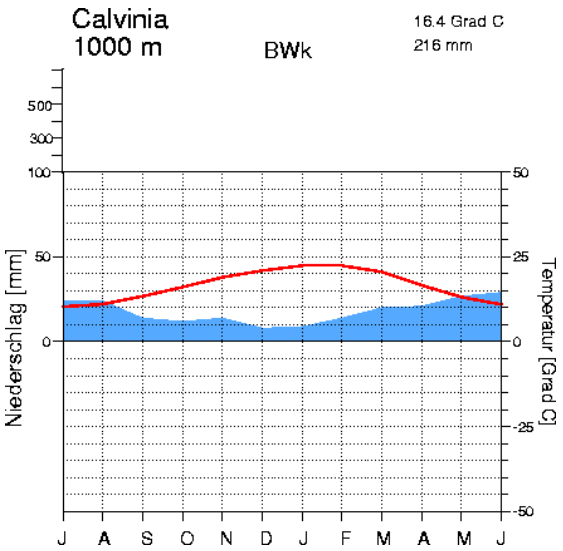
Grade level: Lower years of academic secondary Schools ('Gymnasium')

Junior secondary level, grades 7 / 8

Duration: 8 hours

Conopyhtum

Conophytum truncatum (Thunb.) N.E.Br.



31°28'S,19°46'E,1000 m

Contents

Summary:

In the grounds and greenhouses of SBZH, plants from nearly all climatic zones are cultivated. They can be used not only at the centre; SBZH also provides (mostly potted) ‘plant sets’ as learning packages on specific topics to all schools throughout the year. One such set is named ‘Plants and Climate’ and consists of 24 plants with various specific typical adaptations to their original habitat.

Pupils should develop an awareness of biodiversity while working with the different plants within the set. They build up hypotheses on the advantages for survival of each plant based on the morphological structures of the plants.

The pupils investigate the specific morphology of each plant using various scientific methods and conduct certain experiments related to investigating physiological plant processes.Subsequently they relate climate diagrams to the respective plants, justifying how the specific morphology of each corresponds to the climatic conditions to the climate diagram.

Lessons held in the botanical gardens can start with the plant image sets. Students are asked to find the species in the grounds of the botanical garden to compare the cultivated plants with the more original shape of the species as shown in the image. They can also use resources such as the climate diagrams, identification cards and the plant management plan to work outdoors.

The ‘Climate and Plants’ lesson in the context of the Secondary school curriculum

Topics:

Content-related competences

- Store food stuffs in rodent proof containers.

- Types of plant form
- Indicator plants, plant form types in relation to climatic conditions
- Plant physiology in relation to climatic conditions
- Identification exercises
- Devising care plans for various types of plant
- Allocating plants to regions on a climate diagram
- Indicator plants
- Experiments with plant physiology:
    - Morphological adaptations of plants and leaves
    - Types of stomata
    - Water transportation (capillary action) in plants
    - Transpiration
    - Succulence
    - Development of a window leaf in *Peperomia*
    - Photosynthesis

Process-related competences:

- Acquiring knowledge
    - Observing, describing and comparing different plants in the ‘learning package’
    - Applying knowledge transfer
    - Devising scientific questions and setting up hypotheses
    - Planning, carrying out and evaluating experiments
    - Working with scientific models
    - Accessing data sources
- Communication, teamwork, discussion, devising criteria
- Evaluation, critical reflection

Learning objectives – students should:

- develop an awareness of biodiversity
- understand the influence of climatic factors on plant morphology
- identify and know about various plants
- assign morphologically adapted plants to a climate diagram
- learn about plant anatomy and plant physiology
- be encouraged to take responsibility for their own research-based learning.

Teaching principles and methodology

Habitat and habit

A plant's degree of adaption is often expressed in the habit of the living organism. With experience one can, for example, see that a certain plant is 'succulent' and would assign it to a dry habitat. There are many recurring 'adaption strategies', especially in extreme conditions. In deserts the predominant plants have a reduced surface area (e.g., spherical form), spikes and thorns (defence against herbivores) and recessed stomata (limiting evaporation). Many such 'adaptations' are convergent i.e. they emerged independently in various locations and in species that are not closely related.

The 'Plants and Climate' activity set contains plants that are adapted to their local climate in morphologically diverse ways. Students should thereby develop an awareness of biodiversity and an understanding of the ways in which plants adapt to their environment (abiotic factors). Other plant learning sets produced at Schulbiologiezentrum (SBZH) Hannover e.g., the form series of *Peperomia* demonstrates the development of succulence, of surface area reduction, and of the staged development of a light window from what were originally broad-leaf moist tropical forms. *Peperomia dolabriformis* is included in the 'Plants and Climate' set. Further phylogenetic series with other adaptation developments are available.

Further pedagogical approach: climate zones and diagrams as indicators of how to care for plants (plant management)

Many of the plants in the set are common houseplants and familiar to the pupils. How do we create suitable growing conditions for these plants from far away? What about taking a look into the atlas? Can we derive care management strategies from climate diagrams? To this end, the teacher's notes in this set include climate diagrams and a worksheet for a plant care /plant management plan.

Introduction to the topic:

Following a brainstorming session about plants in different climatic zones to recap on prior knowledge, students in small groups are assigned a table /working space. The entire plant collection is spread out randomly on a table Students collect as many different plants, as they want, and take them to their own group's table. Any doubles need to be returned. Student groups then develop their own criteria for classifying the plants on their table, justifying their reasons for selection. Often, students will sort the plants according to size, colour or leaf shape. Usually, and without prompting, the sorting leads to a hierarchy according to water requirements.

In the next stage, students need to categorise the various plants according to abiotic factors (represented by labels – e.g. moist, warm, sunny, cold etc.,) so that in the subsequent stage their habitats will be easier to identify.

The following categorisation of climate zones (moist inner tropics, dry tropical, sub-tropical, temperate zones, boreal regions) is then simpler to deduce. As each zone, with the exception of the moist inner tropics, is represented twice, an indication is needed as to whether the plant is from the northern or southern hemisphere. **NB** This is not apparent from looking at the plants and it is unlikely that students will know the answer. **Tip**: You could place the plants on the climate diagram and ask students to find the locations in an atlas.

With the help of further thematic maps (physical, climate zones, annual rainfall, wind systems, inter-tropical convergence, soil distribution, natural vegetation etc.) a relatively detailed picture of conditions at the plants' locations can be established.

Student Activities

Context: Basic questions: What is the characteristic morphology of each plant? Why has the plant developed such an appearance? How can you investigate the plants?

Student tasks

Topic/Question	Time	Prior Learning	Activity: What happens and how is it achieved
Introduction Knowledge about typical plants which live in certain climate zones.	10 min.	Climate zones	Brainstorming about typical plants which live in certain climate zones.
Distinguishing as many different plants as possible	15 min.	Previous knowledge about the structure of plants	Pupils work in groups of four to six. The activity takes part in the classroom or in a botanical garden. There is a table with 5 plant sets, The first task for each group is, to find different plants and take them to their group table.
Grouping the plants according to self-developed criteria	15 min.	Structure of plants, climate zones	The pupils are asked to find criteria to group the plants and present their outcomes to the rest of the class (justifying their decisions!)
Grouping the plants according to their abiotic needs	15 min.	Structure of plants, climate zones	The pupils are asked to group the plants according to their abiotic needs using the pictograms (temperature, sun, shadow, moisture, rain).

Plant care / management plan	90 min.	Structure of plants, abiotic factors, climate zones	The pupils are asked to create a plan to care for the plants needs. Groups develop criteria for a plant care plan. Internet research for climate data of the original habitat of the plants as basis for their care plan They develop their own worksheet or use the SBZH worksheet.
Investigate plants' morphology and physiology	90 min. or long-term investigations, max. 6 months	Structure of plants	Pupils are asked to select three different plants and make hypotheses about their obvious adaptations to a certain climate. What is an advantage for surviving in a certain climate, and what has the plant developed? How can you investigate your hypotheses? (A pool of material for experiments is provided from which pupils can choose).
Relate plants to original habitat	45 min.		Pupils relate the climate diagram to the plant. They search for the area on the world map and place the plant on the map

Resources

Resource 1: The ’Plants and Climate’ – Plant Set

Criteria for the selection of particular plants for the plant set

- The set should include plants from all important climate zones
- The set should include annuals, perennials, trees
- Each plant has to show good morphological and anatomical adaptation strategies to the climate
- Many plants should be stenoecious (Restricted to a narrow range of habitats and environmental conditions) and react sensitively to climate changes
- The plants should be easy to cultivate in a nursery.
- The set should include common plants e.g. known house plants as well as unknown ones with unusual shapes

List of Species:

Botanical name	English name	Original habitat	Species in genus
Asplenium nidus	Bird's Nest Fern	East Africa, Himalayas, trop. Asia, Australia and Polynesia in tropical rainforests with only short dry seasons. below 2,000 m, on old trunks and branches or rocks in dense forests or below huge canopies	361
Buphthalmum salicifolius	Yellow Ox-Eye Daisy	France, northern Italy to Balkans, eastern central and central Europe, on calceous, stony or peaty soils with low nutrition content, semi-dry grassland, dry forests and fens, in the Alps up to 2000 m	2
Calendula officinalis	Pot Marigold	Probably Mediterranean, naturalized in Spain, Italy, Great Britain	11
Conophythum truncatum	Conophytum, Living Pebble	Cape through Namaqualand to western South Africa, on rocky and permeable subsoils, mostly in winter rain areas (<300 mm)	95
Dryas octopetala	Mountain Avens	Boreal circumpolar, in more southerly latitudes in corresponding altitudes in the mountains	6
Echeveria setosa	Hen and chicken, Mexican Firecracker, Bristly Echeveria,	Southern Mexico (Oaxaca, Puebla, San Luis Atolotitlán, Cerro de la Yerba)	167
Echinopsis thelegona		Argentina (Jujuy, Salta, Tucumán), dry slopes, 500-1000 m	130

Euphorbia milii	Crown of Thorn, Christ´s Thorn	Central, eastern and southern Madagascar, in bush and forest habitats, on rocks (mostly granite)	2031
Ficus benjamina.	Weeping Fig, Benjamin´s Fig	Himalayas, India, Myanmar, S. China, Malaysian Archipelago, N. Australia; grows as a semi-epiphyte in rain and monsoon forests	830
Grimmia pulvinata	Grey Cushioned Grimmia	Worldwide distribution on sunny dry stones and concrete, never soil, in altitudes from 0 – 1,000 m	86
Kleinia ficoides .		Northern Cape: Namaqualand (Alexander Bay)	54
Lavandula officinalis	Lavander, Common Lavender	NW. Mediterranean area, Spain to the Balkans, in rocky habitats and garrigues	45
Lecanora sp.	Crustose Rock Lichen	Worldwide on silicate and limestone, on exposed aggregate concrete, bricks, asphalt; only seldom on wood	ca. 300
Mammillaria microhelia		Mexico, federal state of Queretaro (northeast of Mexico City), Cerro Zamorano, St. Maria del Mexicano, Colón to San Pablo Tolimán; rocky slopes, 1,200-2,600 m	176

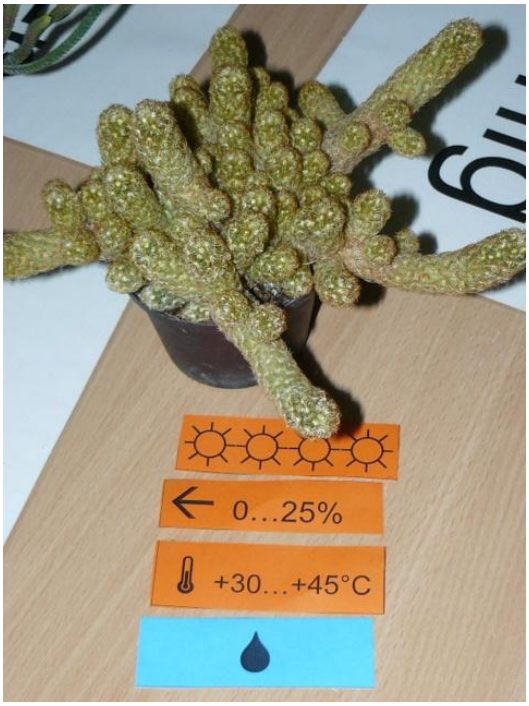
Maranta leuconeura	Prayer Plant	Western, central and southeast Brazil; in warm humid forests	41
Marchantia aquatica	Well Liverwort	Worldwide in cool wet places	6
Nerium oleander	Oleander	Mediterranean, S. Portugal, naturalised in the Crimea and the Caucasus; in summer-dry rivers and in the mountains	1
Peperomia dolabriformis	Prayer Peperomia	Northern Peru (Caja-marca), in sandy places at Rio Huancabamba from 600-1,200 m as small shrubs	845
Spathiphyllum floribundum	Peace Lily	Columbia to northwest Venezuela, northern Peru, wet warm forests	50
Streptocarpus saxorum	False African Violet, Cape Primrose	Tanzania and Kenya, on rocks and cliffs	18
Tillandsia usneoides	Spanish Moss	From Virginia to Chile, West Indies, from 0 – 3,300 m; on trees, power poles, rocks, cacti, in dry habitats with temporarily high atmospheric humidity	671
Tradescantia sillamontana	Hairy Spiderwort, Cobweb Spiderwort, White Velvet Spiderwort,	Northeast Mexico, Federal State of Nuevo Leon on the Texan Border	75
Viola cornuta	Horned Pansy, Horned Violet	Pyrenees, Cantabrian Cordillera	265
Vrisea psittacina		Brasil (Bahia, Espirito Santo, Rio de Janeiro), Paraguay; epiphytic in humid forests	340

Resource 2: Labels for abiotic factors

- Hot
- Warm
- Sunny
- Humid
- Dry
- Wet
- Cold
- Shaded

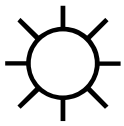
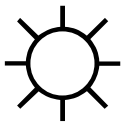
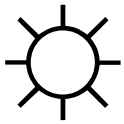
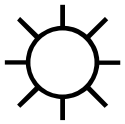
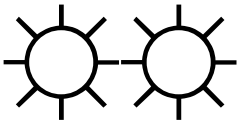
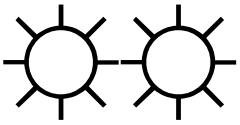
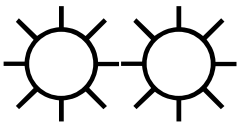
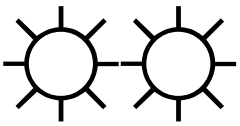
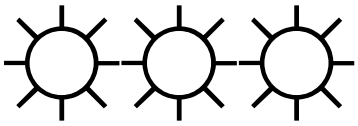
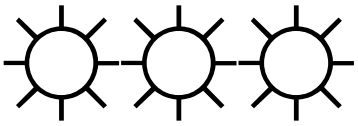
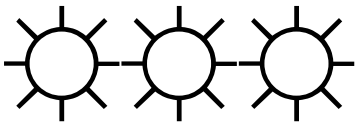
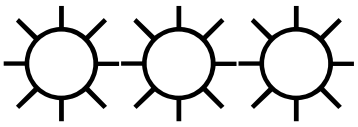
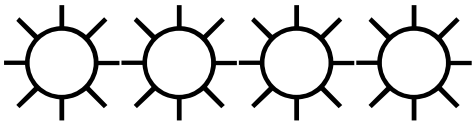
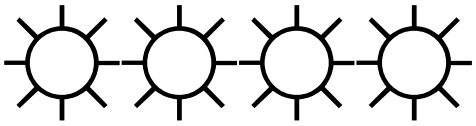
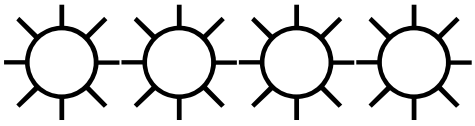
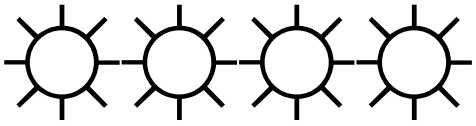
N.B: Plants are sorted according to their climatic requirements

Resource 3: Symbols of abiotic factors



Plants related with pictograms and symbols to their abiotic needs

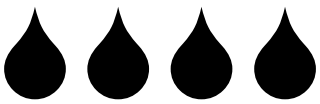
Symbols for Light

Symbols for Temperature

-15…0°C	-15…0°C
-15…0°C	-15…0°C
0…+15°C	0…+15°C
0…+15°C	0…+15°C
+15…+30°C	+15…+30°C
+15…+30°C	+15…+30°C
+30…+45°C	+30…+45°C
+30…+45°C	+30…+45°C

Symbols for Water

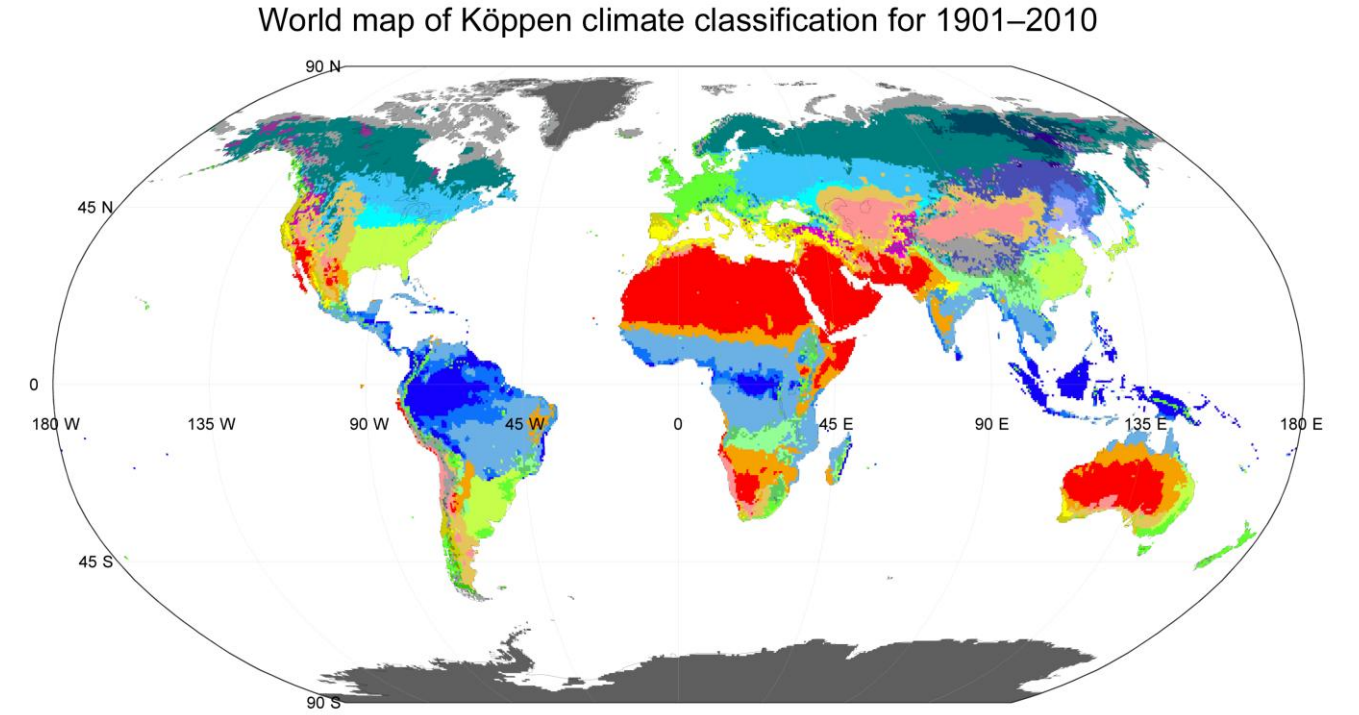
Symbols for Humidity

← 0…25%	← 0…25%
← 0…25%	← 0…25%
↖ 25…50%	↖ 25…50%
↖ 25…50%	↖ 25…50%
↗ 50…75%	↗ 50…75%
↗ 50…75%	↗ 50…75%
→ 75…100%	→ 75…100%
→ 75…100%	→ 75…100%

Symbols for Nutrition

Resource 4: World Map of Climate



First letter	Second letter		Third letter
A: Tropical	f: Fully humid	T: Tundra	h: Hot arid
B: Dry	m: Monsoon	F: Frost	k: Cold arid
C: Mild temperate	s: Dry summer		a: Hot summer
D: Snow	w: Dry winter		b: Warm summer
E: Polar	W: Desert		c: Cool summer
	S: Steppe		d: Cold summer

Data source: Terrestrial Air Temperature/Precipitation: 1900-2010 Gridded Monthly Time Series (V 3.01)

Resolution: 0.5 degree latitude/longitude

Website: http://hanschen.org/koppen

Ref: Chen, D. and H. W. Chen, 2013: Using the Köppen classification to quantify climate variation and change: An example for 1901–2010. Environmental Development, 6, 69-79, 10.1016/j.envdev.2013.03.007.

Resource 5: Pants- from ‘habit’ to a ‘care plan’

Portrait: **Habit:**

English name:
_____

Botanical name:_____

Origin: _____

Drawing:

The plant grows…
□ …on the ground in deserts
□ …on the ground in forests
□ …on top of other plants (epiphytic)
□ …as a bush or tree

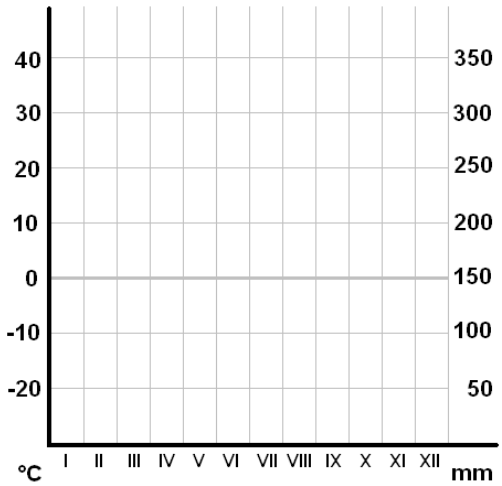
Climate in the original area of the plant: Region: _____Country:_____Continent:_____

Geographically coordinates (longitude/latitude): __° __ , __° ___Climate zone/-type_____

Climate table

	P. mm	T °C
January		
February		
March		
April		
May		
June		
July		
August		
September		
October		
November		
December		

Climate diagram



Needs of the plants / abiotic factors

Try to apply the climate and soil conditions of the original habitat to a care plan for indoor plants

Original habitat	**Requirements as a potted plant:** □ indoor, □ outdoor
Light: Summer: _____ Winter: _____	Light: Summer: _____ Winter: _____
Temperature Summer: _____ Winter: _____	Temperature Summer: _____ Winter: _____
Precipitation/ humidity Summer: _____/ _____ Winter: _____ / _____	Irrigation/ humidity Summer: _____ / _____ Winter: _____ / _____
Soil: _____	Potting ground: _____ Soil humidity: _____
Nutrition content	Nutrition content/fertilization :

Care instructions

Light (Summer)	☼less			☼☼			☼☼☼			plenty ☼☼☼☼		
Light (Winter)	☼less			☼☼			☼☼☼			plenty ☼☼☼☼		
Temperature (Summer) °C	-10	-5	0	5	10	15	20	25	30	35	40	45
Temperature (Winter) °C	-10	-5	0	5	10	15	20	25	30	35	40	45
Irrigation (Summer)	♦ low			♦♦			♦♦♦			high ♦♦♦♦		
Irrigation (Winter)	♦ low			♦♦			♦♦♦			high ♦♦♦♦		
Humidity (Summer)	← low			↖			↗			high →		
Humidity (Winter)	← low			↖			↗			high →		
Fertilization (Summer)	☺ very little			☺☺			☺☺☺			A lot ☺☺☺☺		
Fertilization (Winter)	☺ very little			☺☺			☺☺☺			A lot ☺☺☺☺		

Example of care instructions:

Flora examplissimo communis	S	☼☼☼☼	15	♦♦♦	↗	☺
	W	☼☼☼	0	♦♦	↗	☺

Resource 6: Plants and abiotic factors

	Light	Water	Humidity	pH	Others
Asplenium nidus Bird's Nest Fern					
Buphthalmum salicifolium Yellow Ox-Eye Daisy					
Calendula officinalis Pot Marigold (plant or seed)					
Conophytum truncatum Conophytum, Living Pebble					
Dryas octopetala Mountain Avens					
Echeveria setosa Mexican Firecracker, Hen and Chicken, Bristly Echeveria					
Echinopsis thelegona					
Euphorbia millii Crown of Thorn, Christ's Thorn					
Ficus benjamina Weeping Fig, Benjamin´s Fig					

	Light	Water	Humidity	pH	Others
Grimmia pulvinata Grey Cushioned Grimmia					
Kleinia ficoides					
Lavandula angustifolius Lavander, Common Lavender					
Lecanora sp. Crustose Rock Lichen					
Mammillaria microhelia					
Maranta leuconeura Prayer Plant					
Marchantia sp. Well Liverwort					
Nerium oleander Oleander					
Peperomia dolabriformis Prayer Peperomia					

	Light	Water	Humidity	pH	Others
Spathiphyllum floribundum Peace Lily					
Streptocarpus saxorum False African Violet, Cape Primrose					
Tillandsia usneoides Spanish Moss					
Tradescantia sillamontana Hairy Spiderwort, White Velvet Spiderwort, Cobweb Spiderwort					
Viola cornuta Horned Pansy, Horned Violet					
Vrisea psittacina					

Resource 7: Identification Cards without plant pictures

• Leaves form a funnel • Basal leaves narrow, broad in the middle • Leaf ribs are dark brown • Leaf underside partly covered with powdery stripes (Sporangia) ***Bird´s Nest Fern*** *(Asplenium nidus)*	• Shoots withered (or cut down)in winter • Old plant remains at base • Soft leafy rosette • Fresh leaves are hairy ***Yellow Ox-Eye Daisy*** *(Buphtalmum salicifolium)*
• *Only exists as seed in winter* ***Pot* Marigold** (Calendula officinalis)	• Plant small • Plant is grey-green with translucent areas at top • Usually only two leaves per shoot visible • Leaves are very thick and fleshy ***Conophytum, Living Pebble*** *(Conophytum truncatum)*
• Plant small • Plant is grey-green with translucent areas at top • Usually only two leaves per shoot visible • Leaves are very thick and fleshy ***Mountain Avens*** *(Dryas octopetala)*	• Plant small • Plant is grey-green with translucent areas at top • Usually only two leaves per shoot visible • Leaves are very thick and fleshy ***Mexican Firecracker, Hen and Chicken,*** *(Echeveria setosa)*

- Young plants grow upright - Shoots (stems) have ribs - Plants have modified leaves (spines) which grow out from a white circular basal section (areole) *(Echinopsis thelegona)*	- Shoot upright and branched - Shoot light grey - Shoot with thorns - Green, spathulate leaves ***Crown of Thorn, Christ´s Thorn*** *(Euphorbia milii)*
- Plant upright, branched, (in maturity a tree) - Young shoots with grey brown bark; later light grey - Leaves with slightly waxy surface Leaves with pointed tips ***Weeping Fig, Benjamin' s Fig*** *(Ficus benjamina)*	- Plant is small and grows cushion shaped - Cushion appears greyish green - Many unbranched shoots - Leaflets small, lying close to the stem - Plant bears green capsules (visible with a magnifying glass) ***Grey Cushioned Grimmia*** *(Grimmia pulvinata)*
- Young plants growing straight up - Leaves fleshy; round in section - Leaves bluish and waxy with a whitish powdery coating *(Kleinia ficoides)*	- Plant an upright semi-shrub - Leaves small and narrow, covered with light grey hairs - Plant has a strong fragrance ***Lavender, Common Lavender*** *(Lavandula angustifolia)*

