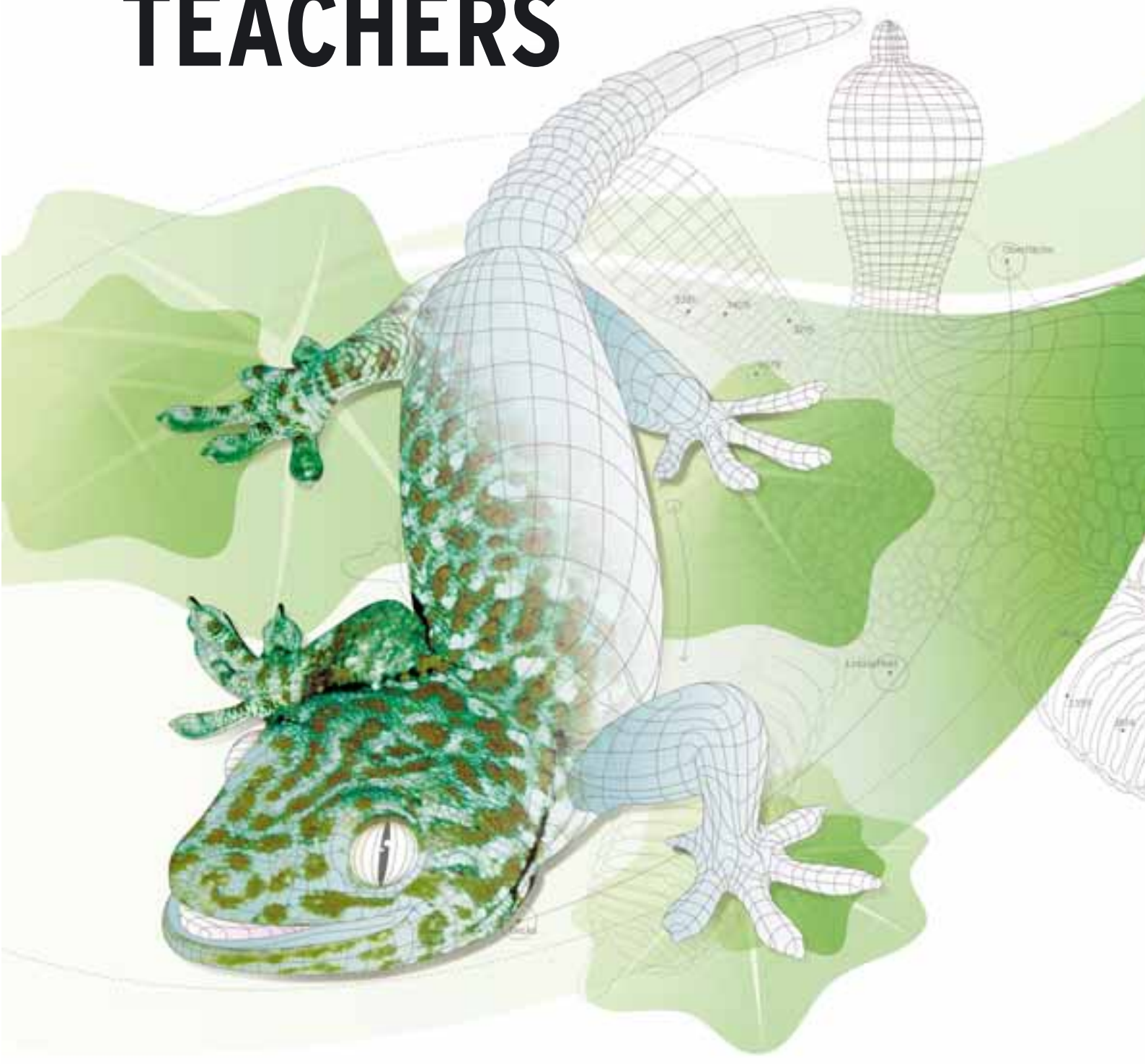
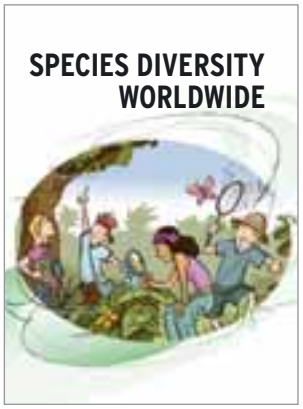
BACKGROUND INFORMATION FOR TEACHERS





The Biological Diversity module sets out to show, with the aid of scientific questions and exercises, what benefits nature in all its variety has to offer us, what we can learn from nature, and also why this variety is worth protecting and how it can be protected.

A framework "plot" with four young people leads into the three sets. The introduction via the theme of bionics creates a link with the young people through their fascination with technology. The second set takes up the topic of biological diversity in Germany, using the example of the Rhön Biosphere Reserve, which the pupils can transfer to other regional domestic animal breeds/livestock species in an exercise. The third set focuses on biodiversity in a global context, using the example of the "Rainforest Pharmacy" – including conflicts of use. In 2008, the next UN nature conservation summit, the UN Conference on Biological Diversity (CBD), will be hosted by Germany. One of the main themes of the conference will probably be the sustainable use of biological diversity. Safeguarding biological diversity is today regarded as a central element in the fight against hunger and poverty worldwide.

POINTS OF CONTACT WITH SYLLABUS

- Learn about biodiversity/variety of biological forms
- Biological diversity; ecological significance; human use
- Environmental and economic benefits of biological diversity
- Need to conserve biotopes and biological diversity
- Importance of biological diversity for sustainable use of ecosystems
- Realisation that only sustainable development as an ecological interlinking of nature, economic activity and mankind ensures future conservation of the biosphere: global networking of ecosystems, conservation of biological diversity etc.
- The tropics / biodiversity of the rainforests: Use and threats
- Origin and extinction of species
- Anthropogenic influences on nature: Extermination of species
- Responsibility for nature
- Current challenge: Limits of growth
- Human intervention: Availability of and limitations on resources
- Human intervention and its consequences, e.g. impacts of intensity of use and changes of use on biological diversity
- Biology lessons show the limits of the stress resistance of the abiotic and biotic basis for life, the need to protect biotopes and biological diversity, and the repercussions of anthropogenically influenced ecosystems on health, food, renewable raw materials and production of energy from renewable sources. Existing ecosystems can only be preserved if natural resources are used in a sustainable fashion.
- Biological value is an intrinsic value that has to be protected as a moral obligation to our descendants.