• Flat crust-like growth • At the edge of the growth area, often lobe-shaped and divided • Lichen carries shield-shaped elevations (Apothecia) (visible with a magnifying glass ***Crustose Rock Lichen*** *(Lecanora sp.)*	• Thick green shoots • Branching only from the base • Covered with bright, star-shaped spines raised up from the surface *(Mammillaria microhelia)*
• Shoots growing flat • Leaves thin; patterned on the top side • Leaf underside partly reddish coloured • Young leaves partly curled ***Prayer Plant*** *(Maranta leuconeura)*	• Plant grows with flat branching structures close to the ground • Plant dark green; very delicate • Plant with little 'umbrella' or 'cup- like' structures on the upper surface ***Well Liverwort*** *(Marchantia aquatica)*
• Shoots upright, becoming woody • Three leaves at each node • Leaves narrowly ovate, with a tip • Leaves evergreen, leathery ***Oleander*** *(Nerium oleander)*	• Young shoot green, later becoming woody • Leaves are hatchet-shaped and fleshy • Leaves waxy • Leaf underside is translucent and appears to be dark green ***Prayer Peperomia*** *(Peperomia dolabriformis)*

• Plant without a visible stem • Leaves clearly divided into leaf blade and petiole (leaf stalk) • Leaf blade as big as a hand; long petiole • Leaves dark green ***Peace Lily*** *(Spathiphyllum floribundum)*	• Plant herbaceous; soft to the touch • Plants divided into leaf blade and petiole • Leaves with small bumps(visible with magnifying glass) • Leaf blades and petioles with fine hairs • Three leaves at each node ***False African Violet, Cape Primrose*** *(Streptocarpus saxorum)*

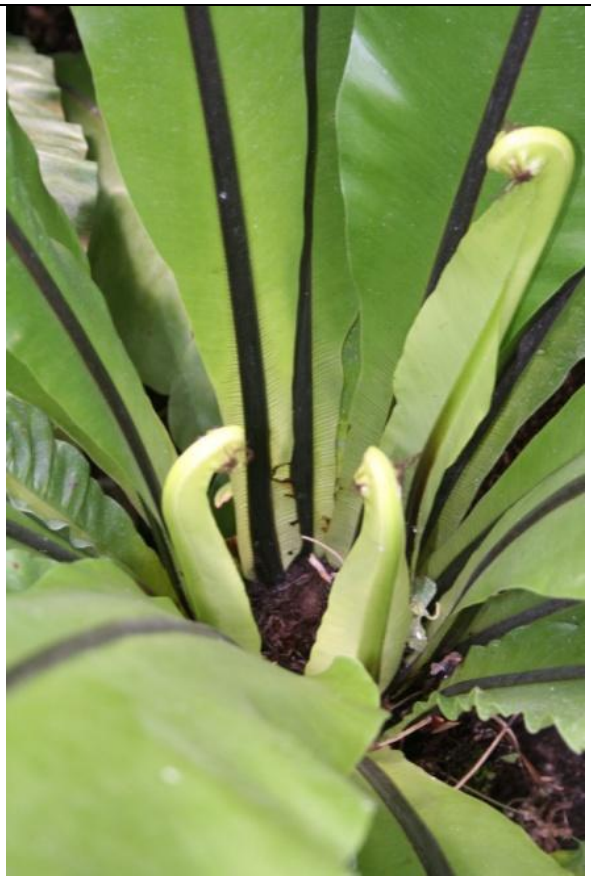
• Plant pendulous (weeping/ hanging down) • Shoot and leaves difficult to distinguish • Plant is densely grey scaled (visible with magnifying glass) • Plant has no roots ***Spanish Moss*** *(Tillandsia usneoides)*	• Plants herbaceous, upright or decumbent (growing across ground) • Shoots with a high water content • Leave blades sessile, (without a leaf stalk) • Leaves with soft white hairs ***Hairy Spiderwort,*** ***White Velvet Spiderwort, Cobweb Spiderwort*** *(Tradescantia sillamontana)*
• Plant small; branched from the base • Plant herbaceous, with a high water content • Leaves divided into leaf petiole and blade • Leaves crenate (wavy edged) ***Horned Pansy, Horned Violet*** *(Viola cornuta)*	• Leaves sword-like, broad at base • Leaves growing from a rosette • Leaves form a water retaining funnel *(Vrisea psittacina)*

Identification cards with plant pictures

- Leaves form a funnel
- Basal leaves narrow, broad in the middle
- Leaf ribs are dark brown
- Leaf underside partly covered with powdery stripes (Sporangia)

Bird´s Nest Fern

(Asplenium nidus)



- Shoots withered (or cut down)in winter
- Old plant remains at base
- Soft leafy rosette Fresh leaves are hairy

Yellow Ox-Eye Daisy

(Buphtalmum salicifolium)

- *Only exists as seed in winter*

Pot Marigold

(Calendula officinalis)

- Plant small
- Plant is grey-green with translucent areas at top
- Usually only two leaves per shoot visible
- Leaves are very thick and fleshy

Conophytum, Living Pebble

(Conophytum truncatum)

- Plant grows close to the ground
- Basal shoot parts are woody
- Leaves are dark green and leathery
- Leaf underside with dense white hairs (visible with magnifying glass)

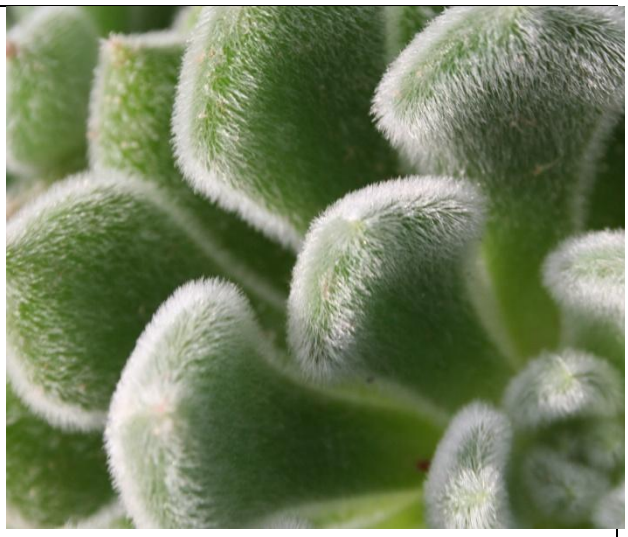
Mountain Avens

(Dryas octopetala)

- Plant grows as a compressed rosette
- Leaves are spathulate (spoon shaped) and fleshy
- Leaves covered in bristly white hairs

Mexican Firecracker,
Hen and Chicken,

(Echeveria setosa)



- Young plants grow upright
- Shoots (stems) have ribs
- Plants have modified leaves (spines) which grow out from a white circular basal section (areole)

(Echinopsis thelegona)

- Shoot upright and branched
- Shoot light grey
- Shoot with thorns
- Green, spathulate leaves

Crown of Thorns, Christ´s Thorn

(Euphorbia milii)

- Plant upright, branched, (in maturity a tree)
- Young shoots with grey brown bark; later light grey
- Leaves with slightly waxy surface
- Leaves with pointed tips

Weeping Fig,
Benjamin' s Fig

(Ficus benjamina)

- Plant is small and grows cushion shaped
- Cushion appears greyish green
- Many unbranched shoots
- Leaflets small, lying close to the stem
- Plant bears green capsules (visible with a magnifying glass)

Grey Cushioned Grimmia

(Grimmia pulvinata)

- Young plants growing straight up
- Leaves fleshy; round in section
- Leaves bluish and waxy with a whitish powdery coating

(Kleinia ficoides)

- Plant an upright semi-shrub
- Leaves small and narrow, covered with light grey hairs
- Plant has a strong fragrance

Lavender,
Common Lavender

(Lavandula angustifolia)

- Flat crust-like growth
- At the edge of the growth area, often lobe-shaped and divided
- Lichen carries shield-shaped elevations (Apothecia) (visible with a magnifying glass)

Crustose Rock Lichen

(Lecanora spec.)

- Thick green shoots
- Branching only from the base
- Covered with bright, star-shaped spines raised up from the surface

(Mammillaria microhelia)

- Shoots growing flat
- Leaves thin; patterned on the top side
- Leaf underside partly reddish coloured
- Young leaves partly curled

Prayer Plant

(Maranta leuconeura)

- Plant grows with flat branching structures close to the ground
- Plant dark green; very delicate
- Plant with little ‘umbrella’ or ‘cup- like’ structures on the upper surface

Well Liverwort

(Marchantia aquatica)

- Shoots upright, becoming woody
- Three leaves at each node
- Leaves narrowly ovate, with a tip
- Leaves evergreen, leathery

Oleander

(Nerium oleander)

- Young shoot green, later becoming woody
- Leaves are hatchet-shaped and fleshy
- Leaves waxy
- Leaf underside is translucent and appears to be dark green

Prayer Peperomia

(Peperomia dolabriformis)

- Plant without a visible stem
- Leaves clearly divided into leaf blade and petiole (leaf stalk)
- Leaf blade as big as a hand; long petiole
- Leaves dark green

Peace Lily

(Spathiphyllum floribundum)

- Plant herbaceous; soft to the touch
- Plants divided into leaf blade and petiole
- Leaves with small bumps(visible with magnifying glass)
- Leaf blades and petioles with fine hairs
- Three leaves at each node

False African Violet,
Cape Primrose

(Streptocarpus saxorum)

• Plant pendulous (weeping/ hanging down) • Shoot and leaves difficult to distinguish • Plant is densely grey scaled(visible with magnifying glass) • Plant has no roots ***Spanish Moss*** *(Tillandsia usneoides)*	
• Plants herbaceous, upright or decumbent (growing across ground) • Shoots with a high water content • Leave blades sessile, (without a leaf stalk) • Leaves with soft white hairs ***Hairy Spiderwort,*** ***White Velvet Spiderwort, Cobweb Spiderwort*** *(Tradescantia sillamontana)*	

- Plant small; branched from the base
- Plant herbaceous, with a high water content
- Leaves divided into leaf petiole and blade
- Leaves crenate (wavy edged)

Horned Pansy, Horned Violet

(Viola cornuta)

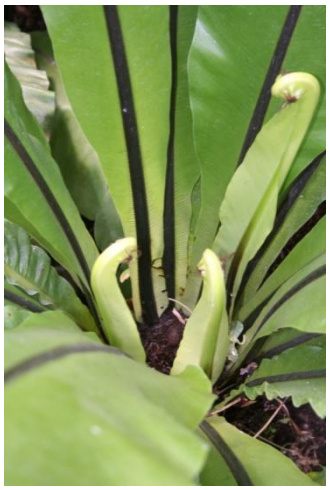
- Leaves sword-like, broad at base
- Leaves growing from a rosette
- Leaves form a water retaining funnel

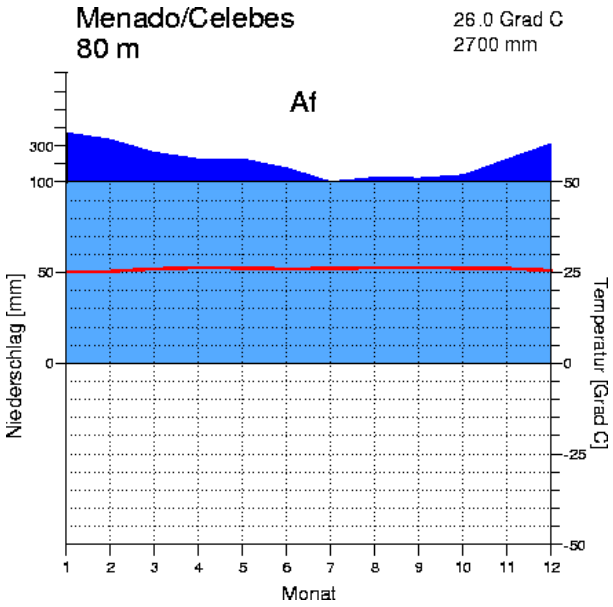
(Vrisea psittacina)

Resource 8: Climate diagrams with plant pictures

Bird´s Nest Fern

Asplenium nidus L

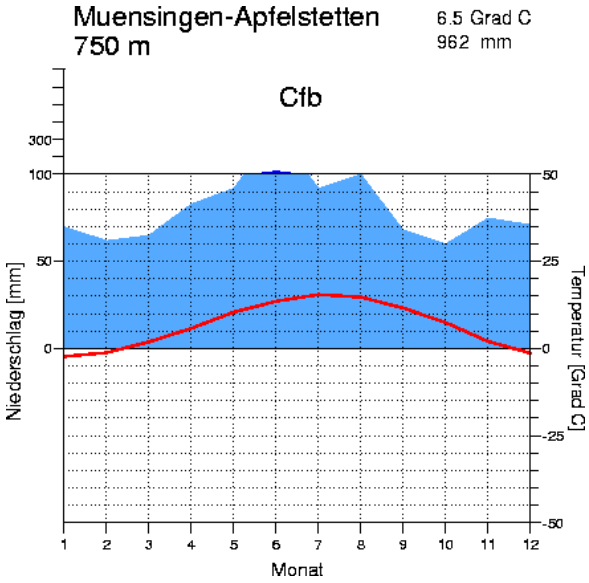




1°32'N, 124°55'E, 80 m

Yellow Ox-Eye Daisy

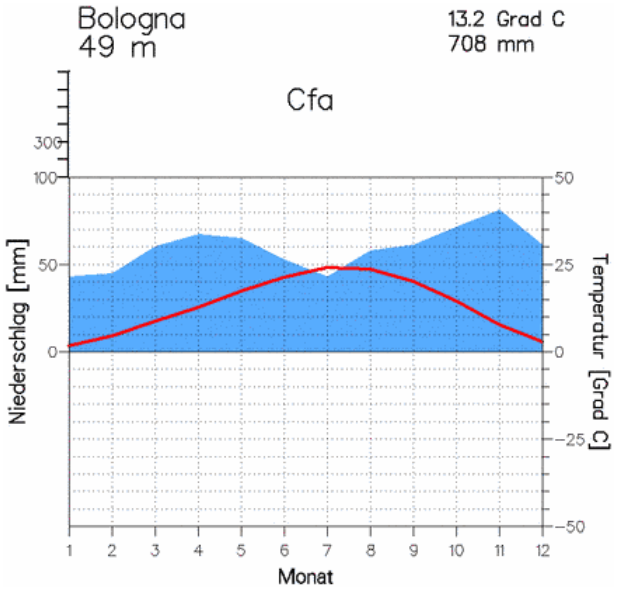
Buphthalmum salicifolium L.



48°23'N, 9°29'E, 750 m

Pot Marigold

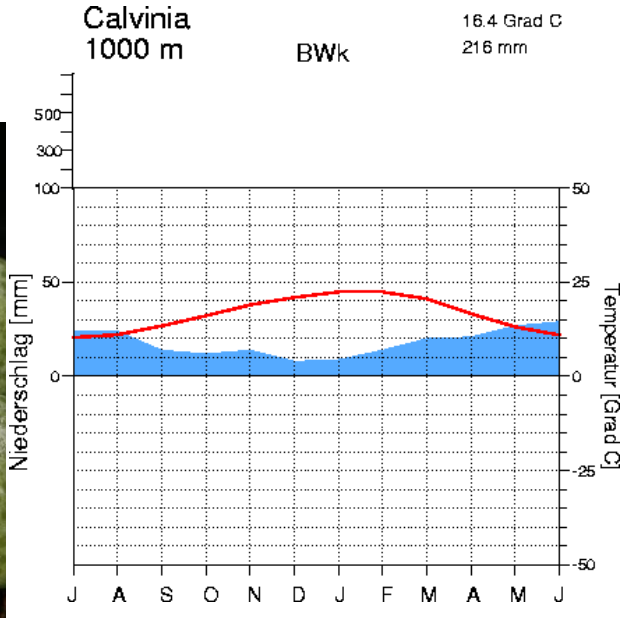
Calendula officinalis L.



44°32'N, 11°18'E, 49 m

Conophytum, Living Pebble

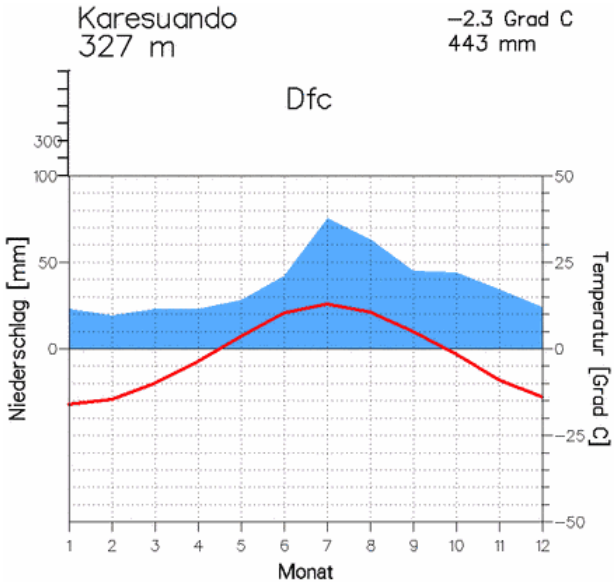
Conophytum truncatum (Thunb.) N.E.Br.



31°28'S,19°46'E,1000 m

Mountain Avens

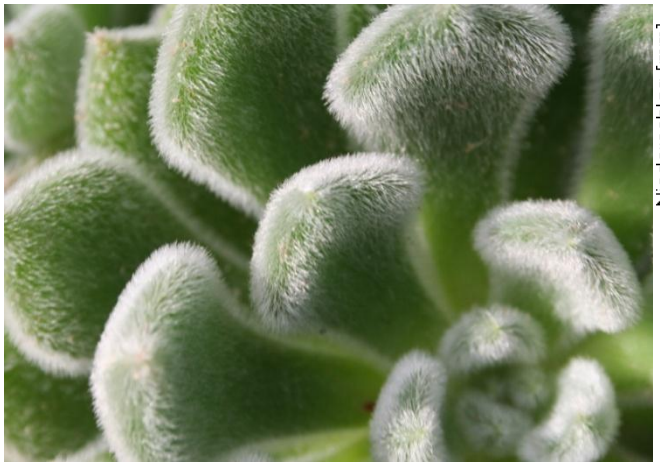
Dryas octopetala L.

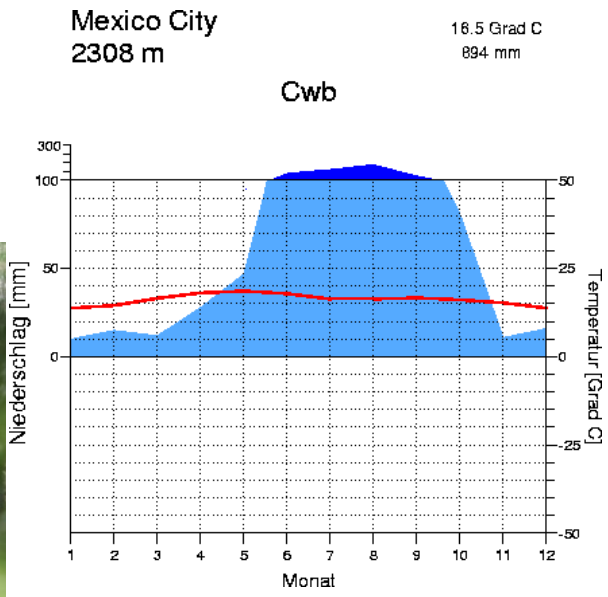


68°27'N, 22°30' E , 327 m

Mexican Firecracker, Hen and Chickens

Echeveria setosa Rose et Purpus

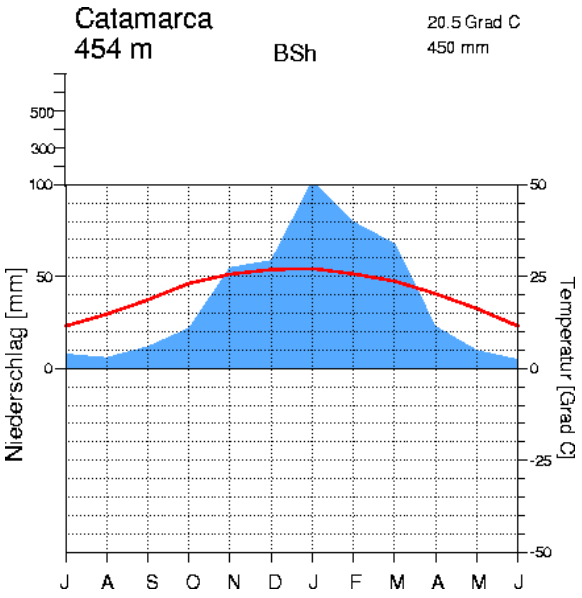




19°24'N, 99°12'W, 2308 m

Echinopsis thelegona

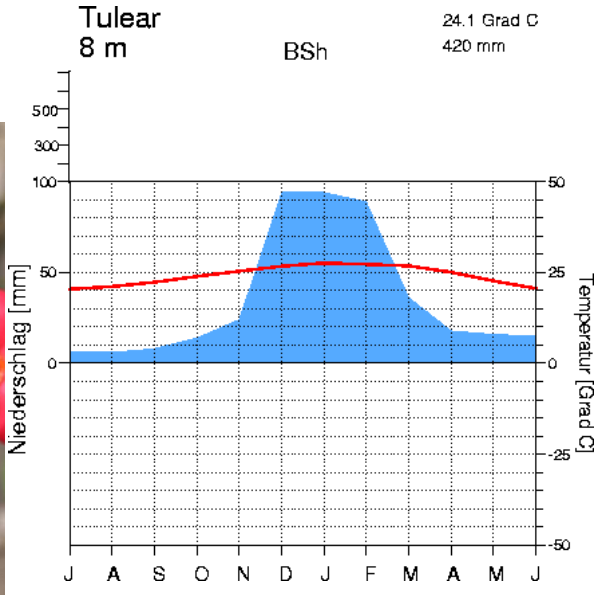
(Web) Friedrich & G. D. Rowley



28°36'S, 65°46'W, 454 m

Crown of Thorns, Christ´s Thorn

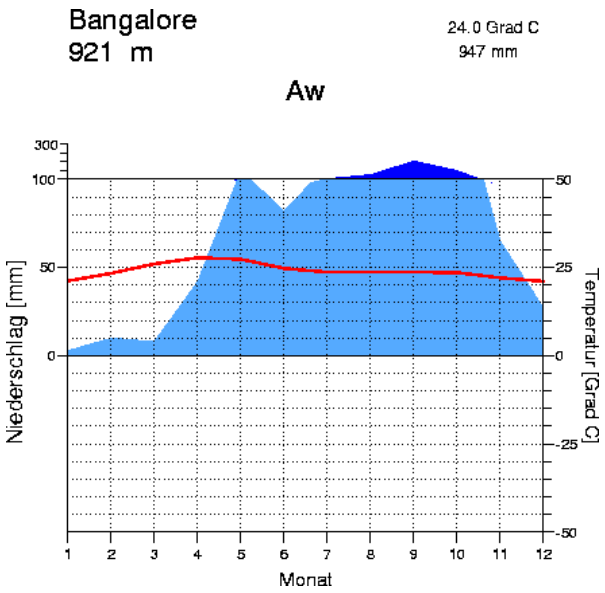
Euphorbia millii Des Moul



23°23'S, 43°44'E, 8 m

Weeping Fig,
Benjamin´s Fig

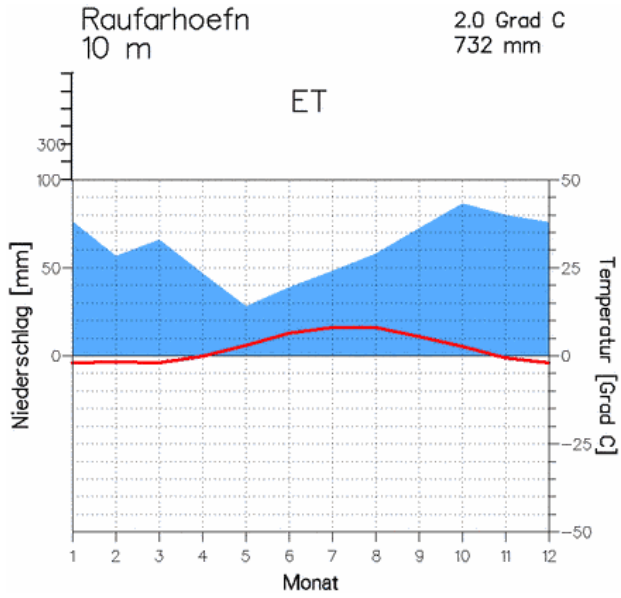
Ficus benjamina L..



12°58'N, 77°35'E, 921 m

Grey Cushioned Grimmia

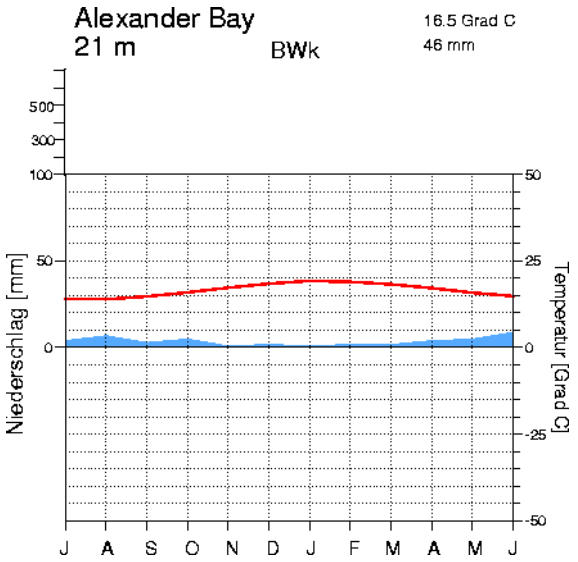
Grimmia pulvinata (Hedw.) Sm.



66°27'N, 15°57'W, 10 m

Kleinia ficoides

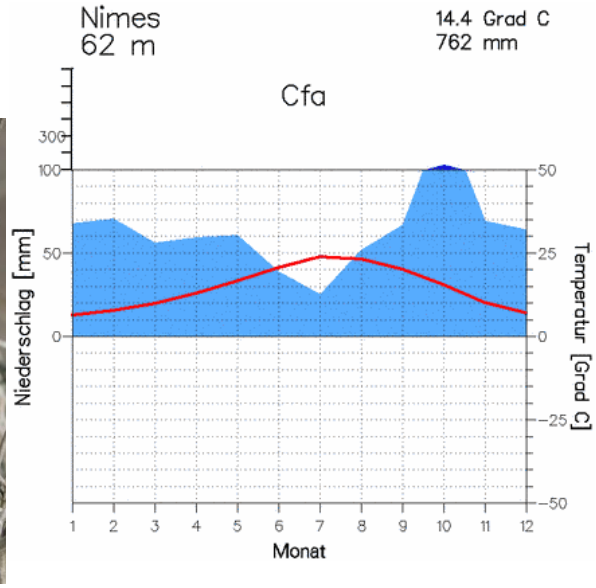
(L.) Haw.



28°34'S, 16°32'E, 21 m

Lavander, Common Lavender

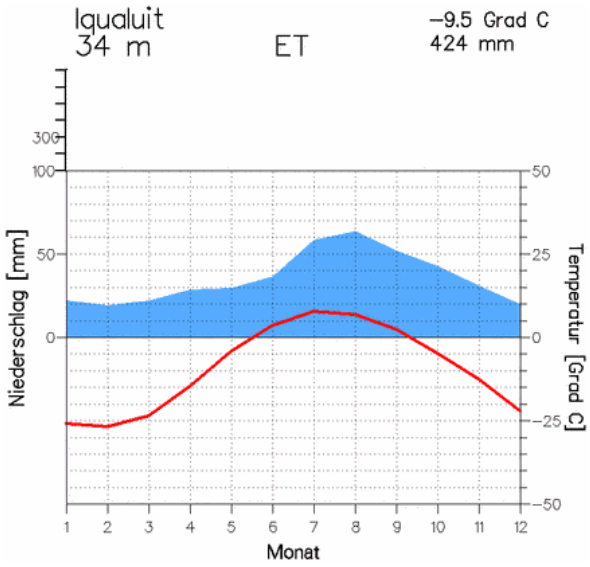
Lavandula angustifolius Mill.