METHODS

Action-oriented and problem-oriented interdisciplinary teaching, autonomous learning at different stations in individual work, partner work and group work; team-based group work (role games)
Age: 13 to 16 years
Subjects: Geography, Biology, Politics, Ethics, Religion

CONTENT-ORIENTED LEARNING GOALS

Set 3 focuses on biodiversity in a global context, including conflicts of use. The pupils work on a combination of scientific and social/ethical problems and issues. On this basis they indicate what benefits nature in all its variety has for mankind and why this variety should be protected. In this way they recognise the global importance of biodiversity as a resource, e.g. for medicinal purposes. In this connection they learn about the global "hot spots" of biodiversity and contrast them with the problems of poverty and environmental damage. In a final expert discussion they explain the four perspectives of the biodiversity conservation strategy (environmental, economic, social and ethical). Thus the aspects of sustainability are brought into the discussion.

Specifically, the pupils should...

- Identify and name centres of biological diversity on a map of the world,
- Recognise and name the geographical location of these centres (South America and the Indonesian archipelago),
- Name eight countries of the world's five biodiversity centres,
- Describe geographical and natural similarities of these countries,
- Describe and understand the social problems that these countries have in common: large population, poverty, over-exploitation of resources (environmental destruction), and recognise the interactions between the individual points (see also under "Answers"),
- Analyse problems of non-sustainable development (functional principles of civilisation),
- Name species centres in Europe,
- Identify and describe geographical similarities with the aid of a map,
- Name five main reasons for the current extinction of species,
- Obtain information on the subject from texts and understand its essential content,
- Identify and classify causal categories for the different texts,
- State arguments for preserving biodiversity,
- Analyse the background to different points of view about the conservation of biodiversity,
- Assess and weight individual reasons/arguments, and deal democratically with controversies arising in this context (discussion, role game).

Learning goals in relation to Gestaltungskompetenz / OECD key competencies:

The following OECD key competencies or individual elements of Gestaltungskompetenz are addressed:

Interactive utilisation of media and tools:

- Building knowledge to integrate new perspectives, with an open mind:
    - By getting the pupils to describe and assess diversity and variety in the ecological field
    - By getting them to present various points of view and forms of knowledge
- Ability to use interdisciplinary knowledge interactively: Interdisciplinary acquisition of topic

Interacting in heterogeneous groups:

- Planning and acting jointly with others (group work)
- The pupils, working in groups, are able to identify and analyse different points of view on sustainability and deal democratically with controversies arising in this context (discussion, role game)
- Being able to take part in decision processes,
    - where the pupils demonstrate how cooperative problem solving can be achieved in the development of action strategies for sustainable development
    - where they demonstrate procedures for reaching agreement on goals and processes of sustainable development in cases of normative and political differences
    - where they constructively overcome differences of opinion and conflicts with regard to questions of (non-)sustainable development (role game/discussion)
- Be able to motivate others to play an active role, by describing their own and joint motivations for taking part in democratic decision processes and in sustainable activity

Acting autonomously:

- Considering one's own and other people's guiding visions
- The pupils, by implementing a sustainability project, demonstrate their own experience of autonomous planning and autonomous action.

SUGGESTED APPROACH

Initial and in-depth/work phase "Station learning":

The pupils elaborate the topic on a largely autonomous basis by working through various stations (see Station Pass at end of handout). The station learning phases are:

- **Initial briefing:** The pupils are introduced to the topic with the aid of Worksheet 1 (introductory story). The relevant Information sheet 1 "Glossary" provides the necessary definitions.
- **Tour of stations:** The pupils find out what they can expect at the individual stations (Worksheets 2, 3, 4 plus Information sheets 1 and 2 and research assignments).
- **Instructions:** The pupils are given the Station Pass as a control sheet showing the tasks that are to be completed within a time set by the teacher. They can start the circuit at any point. The teacher observes them and gives guidance and assistance.
- **Work at the stations:** The pupils decide their work sequence for themselves and allocate their time individually. The stations are designed so that a choice of individual, group or partner work is possible at some of them, and the pupils can select the social form that best suits them and the matter in hand. The pupils can if they wish monitor their own work at the stations.

Evaluation of work phase "Station learning":

At a final discussion the results are presented, corrected if necessary, summarised, examined in greater depth and appraised.

Transfer phase "Role game" (Worksheet 4 and Information sheet 3, recap Worksheet 3):

Task (group work)

The pupils are informed about the role-playing game, in which each group is to assume one of the positions laid out on Worksheet 4. With the aid of Worksheet 3 and Infosheet 3, they deal with the arguments for conserving species diversity. They consider which role they would like to play. One group is formed for each position, resulting in a total of five groups. Playing the roles calls for

imagination on the part of the pupils. Information that may help them to understand the different standpoints of the role characters better can also be found on the Internet. They can use a search engine like “Google”, “Yahoo” etc. to search for pairs of keywords such as “timber felling Amazon”, “Medicines from rainforest”, “Village + rainforest”. They should try out a variety of search terms or combinations.

A pupil is selected to act as facilitator for the discussion session. The pupils present their positions. After the presentations are over, each pupil assesses the arguments put forward. They use Worksheet 5 for this purpose. If there is not enough space, the sheet can be copied. Finally, the class decides which arguments meet with acceptance and which do not. They draw up a brief overview/statistics. The pupils discuss the results in the class as a whole.

Note

The issue of biopiracy should also be addressed in connection with the discussion about the value of biological diversity. The following section provides a few ideas:

Biological diversity and biopiracy

In the age of globalisation, transnational companies are operating worldwide and looking for new active substances in the centres of biodiversity. This raises political problems in the light of the systematic imbalance between the availability of genetic resources and the availability of technology. The negotiations that started in 1960 were thus characterised by serious conflicts between developing nations and industrialised countries. In over-simplified terms, the industrialised countries (or their private-sector actors) want access to biological diversity in order to advance their own research and production. The developing countries, although they own the biological resources, are unable to make proper use of them because they lack the necessary technology. A World Bank study found that in 1990 sales of 43 billion US dollars were made with medicines that had been discovered by indigenous peoples who did not receive any appreciable portion of the profits. And in 1999 the United Nations Development Programme (UNDP) stated: “Biological diversity is of paramount importance for the development of medicines. It is estimated that 90 percent of the world’s biological resources are to be found in the developing countries. (...) It is this traditionally accumulated knowledge of the potential occurring in nature that is so valuable to pharmaceutical companies today. (...) This knowledge has been used to develop highly profitable medicines without approval by the local population. In any other situation this would be classed as industrial espionage.” In mid February 2002 twelve developing countries and emerging economies, including China, India and Brazil, founded an alliance against biopiracy. Their aim is to prevent genetic diversity from continuing to be exploited by transnational companies, and to make it impossible for such firms to obtain exclusive commercial rights in the form of relevant patent protection without the local population gaining any benefits. These twelve countries are home to about 70 percent of the world’s biological diversity. The initiators stated that the initiative also had the aim of raising the issue of patents on animals and plants at the UN Summit on Sustainable Development in August 2002 and resolving it under the aegis of the United Nations.

Source: Final report of the Commission of Inquiry into “Globalisation of the World Economy” (2002) (in German). Bundesdrucksache 14/2350 (excerpt, only in German available)

Other action options

At this point it is reasonable to ask what the pupils can do with their newly acquired knowledge. Can they use it to draw conclusions for their own day-to-day activities? Possible keywords here might be: travel/tourism, leisure, consumerism, commitment, information. Hold a discussion group and get your pupils to reflect on what they have learned. Are they all prepared to put possible conclusions into practice, or is there anything stopping them? Apart from this, the pupils can show active commitment of their own, for example by taking part in work by the youth groups of the nature conservation organisations, or by performing tasks on Biodiversity Day.

Medicine from nature

Valuable medicinal plants useful to man do not only exist in remote tropical rainforests. Our own ancestors had no choice but to make use of their local "treasure trove of nature". Even if the triumphal march of modern medicine in the industrialised countries has resulted in a loss of widespread knowledge about medicinal plants, many people still like to make use of the traditional herbal remedies. Get your pupils to search in old books about herbs (libraries, bookshops) or on the Internet. They can also ask their own families or older neighbours about medicinal plants that are still known today: what are they used for, what do they look like and where do they grow? Who still knows the bloodwort, a tried-and-tested remedy for stopping bleeding and wound infections?

NOTES AND ANSWERS ON THE WORKSHEETS

Worksheet 1 (2 pages):

Task 1: Costa Rica, Atlantic Brazil, tropical East Andes, Borneo, New Guinea.
Three centres in South America, two centres in the Indonesian archipelago.

The countries of the world's five biodiversity centres more than 5,000 species per 10,000 km2): Costa Rica, Panama, Colombia, Ecuador, Peru, Brazil, Indonesia (Borneo), Papua New Guinea

Note: The special features of these five centres are described in Information sheet 2 "Treasure troves".

Task 2: The special geographical and natural features of these countries (location, size, altitude, climate, mountains, lakes, rivers, deserts, forests etc.)

Background: The pupils learn that the most species-rich regions of the world lie in the hot and humid tropical belt, mainly in the lowland rainforests (Panama/Darien, Amazon lowlands, Congo basin), but also in the rainforests of mountain regions (Costa Rica, Andes, East Brazilian highlands, North Borneo, highlands of New Guinea).

Task 3: Other countries with high species diversity (3,000 – 5,000 species per 10,000 km2):

- Mexico, Guatemala, Honduras, Nicaragua, Venezuela, the Guyanas, Cuba, Congo basin with parts in Cameroon/the two Congos/Gabon,
- East African rift valley with parts in: Uganda/Tanzania/Rwanda/Burundi/Malawi/Zambia, South Africa (Cape Province), Madagascar,
- India (Ghats), Himalayas with parts in: India/Nepal/Bhutan/Myanmar,
- Southern China, Laos, Vietnam, Thailand, Cambodia, Malaysia,
- Indonesia (Sumatra, Borneo, Irian Jaya),
- Philippines, peripheral zones of Australia

To give them a better understanding and in-depth appreciation of the social and economic situation in the relevant countries, you can get your pupils to draw up an overview covering the following aspects: size of country (in km2), environmental issues, population, population growth rate, economy overview, GDP per capita, population below poverty line. They should compare the results with the figures for Germany. What are the salient points? All necessary information (in English) is obtainable from:
www.cia.gov/cia/publications/factbook
http://en.wikipedia.org/wiki/Main_Page > Search: name of country

Background: Most of the countries concerned are notable for their large population or rapid population growth, major environmental problems, and usually a poor economic situation, low purchasing power, corruption, and a lack of state authority and monitoring of protected areas. These factors indicate why the pressure on the biodiversity centres is often so great, e.g. from slash-and-burn cultivation, settlement expansion, over-exploitation of resources (hunting, mining, timber felling).

Task 4: Pyrenees, Alps, Macedonian mountain region (Balkans)
Common feature: All are mountain regions.
www.unesco.org/mab/ecosyst/mountains/gcmbr.shtml
www.environmentforeurope.org/themes/biodiversity.html
www.unep-wcmc.org/posters/ScientificSeries/mountains.htm

Worksheet 2:

Task 1: Greatest biodiversity = today; least biodiversity = before the “Cambrian explosion”

Task 2: 440 million years ago, Ordovician/Silurian; 370 million years ago, Devonian/Carboniferous; 250 million years ago, Permian/Triassic (biggest mass extinction, nearly 90% of marine organisms); 210 million years ago, Triassic/Jurassic; 65 million years ago, at the end of the Cretaceous period (including the dinosaurs)

Task 3: Worldwide volcanic eruptions, cracks in the Earth’s crust with massive lava flows, supernova (gamma burst), meteorite impacts, abrupt climate change, disturbances of the oceans due to CO_2 increase, methane hydrate eruptions etc.; also under discussion: mass occurrence of deadly parasites (in the oceans)

Task 4: Five reasons for extinction of species today: destruction of habitats, environmental pollution, overfishing, introduction of non-native species resulting in displacement of native species, population explosion. Big difference from past occasions: these are anthropogenic causes.