43°52'N, 4°24'E, 62 m

Crustose Rock Lichen

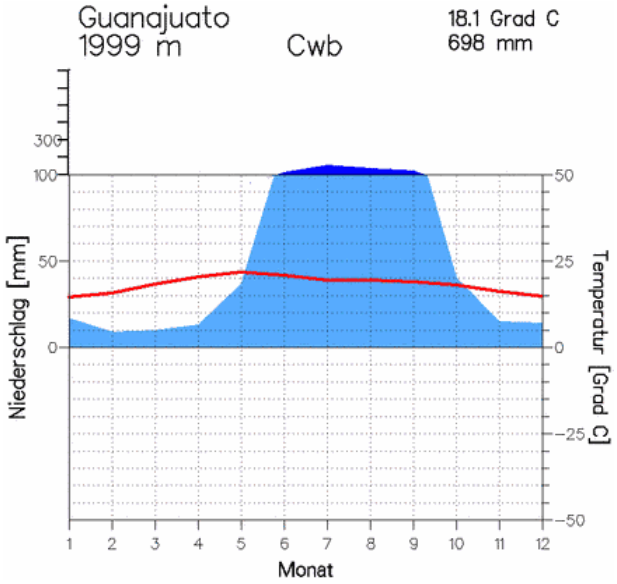
Lecanora sp.



63°45'N, 68°32'W, 34 m

Mammillaria microhelia

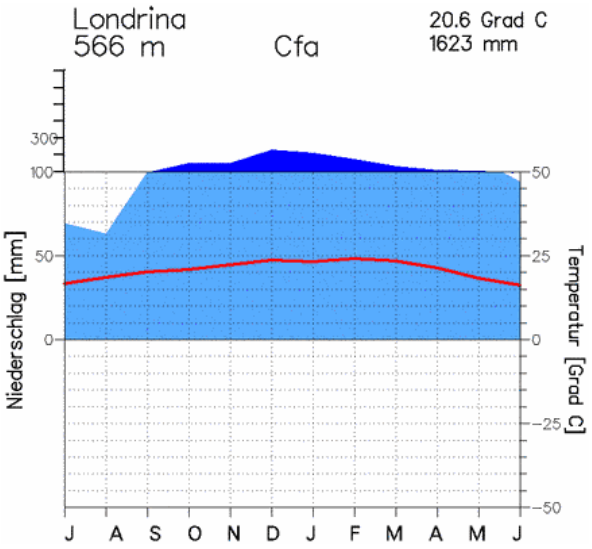
Werderm.



21°01'N, 101°15'W, 1999 m

Prayer Plant

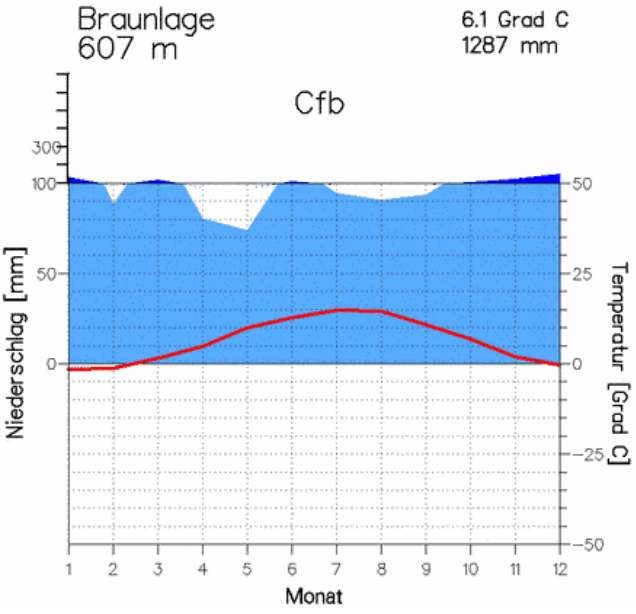
Maranta leuconeura Morren



23°30'S, 51°13'W, 566 m

Well Liverwort

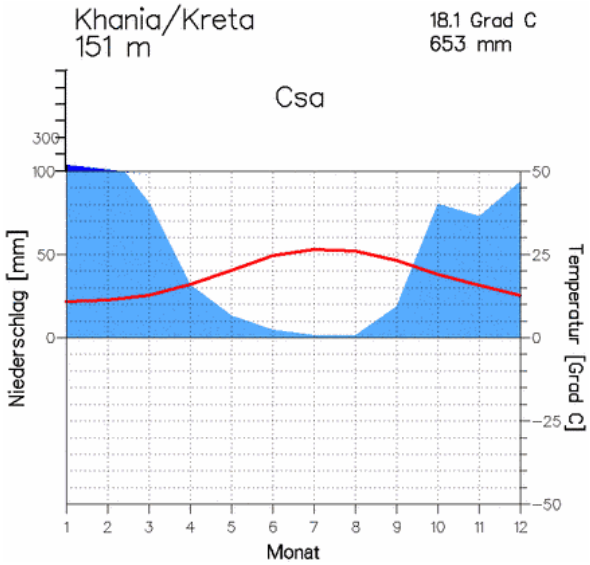
Marchantia aquatica (Nees) Burgeff.



51°44'N, 10°36'E, 607 m

Oleander

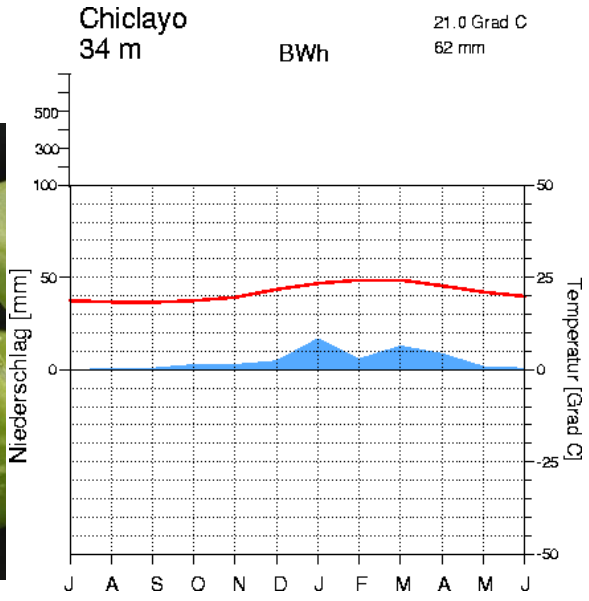
Nerium oleander L.



35°29'N, 24°07'E, 151 m

Prayer Peperomia

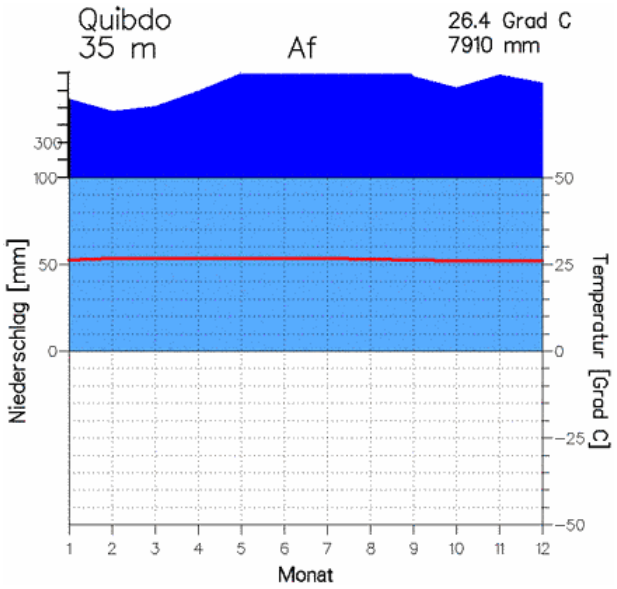
Peperomia dolabriformis Kunth.



6,8° S / 79,8° W, 34 m

Peace Lily

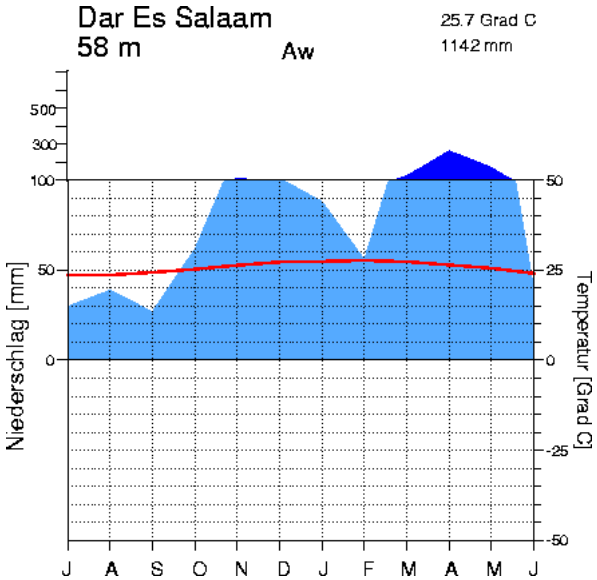
Spathiphyllum floribundum (Linden & André) N.E.Br.



5°41'N, 76°39 'W, 35 m

False African Violet,
Cape Primrose

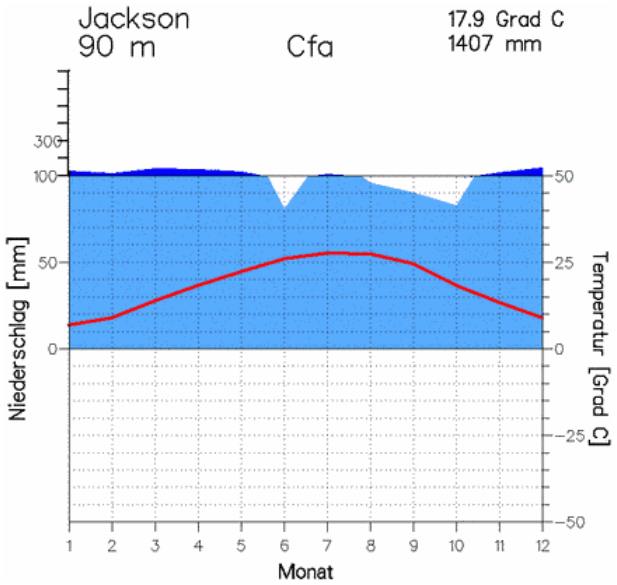
Streptocarpus saxorum Engl.



6°52'S, 39°12'E, 58 m

Spanish Moss

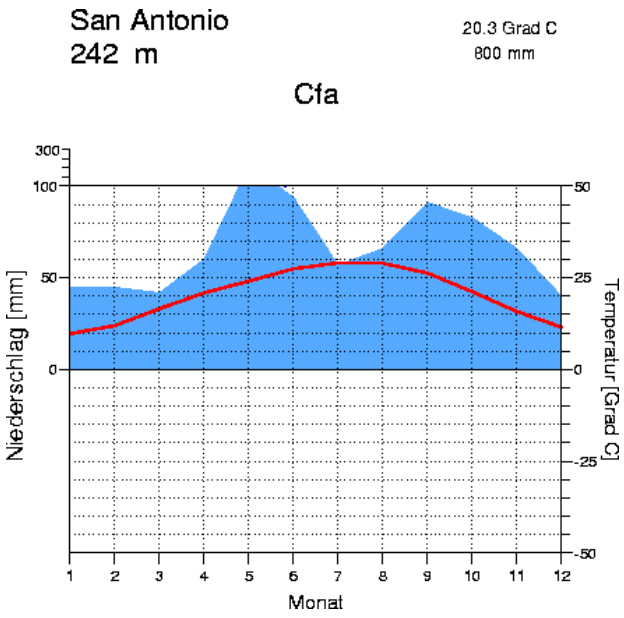
Tillandsia usneoides (L.)



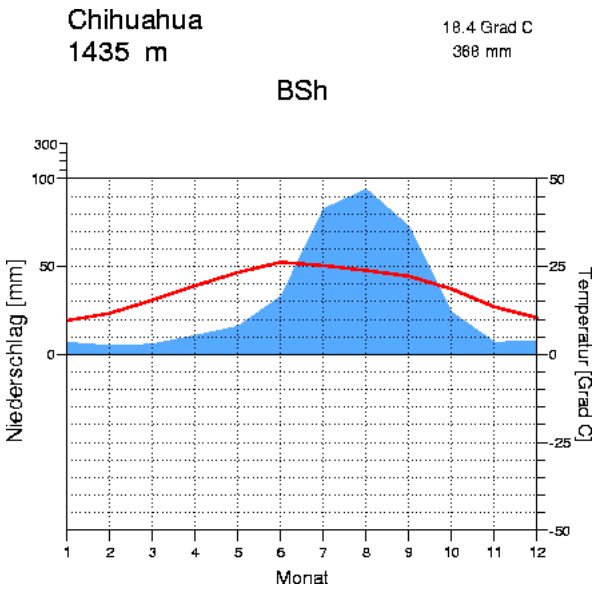
30°50’ N, 91°13’ W, 90 m

Hairy Spiderwort, White Velvet Spiderwort, Cobweb Spiderwort

Tradescantia sillamontana Matuda



29°32'N, 98°28'W, 242 m

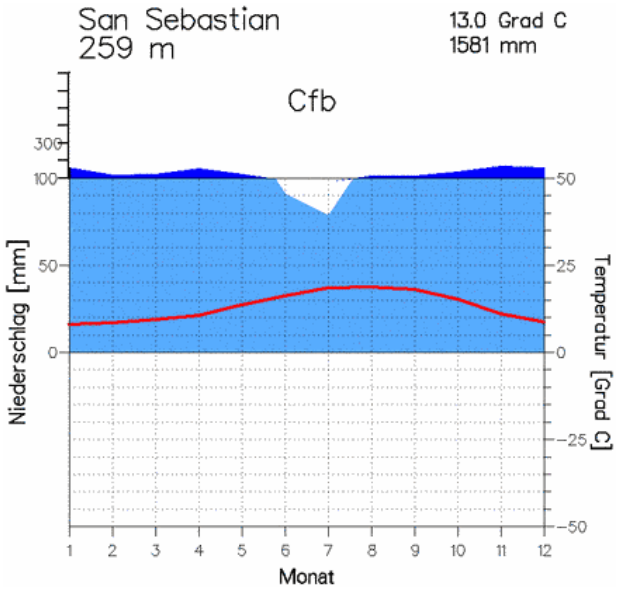


(two diagrams)

28°38'N, 106°05'W,1435 m

Horned Pansy,
Horned Violet

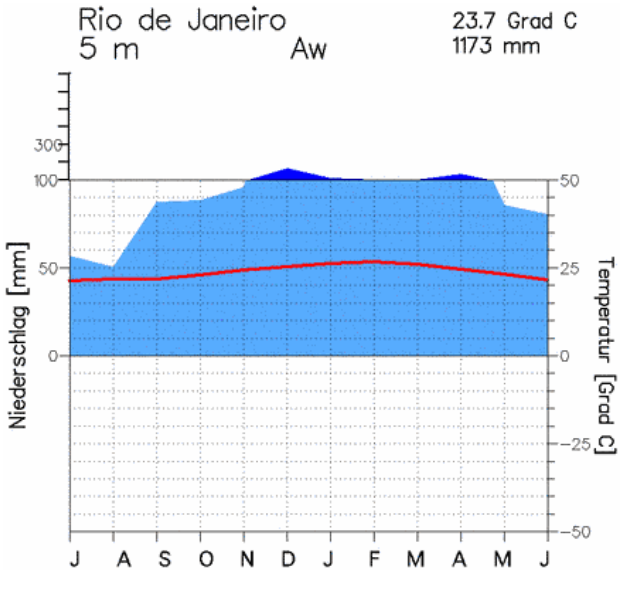
Viola cornuta L.



43°18'N, 2°03'W, 259 m

Vrisea psittacina

(Hook.) Lindl.

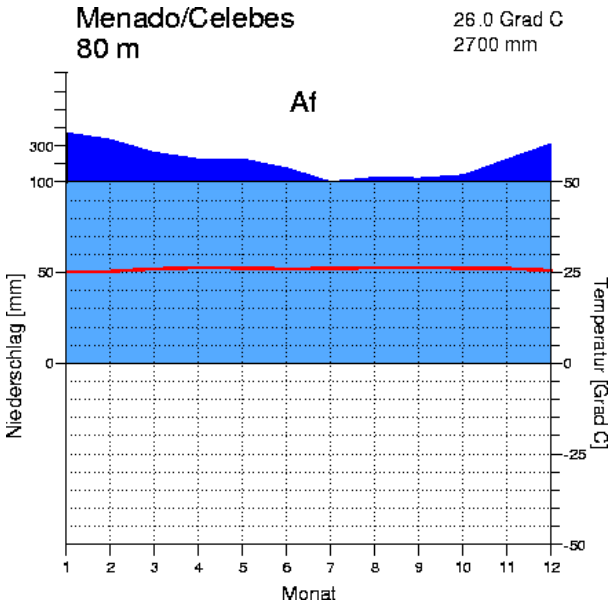


22 ° 54 'S, 43°12'W 5 m

Climate diagrams without pictures

Bird´s Nest Fern

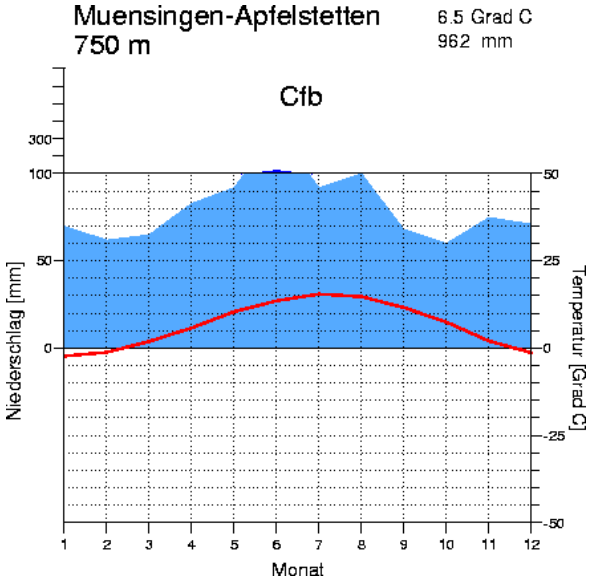
Asplenium nidus L



1°32'N, 124°55'E, 80 m

Yellow Ox-Eye Daisy

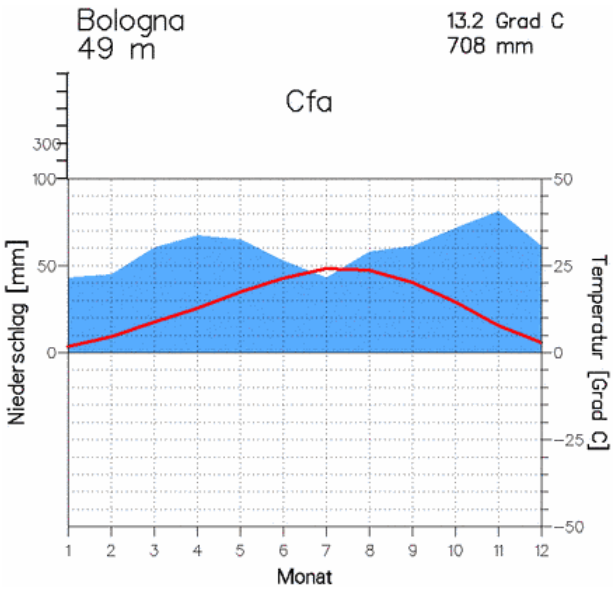
Buphthalmum salicifolium L.



48°23'N, 9°29'E, 750 m

Pot Marigold

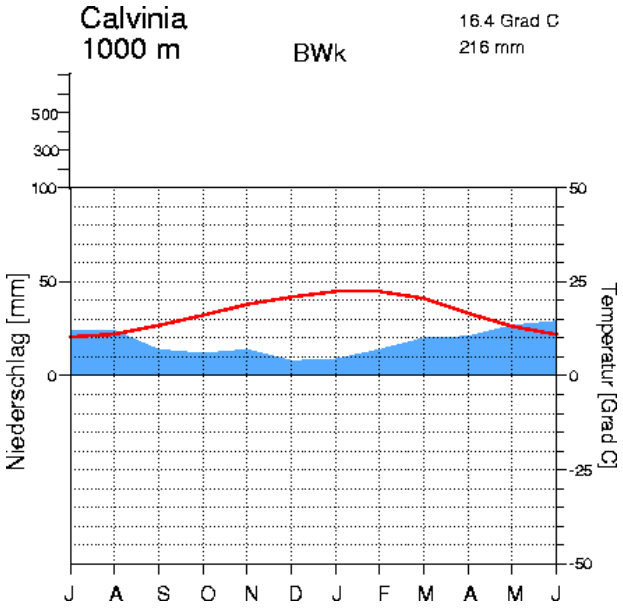
Calendula officinalis L.



44°32'N, 11°18'E, 49 m

Conophytum, Living Pebble

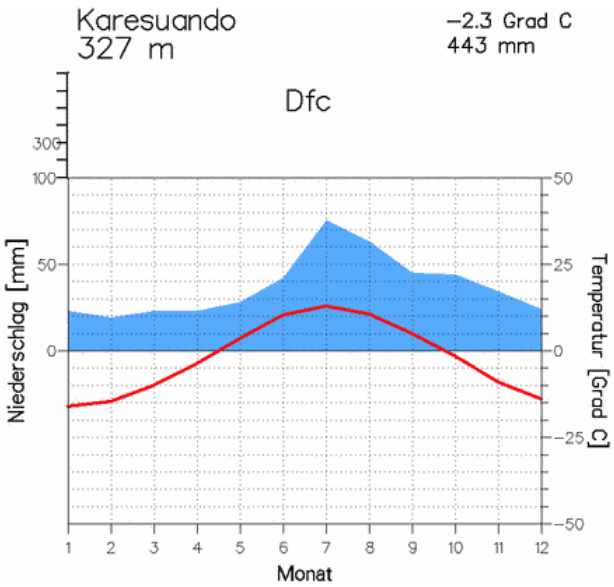
Conophytum truncatum (Thunb.) N.E.Br.



31°28'S,19°46'E,1000 m

Mountain Avens

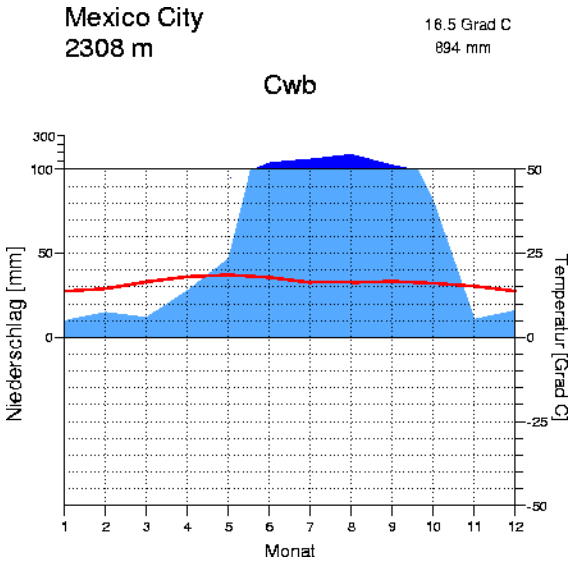
Dryas octopetala L.



68°27'N, 22°30' E , 327 m

Mexican Firecracker, , Hen and Chicken

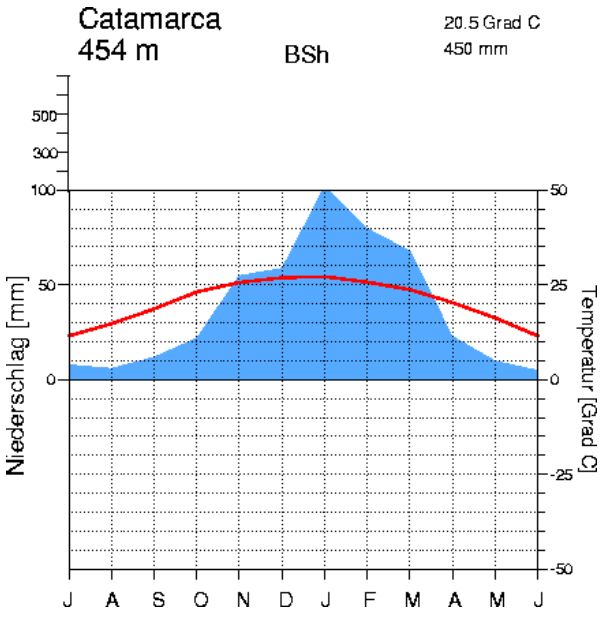
Echeveria setosa
Rose et Purpus



19°24'N, 99°12'W, 2308 m

Echinopsis thelegona

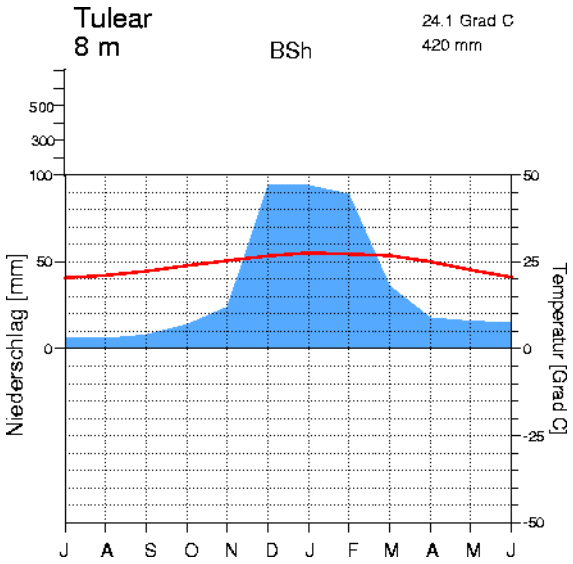
(Web) Friedrich & G. D. Rowley



28°36'S, 65°46'W, 454 m

Crown of Thorns, , Christ´s Thorn

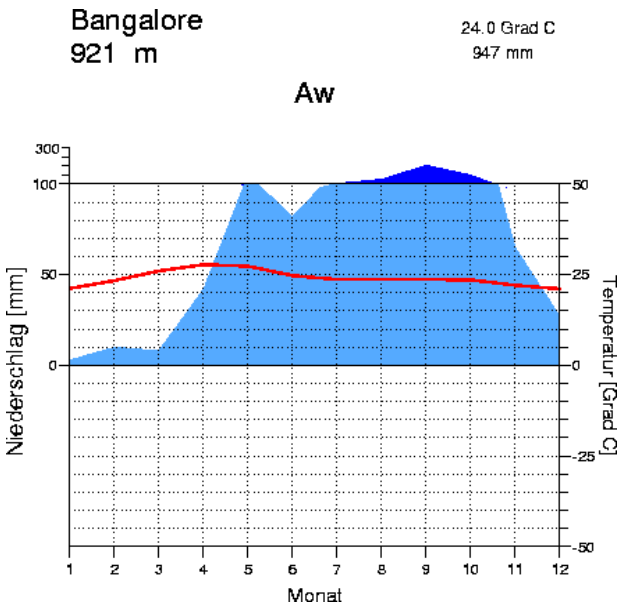
Euphorbia millii Des Moul



23°23'S, 43°44'E, 8 m

Weeping Fig, , Benjamin´s Fig

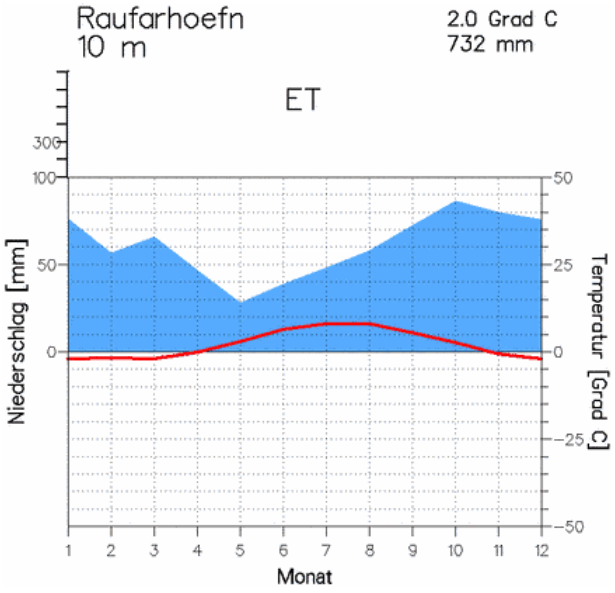
Ficus benjamina L..