Further information on past mass extinctions:
www.nerc.ac.uk/research/issues/biodiversity/extinctions.asp
www.actionbioscience.org/newfrontiers/eldredge2.html

Worksheets 3, 4 and 5 (the discussion):

Task 1:
Economic factors (use of biodiversity in medical research, aesthetic factors (conserve the beauty of nature), social and cultural factors (conserve nature for future generations)

Possible arguments for discussion/appraisal
Beauty of nature as an end in itself, variety, sustainability, protective functions, medicine/ remedies, food, raw materials, tourism, respect for creation, “man as part of the network of life”, aesthetics, obligation to future generations.

Note
As preparation for the topic or as in-depth follow-up of individual aspects, you can also use the material from the One World website:
www.service-eine-welt.de/en/home/index.html > Topics, Projects, Publications, Downloads, Links

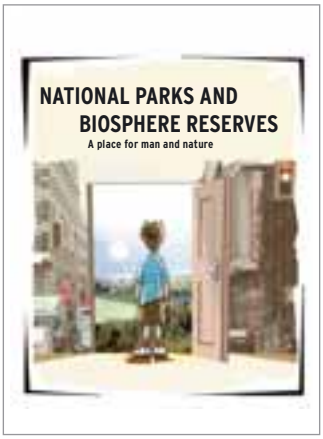
MATERIALS

- **Introductory story**
- **Worksheets 1 to 5**
- **Station Pass with learning check**
- **Teacher handout**
- **Information sheets 1 to 3:**

THE STATION PASS

Name ..... First name ..... Class/Course .....

Station number	Station name	Learning check
Station 1: Information sheet 1 Worksheet 1 (Page 1)	**"The treasure troves of nature"**	Question: Biodiversity is ....
Station 2: Worksheet 1 (Page 2) Information sheet 2	**"The world map of species diversity"**	Question: A "hot spot" is not just something to do with computers; it also occurs in nature. It is ....
Station 3: Worksheet 2	**"Down the ages..."**	Question: After a mass extinction it takes ..... of years. for fresh ..... to develop. Biologists today see signs of a ..... triggered by ....
Station 4: Worksheets 3, 4, 5 Information sheet 3	**"Diversity of species – a priceless asset?"**	Question: There are many reasons for conserving biological diversity. They are of the following kinds: eth ..... reasons en ..... reasons ec ..... reasons s ..... reasons c ..... reasons r ..... reasons ae ..... reasons



The Biological Diversity module sets out to show, with the aid of scientific questions and exercises, what benefits nature in all its variety has to offer us, what we can learn from nature, and also why this variety is worth protecting and how it can be protected.

This second set takes up the topic of biological diversity in Germany, using the example of the Rhön Biosphere Reserve. Biosphere reserves are good examples for taking a look at sustainable development in practice. First of all, here is some brief information about the UNESCO programme "Man and the Biosphere".

THE UNESCO PROGRAMME "MAN AND THE BIOSPHERE"

The programme "Man and the Biosphere" (MAB) was launched by UNESCO in 1970, in response to global environmental problems and the impacts of human intervention in the natural regime. Initially the focus was on research into the relationship between man and the environment. Today the aim is to design new models for careful management of the biosphere. This concept, which is more application oriented, is developed, tested and implemented in representative natural and cultural landscapes. About 100 member states of UNESCO are currently taking part in this programme. Its international organisation, planning and coordination are handled by the International Coordinating Council (ICC), made up of representatives from 34 UNESCO member states. National committees put the international programme into practice in national work programmes. The MAB programme centres on the establishment of a worldwide network of biosphere reserves. There are currently 482 biosphere reserves around the world. Fourteen of these are in Germany. Biosphere reserves are divided into a strictly protected core zone, a buffer zone, and a transition zone (with a regeneration zone if appropriate), depending on the influence of human activities in the relevant zone. Biosphere reserves not only have the function of protecting and maintaining specific ecosystems, but also serve the interests of ecological research, environmentally sound agricultural (land) use, and education for sustainable development.

PRINCIPAL FUNCTIONS OF BIOSPHERE RESERVES

- Development of sustainable land use (e.g. fostering organic farming, near-natural forestry management, environmentally sound technologies and marketing of products produced by such means) and sustainable forms of management.
- Protecting the natural regime and conserving genetic resources (i.e. protecting natural ecosystems and conserving semi-natural ecosystems and valuable cultural landscapes).
- Environmental research and environmental monitoring (biosphere reserves are an ideal system for investigating and observing ecosystems).
- Education for sustainable development and public relations work: biosphere reserves are very suitable for conveying to pupils the basic principles of sustainable development and the necessary competencies in a practical and easily understood manner.

For more information, see: **www.unesco.org** > English > Search: Biosphere

METHODS

Action-oriented and problem-oriented interdisciplinary teaching, individual work, presentation, identical group work (planning a conservation area)
Age: 12 to 16 years
Subjects: Geography, Biology, Politics

POINTS OF CONTACT WITH SYLLABUS:

- Need to conserve biotopes and biological diversity
- Importance of biological diversity for sustainable use of ecosystems
- Biological diversity; ecological significance; human use
- Environmental and economic benefits of biological diversity
- Realisation that only sustainable development as an ecological interlinking of nature, economic activity and mankind ensures future conservation of the biosphere: global networking of ecosystems, conservation of biological diversity etc.
- Origin and extinction of species
- Anthropogenic influences on nature: Extermination of species
- Responsibility for nature
- Current challenge: Limits of growth
- Human intervention: Availability of and limitations on resources
- Human intervention and its consequences, e.g. impacts of intensity of use and changes of use on biological diversity
- Biology lessons show the limits of the stress resistance of the abiotic and biotic basis for life, the need to protect biotopes and biological diversity, and the repercussions of anthropogenically influenced ecosystems on health, food, renewable raw materials and production of energy from renewable sources. Existing ecosystems can only be preserved if natural resources are used in a sustainable fashion.

CONTENT-ORIENTED LEARNING GOALS

Set 2 familiarises the pupils with the Rhön Biosphere Reserve. It uses the example of the Rhön sheep to raise their awareness of the various fields of interests and groups of people that play a role in such a biosphere reserve (nature conservation, industry, tourism etc.). With the aid of brief facts and (optionally) an Internet search they have the task of compiling as much information as possible about the Rhön sheep, which is used here to represent the entire complex.

In the second part the pupils, acting as a planning team, have to develop a conservation area and enter it on a map. They have to reconcile a number of divergent – and at first glance incompatible – interests. The pupils are called upon to bring the requirements (environmental, economic, social) into line and resolve the conflicts. In doing so, they also learn something about the differences and similarities between the two conservation area strategies for national parks and biosphere reserves, and use the strategies to find creative solutions to problems in a fictitious area. On the basis of specifications, the pupils draw up a use plan for a (fictitious) biosphere reserve. In this process they have to take account of different and conflicting interests and undertake appropriate zonation where necessary.

Learning goals in relation to Gestaltungskompetenz / OECD key competencies:

The following OECD key competencies or sub-competencies are addressed:

Interactive utilisation of media and tools:

1. **Building knowledge to integrate new perspectives, with an open mind:**
   - The pupils are able to describe and assess the sustainable development approaches and concepts of the biosphere reserve
   - The pupils present various points of view and interests with regard to global (non-)sustainable developments (conflicts of objectives when drawing up a land use plan) on the basis of the new perspectives they have come to know
2. **Forward-looking thinking and acting**
   - The pupils analyse problems of non-sustainable development and anticipate possible sustainable developments
3. **Ability to acquire and use interdisciplinary knowledge interactively**
   - The pupils present sustainability concepts (here: biosphere reserve)

Interacting in heterogeneous groups:

1 **Planning and acting together with others (group work):**
   - The pupils, working in groups, are able to identify and analyse different points of view on sustainability and deal democratically with controversies arising in this context (use plan for fictitious biosphere reserve)
2. **Being able to take part in decision processes**
   - The pupils demonstrate how cooperative problem solving can be achieved in the development of action strategies for sustainable development
   - The pupils constructively overcome differences of opinion and conflicts with regard to questions of (non-)sustainable development (use plan)

Acting autonomously:

1. **Considering one's own and other people's guiding visions**
   - The pupils describe ways of life that safeguard and promote sustainable consumption, health, and environmentally and socially acceptable mobility and leisure activities
   - The pupils identify and assess the background, aspects and impacts of the lifestyles of other people or social groups on the biosphere of other people (Rhön sheep concept, sustainable use of biosphere reserve)
2. **Being able to plan and act autonomously**
   - The pupils, by implementing a sustainability project, demonstrate their own experience of autonomous planning and autonomous action.

SUGGESTED APPROACH

Introduction and Phase 1:
The pupils familiarise themselves with the topic with the help of the introductory story. Then they jointly work through Worksheet 1 and acquire a deeper knowledge of the subject. It is important that the pupils identify, describe and assess the economic, environmental and social aspects of the use of the Rhön sheep.

In-depth work (plan conservation area) and Phase 2 (identical group work):
The pupils are divided into small groups. Their assignment is to plan an ideal conservation area **(see also Worksheets 2, 3 and 4)** and draw up a use plan that takes account of the interests of man and of nature conservation. They also find out about the differences and similarities between biosphere reserves and national parks (Infosheets 1 to 3, Internet). The pupils document their ideas in writing on the worksheet or on posters for presentation to the class. The results of the group work are presented to the whole class. The pupils present their conservation areas and discuss their results.

Background information on the topic:
Since the United Nations developed the concept of biosphere reserves, there has been a massive increase in the number of such reserves. Today the classic national parks frequently form a part of the biosphere reserves where sustainable human use is practised and at the same time nature conservation interests are taken into account. In Germany there are national parks and biosphere reserves in nearly all non-city states with the exception of Baden-Württemberg and Saarland, which makes it possible to visit them on a class trip, e.g. to an information centre in one of these areas. These local information centres offer a wealth of information on the particular conservation area. Contacts with local environmental centres (run either by public authorities or by environmental associations) can also be a useful supplement to school lessons. Traditional breeds of farm animals are also a subject that can be discussed in almost any part of the country with the aid of a local example – an Internet search will reveal opportunities for contact with breeders. Numerous regional associations are bound to be willing to cooperate.

Note
In livestock farming today there are, generally speaking, only a small number of breeds, which are bred for (high) performance in specialised fields (milk, meat, wool, etc.). In the case of sheep these are the Merino sheep (wool), German White-Headed Mutton sheep (meat), East Friesian dairy sheep (milk). By contrast, there are the local sheep breeds (e.g. the Rhön sheep), which as a rule are less demanding in terms of fodder (protein content) and are also adapted from the point of view of climate and fodder quality to the countryside in which they were bred. They are mostly "all-rounders", in other words not specialised, but less productive (smaller, slower-growing) than the high-performance breeds, and this is also the reason for their displacement from the market. For these reasons the Rhön sheep had disappeared from the market and would have become extinct without the dedicated efforts of environmental and nature conservation associations. Traditional local breeds can only be preserved by means of special marketing channels of the kind successfully developed for the Rhön sheep. In reality, the relationships shown (see Worksheet 1) only apply to these local breeds, like the Rhön sheep.

The Rhön sheep is only one example of many hundreds of specific breeds of farm animals. Get your pupils to research into whether there was a traditional breed of farm animal that used to be widespread in your locality, and whether the use of this breed shaped the characteristic appearance of the local countryside. Have the breed and the way it is used, and also the resulting landscape, been preserved? (Examples: German Heath sheep, Swabian-Hall swine, Bentheim Black Pied swine ...). The pupils should also consider whether the experienced gained with the Rhön sheep can be applied to other traditional breeds of farm animals.

Links relating to Rhön sheep / Rhön Biosphere Reserve:
www.fondazioneslowfood.it/eng/arca/dettaglio.lasso?cod=676&prs=0
www.biosphaerenreservat-rhoen.de/englisch/indexengl.html
Links relating to other breeds of farm animals / sustainable agriculture:
www.sciencedaily.com/releases/2007/09/070903094320.htm
www.fao.org/NEWS/2000/001201-e.htm

NOTES AND ANSWERS ON THE WORKSHEETS

Worksheet 1:
Task 1:
Economic aspects:
Sheep supply meat and wool, which are processed and marketed.

Environmental aspects:
Extensive grazing by sheep maintains the typical open countryside of the Rhön uplands without causing harm to the local environment through over-grazing; the open nature of the countryside permits the settlement or continued existence of numerous animals and plants that need open fields.