12°58'N, 77°35'E, 921 m

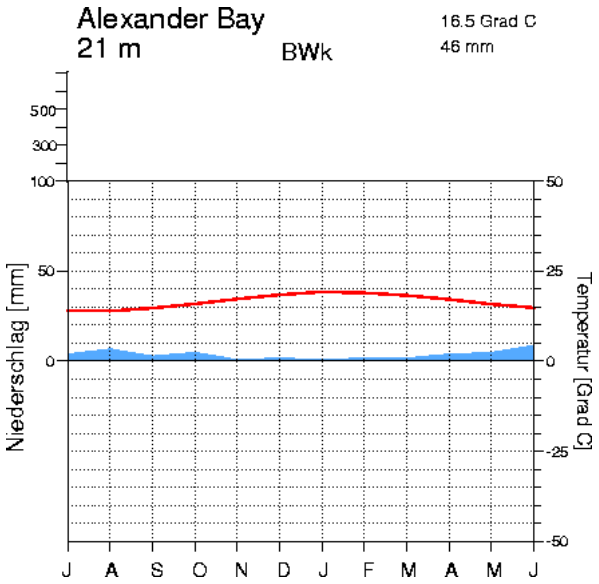
Grey Cushioned Grimmia

Grimmia pulvinata (Hedw.) Sm.



66°27'N, 15°57'W, 10 m

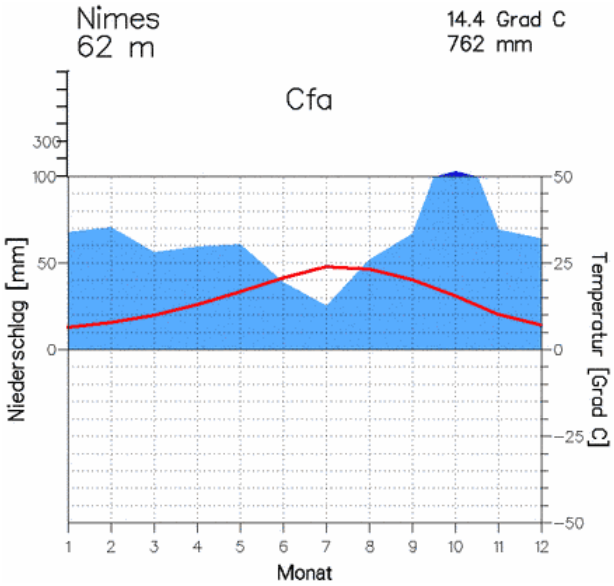
Kleinia ficoides (L.) Haw.



28°34'S, 16°32'E, 21 m

Lavender, ,
Common Lavender

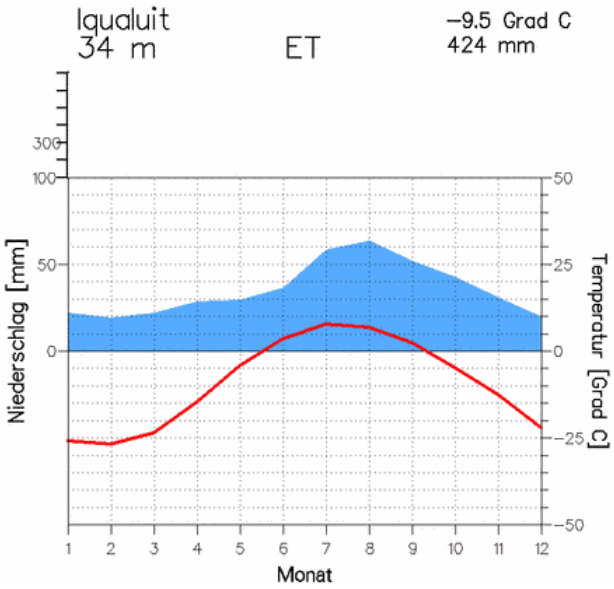
Lavandula officinalis L.



43°52'N, 4°24'E, 62 m

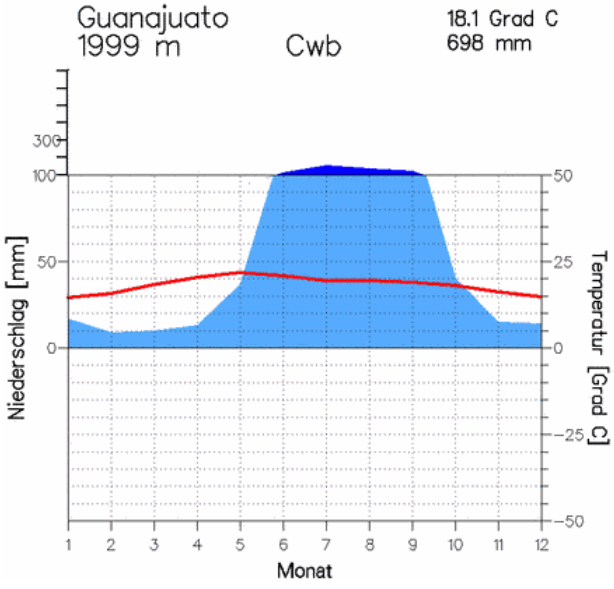
Crustose Rock Lichen

Lecanora spec.



63°45'N, 68°32'W, 34 m

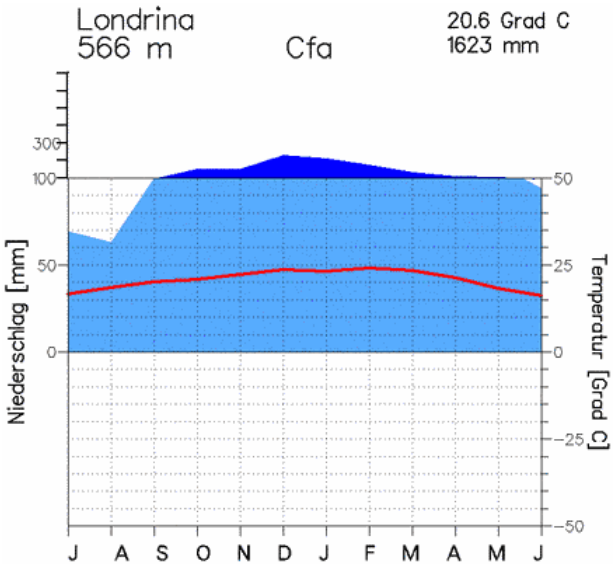
Mammillaria microhelia
Werderm.



21°01'N, 101°15'W, 1999 m

Prayer Plant

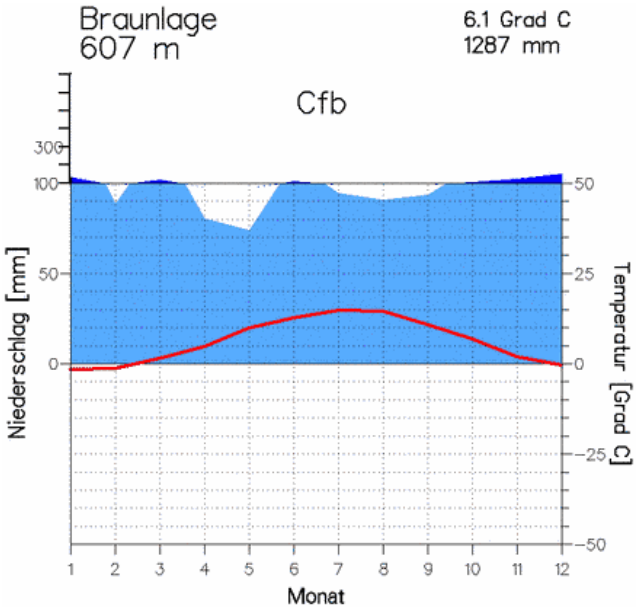
Maranta leuconeura
E. Morren



23°30'S, 51°13'W, 566 m

Well Liverwort

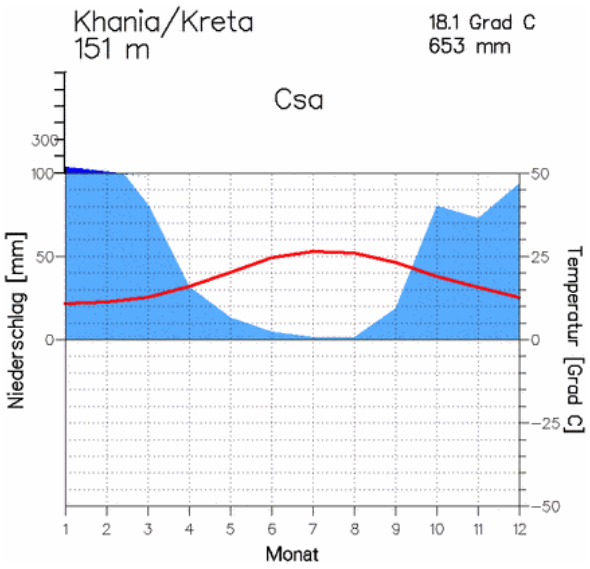
Marchantia aquatica
(Nees) Burgeff.



51°44'N, 10°36'E, 607 m

Oleander

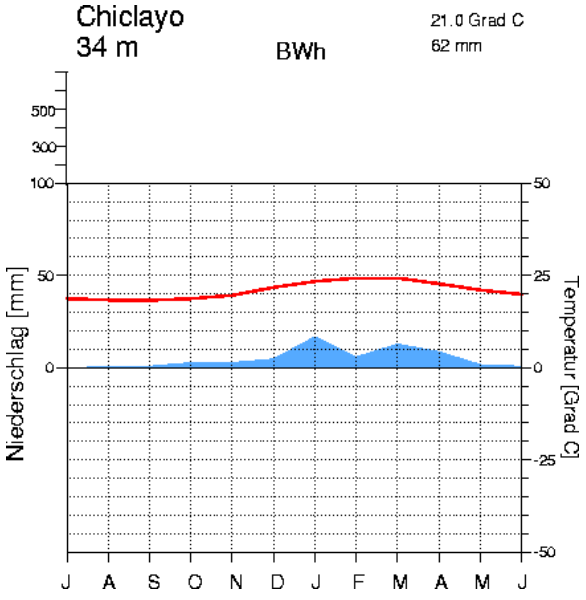
Nerium oleander L.



35°29'N, 24°07'E, 151 m

Prayer Peperomia

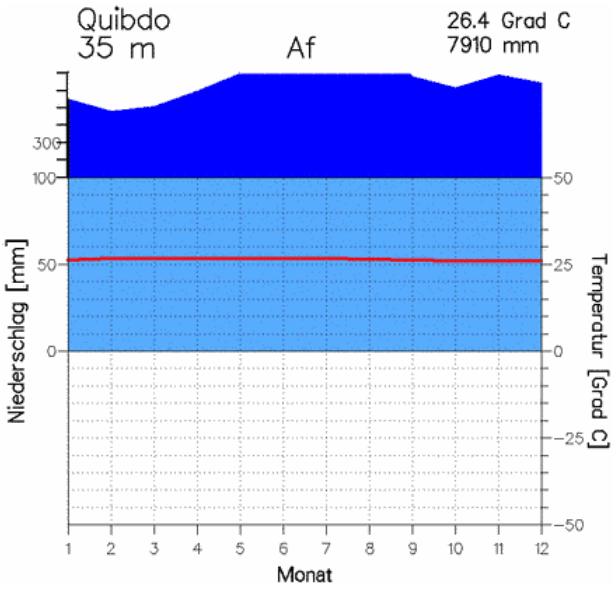
Peperomia dolabriformis Kunth.



6,8° S / 79,8° W, 34 m

Peace Lily

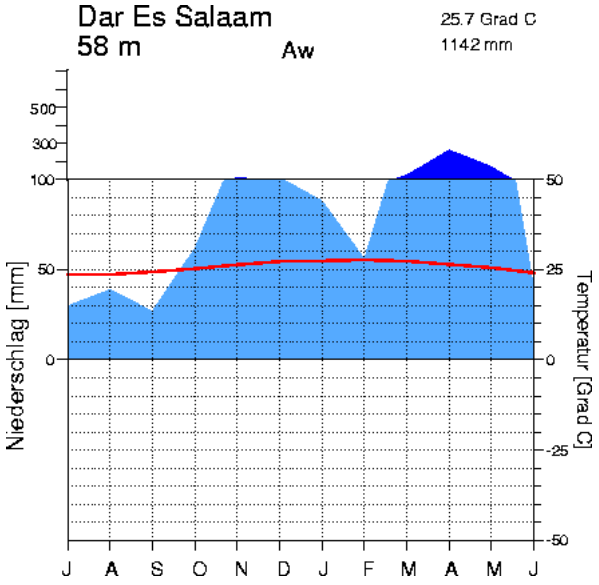
Spathiphyllum floribundum (Linden & André) N.E.Br.



5°41'N, 76°39 'W, 35 m

False African Violet, Cape Primrose

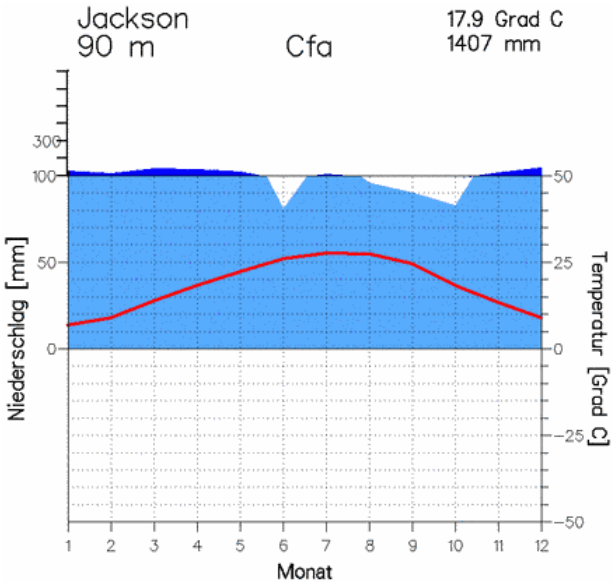
Streptocarpus saxorum Engl.



6°52'S, 39°12'E, 58 m

Spanish Moss

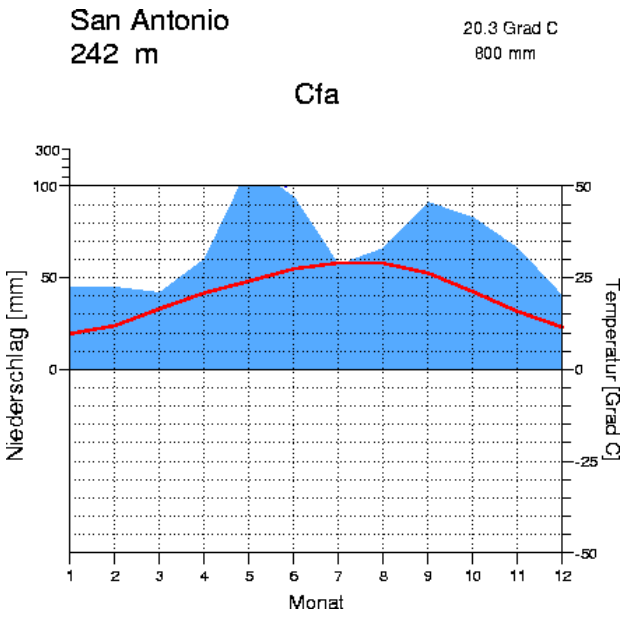
Tillandsia usneoides (L.) L.



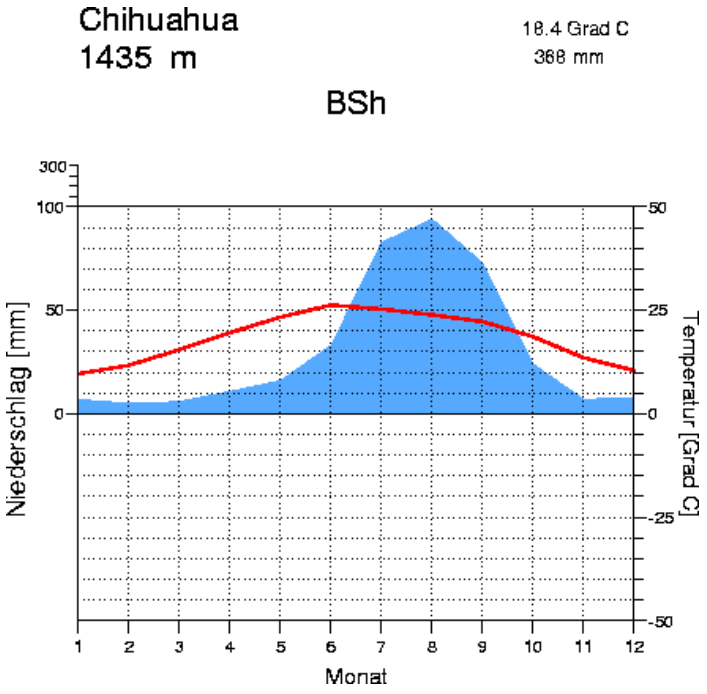
30°50’ N, 91°13’ W, 90 m

Hairy Spiderwort,
White Velvet Spiderwort,
Cobweb Spiderwort

Tradescantia sillamontana
Matuda



29°32'N, 98°28'W, 242 m

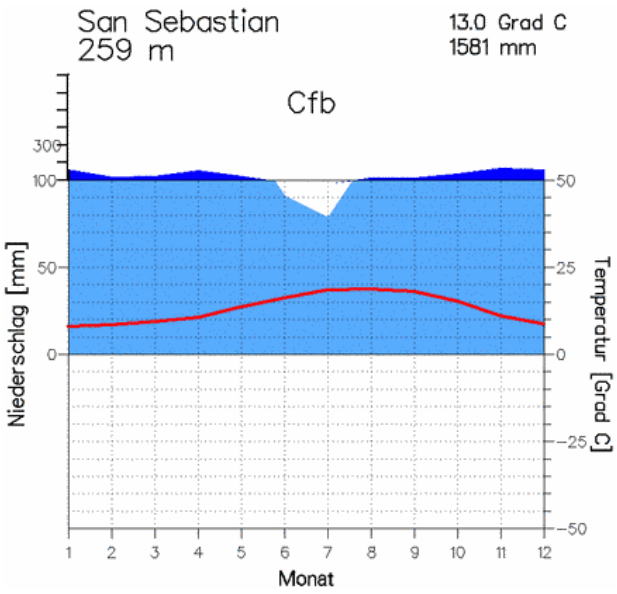


(two diagrams)

28°38'N, 106°05'W,1435 m

Horned Pansy, Horned Violet

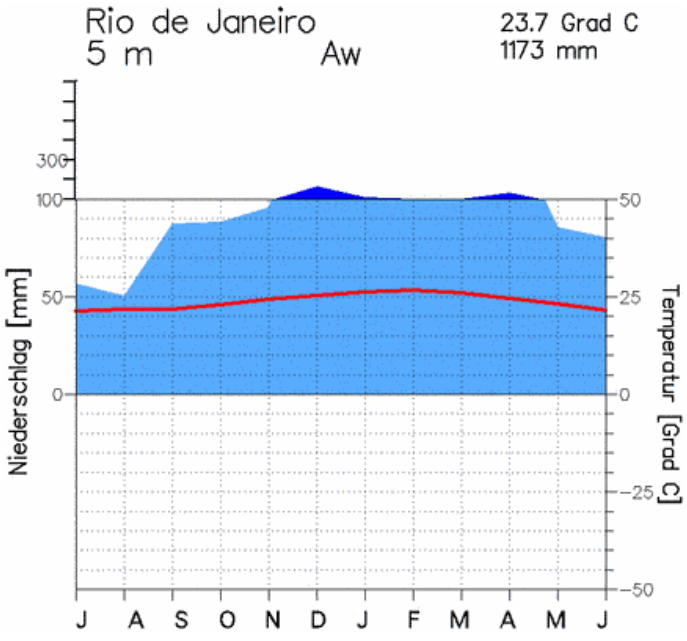
Viola cornuta L.



43°18'N, 2°03'W, 259 m

Vrisea psittacina

(Hook.) Lindl.



22 ° 54 'S, 43°12'W 5 m

Climate diagrams: http://www.klimadiagramme.de

What isBiodiversity?

Institute: BORD- Botanic Garden of Bordeaux

Lesson developed by: Mélissa GARRIGUE and Réjane LIMET

Grade / level:

Primary level (9-12 years old)
NB: Differentiation for older students (12-14years old) is noted in blue

Anticipated time:

3 hrs

Summary

The lesson is divided into three sections.

- The first part is designed to explore the concept of the 'ecosystem'. By observing and recording biodiversity in the reconstituted local ecosystems in the botanic garden, students need to understand the existing interrelationships between living organisms and consider the importance of balance in an ecosystem.

- The second part is dedicated to the concept of 'biodiversity'. Students must measure and compare the biodiversity of plants and insects in two different areas of similar dimensions. One has been left free to grow naturally; the other is maintained by humans.

- The third part is devoted to class debate /discussion to explore the importance of biodiversity in everyday life and to look at the different pressures that humans impose on biodiversity.

Learning outcomes:

- Students should understand the concepts of 'biodiversity' and 'ecosystem'.

- Students should recognise that natural habitats are dynamic systems which are often put under a lot of pressure / threats.

- Students should recognise the impact (negative and positive) that humans have on ecosystems.

Competences:

- Working together in groups,
- Formulating hypotheses
- Group decision making
- Presentation skills
- Debate and discussion ; analysing comments
- Observation skills and articulation of findings
- put into practice their observations
- Literature research,
- Following a research plan
- Developing and implementing a research plan

Curriculum content

For French students from 9 to 12 years old:
'The goals of experimental science and technology are to understand and describe the real world, the natural world and the man-made one, to develop and master the changes in human activity […]. Observation, questioning, experimenting and debating processes, […], are essential to reach those aims; that is why knowledge and competences are acquired using an inquiry based science approach which develops curiosity, creativity, critical thinking, and an interest in scientific and technological progress.'

- ' unity and diversity of livings: introduction to biodiversity'
- 'Living things in their environment: places and roles of living beings, food chains and networks; the environmental evolution developed by man: the forest; importance of biodiversity.'

For French students from 12 to 14 years old:

- The IBSE approach.
- To understand human impact on biodiversity: directed and undirected, in relation to the local and the global levels.

Overview of activities

Students must:

- Reconstitute a food chain. They will also have to discuss different relationships that exist in an ecosystem, discovering that those relationships may be very complex.

- Follow a research plan, counting plant species in a quadrat to identify the biodiversity in it and to compare two different areas.

Prior learning

Pupils will have to know about the everyday life use of plants before the lesson (see the appendix)

Guidelines for Teachers

Introduction to the lesson

The principal aim of this lesson is to help students understand biodiversity and the impact human being can have on it. To help them understand the complexity of this concept, they are asked to study an ecosystem and to measure the biodiversity as well as explore the interrelationships characterised within it.

Outline of activities Primary level (9-12 years old)	RESOURCES
Part 1: what is an ecosystem? (1h15 for primary, 45 min for higher level) Children are taken to the regional ecosystem reconstruction part of the garden (see pictures 1 and 2 below) .They are not told that these are ecosystems (this word is not used until the end part 1). Question 1 is asked: 'What can you see?' The educator divides the students into 4 groups. Each group compares and records the differences between two natural landscapes of the Aquitaine region (NB the students do not, as yet, know that these landscape blocks within the garden are not natural but have been man-made). These constructed ecosystems representing the natural ones within the region: the sand dune ecosystem (perennial lower plants; the soil is sand) and the fixative forest (poor in species, mostly pines trees). The educator facilitates discussion with the groups in a plenary session, to talk about their observations to others and to have time for questions. The educator divides the class into two and gives each group one of the areas to study in more depth. Students are given c30 minutes to focus on researching / observing and recording the different components of their area (living and non- living things) and to consider the interrelationships between the components. (NB Educators should have marked out some specific components with some information to assist the groups with their research on the links between species etc.) . Other research resources should be available for the students to use (e.g. books with examples of food chains). Students should use the string, paper/ labels and pens to develop and set up an ecosystem 'web' representative of their researched area. Each group presents their findings to the other group; the educator will discuss and draw out evidence of the abiotic and biotic parts of an ecosystem with the students (posing questions such as: 'What do plant needs to grow?'). Students should use any additional evidence from this session to complete their ecosystem web. The educator explains that the students have completed a study on the interrelationships of an ecosystem (with both biotic and abiotic components), emphasising the complexity and diversity of species and components within it. Finally, the educator modifies one ecosystem web (e.g. removing a key species / changing an abiotic component etc.) and discusses what can cause these modifications and how this might impact on the area. The educator should emphasise the importance of the balance required within an ecosystem and how fragile it is.	Books about food chains and regional ecosystems Materials needed: big identification labels, string, post-it notes, paper and felt-tip pens

Part 2: Biodiversity. (1h for the first level / 1h30 for the higher level) The educator takes the class to a border of the garden (see picture 3 below) where an area has been left more or less to nature (cut only twice a year) alongside an area which has been managed (cut every two weeks). A question is posed: 'What do you observe?'; the educator should facilitate the students' answers. Afterwards, the educator should read the first section of *Mr Noé's Garden* (see story in appendix) and ask the students to discuss their thoughts about it. Students should develop a hypothesis about what will grow once Mr Noé stops cutting the grass in his garden. The educator should then lead a discussion about the difference of biodiversity in the two garden areas on view where the students are standing. A question should be posed –'How can you measure the difference of biodiversity between the two zones?' Students at a higher grade are expected to create a methodology to compare the two zones and carry out their examination using this methodology. Divide the class into 4 groups and ask the students to count the different plant and animal species they find in a 1m² quadrat in each of the zones (regularly cut zone and cut twice a year zone) (20mins). Students should discuss their results and explain why there are differences between the two zones. They should come to a class decision about why the zones are different. . The educator finishes the story of *Mr Noé's Garden* and emphasises that the students have just done research on 'biodiversity' For students at a higher grade, the educator should explain that their research explored just a small element of biodiversity that we can find globally and facilitate a discussion about the various levels of biodiversity e.g. diversity of ecosystems, of species, of genes, diversity inter-species, diversity intra-species, diversity of interaction etc.	DVDs/ videos on biodiversity /ecosystems watched prior to the lesson. The extract from '*Mr Noé's Garden*',(National Commission of Switzerland for UNESCO) 2 1m² quadrats to use in the 2 garden zones (i.e. one that is regularly cut and one that is only cut twice a year). Rulers and tape measures Recording worksheet written (for primary students only) Paper, pens, hand lenses magnifying boxes, pooters, collection trays
Part 3 : Uses of and threats to Biodiversity The educator should ask students why biodiversity is important for mankind (This element should have been previously covered by the students). The educator should emphasise that species biodiversity is very important in an ecosystem as the more species are present in the ecosystem, the more stable it will be stable under threat/ pressure. The students should finally be asked what threats to biodiversity there are and their discussion facilitated by the educator. Students could use the 'Biodiversity and useful Plants' sheets in the appendix to recap their knowledge. For students at a higher grade, the discussion should be extended to explore how biodiversity loss can be mitigated against.	Information about species / habitat loss (current numbers). Images to illustrate threats to biodiversity.

Photo 1

Photo 2

Photo 3

Plenary
The principal concepts the students should understand include:

- An ecosystem is characterized by biotic (livings things) and abiotic (climate, soil, sun, minerals etc.) elements. There are some closed and complex relationships that exist in ecosystems: trophic relationships between the biotic elements (food chain) and between biotic and abiotic elements (e.g. soil- type affecting plant growth, plant type etc...). Balance in an ecosystem is very important. When it becomes unbalanced (e.g. through species loss or change to an abiotic feature such as climate change), that will usually have an impact on many other living organisms within the ecosystem, causing further losses or damage.
- Biodiversity means 'the diversity of living organisms'. We can measure it by counting the number of different living organisms in an ecosystem. The higher the biodiversity (number of different species in an area), the more secure the ecosystem balance.
- Humans often have a direct and negative impact on biodiversity. Human threats to biodiversity include pollution, habitat destruction, overharvesting, deforestation etc.

Assessment
During the activity students should be observed and monitored by the educator and teacher. They should note whether the students follow the correct methodologies for observing biodiversity, pose questions and seek to answer them and engage fully in the activity.

The educator can allocate a mark out of 10 for each child for each part of the lesson.

Finally, a questionnaire is given to each student to evaluate:

- The concepts they have learned,
- If they enjoyed the IBSE approach,
- If they felt that learning 'outside' was beneficial to gaining knowledge and understanding.

Students should create posters for their school to present what they have learned during the activities

Background information

- Reference list for IBSE
- Books / Films on:
    - Ecosystems
    - Biodiversity: definition, human impact, biodiversity use and biodiversity loss.

APPENDIX

Mr Noé's garden (extract summary of the story)

Mr Noé's was the only garden on the whole of his street... and strangely the street was called 'Butterfly Street'. "How odd!" thought Mr Noé "it doesn't deserve that name!..."

That sunny Saturday morning in spring, Mr Noé looked at the impressive growth of grass in his garden and decided to cut it, as was his habit at that time of year. When he tried to turn on his lawnmower however, it wouldn't start - the special oil reservoir was empty and he had forgotten to buy some more to fill it up again. Looking angrily at his lawnmower, he thought to himself ... "last week it was the starter that wouldn't work and this week I forgot to buy the oil and the petrol to make it run..., I also forgot to water the grass and to buy all the pesticide, fungicide, and fertilizer I use in the garden. Good grief! This garden really costs me a lot of money to manage! What's more - making all that noise with the mowing machine every Saturday – and for what – just to get a few m² of the same plant cut short...!"

That was enough for Mr Noé!! So he decided to not cut the grass anymore and to see what happened.

Story breaks for the educator to ask the children to hypothesise what will happen.

End the story with:

Mr Noé had not mown the lawn or tended his plants in the garden for two weeks. His wife, Mrs Noé, looked out of the kitchen window and shouted to her husband while he was standing in the garden. "You wanted to see what would grow. Look, it doesn't take long; I can already see some weeds!!"

"Weed, hmm... I'm not so sure" replied Mr Noé... "look that long, thin, dark green herb, it looks very like...," he cuts a piece and smells it, ..."like chive! It is some type of wild chive."

He looks at all the little buds around him in the garden, ready to bloom. There are so many different ones. Mr Noé wonders to himself.... "What kind of plants are these? Maybe some wild flowers? But which flowers? **Let's see what will happen!"**

BIODIVERSITY AND USEFUL PLANTS

EDUCATIONAL AIMS

- To recognise the importance of plants in everyday life
- To recognise the main groups of useful plants
- To develop an interest for protecting biodiversity
- To understand the interrelationship of man and nature

SEQUENCE OF ACTIVITY

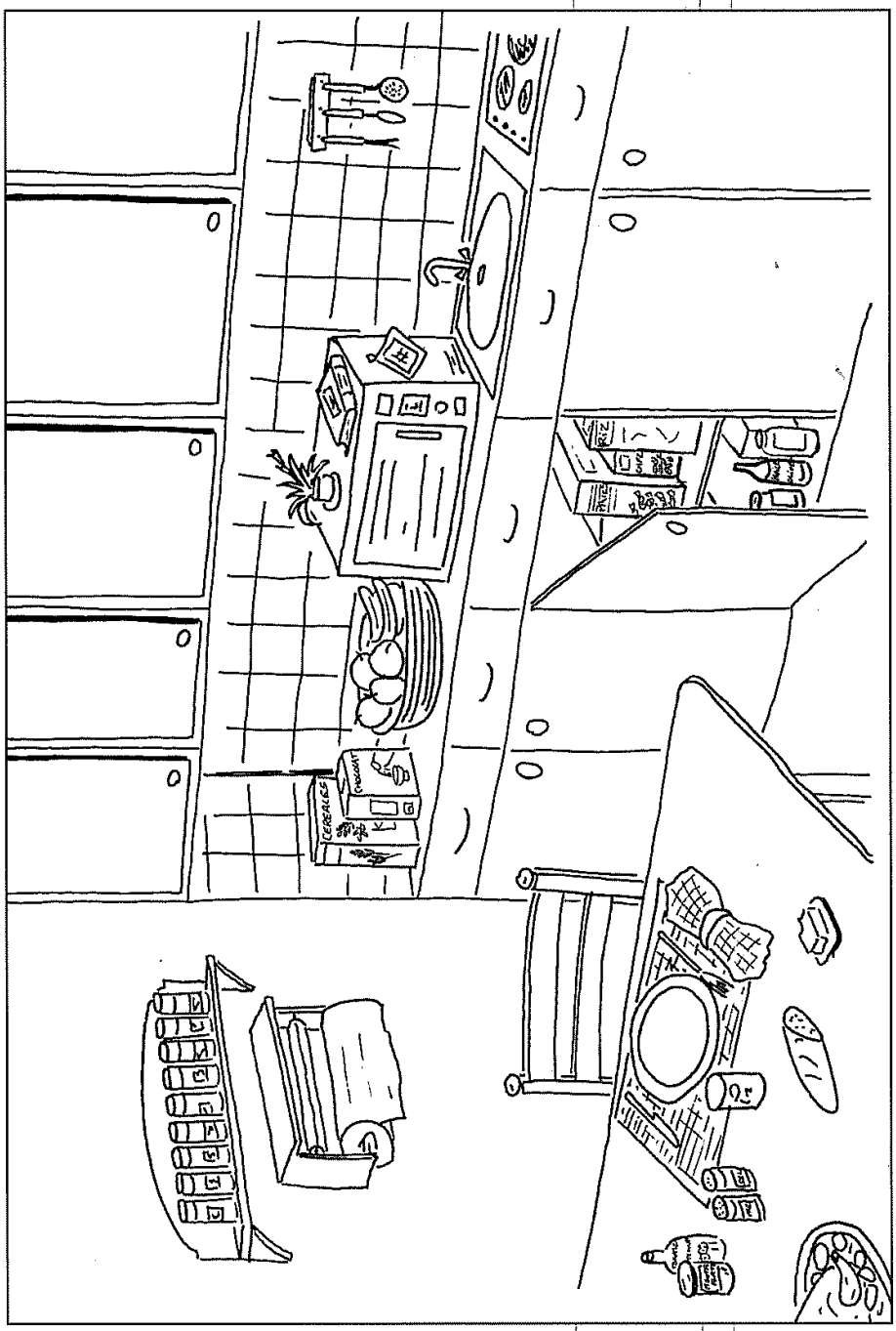
In the classroom *(45 min)*

The teacher divides the students into 4 groups and gives them a drawing of a room in a house See sheets attached)
Using coloured pens, students should colour in the items made from plants
Each group should justify their choices during a plenary discussion.

The educator can ask them to group the items coloured in according to their use e.g. textile, food, medicinal, decorative etc. Using the colour coded sheets; the educator can point out the various groups.

The educator should draw out the concept that plants (and biodiversity) are vital for our everyday life and that it should be protected. .

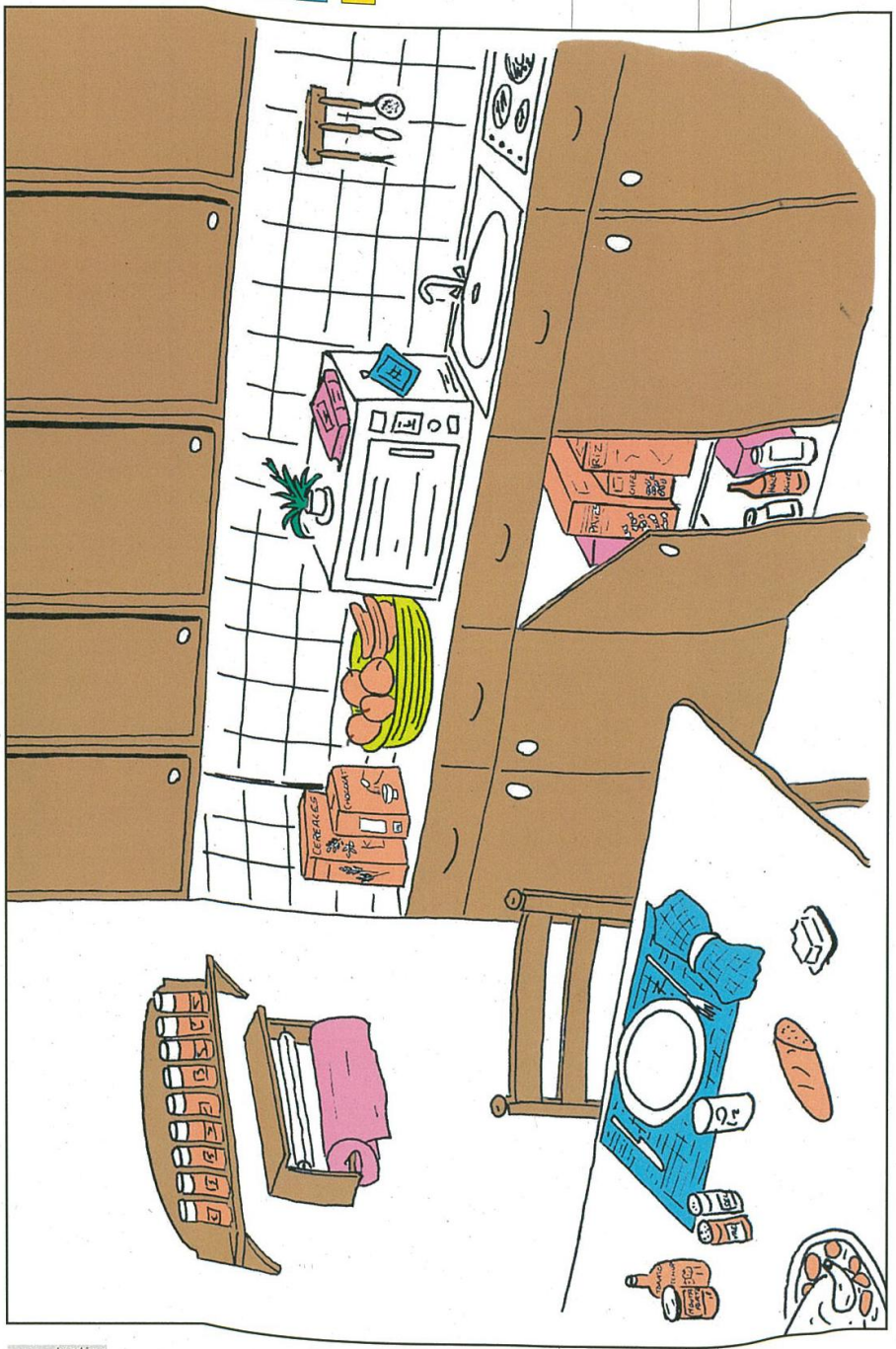
la cuisine



Atelier "les plantes utiles" 2

Bois de construction
Médicaments / produits de toilette
Plantes de décoration
Alimentation
Papier / carton
Objets en bois
Tissus
Autres

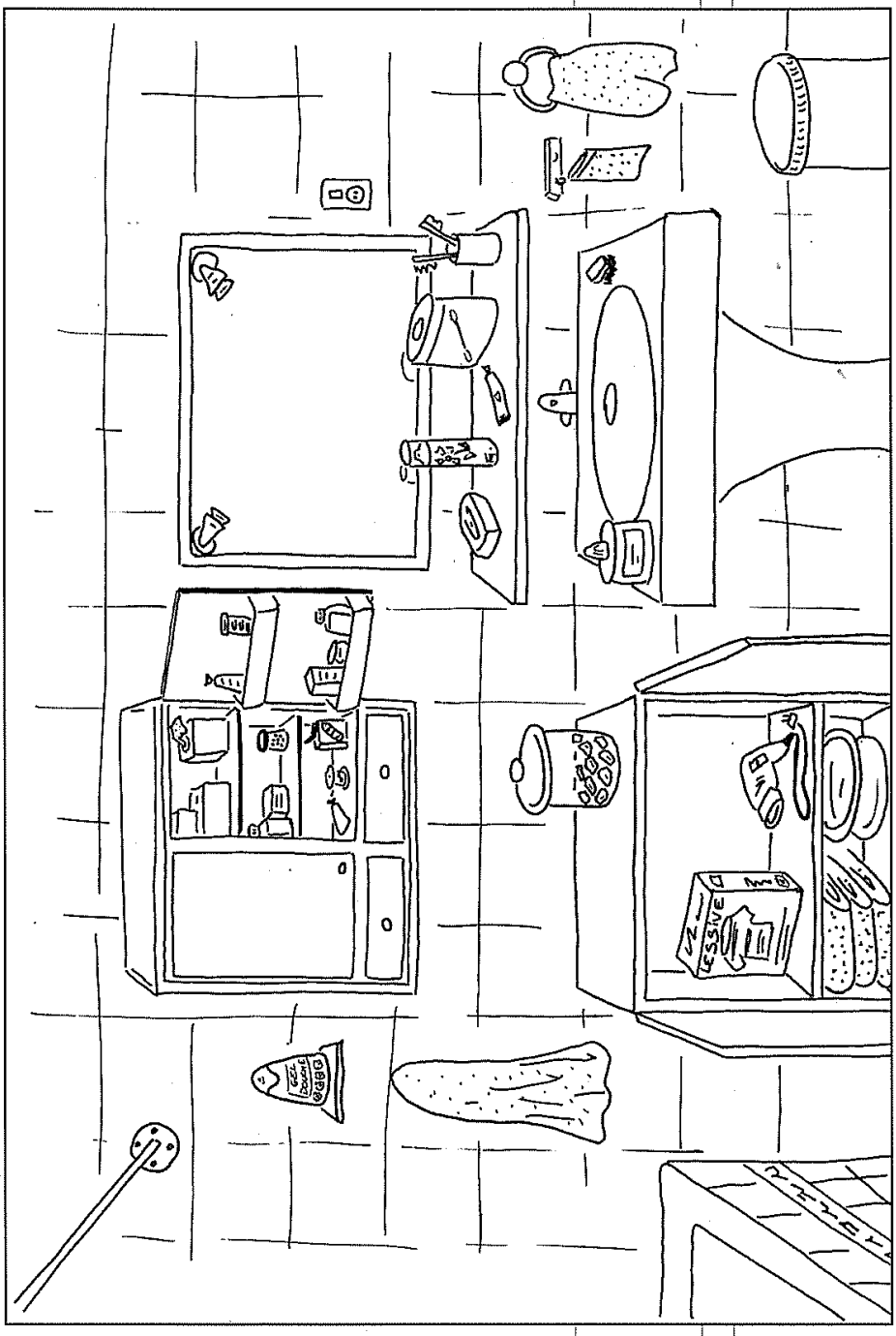
la cuisine



Jardins botaniques de France et des pays francophones
ibotanik

PU 7

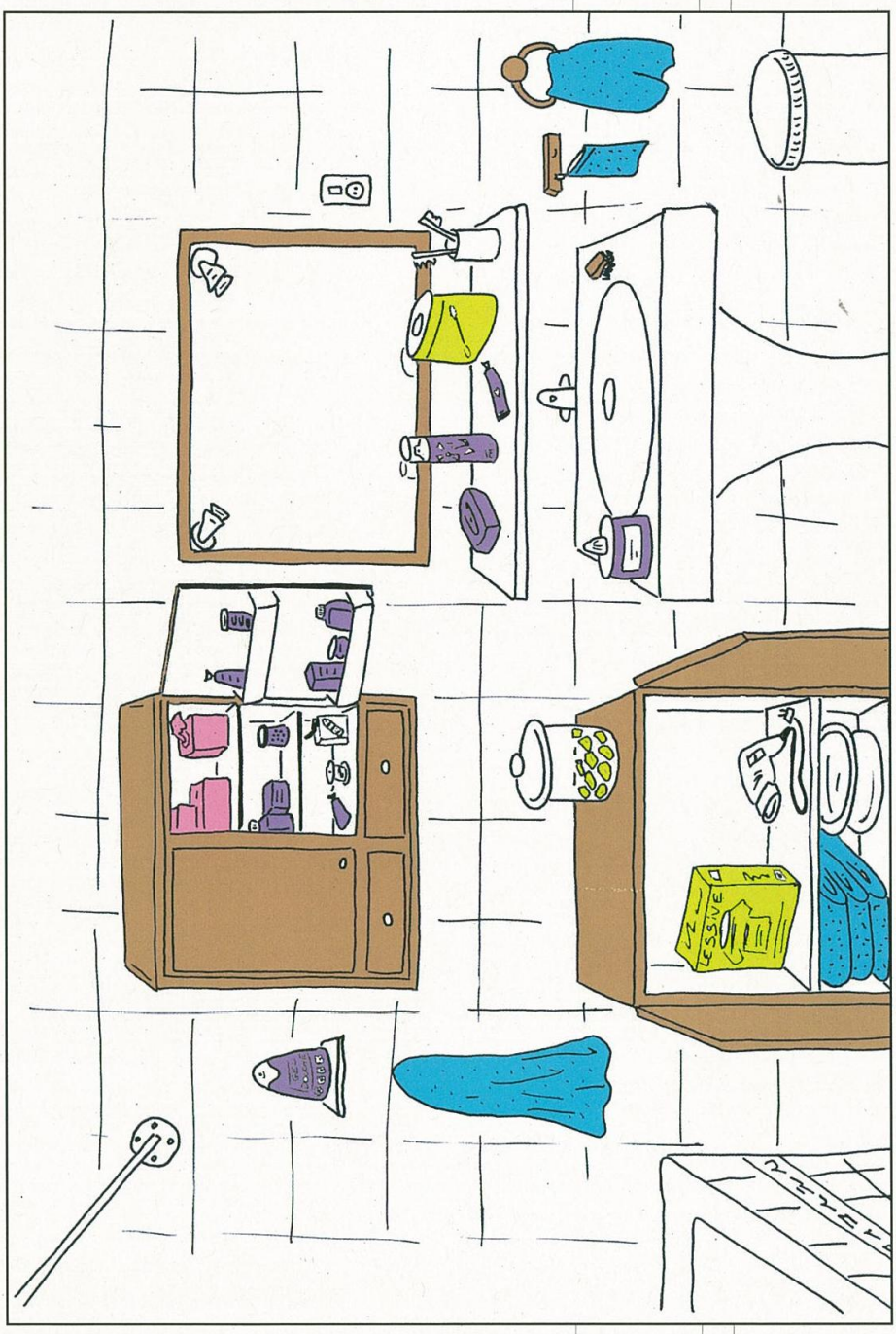
la salle de bain



Atelier "les plantes utiles" 2

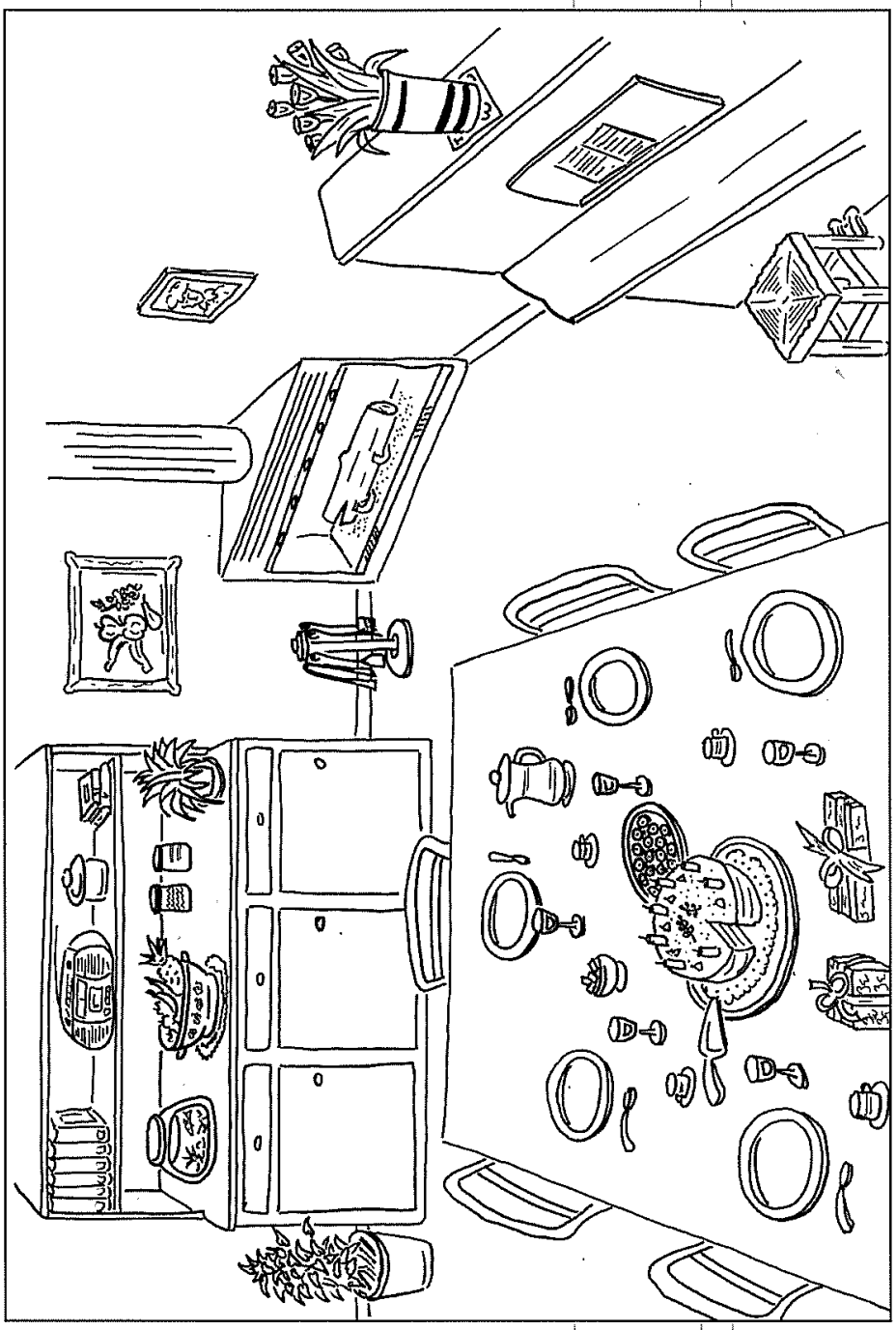
la salle de bain

Bois de construction
Médicaments / produits de toilette
Plantes de décoration
Alimentation
Papier / carton
Objets en bois
Tissus
Autres



Jardins botaniques de France et des pays francophones
[botanik]

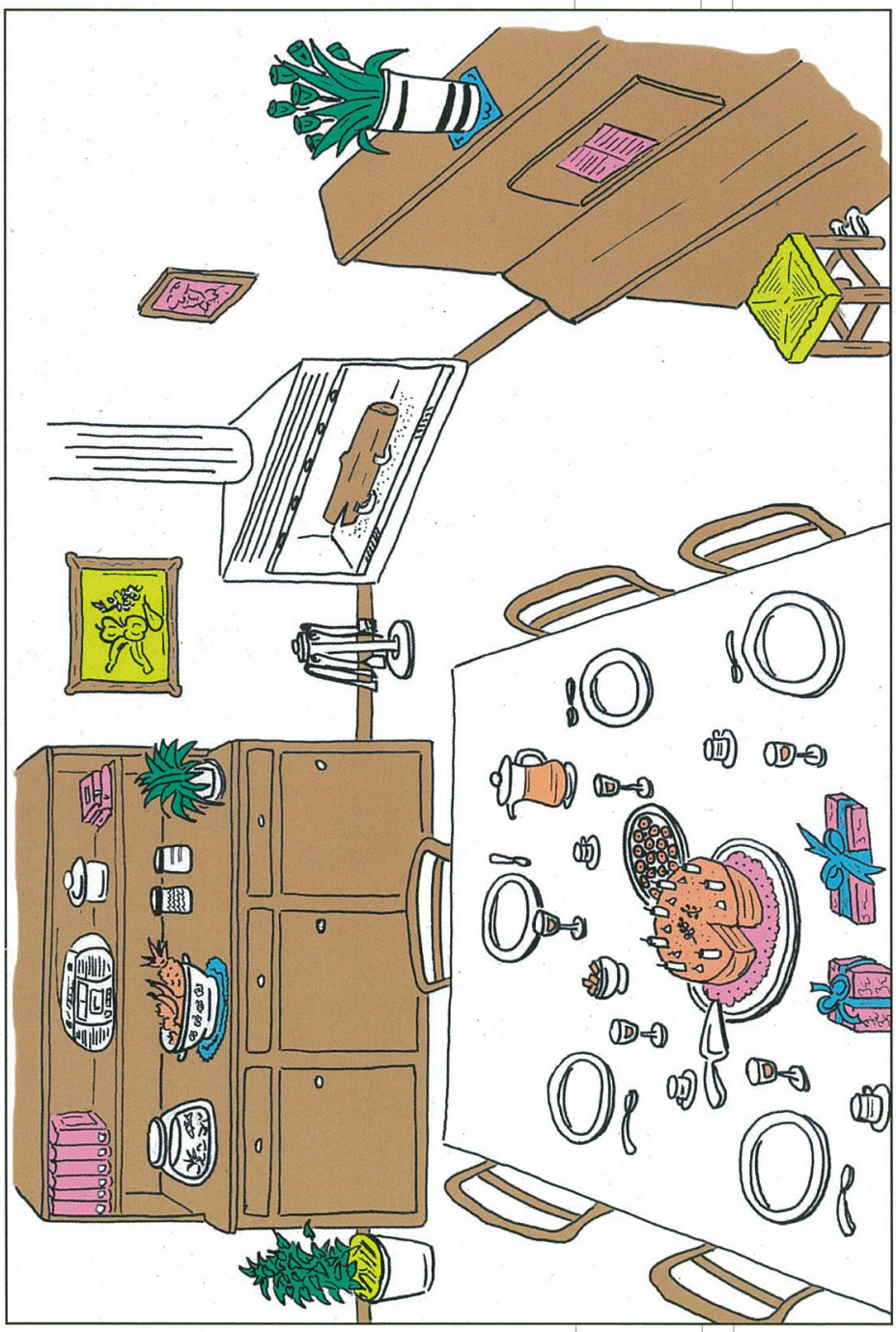
le salon



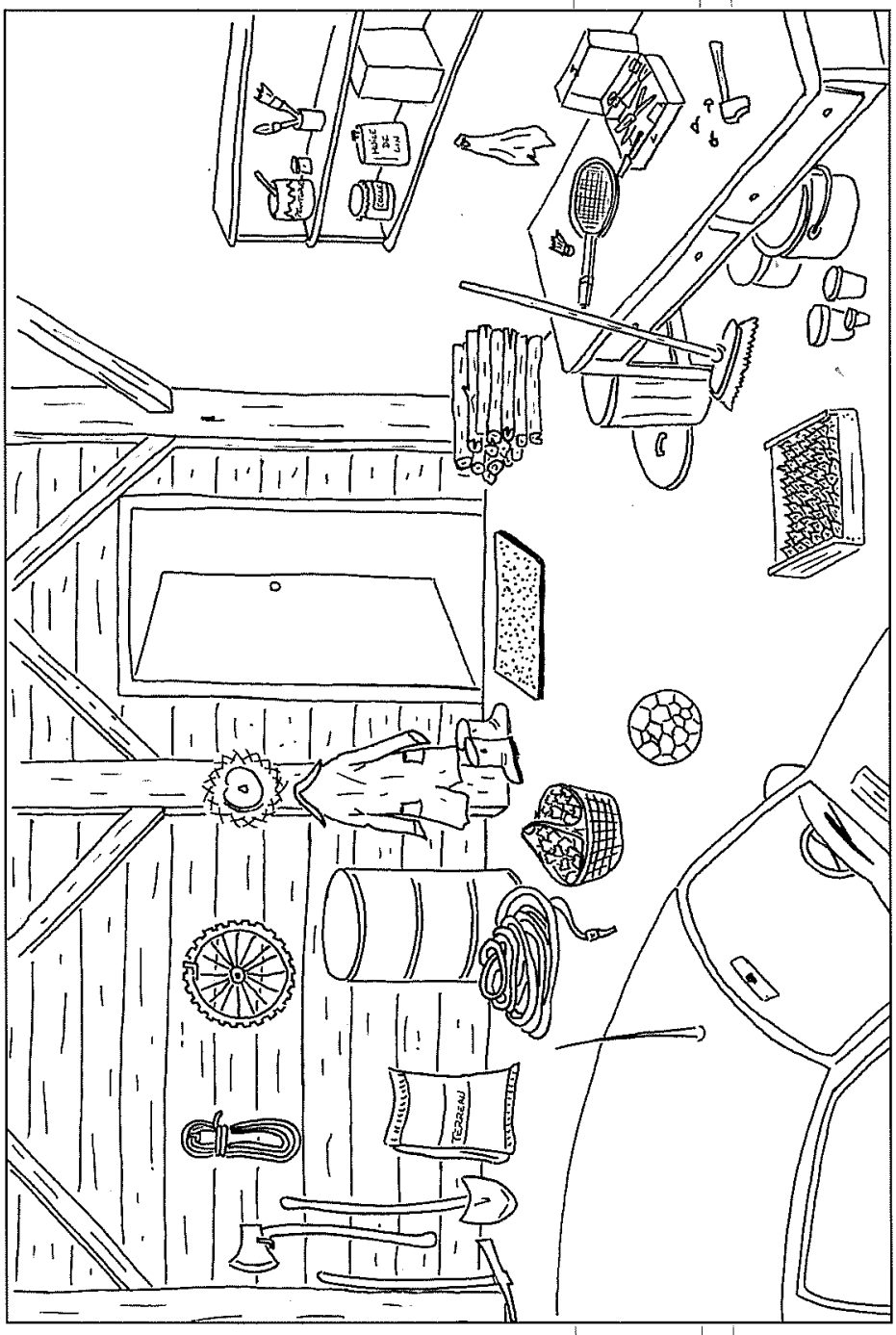
Atelier "les plantes utiles" 2

Bois de construction
Médicaments / produits de toilette
Plantes de décoration
Alimentation
Papier / carton
Objets en bois
Tissus
Autres