Social aspects:
Sheep farming makes for jobs and businesses that are directly dependent on this domestic animal: shepherds, farmers, butchers, innkeepers, veterinary surgeons; there are also indirect impacts on tourism (restaurants, tourism services in general).

Task 2:
The pupils discover that the Rhön sheep is at the centre of a network of relationships (selection):
- The sheep provides food (meat), which is processed and marketed by the butcher or farmer, partly to local restaurants,
- The sheep also eats young tree shoots, thereby keeping the countryside open (grazing); this preserves the experience for hikers, and they in turn provide the basis for the local restaurant trade.
- Sheep provide manure, which is used to fertilise the fields; they also provide meat and wool, which are either processed directly and then marketed, or passed on by the farmer.

Worksheet 2:
Possible answers to the map questions (Worksheets 3 and 4)

1. Black storks are forest breeders and very shy. To protect the black storks it is necessary to designate a radius of 500 metres around each of the nests as an absolute core zone.
2. The observation platform should be accessed by a track from the south, in order to avoid crossing the absolute core zone and to minimise surface sealing. Car parking areas should be as peripheral as possible; this could mean close to the road, in which case the surfaced track could be longer.
3. The footpath can initially run along to the right of the stream, but should then turn away and run along the western fringe of the forest (shade!). A bridge over the stream is also conceivable, but this would be a comparatively serious encroachment. The footpath crosses the heath land in the southern part, after which it runs along the eastern side of the forest and back to the starting point.
4. The mountain-bike route can run parallel with the visitors' track, but should not cross it. It would make sense for the route to start on the steeper slope on the left.

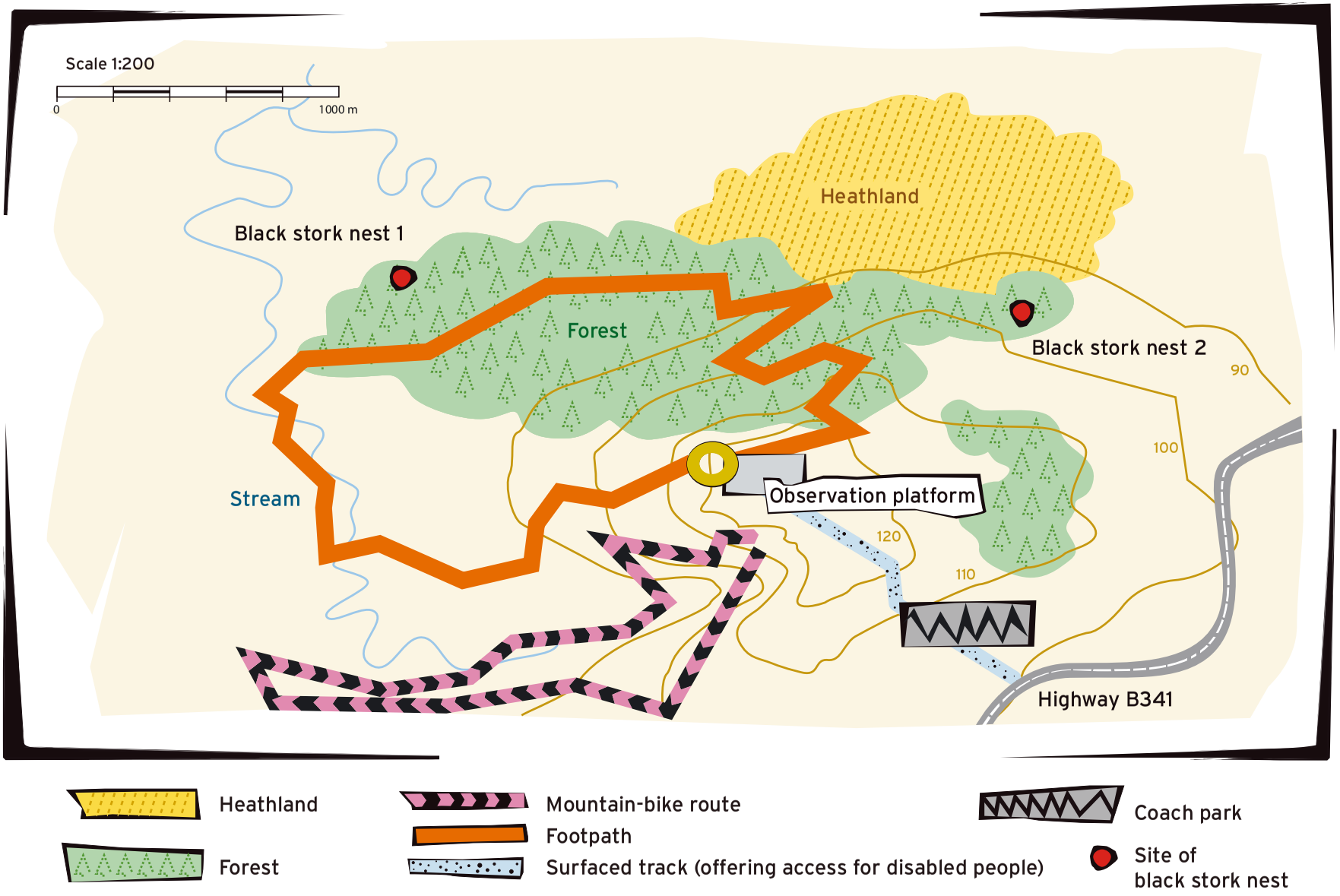
Other action options
What can the pupils do with their newly acquired knowledge? Particularly the biosphere reserves in Germany offer a wealth of opportunities for pupils of all ages to play an active role. For example, they can help to design teaching paths, participate in the Junior Ranger programme or take part in work experience opportunities. For further information, see the websites of the individual biosphere reserves. Go to the umbrella organisation EUROPARC (www.europarc.org), where you will find the links to the individual sites.

MATERIALS

- Introductory story
- Worksheets 1 to 4
- Teacher handout
- Information sheets 1 to 4: Biosphere Reserves and National Parks

ANSWER WORKSHEET 4

One possible solution is as follows (differences are possible within the limits of the conditions stated above):



The Biological Diversity module sets out to show, with the aid of scientific questions and exercises, what benefits nature in all its variety has to offer us, what we can learn from nature, and also why this variety is worth protecting and how it can be protected.