le salon



le garage



Jardins botaniques de France et des pays francophones

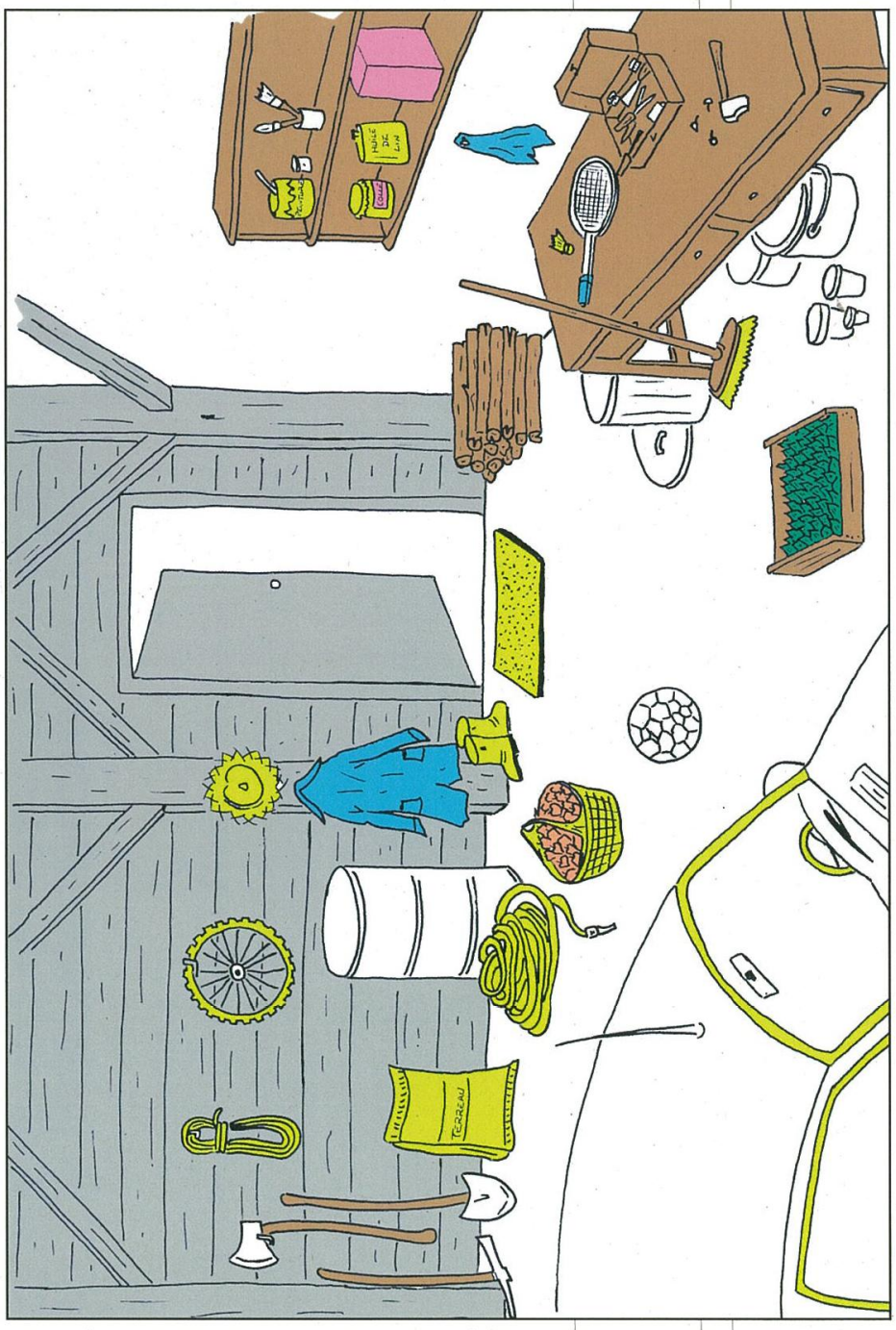
Botanik

Page à photocopier

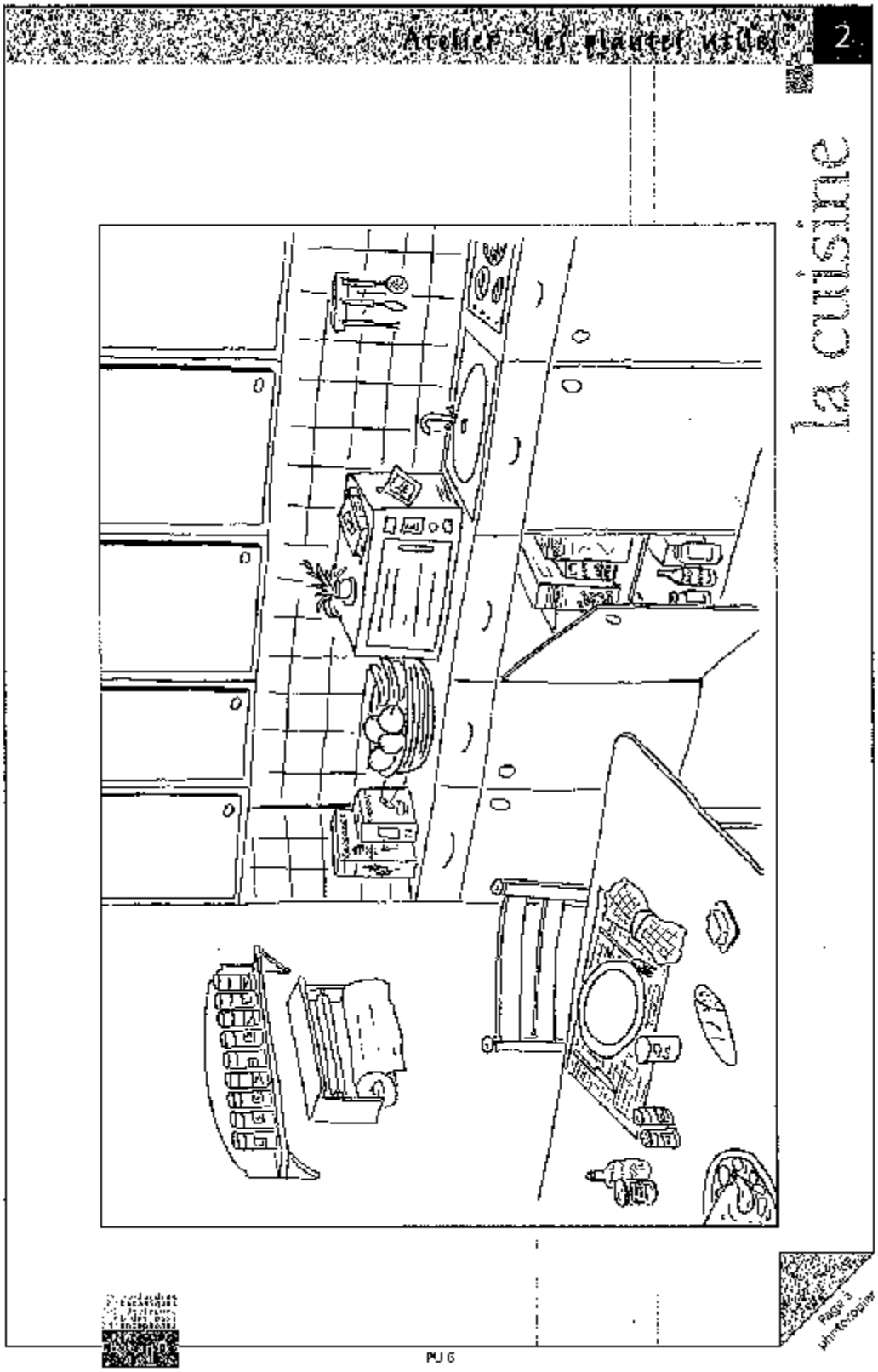
Atelier "les plantes utiles" 2

le garage

Bois de construction
Médicaments / produits de toilette
Plantes de décoration
Alimentation
Papier / carton
Objets en bois
Tissus
Autres



Jardins botaniques de France et des pays francophones
Ibotanik


Atelier "les plantes utiles"
2
la cuisine

Explorers in the Botanic Garden

Institute: Botanic Garden of the University of Coimbra

Developed by: Ana Cristina Tavares

Lesson Overview

Grade: Basic education level on current biodiversity and sustainability curricular programs/3rd to 9th Portuguese grade (ages 9-14) / School students.

Timing: 90-120 minutes.

Abstract

Each sampling exercise and discussion, with new groups of explorers, will bring new results and hypotheses. Once all of these varied results are collated and data-based, they will offer an interesting

In a journey throughout the botanic garden, students are invited to explore different areas of the garden, observing and collecting 'biodiversity' that they find, particularly materials that may reflect adaptation to the environment or seasonal changes. Splitting into small groups, each group will discover a range of different biodiversity samples, during a defined period of time. Following the sampling period, students make a plan of how they will interpret any data about their collected samples . This exercise is best repeated at different times of the year.

- The main goal is to observe the different habitats in the garden and the species that live there, recognizing how and why biodiversity can change through the year/s and observe the different adaptations of the living biodiversity. At the end of the exercise, students are asked to decide in which area they would prefer to live and why, reflecting on how the local biodiversity in that area can adapt.

At the end, students should be able to articulate:

- What is biodiversity; what is the biodiversity of the sampled areas like?
- How and why does biodiversity change during the year/s?
- How can this change be explained?
- What different adaptations occur in different species?

They should also be able to hypothesise and collect evidence to support their argument on:

- Will they find the same biodiversity in the same zone of the garden, in the same seasonal period?
- What are the main factors affecting biodiversity?

study of the Botanic Garden and its biodiversity over time.

Objectives:

1. To provoke curiosity about biodiversity;
2. To develop / enhance observation skills
3. To develop skills for creating hypotheses and evidencing this;
4. To construct knowledge
5. To explore and consider the effects of climatic changes on biodiversity

Type of activity

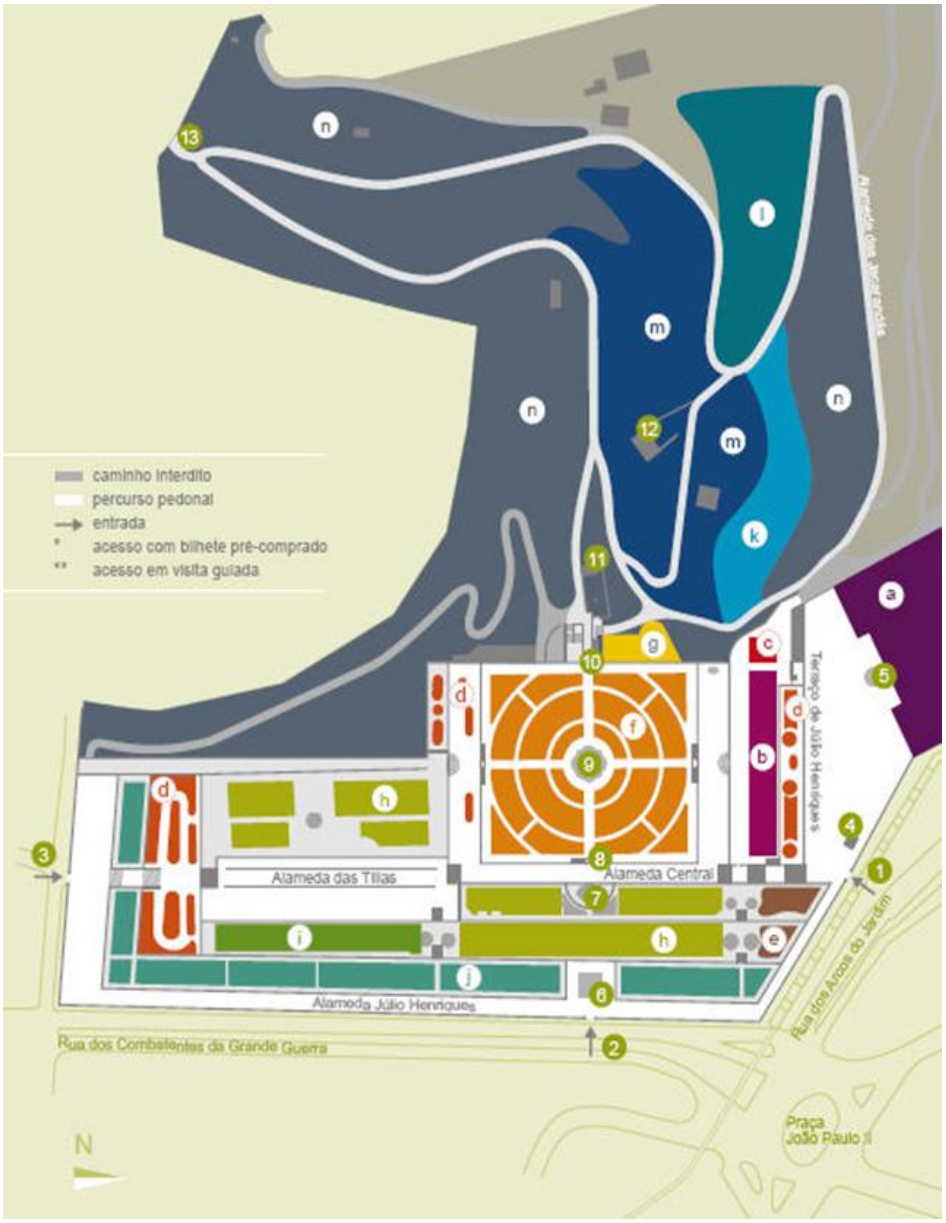
Exploration work in the garden followed by team work, data presentation and plenary discussion with reflection and conclusions.

Student activities

***Context*:** Choose a sample area, using those indicated on the map (Fig. 1) and collect and record all the diverse objects found during the agreed period of time. **Record, design and interpret your biodiversity samples, including factors affecting it, using or improvising any resources you have with you or that you can produce (photos, drawings, sounds, films etc.).**This action should be repeated at different seasons throughout the year/s or (if this is a one-off visit) hypothesise what changes might happen in your sampling area at different seasons. You will need to present your data and findings and share these with your colleagues and teachers. You should reflect on:

- **The biodiversity of the sample area; what was different in this area from any others? Why was it different?**
- **What biotic and abiotic factors are present that might affect the biodiversity in this area?**
- **Will you find the same biodiversity in the same area of the garden on another (later / different season) visit?**
- **Which area of the garden would you prefer to live in and why?**

Students' resources: Any recording material, improvised by students; blank paper; pencil or pen; a bag. N**o support is provided for this activity; students are encouraged to use their imagination and skill to construct their hypotheses, research design and collation of data.**



a. Department of Life Sciences
b. Large Greenhouse
c. Victoria Greenhouse
d. Flower-beds
e. Tropical Corner
f. Central Square
g. Cold Greenhouse
h. Systematic beds
i. Medicinal Plant beds
j. Coniferous Tree Terrace
k. Monocotyledon zone
l. Orchard
m. Bamboo Forest
n. Arboretum

1. Arch Gate
2. Main Gate
3. Ursulina's Gate
4. Ticket Office/ Information Point
5. Statue of Júlio Henriques
6. Statue of Avelar Brotero
7. Bas relief of L. Carrisso
8. D.Maria I Gate
9. Fountain
10. Gateway to the Arboretum
11. S. Ilídio Chapel
12. S. Bento Chapel
13. Terrace (Belvedere)

Fig. 1 – Botanic Garden map

Teaching guide

Prior knowledge: Students are expected to have had previous contact with the garden collections, interpretation and spaces. Any previous visit to and workshops about the Botanic Garden collections by the teacher/educator would be advantageous.

Summary

Small groups of pupils, who have previously been introduced to the gardens and its collections, are invited to explore different areas of the garden, that are representative of different zones and biodiversity. (See map of Garden Zones).

- Each group chooses a sample area, observing and collecting all the biodiversity samples they find, over a set period of time. They are invited to study, organize and record data to describe the sample areas using any methodology, tools and recording options they wish (photos, drawings, worksheets, sounds, films etc.).

Afterwards, through discussion, each group produces a piece of work about the origin, function and use of all their biodiverse findings, characterizing their samples to present to their colleagues.
The main IBSE question is to hypothesise about the value, usefulness and adaptation of the biodiversity in their chosen biodiversity area and to decide if, and how, it may change throughout the year. Students should present their evidence to back up their hypotheses. At the end, each group will decide which area they would prefer to live in, giving their reasons.

Learning outcomes and competences

Knowledge:
Students should be able to:

- Identify and recognize biodiversity in its outdoors context
- Understand the value of biodiversity
- Construct knowledge about the sample areas and their ecological characterization
- Recognise that there is a range of biodiversity in different areas and explain what makes the areas different.
- Have good knowledge of biotic and abiotic factors and their interactions
- Evaluate the effects of climatic changes on biodiversity;
- Understand why the three ecologic factors (biotic, abiotic and interactions) affect our life on Earth
- Relate their knowledge to real life scenarios and human values, attitudes and behavior

Skills: curiosity about nature and interest in biodiversity; observation; creativity; improvisation of tools and resources; developing a research plan; use prior scientific knowledge to recognise and solve problems; work individually and in groups; share a hypothesis with colleagues, negotiating a consensus statement; explore and compare biodiversity to understand its value.

Social learning: to work in a team; to discuss issues with other students; to make decisions; to understand the importance of natural sciences and of scientific work; to understand the need for a sustainable future and behave accordingly.

Lesson outline

Introduction: following the curricular programmes on ecosystems, biodiversity and sustainability, an IBSE approach is developed using the garden areas and resources within different sites and with small groups of students. Different research plans, samples and experiments are interpreted, shared, discussed and reflected on, leading to new knowledge and attitudes.

This is an 'open' activity, however advice can be made available and a range of tools and resources also laid out and made available for the students to use if they wish e.g. plant/animal keys, quadrats, worksheets, magnifying glasses, paper, pencils and measuring instruments, including those to test soil, temperature, ph, sunlight etc.

List of activities:

- **The lesson could start** by asking students to look into one area of the gardens and observe the diversity of living organisms. Then the students can discuss their findings. The educator can introduce the term biodiversity and ask students 'what factors may affect biodiversity in an area?'. The educator can later ask the students 'Do all the areas in the botanic garden have the same degree of biodiversity?' Students should brainstorm how they may find answer to the question (e.g. methods, focus of their investigation etc.).
- Students should reflect on how each group could explore a different area but have comparable results? Students should come to a consensus on how they will assess biodiversity in a consistent way so that groups can compare their findings. Ask pupils not only to look at the biodiversity of different areas in the garden but also try to explain what factors effect biodiversity in their selected area.
- Once each group has visited its chosen Garden zone and collected / recorded their findings and samples, each group should analyse their results and come to a conclusion about the nature of their area's diversity.
- Questions to provoke discussion could include:
    - Do all the areas have the same degree of biodiversity?
    - Which areas have higher biodiversity and why?
    - Will the biodiversity levels stay the same throughout the year?
    - How can they answer the previous question?

NB

IBSE is about taking students on a journey. The teacher has the role of facilitator that helps students to scaffold their learning. This can be done by setting challenges and providing students with helpful questions.

This lesson can also build students' understanding of biodiversity by looking at plants adaptations. If plants do not adapt, they will not survive. Different adaptations lead in biodiversity.

Instead of giving students a very general question to answer you can give them 'challenge' questions.

e.g. 'Visit different locations and report back on what you find through observation. Think about how you are going to do this. Think about how you will explain your findings to the rest of the class'.

Alternatively you may start this session by the following introduction:

‘In the botanic garden we have created areas that resemble areas in the world. What is different and what is the same between these areas? Can you explain why?’

- You can use various open questions to help students focus their investigations.
- What are you seeing? Can you explain what you see?
- How do plants survive in very wet areas? What challenges to they face?
- How would you survive in a desert? Can you see any plants that can survive in a desert?
- Find where this plant would survive. How does having leaves like that help the plant to survive?
- Describe the place by using your senses. Feel, smell, look and touch.
- How many different plants can you see? How do you know they are different?
- What makes the plants different? (You may need to provide students with information cards)
- Could you live here? What challenges would you face? How would you overcome them?
- What challenges do the plants face? Do they overcome them?
- What can you learn about survival by looking at plant adaptations?

Send the students to look at areas. Ask them to describe the following when they come back: What are you seeing? Can you explain what do you see? Ask the students to think about the differences and go back and observe in more detail the differences so that they will be able to give more detailed explanation on why the areas are different.

Provide students with **progressive activities** i.e. They will make an initial observation and come back and discuss their findings. They may then start formulating their own questions; following this, send the students back to do more focused observations and return to discuss their results. This way the teacher can facilitate, but not direct, learning.

Plenary: The groups present and discuss their samples in a plenary, using their data and analysis of results, providing evidence to back up any hypotheses.
After each group has presented their findings, there is an open debate session facilitated by the teacher/educator. Students should debate and reflect on: ‘How can biodiversity be defined and studied?’; ‘What is the value of biodiversity?’; ‘How can biodiversity be affected and what are the main factors that affect it?’; ‘Will we find the same biodiversity in the same garden zone next year?’; ‘If you have to live in this garden, which area would you prefer to live in and what challenges would you face?’

Assessment

Observation of the students; oral communications between the student and teacher; debates and discussions; feedback questionnaire (See sheet below)

Resources

Students can use any personal resources they have brought with them; blank paper, pencil/pen, a bag etc. Completing worksheets is an activity that can make the students lose their curiosity and creativity and it is important that students are facilitated to formulate questions and find answers. If desirable, the following resources can be made available for the students to select from; Light meters, humidity meters, cameras, thermometers, information sheets . They should decide themselves which tools they would like to choose for their investigation.

Follow up work

Depending on the garden samples and the research plans of the explorers, each session that takes place will provide a wealth of data. All records /documentation over the years could be held in a 'GBDB-Garden Biodiversity Data Basis', and made available for students to follow up with long term research into the nature and changes to biodiversity in the garden.

Acknowledgements: a special thanks to Asimina Vergou (BGCI) and Christine Newton (Royal Botanic Gardens of Kew) for the commentaries on this teaching guide.

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Feedback questionnaire

Please complete the sentences below:

1. **What I enjoyed doing most today was**
   ……..……..……

2. **One thing I learned about the botanic garden is**
   ……..……..…

3. **I learned that Biodiversity is affected by.....**

4. **Something new I learned today is……..……**

5. **I understand more clearly that……..……..…**

6. **As a result of your experiences in this garden activity, which of the following do you feel <u>more</u> <u>confident doing</u>:** (please circle the best answer)

   a) Working out how biodiversity samples can change during the seasons 'year or throughout the years?
   (Yes) *(No)* *(Maybe)* *(It's not something I would do anyway)*

   b) Talk to a friend about different biodiversity in a botanic garden?
   (Yes) *(No)* *(Maybe)* *(It's not something I would do anyway)*

   c) Present your ideas about world biodiversity in a debate, discussion or assembly at school?
   (Yes) *(No)* *(Maybe)* *(It's not something I would do anyway)*

7. **What I enjoyed the most today was……..……..**

8. **What I least enjoyed was……..……**

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9. **Please circle the words that best describe how you feel:**

'As a result of my experiences in the garden activity today, I feel…
<u>more inspired</u> *<u>less inspired</u>* *<u>about the same</u>*
…to find out more about the natural world.'

10. Is there anything you will do as a result of being involved in today's activity?

- ☐ Nothing
- ☐ Look on the internet for more information
- ☐ Notice nature more and think about what affects it
- ☐ Watch nature programmes on TV
- ☐ Visit another museum, zoo or park
- ☐ Join a nature or science club
- ☐ Read more books or magazines about the natural world
- ☐ Something else – what?

……..……..…..

11. **Has your visit to the Botanic Garden today changed the way you feel about science?** (Please circle)

Not at all 1 2 3 4 5 6 7 8 9 10 A lot

12. If your feelings have changed, in what way have they changed?……

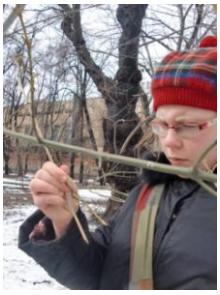
13. How do you think this activity could be improved?……..……..

Thank you and come back soon!

What Story Could a Twig Tell?

Institute: M. V. Lomonosov Moscow State University Botanical Garden

Lesson developed by: Alla Andreeva



Grade level: 5-7 (age 10-13 years)

Duration: 3 hours

Summary:

The aims of the lesson are:

- to study annual growth of various species of trees in the Garden over the past 3 years (or more) and to identify which trees have the fastest and slowest growth rates;
- to establish whether the growth rate is identical for all species;
- to construct a hypothesis about the differences observed in annual growth rates;
- to explain how annual growth depends on weather (climatic conditions) and twig orientation relative to the sun;
- to identify the most and least favourable conditions for plant growth.

Students are asked to construct hypotheses about why some trees grow faster than others in identical conditions. A discussion is held with students on how climate change impacts on plant growth and a forecast is made of how these plants will look after several years of climate change

Key Words: Shoot, annual growth, climate change, apical buds, lateral buds, leaf scars, annual rings.

Learning Outcomes:

- Students recognise the morphological features of twig structure
- Students can identify annual rings and measure annual growth of twigs
- Students can construct hypotheses and draw up research plans to test these.
- Students can draw conclusions from what they observe and make forecasts on the basis of their results.
- Students can observe, in real conditions, that annual growth of shoots on trees varies from year to year depending on growing conditions (humid or dry, warm or cold), and that this is ultimately linked to climate change.
- Students can discuss the possible consequences of how climate change might affect plants growing nearby, establishing what conditions are favourable and unfavourable for plant growth, which trees grow fastest and which grow more slowly, and whether this is due to their origins (e.g. plants from a cold clime grow faster in the Garden than plants from a warm climate, such as the Caucasus)

Competences

Knowledge

Students learn about the structure of shoots (morphology) and where annual rings come from;

They learn to distinguish between twigs of different species of tree, to identify trees in their winter condition (from buds), how to measure annual shoot growth to compare growth in different species of tree over 3 years, building hypotheses to explain these phenomena and their connection with changes to the climate. They draw conclusions and test their hypotheses by analysing their findings.

Skills:

- Ability to make independent measurements, working in small groups;
- Observing and comparing differences in the structure of shoots (attributes);
- Working with a binocular (stereoscopic) microscope and making drawings of shoots;
- Presenting results in the form of graphs (compile graphs) and comparing them. (Computer software may be used to create diagrams if the children have those skills)

Social learning and personal development:

- Communication skills, working in small groups;
- Developing critical and analytical thinking, articulating thought and constructing hypotheses;
- Presenting ideas and evaluating other students' views;
- Conducting thought experiments.

Curriculum content

Students develop a theoretical knowledge of: the structure of shoots (in botany classes), climate and climatic factors and the direction of light (in nature studies and geography classes), as well as mathematical skills and knowledge (compiling graphs, calculating averages), the ability to work with a magnifying glass and microscope, and to make measurements using a ruler (in nature studies classes).

Overview of Activities

Working in small groups, the students use a magnifying glass to study shoots cut from trees, noting their structural features and annual rings. In the field, they make independent measurements of annual growth over a 3 year span, of shoots on different species of tree (growing in the Botanic Garden, parks, near their school etc.).

The results are compared to identify differences in annual growth rates and to discuss how these might be related to climate change. During the discussion they identify which trees are most or least affected by changes in climatic conditions. Students put forward hypotheses about how future climate change might affect various plants in their immediate surroundings (in the natural environment, in town, near their school etc.). They conduct thought experiments about how the plants might look if climatic changes are (1) unfavourable or (2) favourable, and illustrate these with sketches.

Prior Learning:

The students must have an understanding of shoot structure, buds, how plants grow and what growth is. They need to know 3-5 different species of tree, the differences between them and be able to identify them. They must also know what climate is and which climatic factors affect plant growth (temperature, humidity). Finally, they must be able to use a binocular microscope, to construct graphs and diagrams, and to make measurements with a ruler.

Guidelines for Teachers

Equipment and materials: magnifying glasses (binocular microscope), rulers, compass, 6-7 winter twigs cut from various species of tree (depending on number of students), fallen tree branches (6-7), field diary.

Introduction to the Lesson

The teacher asks the students questions designed to recall basic textbook knowledge of what a shoot is and what its structural features are.

Demonstrating several freshly-cut winter twigs* from different species of trees, the teacher asks:

- Are these twigs from the same tree or from different trees? How do they differ?
- What can you see on the twig in winter?
- Is it possible to identify this tree in winter? How?
- What marks can you see on the twig? What are these and how are they formed?

*It is preferable to use freshly-cut twigs as the buds on fallen twigs are often dried up and difficult to identify.

The teacher comments on and develops the students' answers, while drawing the structure of the twig on the board; she then points out the twig's structural features (tip buds, lateral buds, leaf scars, annual rings)

The teacher asks the class to discuss:

- When (during which season) do the trees actively grow?
- Do all plants grow at the same rate each year?
- What might growth depend on? Is this always the case (is it the same every year)?

The teacher invites the students to answer the questions on the basis of their own experience and observations. After a brief discussion, she suggests checking the students' answers in practice and assigns tasks in the form of questions to which the students must find answers through classroom research.

- How much do the trees grow in one year? (Is it always the same, or does growth vary?)
- Do different types of tree grow by the same amount? Which twigs grow fastest?
- What does the growth depend on? Can you predict how much a twig will grow?
- Can you tell from a branch's structure what conditions it grew in?

Lesson Plan

Student Activities and Instructions	Resources
Activity 1 The teacher invites the class to split into small groups of 2-3. Each group is given twigs cut from various species of trees*, magnifying glasses and rulers. The teacher asks the students to study the twigs through the magnifying glass and to identify: 1) how they differ; 2) to which species of tree they belong (with the help of drawings of shoots and buds); and 3) to find annual their rings and measure annual growth for the past 3 years using a ruler (noting the results in Table 1, Resource 3). Each group's measurements are entered in a table, which the teacher draws on a board. The teacher then asks the class to discuss why each group has different measurements and to construct hypotheses - e.g. because the twigs are from different species of tree or are growing in different conditions. Example of Hypothesis: 1 - Growth is not the same for all trees; 2 - Different types of trees have different rates of growth; 3 - Growth depends on germination conditions (discuss which conditions). Discuss how to find an answer to this question. Suggest that the students compile a research plan to find answers to these questions. Discuss the proposed research plans and allocate tasks to each group.	***Resource 1*** Drawing – "prompt" on twig structure in workbooks. Winter twigs cut from different species of tree. ***Resource 2*** Drawings of shoots and buds for identifying tree species. ***Resource 3*** Table 1 (Comparison of measurements of annual growth for the last year in different species of tree)

Activity 2 **Field observations**. The students are invited to go out into the Botanic Garden (school grounds etc.) to perform independent observations based on the research plan they have compiled. As they go out into the Garden the teacher provides orientation for the students (points out which direction is north and which is south) and gives each group a compass. The teacher explains that the students should measure not one, but 3-4 twigs growing in identical conditions. Each group selects a tree, finds out what species it is and where it originates from (from the table) and then measures its annual growth for the past 3 years in the lower branches on the north and south sides. The measurements are recorded in a notebook and subsequently entered in pre-prepared table in the classroom (***Resource 4).***	Trees growing in the botanical garden, school grounds, park, on the street. ***Resource 4*** Table for recording measurements.
Activity 3 Continuation of work in classroom or laboratory. Students present their results in the form of tables and construct diagrams (calculating annual averages and illustrating the results in the form of diagrams or graphs).	***Resource 4*** Table for recording measurements (field observations)
Activity 4 Students are invited to think about their findings in the light of their hypotheses and reach conclusions (where they right or wrong?). Example: Do the results show that growth is different on the north and south sides? (discuss why)	***Resource 5*** Descriptions of climatic conditions in the trees' location in 2011-13 (compiled by the teacher).

Activity 5 Discussion – plenary Each group presents its results and conclusions Questions for Discussion: • In which years was twig growth greatest and smallest? • Are the years of greatest and smallest twig growth the same for all the trees? Invite the students to produce hypotheses to explain their findings. Questions – prompts: The teacher invites the students to establish whether the results are connected with the climatic conditions in each individual year and to answer the question: "Which conditions are favourable and unfavourable for plant growth?" Additional Question: • Which trees have the smallest and greatest growth? Invite the students to propose hypotheses and discuss. Ask them to compare the data in the summary table and draw conclusions about whether there is a connection between the trees' place of origin and their rate of annual growth in the Botanic Garden.	***Resource 6*** Summary table of growth measurements in different trees Descriptions of climatic conditions in the trees' location in 2011-13 (compiled by the teacher).

Assessment Activity 1. The students put forward hypotheses on how future climate change might affect growth in various plants in their immediate vicinity (in the natural environment, in towns, near the school etc.) and conduct thought experiments on how the plants will look in the event of (1) unfavourable or (2) favourable changes in climatic conditions. The teacher presents the results in the form of sketches. The teacher gives each group some fallen branches from different species of tree and invites them to describe the history of each branch, confirming this through observation. They should additionally identify the species of tree from the structure of its shoots and buds.	Hand-outs: fallen branches from various species of tree.

Background Information

Annual growth of shoots depends largely on climatic factors (temperature, humidity and period of active growth). The growth rate is highest in favourable conditions and lowest in unfavourable conditions (drought or lengthy frosts), so the primary impact of climate change is on growth.

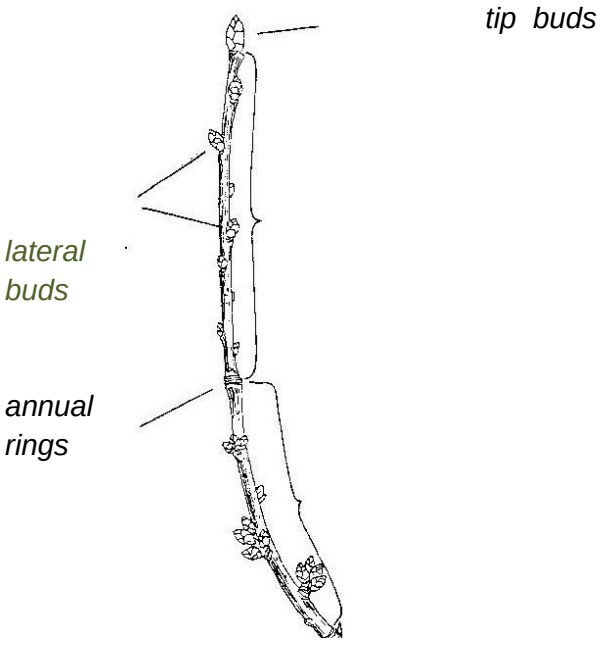
Shoot growth differs depending on which side of the tree a twig is growing (it is usually less on the north side). In their winter state, plants (trees and bushes) can be identified from the structure of their shoots and buds. There are special guides to help identify plants in their winter state on the basis of the following attributes: location of buds on the branch, colour of shoots, form and size of buds, number of bud scales, presence of fluff or hairs, form and size of leaf scar, presence of thorns or barbs on shoot.

Growth in the main shoot (from the apical bud) is usually greater than in lateral shoots.

Student Materials and Worksheets:

Resource 1

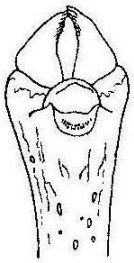
Drawing – "prompt" on twig structure



Show the annual growth of the shoot on the drawing and sign it!

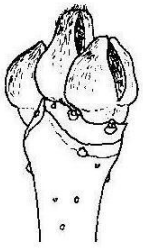
Resource 2

Drawings of shoots and buds for identifying tree species.



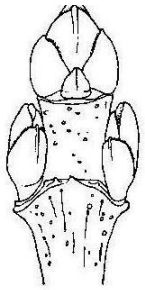
Ясень
обыкновенный

Fraxinus excelsior
Common Ash



Клен
ясенелистный

Acer negundo
Ashleaf Maple

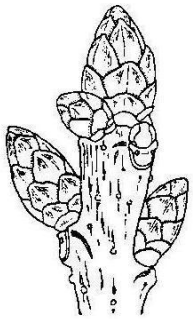


Клен
остролистный

Acer platanoides
Norway Maple

Липа
мелколистная

Tilia cordata
Small- leafed Lime



Дуб черешчатый

Quercus robur
Common Oak

Тополь дрожащий
(осина)

Populus tremula
Aspen

Resource 3

Table 1. Comparison of Annual Growth of Different Species of Tree during the Last Year

Group No.	Tree Species (local name) Examples	Type of Tree (scientific name in Latin), origin	Growth during last year (indicate year, e.g. 2013)	Growth during preceding year (2012)	Growth two years ago (2011) etc.
1.	***Lime***				
2.	***Common Ash***				
3.	***Aspen***				
4.	***Ashleaf Maple***				
5.	***Norway Maple***				

Resource 4

Table of Measurements (Field Observations)
Species of tree: _____

	Growth(North Side)			
	Sample 1	*Sample 2*	*Sample 3*	*Average*
Growth during last year (indicate year, e.g. 2013)				
Growth during preceding year (2012)				
Growth two years ago (2011) etc.				
	Growth (South Side)			
	Sample 1	*Sample 2*	*Sample 3*	*Average*
Growth during last year (indicate year, e.g. 2013)				
Growth during preceding year (2012)				
Growth two years ago (2011) etc.				

Resource 5

Description of Climatic Conditions in 2010-13 for Each Location (compiled by teacher and presented in tabular form)

	Description of Climatic Conditions		
	Average temperature in spring and summer months	***Precipitation, mm***	***General description***
Indicate year e.g. 2013			
Previous year, 2012			
2011			

Resource 6

Summary Table of Growth Measurements in Different Trees

Growth	**North Side (Average Measurements)**			
	Species 1 Name:	*Species 2 Name:*	*Species 3 Name:*	*Species 4 Name:*
Growth during last year (indicate year, e.g. 2013)				
Growth during preceding year (2012)				
Growth two years ago (2011) etc.				
Growth	**South Side (Average Measurements)**			
	Species 1 Name:	*Species 2 Name:*	*Species 3 Name:*	*Species 4 Name:*
Growth during last year (indicate year, e.g. 2013)				
Growth during preceding year (2012)				
Growth two years ago (2011) etc.				

UiO : Naturhistorisk museum

See, smell, taste, cut and cooperate

Institute: Natural History Museum, University of Oslo

Developed by: Kristina Bjureke

Age group: A lesson plan for inquiry based learning for 4th -7th grades.

Duration: Pre-work 1 hour, visit the Botanical garden 2 hours, post-work 2 hours

Summary

This lesson allows students to explore the nature of fruits and vegetables, both botanically and in the culinary sense. Students develop hypotheses on which plant images (or actual fruits and vegetables) are botanical fruits and which are not. Students have the opportunity to sow fruit seeds themselves and monitor their growth. The students also observe the fruiting plants in the Botanic Garden.

Learning Outcomes

Students will learn:

- **What fruits and seeds are**
- **What fruits and vegetables are**
- Different types of fruits
- What makes seeds germinate
- **Where certain fruits originate from**
- That plants can be propagated by seed

Competences / Curriculum links

The lesson plan fits into the following competence in science for *the budding researcher* and *Diversity in nature*:

Competence aims after Year 2

The budding researcher:

- ask questions, talk about and philosophize on experiences in nature and man's place in nature
- use his or her senses to explore the world in the local neighbourhood
- describe his or her own observations from experiments and in nature

Diversity in nature:

- recognize and describe some plant and animal species and sort them

Competence aims after Year 4

The budding researcher:

- use natural science terms to describe and present his or her own observations in various ways
- collect and systematize data and present the results with and without digital aids

Diversity in nature:

- talk about the lifecycle of some plant and animal species

Competence aims after Year 7

The budding researcher:

- formulate questions on something he or she is curious about, prepare a plan for examining a hypothesis he or she has formulated, carry out the examination and discuss the result

Diversity in nature:

- examine and describe flowers and plants and explain the functions of the different plant parts
- describe the characteristics of a selection of plant, mushroom and animal species and tell others how these are ordered systematically

IBSE teaching

The teaching program is based on the inquiry based teaching method in which students should be given the opportunity to explore certain issues and develop their understanding based on their own experiences. The proposals for the work have been prepared to encourage students to work on their own and develop an understanding through direct experience, sowing seeds themselves and identifying fruits and vegetables using taste, smell etc ("do it"), exploring question or researching information in books and on the internet ("read it "), debating and discussing issues in groups or in plenary sessions ("say it"), and developing hypotheses and proposed solutions (" write it ").

Background Information for teachers

There are many websites about fruits. On the following link you can search for common and more exotic fruits. Note that berries are categorized by how they are consumed, not in botanical terms. Each fruit is presented with a printable fact sheet:
http://www.frukt.no/leksikon/frukt/

The Lesson Plan

The proposed lesson program is divided into *a pre-work session* at school, *an excursion to the Botanical Garden or lab/workbenches outside/inside the school*, and *a post-work* session at school. For the students to achieve the best outcome, it is important to complete all three parts.

Pre-work: Fruits

What is a fruit and what is a vegetable?

Begin by showing a familiar example of something everyone has eaten: a tomato.

The educator should work through a number of questions and responses with the class, as per the list below. The answers to the questions are given in italics

Ask: Is the tomato a fruit or a vegetable?

Tomato is in fact both fruit and vegetable - it depends on what glasses you are wearing! When you go to the grocery store to shop tomatoes you go to the vegetable counter. The word 'vegetable' is a non-botanical word that we use daily. Tomato is most often used in savory dishes and appetizers, so in culinary terms we call it a vegetable.

Ask: Can you give examples of other vegetables?

You may receive replies like cucumbers, peppers, celery, beans, peas, avocado, broccoli, cauliflower, carrots and squash.

Ask: We usually refer to the tomato as a vegetable, but it is also a fruit. Why is that true?

Before the tomatoes formed, the tomato plant had flowers. They were pollinated and fertilization took place of eggs inside an ovary. The fertilized eggs developed into seeds and the ovary became the tomato fruit with seeds inside. Ideally the answer you want is that all fruits contain seeds.

Ask: Are all other vegetables also fruits, then?

No. Not all the vegetables that we eat are fruits. Tomatoes, peppers, avocados, beans, peas and squash are fruits. They have grown where there was once a flower. However other vegetables are from other plant parts - cabbage is leaves, cauliflower is undeveloped inflorescences, the broccoli we eat is stems and flower buds, we eat the root of the carrot and parsnip and the celery we eat is the leaf stem.

Ask: How can we know that this tomato, as seen through a botanist's eyes, is a fruit?

It has seeds inside. Suggest the group cut it open and check if there are seeds inside it.

Activity: Hand out sheets with pictures of fruits and vegetables (see images) and ask students (in pairs) to consider which are vegetables and which are fruits. When presenting their results, they must justify their answers.

Fruits, in the view of gardeners and botanists, are divided into different types, and tomatoes are in the category of berries. There are many different fruiting structures. There is a *definition* for each fruit type. Use the set of questions below to explore fruiting structures.

Ask: What is a definition of a berry?

Definition of berries: *juicy, fleshy fruit that is formed from a single carpel. Most often many seeds scattered in the pulp. Exception is a berry with just one seed, the avocado.*

Ask: How can it be right to say that the tomato is a vegetable, a fruit and a berry?

Students should examine the fruit and justify their answers

Task:

Provide definitions of different fruiting structures and ask the students to think of fruits that we eat that might fit into these categories (other than berries)

They might know: nut and capsule. Bring some edible fruits and ask students to suggest what type of fruiting structure their fruits have, with the help of a definition sheet.

Plenary: The group presents the answers on their fruits and fruiting structures to their colleagues, justifying their results. The students can discuss the findings and challenge opinions. The educator should note key words and definitions on a board. This exercise often throws up many other questions that the children could be asked to research such as: 'Why are fruits in the vegetable counter in the store?'; 'the banana is in the fruit counter and not in the vegetable counter - why?'

Visit to the Botanical Garden (or an exercise in the laboratory or other outdoor space)

Resources:

- Sheets with images of fruits / vegetables
- A selection of fruits
- Soil / potting compost
- Large soda bottles (labels removed)
- Knives / Scissors/ awl
- Tags/ labels
- Sticky tape to bind bottle halves together
- Paper to work on
- Water

NB: The class can jointly visit a grocery store and buy the fruits, or the teacher may have prepared the session by shopping in advance.

Ask: What does this fruit come from?

Students should make a connection to a plant.

Ask: How can we get another fruit like this without buying one or being given one?

Students should suggest that we can open the fruit, pick out the seeds, and sow them.

Task: Hand out a different fruit to each student (or groups of students). They can photograph or draw the fruit. They can visit the fruit plants in the botanical garden and make observations / notes.

The students should hypothesise whether all fruits can be grown from seed. Show a banana as an example.

Ask students to find seeds in their fruits, take them out and wash them. Students can create mini greenhouses, in which to plant their seeds, from empty soda bottles.

- Small holes must be punched in the bottom of the bottle.
- Cut the bottle horizontally into two halves and fill in the bottom half with soil.
- Sow seeds from the fruit directly into the soil and water afterwards.
- Write the plant name on a label and attach it to the bottle
- Tape the two parts of the bottle together again

NB: The bottle must get plenty of light and can be hung in the window. Remember that water may trickle out through the holes in the bottom when watering. Place something protective underneath it.

Have the students keep a log of observations of developments in their mini-greenhouses. Their notebooks should record findings, working like scientists. Students should check which species sprout first and which species do not germinate at all. When any plants grow bigger, they should be potted on. Ask the children to discuss their findings at a later plenary session and justify why they think they did or did not grow, and why some fruit species germinated more quickly than others.

NB: Not all seeds germinate quickly and there is no guarantee that all seeds will germinate. Remember that most fruits come from plants that live in subtropical and tropical regions. They like heat, moisture, and light.

Post-visit work:

Using the sheet of fruit images or a basket of bought fruits, students could research:

- Where do these plants come from originally?
- Where in the world are they cultivated now?
- What do they taste like or smell?

Let the students find a creative way to present their results. e.g. by making a fruit salad for the last research question

Using the data on their fruit seed growth:

- Ask students to make a presentation on their findings

Resources for post-visit work:

- Fruit / images of fruits
- world maps/ Reference books on crops / access to internet
- log books
- bowls, knives, sheets of paper/plastic, napkins

Proposed webpage about tropical fruits on NHM's website:
http://www.nhm.uio.no/fakta/botanikk/karplanter/eksotiske-frukter/

A competition: Who can find the best tree for our avenue?

Institutes: University of Bremen & Botanisher Garten, Rhododendron-Park, botanika, Bremen.
Lesson developed by: Jan Möller, Ulrike Ritter, Doris Elster

Grade level: 5 - 8

Anticipated time: 2.5 hours

Summary

The students take on the roles of landscape architecture officers in a number of landscape companies. Each company receives an open call for tender from the Rhododendron Park to plan and plant an avenue of trees. Students are provided with information about the trees most frequently planted on streets. They are also given information on, and tools to analyse, the habitat.

Their task is to research the habitat, as well as the overall look and size of the different tree species, and then to give an appropriate recommendation for planting.

Students need to analyse:

- The soil
- The spread of the treetops and the maximum height of the trees
- The growth, development and the lifespan of the trees
- Aesthetic aspects

Prior to the activity, the students are divided into companies, and within each company into specific expert roles for ‘habitat’, ‘aesthetics’ and ‘growth form’.

The students report the findings and recommendations from each of their landscape offices during a presentation that is made available to the contractors (teaching staff) and other company representatives. The office with the most well justified recommendations and best presentation receives the contract to plant the avenue; the students form part of the ultimate decision making process for the contract.

Learning outcomes:

The aim of this activity is to give students an insight into methods used by landscapers. During the process, the students understand the methodology and importance of analysis of local conditions and how the environment impacts on vegetation.

At the end of the unit the students can show connections between abiotic and biotic environmental factors and are able to name the habitat requirements of various trees.

Competences:

The following competences will be acquired or enhanced:

- Content-related abilities
- Describing the conditions for the incidence of various plants (trees)
- Describing the features of soils promoting the growth of plants (trees)
- Describing the adaptations of plants
- Drawing conclusions from soil characteristics on plant growth

Process-related competences

- Observing and describing organisms
- Presenting results in a suitable form
- Using field equipment
- Analysing results
- Developing strategies through developing and applying criteria

Curriculum content:

The following list gives a guideline to the curriculum links for Bremen Schools

FW = Subject knowledge; EG = knowledge acquisition; KK = Competence in communication; BW = Valuing and decision-making

Bremen classes – 5/6 (grade 5/6)

Content-dependent competences

Learn about plants and animals in their natural environment

- FW1: Name conditions that are essential for the occurrence of plants and animals
- FW2: Name soil parameters that promote the development of plants

Process-related competences

- KK1: Observe and describe organisms
- EG1: Use classification keys
- KK2: Present results in a suitable form
- KK3: Observe and describe phenomena
- EG2: Collect data
- EG3: Experiment together in groups according to instructions

Bremen classes – 7/8 (grade 7/8)

Content-related competences

Green plants - the basis of life

- FW3: Describe adaption of plants to their habitat/environment by using appropriate examples/models

From the field

- FW4: Name detection methods for nutrient salts as well as nitrate and phosphate

Process-related competences

- EG4: Perform experiments according to instructions, verbalize observations and results, make interpretations and draw conclusions
- EG5: Acquire expertise in plant and animal biodiversity/ species

Overview of Activities:

- Establish criteria for selection of a particular tree species
- Work-sharing approach
- Classification of trees and evaluation/assessment of their aesthetic value
- Site analysis
- Calculation of number of trees required using growth and form data
- Collating results within the group; decision-making on tree species
- Poster preparation
- Poster presentation
- Plenary discussion
- Selection of winning landscape office

Prior learning: No previous knowledge is required

Guidelines for Teachers

Introduction to the lesson

Students take on the roles of landscape architects and work in groups for different landscape companies. In each company, the experts on 'habitat', 'aesthetics' and 'growth form' work as a team.

The timetable below gives an overview of the schedule for the activity (2.5 hours):
15 minutes to plan procedure/approach
60 minutes for research and analysis
45 minutes for poster creation
30 minutes for presentations and discussion, including final conclusions on competition

List of activities, and instructions on how to implement them

1. **Introduction and Preparation**

Students are given their role (character sheets) and the open call for tender from the Rhododendron Park. An introduction to the teaching unit takes place as an information event. From now on the students will be addressed as landscape architects. The open call for tender is presented and discussed briefly (See Open call letter).

- Before entering the botanic garden, students group themselves into their 'companies' and have the opportunity to plan their approach to the activity and assign tasks. Every person within the group is an expert for a particular area e.g. soil science, aesthetics and experts on growth / habit of the trees. The experts should understand that they need to work in their particular sections to research their trees and come together at the end to collate and discuss their findings. All resources required for the research will be made available during this preparatory phase.

2. Main Part

Students work independently to research the habitat. They collect knowledge about soil (parameters), growth habit, life span of the trees, and on this basis they come together to collate their research findings and develop a recommendation for the Rhododendron Park.

- Soil experts analyze pH-value, nitrogen, phosphate, soil compaction and soil structure.
- Aesthetic experts consider the visual features of trees at different locations within the botanic garden and classify them - experts can refer to a map of the park with marked/mapped trees (see map) and classification keys to identify trees.
- Experts on growth habit calculate the distance between the trees, including potential spread of the treetops (see Landscape Guide). They calculate development of the roots as well as expected height gain/growth.

3. Poster creation

On the basis of the team's results and collected knowledge, students should select a tree for planting. They should then prepare a presentation using a poster. The poster should include the following components:

- Criteria for selection of tree/s
- Results for particular trees on the basis of the criteria
- Their agreed recommendation, including justifications, for a tree species to plant along the avenue

Additionally, the following quality requirements are set:

Poster:

- Structure and clarity
- Content
- Visual design

Presentation:

- Presentation style
- Professional competence of the students when answering questions

Plenary session

This takes the form of a series of presentations to win the contract:

Teams present results and defend their recommendations. The session should be facilitated by the educator to ensure everyone can present in a fair and open field.

Important steps that can guide the students to an overall decision on who should gain the contract are:

1. development or demonstration of decision-making,
2. demonstration of data collection and well analysed results,
3. Comparison of options using a decision-making matrix. (See sheet)

When compiling the decision-making matrix, the students define criteria for decisions, assess them, and thereby come to a reasonable decision. They have to respond to critical questions from the other teams. Finally, the students vote for the best argued concept

Decision-making matrix

Criteria	Orientation	Quantifier	Horse-chestnut		Norway Maple		Silver Birch		Beech		Small-leaved Lime	
			Points	Value	Points	Value	Points	Value	Points	Value	Points	Value
Growth form												
Tree height												
Tree width												
Soil pH												
Soil nitrogen												
Soil phosphat e												
		Total										

Assessment

To assess students' learning you can use a simple matrix that focuses on group work and the nature of science (see figure 1). Additionally, the posters, the decision-making matrix and the justifications of the teams can be assessed.

Figure 1.

Criteria	Points	Self	Peers	Teacher
Active participation in the group process.	5			
All required elements and data are present; data is presented accurately.	5			
Data and interpretations are clearly communicated to the other teams by individual	10			
Options are weighed, based on available background information and own investigation.	10			
Conclusions are clearly and logically communicated.	10			
Poster is complete.	5			
TOTAL **Comments:**	**43**			

Background information:

The term ‘landscape architect’ is a job title describing a profession for which one has to study at an advanced technical college or at university. The landscape architect’s field of activity is to create and design the environmental landscape, for example open space/ open areas within townships or cities. This may involve conceptual development/planning of green spaces for recreation/relaxation, as performed in this teaching unit. Another possible activity is to conceptualize arrangements and activities to respond to urban problems, to redevelop Brownfield sites, or to plan tourism or sustainable development within cities or township.