A framework "plot" with four young people leads into the three sets. The introduction to bionics in the first set establishes a relationship with the young people via their fascination with technology. The second set takes up the topic of biological diversity in Germany, using the example of the Rhön Biosphere Reserve, which the pupils can transfer to other regional domestic animal breeds/livestock species in an exercise. The third set focuses on biodiversity in a global context, using the example of the "Rainforest Pharmacy" – including conflicts of use.

CONNECTION WITH SYLLABUS:

- Biological diversity; ecological significance; human use
- Environmental and economic benefits of biological diversity
- Need to conserve biotopes and biological diversity
- Importance of biological diversity for sustainable use of ecosystems
- Realisation that only sustainable development as an ecological interlinking of nature, economic activity and mankind ensures future conservation of the biosphere: global networking of ecosystems, conservation of biological diversity etc.
- Future technologies: Nature and technology
- The tropics / biodiversity of the rainforests: Use and threats

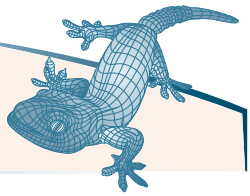
METHODS

Action-oriented and problem-oriented interdisciplinary teaching, independent learning in individual work, partner work and team-based group work (experiments)

Age: 12 to 16 years
Subjects: Biology, Physics, Politics, Ethics

CONTENT-ORIENTED LEARNING GOALS

In Set 1 the pupils can familiarise themselves with possible uses of nature in the field of bionics through examples (self-cleaning surface, gecko's foot etc.) and experiments. Their creativity and imagination are called for when they have to think of potential practical (technical) applications of various natural phenomena ("effects"). At the same time they are required to take account of the aspect of sustainability, e.g. savings in raw materials.



Learning goals in relation to Gestaltungskompetenz / OECD key competencies:

The pupils learn to use the scientific knowledge they have acquired about biological diversity, recognise the scientific problem, and can draw conclusions from this knowledge that enable them to make decisions for their own everyday activities.
The following OECD key competencies or individual elements of Gestaltungskompetenz are addressed:

Interactive use of media and tools:

- Build up knowledge in a way that is open to the world and integrates new perspectives, by getting the pupils to describe and assess diversity and variety in the ecological field.
- Ability to use interdisciplinary knowledge interactively: Interdisciplinary acquisition of topic, problem and solution (experiments)

Interacting in heterogeneous groups:

- Planning and acting jointly with others (group work)

Acting autonomously:

- The ability to plan and act autonomously (group work), with pupils demonstrating their own experience of autonomous planning and autonomous acting in the implementation of a sustainability project

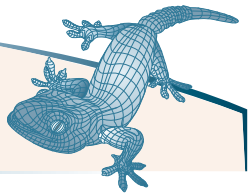
SUGGESTED APPROACH

Worksheet 1 and Worksheet 2:

Worksheet 1 serves as an introduction to the topic. The pupils learn the secret of the gecko's unique sticking power. **Worksheet 2** provides further interesting examples of how nature can serve as a model for possible technological applications. The pupils work on the exercises in small groups. For this purpose they can use the Internet or relevant literature. Then they evaluate the results of their work. Their ideas on Exercises 2 and 3 are presented to the whole class, collected and documented (e.g. dossier, wall newspaper, poster etc.). The pupils define the term "bionics" and then collect examples of possible uses of natural effects for human life. They make a creative search for potential uses for such effects, and consider what applications and benefits the effects could have, especially with regard to sustainability (e.g. using fewer raw materials, saving time, cutting costs, achieving efficiency gains). Another possibility is a brief survey on the topic among other pupils in the school playground. They could tell their friends about an example of bionics, and then ask them for other ideas. These results supplement their own ideas.

Suggestion for transfer phase:

Once the pupils have become familiar with a number of examples of bionics, they should transfer what they have learned by looking for models in nature for the development of an environmentally friendly means of transport. The pupils are divided into groups and assigned the task of developing a futuristic, environmentally friendly means of transport that is based on models occurring in nature (e.g. dolphin skin, wingtips of birds of prey etc.). It can fly or swim or move in any other way. The pupils produce a model, drawing or poster to present their ideas.
(see **Worksheet 2**, Exercise 3).

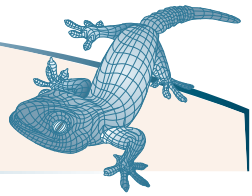


In depth: Work Phase 2 (experiments, Worksheets 3 and 4):

The pupils learn about the Lotus Effect® as another example in the field of bionics by working together on **Worksheet 3**. The results are evaluated by the whole class. The pupils are then divided up into groups of 4 to 5 pupils, to perform experiments on the Lotus Effect® **(Worksheet 4)**. The groups work separately on two different assignments **(Worksheet 4)**, with two to three groups working on each assignment. The pupils record their observations so that they can subsequently present them to their fellow pupils. During the evaluation of results, the questions on **Worksheet 4** are clarified in a group discussion.

Remarks / Further transfer:

It may be possible to bring the collected material together to produce a small exhibition, which can be displayed in the school, in other classes or at a parents' evening. After all, the pupils are now bionics experts!



NOTES AND ANSWERS ON THE WORKSHEETS

Worksheet 1:

Task 1: The usual adhesives are manufactured on the basis of organic compounds. Their adhesive action is based largely on chemical bonding, or in a few rare cases on physicochemical interactions. The gecko's foot, by contrast, sticks as a result of physical forces acting on a nano scale.

Task 2: Possible uses relating to climbing, e.g. for industrial climbers (facade cleaning, construction, restoration), rescue services

Task 3: Discontinuation of production, storage and disposal of health-risk adhesives that use organic solvents.

Links to "nanotechnology"
The topic offers good links to other interesting questions. The way the gecko's foot sticks to surfaces is connected with forces acting in the nanometre range (millionths of a millimetre). Scientists are hoping to make important discoveries for the future on this minute scale in particular. Nanotechnology is increasingly see as "the" technology of the future. Instead of "higher and higher, farther and farther", its motto is "smaller and smaller, faster and faster". Nanotechnology opens up the world of the very smallest things. The possible applications of this technology are immense. Future advances in nanotechnology will play an important part in determining the future development of future-oriented industries. But there are also constant warnings about the possible risks of this technology. Central issues in the debate about nanotechnology include the potential risks to the environment and health posed by ultra-fine particles. Nano-particles can present risks to health and are therefore an important issue in technological impact assessment.