Dealing with the locations enables the landscape architect, or in this case the students, to make a well judged statement about which of the trees is most suitable for the avenue. The site analysis includes biotic as well as abiotic factors that may have an influence on tree development. Abiotic factors are climate (e.g. rainfall, light, temperature), soil (e.g. nutrients, soil structure, water availability) and topographic factors/relief (e.g. wind- and light exposure, slope of underground/subsurface).
Biotic factors include all the influences by living organisms. They are a result of interaction between the different species within the ecosystem. There are interactions that have positive effects on at least one species, for example:

- Symbiosis
- Reproduction

Interactions which have negative effects on at least one species include:

- Interactions between producer, consumer and decomposer
- Parasitism
- Competition (e.g. within root zone, for light, water and nutrients)

In this teaching unit, students work on abiotic factors such as light, water, nutrient and soil structure. Nitrogen and phosphate, as two of the five macronutrients (nitrogen, phosphorus, potassium, sulphur and magnesium) of plants, should be detected. Apart from carbon, hydrogen and oxygen, nitrogen is one of the main components of the biomass of most plants and therefore an important indicator for nutrient availability.
Growth habit is one of the biotic factors that students are expected to analyse. Through this analysis one understands the morphological features of the plant, which are partly determined genetically but are also influenced by environmental factors. Students should investigate the possible development of tree canopies and tree roots to estimate/calculate the required distance between the trees in the avenue. In that way, students should recognise two interactions that have negative effects on at least one species (light availability and root space competition).

Resources

Context:

Students acting as landscape architects receive an open call for tender to plant an avenue of trees within the Rhododendron Park. Every landscape company has its own reasons to want to win the contract.

Student materials and worksheets:

- Character sheets
- Open call for tender
- Planning guide booklet for landscape architects
- Map of the park
- Toolkit for soil analysis, including instructions
- Measuring equipment and calculator
- Plant / tree classification keys
- Materials for poster presentation

Literature: Bruns Gehölzkatalog 2009/2010 (2009). Sortimentskatalog Gehölze 2009/2010. Stuttgart: Ulmer (Eugen)


Herr Martin Köppke


Frau Lisa Meier


Frau Julia Hinrichs


Herr Peter Werner

Horticulture


Herr Paul Köhler


Frau Tatijana Schreiber


Herr


Frau

Aesthetics


Herr


Frau


Herr


Frau

Herr Dennis Mahkle

Frau Louisa Tische

Herr Torben Kranich

Frau Nina Denecke

Horticulture

Herr Julian Fenski

Frau Sabrina Műller

Herr

Frau

Aesthetics

Herr

Frau

Herr

Frau

Location study

Herr Heinz Fichter

Frau Llja Haberkern

Frau Odilia Denecke

Herr Eric Keyser

Horticulture

Herr Paolo Jebe

Frau Jeannette Fröse

Herr

Frau

Aesthetics

Herr

Frau

Herr

Frau

Herr Marel Hillbrect

Frau Kerstin Claas

Frau Claudia Nemitz

Herr Marius Eisfield

Horticulture

Herr Dennis Pfnűr

Frau Sonia Zwerg

Herr

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Aesthetics

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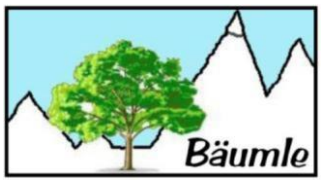
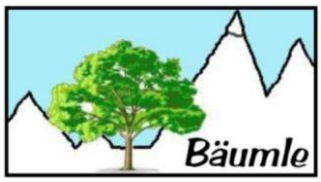
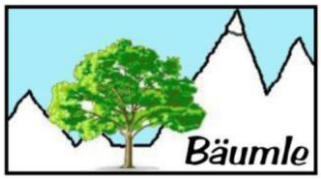


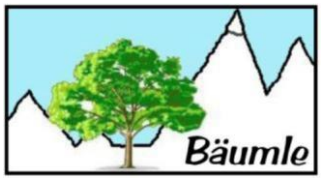
Herr Frederik Hofmann



Frau Lara Gossing

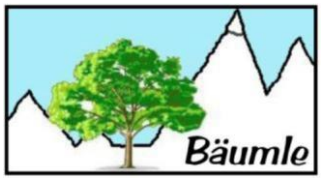


Frau Liane ruffel

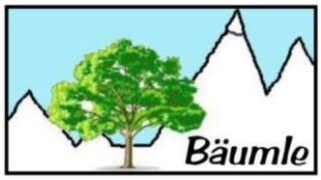


Herr Till Uhse

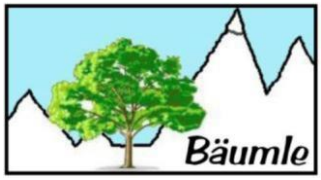
Horticulture



Herr Jens Seyffert



Frau Sahra Tayert



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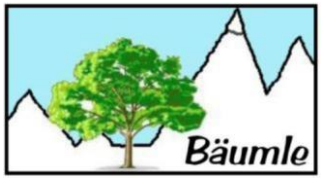
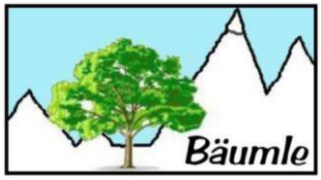


Frau

Aesthetics



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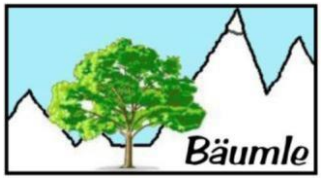

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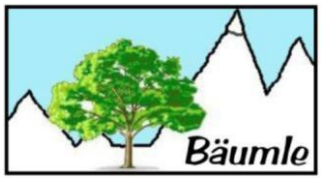

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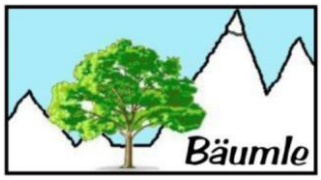


Frau

Landscape architecture office:

Avenue of Innovation

Motivation to get the job:
The company is having serious financial problems because the last client was not able to pay the bill. As a consequence the company cannot pay any salaries at the moment.

Characters:

Martin Köppke	Area of expertise: Location study
Lisa Meier	Area of expertise: Location study
Julia Hinrichs	Area of expertise: Horticulture
Peter Werner	Area of expertise: Horticulture
Paul Köhler	Area of expertise: Aesthetics
Tatjana Schreiber	Area of expertise: Aesthetics

Landscape architecture office:

Motivation to get the job:
The senior partner of the company has just retired und the young team has no proof that they will be able to resolve demanding workloads as well as they have done previously.

Characters:

Dennis Mahlke	Area of expertise: Location study
Louisa Tische	Area of expertise: Location study
Torben Kranich	Area of expertise: Horticulture
Nina Denecke	Area of expertise: Horticulture
Julian Fenski	Area of expertise: Aesthetics
Sabrina Müller	Area of expertise: Aesthetics

Landscape architecture office:

Green thumbs

Motivation to get the job:
The members of this team have just finished university and set up this new company. They need to get their first contract to take the business forward.

Characters:

Heinz Fichter	Area of expertise: Location study
Ilja Haberkern	Area of expertise: Location study
Eric Keyser	Area of expertise: Horticulture
Odilia Denecke	Area of expertise: Horticulture
Paolo Jebe	Area of expertise: Aesthetics
Jeanette Fröse	Area of expertise: Aesthetics

Landscape architecture office:

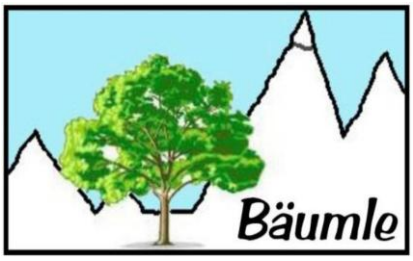
Crown of Architecture

Motivation to the job:
The Company has applied for a large-scale project and has a good chance of getting the contract; however they need to have another reference from a previously completed contract.

Characters:

Marek Hillbrecht	Area of expertise: Location study
Kerstin Claas	Area of expertise: Location study
Marius Eisfeld	Area of expertise: Horticulture
Claudia Nemitz	Area of expertise: Horticulture
Dennis Pfnür	Area of expertise: Aesthetics
Sonia Zwerg	Area of expertise: Aesthetics

Landscape architecture office:



Motivation to get the job:

The headquarters of the company is located in Munich. The company has just opened a branch office in Bremen, which is supposed to be profitable within the next half year. If this is not happening, the branch office will be closed and the employees will be dismissed.

Characters:

Frederik Hofmann	Area of expertise: Location study
Lara Gossing Till	Area of expertise: Location study
Uhse Liane Rül	Area of expertise: Horticulture
Jens Seyffert	Area of expertise: Horticulture
Sahra Tayert	Area of expertise: Aesthetics
	Area of expertise: Aesthetics

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Order type:	Landscape architecture
Closing date:	15. September 2014
Region:	DE: Bremen

Characterization
There is a requirement to plan and plant an attractive and long lifespan tree avenue alongside a paved footpath within the Rhododendron Park of Bremen.

The following tree species have been pre-selected
Horse-chestnut - *Aesculus hippocastanum*
Silver Birch - *Betula pendula*
European Beech - *Fagus sylvatica*
Norway Maple - *Acer platanoides*
Small-leaved Lime - *Tilia cordata*

Applications are to be submitted in the form of poster presentations.

Product criteria / List of issues, which must be considered for the presentation:
- Criteria for the choice of the tree species
- Characteristics of the tree species in the context of the chosen criteria
- Clear and evidence based desicions
-

Quality Control / assessment criteria
Key to the presentation is content, however the presentation should be should be well designed and appealing. The presentation team should be able to answer in depth questions and defend their choices from both other competing architectural companies as well as the contracting authority.

botanika
Das Grüne Science Center

Contents

Tree species

Norway Maple (*A. platanoides)*
Horse-chestnut (*A.hippocastanum)*
Silver Birch (*B.pendula)*
European Beech (*F. sylvatica)*
Small-leaved Lime (*T. cordata)*

Root Types

Growth Form

Norway Maple

Acer platanoides

Height

20 - 30 m tall
15 - 22 m wide
45 - 60 cm increase in height each year
15 - 22 cm increase in width each year

Lifespan

Up to 200 years

Roots

Flat heart-sinker root growth with intense fine root system

Habitat

From sun to half shade

Soil

No special requirements
Tolerates most soil types but do not grow on swampy and peaty soils

Attributes

Frost tolerant Heat tolerant
Exceptional drought resistance Very resistant to wind Compatibility with shade
Good growth even in urban conditions

Horse-chestnut

Äesculus hippocastanum

Height

25 - 30 m tall
15 - 20 m wide
45 - 50 cm increase in height each year
25 - 35 cm increase in width each year

Lifespan

Up to 300 years

Roots

Heart shaped root system with high percentage of fine roots, but also bigger side roots close to surface

Habitat

From sun to light shade

Soil

No special requirements but prefers moist and open soils
Prefers nutrient rich sand and clay, weakly acidic to basic
Soils / tolerates lime

Attributes

Very frost tolerant
Sensitive to emissions and salt

Silver Birch

Betula pendula

Height

10 - 15 m tall
10 - 15 m wide
45 cm increase in height each year
25 cm increase in width each year

Lifespan

From 90 - 120 years

Roots

Heart shaped system with side roots and very high occurrence of fine roots within the top soil zone/area

Habitat

Sun

Soil

Tolerates every soil type
Tolerates very dry, as well as very wet, habitats
Will grow on nutrient poor sandy soils

Attributes

Exceptionally frost tolerant
Drought resistant
Stabilises soil

European Beech

Fagus sylvatica

Height

25 - 30 m tall
40 m wide
50 cm increase in height each year
40 cm increase in width each year

Lifetime

From 300 – 400 years

Roots

Heart-shaped root system with very expansive and more or less fused side roots.
Most intense topsoil rooting of all endemic forest trees

Habitat

From sun to shade

Soil

Will tolerate most soils but prefers nutrient rich, clay rich soils with lime

Attributes

Compatible with deep shade
Vulnerable to late frosts
Heat sensitive
Favours high air moisture
Sensitive to air and soil pollution

Small-leaved Lime

Tilia cordata

Height

18 - 25 m tall
10 - 15 m wide
30 cm increase in height each year
25 cm increase in width each year

Lifetime

Up to 1000 years

Roots

Formation of tap root system within the first eight years. Subsequently formation of heart-shaped root system with high occurrence of fine roots

Habitat

From sun to half shade

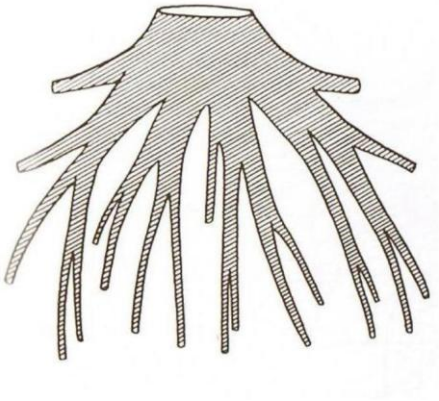
Soil

Prefers moderately dry and open, weakly acidic to basic soils
Will grow on nutrient poor soils which are not too dry

Attributes

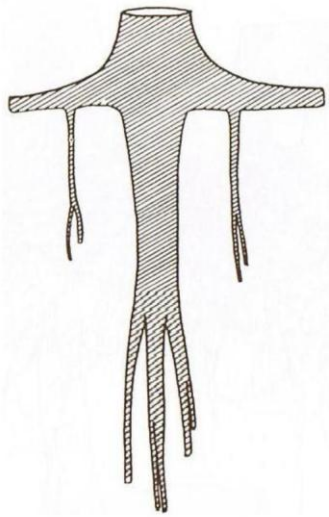
Very frost tolerant
Semi shade tree
Compatible with urban conditions Resistant to strong winds
Tolerates warm and dry air

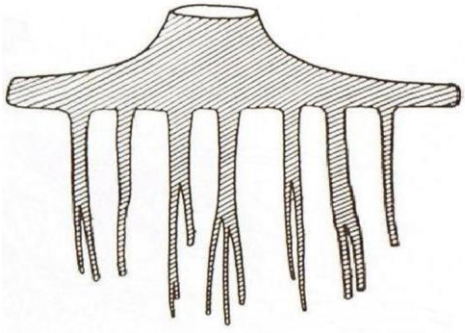
Root types



Tap root system
Formation of a vertical growing
Thickened main root

Sinker root system
Several roots are growing out of the horizontal side roots down into the soil





Heart-shaped root system
Formation of a number of roots different in size

Growth form

Norway Maple *A. platanoides:*	Spherical / Round
Horse-chestnut *A. hippocastanum:*	Irregular
Silver Birch *B. pendula:*	Weeping shape
Beech *F. sylvatica:*	Oval/ Columnar
Lime *T. cordata*:	Conical

Tree top density

T (Translucent tree top)

O (Opaque tree top)

Norway Maple *A. platanoides:*	O
Horse-chestnut *A. hippocastanum:*	O
Silver Birch *B. pendula:*	T
European Beech *F. sylvatica:*	O
Small-leaved Lime *T. cordata:*	O

Resistance to disease

G (good) A (average) P(Poor)

Norway Maple *A. platanoides:*	A
Horse-chestnut *A. hippocastanum:*	A
Silver Birch *B. pendula:*	P
European Beech *F. sylvatica:*	A
Small-leaved Lime *T. cordata:*	A

botanika
Das Grüne Science Centre

Homer Kirche

Straßenbahnlinie 4,5 *ff)*

Bus 20, 21,33,34

Plants and Insects:

Pollinators are needed!

Institute: University of Lisbon.

Developed by: Adriana Galveias, Inês Paulino and Raquel Barata.

Overview

This game aims to engage families with children from 6 years onwards on a quest to find the relationship between seven plants and seven insects on the loose from the Botanical Garden and the butterfly house of the National Museum of Natural History and Science.

Grade level: 6 yrs +

Duration: 2 hours

Resources (for each group)

- A map of the botanic garden with plant locations
- A recording sheet with clues
- A box displaying seven insects, and photos of their mouthparts

Competences

- Critical thinking
- Teamwork
- 'Hands on' skills
- Development of empathy for the natural world and its conservation
- Debating / discussion skills

Introduction

Seven suspect insects are on the loose somewhere in the garden, however each regularly visits a particular plant. Students take on the role of 'Sherlock Holmes' to try to figure out which insect has pollinated each of the seven plants and why the relationship between plants and insects is so important

Summary

This is a mystery trail in the Botanical Garden and the butterfly house. Seven insects are on the loose, but each regularly visits a particular plant. The relationship is beneficial for both because the insects feed on the nectar or pollen of the flowers but they also carry pollen which allows the fertilization of the plants and the development of new seeds. Students need to investigate which suspect visits each flower to ensure both the flower and pollinator can be monitored and preserved for the future of biodiversity in the botanical garden and butterfly house.
The students take on the roles of experienced researchers, who gather information about the seven insects and the flowers they visit, in order to find out 'who visits who?'
The activity takes place in the botanical garden and to unravel this 'mystery', students need to follow the activities suggested. Botanic Gardens are living museums. Students should respect the collections and help to preserve the plants and insects by not walking in flower beds and not picking plants or plant parts. This activity should be done preferably in the late spring.

The Activity

Students should look at the map of the Botanical Garden of the National Museum of Natural History and Science and note the flowers that the insects prefer to visit marked on the map.

Students should visit each station marked on the map and investigate the plants and information found there.

Station 1

Students should use the image and the following clue:
“My flower is brown and hairy and smells like rotten fruit. Insects have to force their way in to get the nectar”.
Using the recording sheet, students write the name of the plant down and note any particular features.


Station 2

Students should use the image and the following clue:
"I'm a large tubular flower and can be found in a lot of different colours. I love living near the water and I have a ‘landing strip’ marked out down the middle of the petals.”
Using the recording sheet, students write the name of the plant down and note any particular features.

Station 3

Students should use the image and the following clue:
"I'm blue and I have a flat shape to serve as a ‘landing platform’. I'm an open flower; my nectar is not difficult to get. "
Using the recording sheet, students write the name of the plant down and note any particular features.

Station 4

Students should use the image and the following clue:
"I have orange and pinkish flowers with a little tube; deep down there is very sweet nectar."
Using the recording sheet, students write the name of the plant down and note any particular features.

Station 5

Students should use the image and the following clue:
"I'm a tall plant but I'm not a tree. I have rounded red flowers. My nectar is in a ‘cup’ and is easy to reach. "
Using the recording sheet, students write the name of the plant down and note any particular features.

Station 6

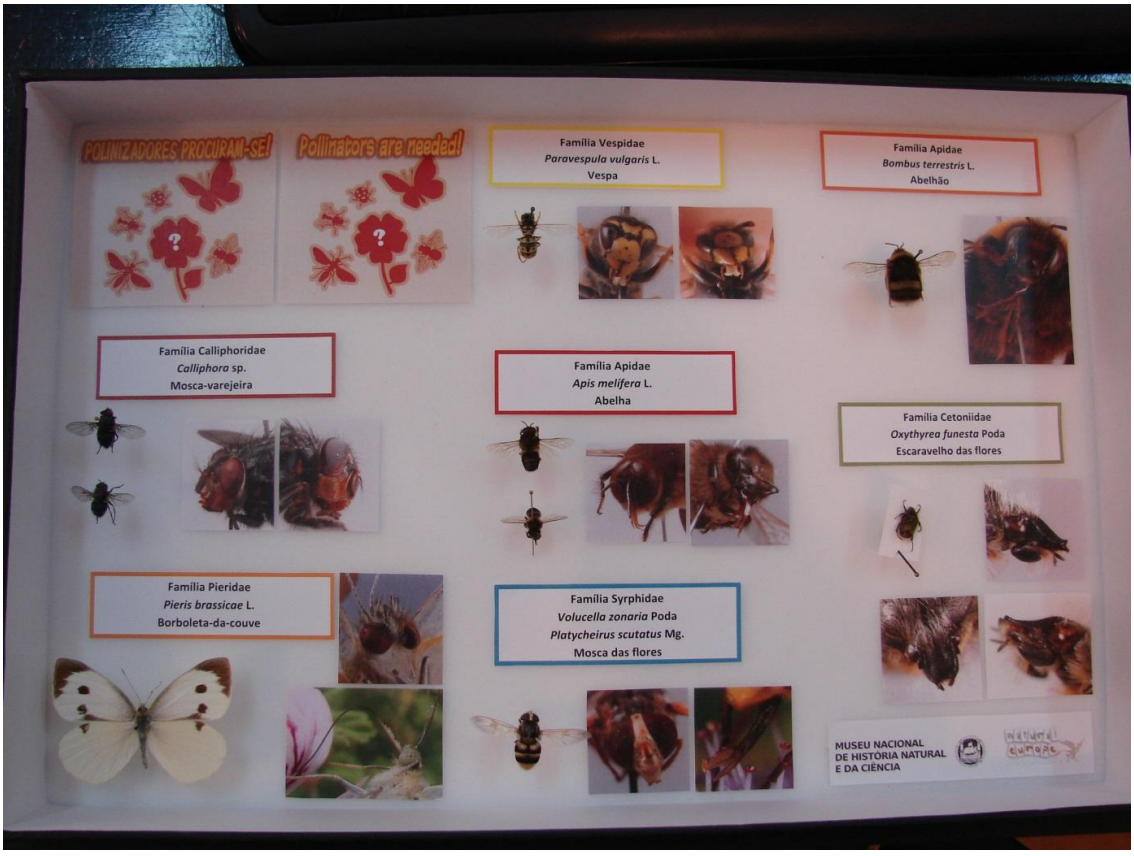
Students should use the image and the following clue:
“My flowers are small and white and together they look like an umbrella; they are open to give access to the nectar”
Using the recording sheet, students write the name of the plant down and note any particular features.

Station 7

Students should use the image and the following clue:
"I'm a flower with white, smooth, flat petals that make it easy for insects to land. The middle of my flower is bright yellow."
Using the recording sheet, students write the name of the plant down and note any particular features.

Station 8

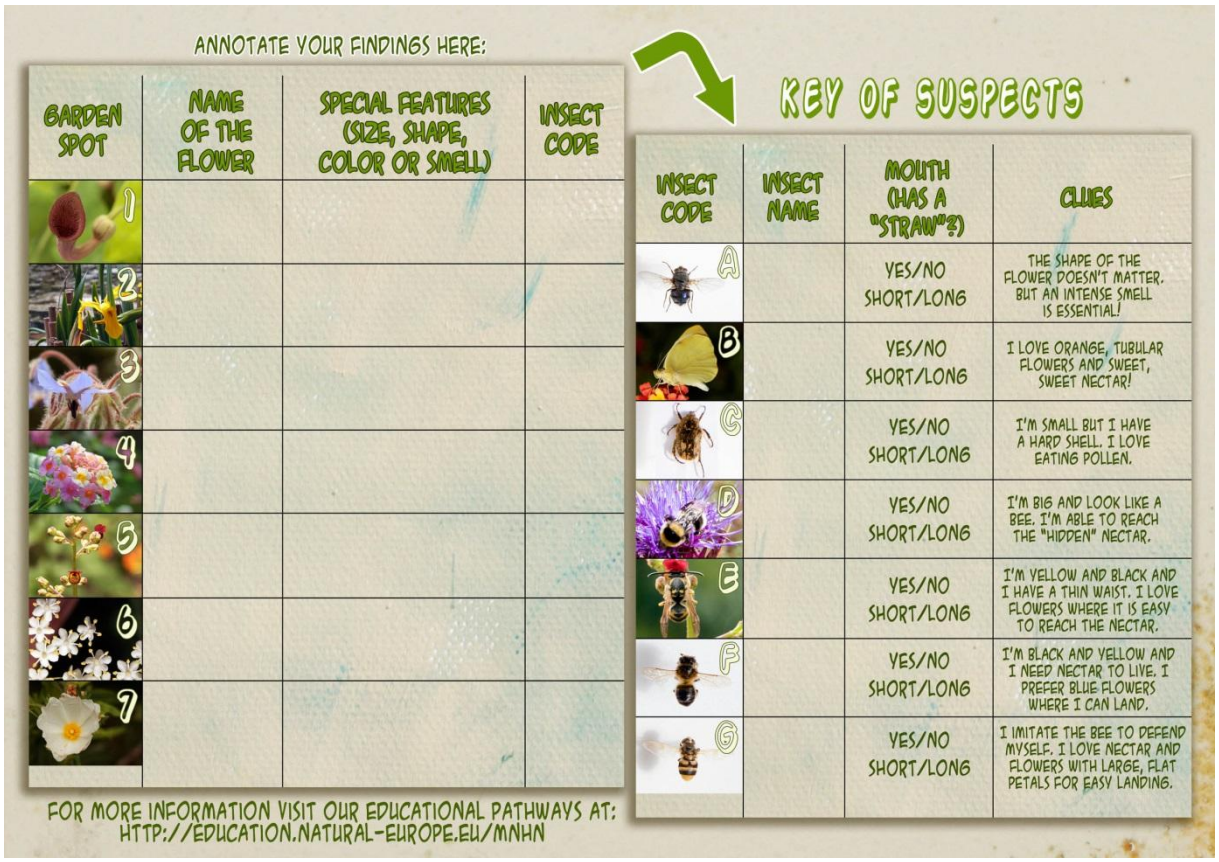
Students should investigate the insect box in the butterfly house where the 'suspects' in this investigation are displayed. Using the recording sheet the common and Latin names of the insects are written down. Students should study the mouthparts of each insect displayed and find the right features for each insect in their recording sheets to match up their insects to.



Station 9

Using the clues provided and their observational recordings, students should decide which plant has been pollinated by which insect, matching the special characteristics of the flowers that have been observed with the insect clues in the table. The answers should be recorded on the sheet. Children should be able to justify their selection. Ask children to reflect on what would happen if one of the plants or insects became extinct.

Plants produce nectar to feed the insects but in turn they depend on them for reproduction; the conservation of each one of them depends on the conservation of the other.



ANNOTATE YOUR FINDINGS HERE:

GARDEN SPOT	NAME OF THE FLOWER	SPECIAL FEATURES (SIZE, SHAPE, COLOR OR SMELL)	INSECT CODE
1			
2			
3			
4			
5			
6			
7			

FOR MORE INFORMATION VISIT OUR EDUCATIONAL PATHWAYS AT:
HTTP://EDUCATION.NATURAL-EUROPE.EU/MNHN

KEY OF SUSPECTS

INSECT CODE	INSECT NAME	MOUTH (HAS A "STRAW"?)	CLUES
A		YES/NO SHORT/LONG	THE SHAPE OF THE FLOWER DOESN'T MATTER, BUT AN INTENSE SMELL IS ESSENTIAL!
B		YES/NO SHORT/LONG	I LOVE ORANGE, TUBULAR FLOWERS AND SWEET, SWEET NECTAR!
C		YES/NO SHORT/LONG	I'M SMALL BUT I HAVE A HARD SHELL. I LOVE EATING POLLEN.
D		YES/NO SHORT/LONG	I'M BIG AND LOOK LIKE A BEE. I'M ABLE TO REACH THE "HIDDEN" NECTAR.
E		YES/NO SHORT/LONG	I'M YELLOW AND BLACK AND I HAVE A THIN WAIST. I LOVE FLOWERS WHERE IT IS EASY TO REACH THE NECTAR.
F		YES/NO SHORT/LONG	I'M BLACK AND YELLOW AND I NEED NECTAR TO LIVE. I PREFER BLUE FLOWERS WHERE I CAN LAND.
G		YES/NO SHORT/LONG	I IMITATE THE BEE TO DEFEND MYSELF. I LOVE NECTAR AND FLOWERS WITH LARGE, FLAT PETALS FOR EASY LANDING.