Get your pupils to discuss the pros and cons of this topic – which is undoubtedly of relevance for the future.

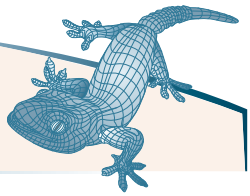
Worksheet 2:

Task 1: The aim is to make it clear that bionics is an interdisciplinary subject in which biologists, physicists and engineers work together. It must also be stressed that it is not a matter of making faithful copies of nature, but of getting ideas for developing new technological solutions.

Task 2: A large number of items can be found on the Internet, e.g. at:
www.biokon.net/bionik/beispiele.html.en

Possible models in nature could include: Sandfish (reducing friction), winglets of birds of prey (improving aerodynamics), sharkskin and dolphin skin (reducing flow resistance), recoil propulsion principle of jellyfish and squid, motion sequence in articulate animals (spiders' and beetles' legs as a model for walking robots).

Task 3: The pupils search for appropriate examples with the aid of the Internet links provided, e.g. sharkskin and swimsuits.



Worksheet 3:

Task 1: A detailed description of how it works can be found on the info sheet.

Task 2: Car paint, self-cleaning facades etc.

Task 3: Solvents, cleaners, cleaning equipment

Task 4: Self-cleaning surfaces need running water to clean them. It therefore makes little sense to use products based on the Lotus Effect® for certain indoor applications, e.g. wallpaper or furniture. Such products always have a micro to nano-structured surface. Most of these products cannot therefore be exposed to extreme mechanical stresses. This means that floors, slide rails or similar objects are not potential applications at present.

Worksheet 4 (experiment):

Note: **The pupils should be particularly careful to pour the liquids onto the leaf surfaces as evenly and smoothly as possible.**

Experiment group 1:

Task 3: The plant surfaces tend to repel the water better than the artificial surfaces.

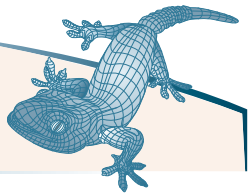
Tasks 4 and 5: The plant surfaces have a micro and nano structure that ensures the water droplets cannot cling to them. This results in strong surface tension which pulls a water droplet together on such a surface structure and keeps it almost spherical. On the artificial surfaces, e.g. glass, the droplets look flatter (see also info sheet).

Experiment group 2:

Task 3: The plant surfaces will repel the dirt better than the artificial surfaces. And among the latter, the surfaces with a wax component (e.g. ice cream pack) will repel the dirt better than those without wax (e.g. glass, tiles).

Task 4: Even sticky substances like honey, sugar or all-purpose adhesives are repelled by the plant surfaces, whereas they are almost impossible to remove from the artificial surfaces (with the exception of those with a wax component).

Task 5: See the explanation for Experiment Group 1.



LINKS

Worksheet 1:
Information on gecko foot:
www.sciencenews.org/articles/20050108/fob6.asp
www.lclark.edu/~autumn/dept/geckostory.html

Worksheet 2:
Background information and examples (for schools as well):
www.biokon.net/bionik/beispiele.html.en
http://en.wikipedia.org/wiki/Bionic

Bionics, applications in architecture:
http://en.wikipedia.org/wiki/Bionic_architecture

Worksheet 3:
Background information on the Lotus Effect®
http://en.wikipedia.org/wiki/Lotus_effect
http://lotus-shower.isunet.edu/the_lotus_effect.htm

MATERIALS

- **Introductory story**
- **Worksheets 1 to 4**
- **Teacher handout**
- **Bionics Infosheet**

FIT FOR THE FUTURE – ACQUIRING GESTALTUNGSKOMPETENZ

The goal of modern learning is to shape society and one's own life in a well considered, soundly reasoned and self-determined manner, working alongside others. This being so, schools must do more than teach pupils to merely react to the school's demands and to changes in later life. Teaching must enable them to acquire competencies, not only for coping with the future, but also for actively shaping the future. One fundamental aspect is therefore the acquisition of competencies that are not confined to managing and structuring everyday life in a self-determined fashion, but are also suitable for shaping life in the world of tomorrow.

So it is hardly surprising that topics like Renewable Energy Sources, Biological Diversity, Environment and Health, Water, Use of Natural Areas, or Waste and Recyclable Materials are commonly found as subjects in a modern syllabus or curriculum. These are important issues in everyday life today, and are of central importance for shaping a life worth living the world over.

But is it sufficient merely to put these topics on the timetable? What kind of results do we expect as the outcome of such learning? To arrive at a clearer and more detailed picture, it makes sense to take a closer look at the competencies for shaping this future. According to a definition by F. E. Weinert, competencies are "the cognitive abilities and skills that individuals possess or can learn for solving specific problems, and the associated motivational, volitional and social readiness and abilities that enable them to use these solutions responsibly and successfully in a variety of situations." Thus competencies are primarily a matter of the ability to take action, not of abstract school knowledge. The ability to solve problems is seen here in close connection with standards, values, readiness to act and – of course – available knowledge. As the ability to take action, competencies are tied to specific objects, contents, knowledge and skills.

Competence-oriented education strategies are output-oriented, whereas conventional curricula and didactic approaches are input-oriented: the latter ask what topics the pupils should be studying. The output approach, by contrast, asks what problem-solving strategies, action concepts and abilities they should possess. Only on this basis is it possible to determine what needs to be learned. This can to some extent be made dependent on pupils' prior knowledge, motivation, local and individual everyday associations – and can thus enhance both the learner's interest in the subject and an acquisition of competence that is not confined to the mere accumulation of "dull knowledge" (Weinert).

What abilities and skills, social and cultural reference points should children and young people possess to enable them to manage and shape their future? What knowledge should they share and have in common? These questions guide the search for teaching content when approaching the problem from the competence point of view. Looking at things from this angle, the list of possibilities is extremely long. It is nevertheless possible to identify a few over-arching educational objectives that help with the selection of what is to be learned. A study commissioned by the OECD mentions human rights, the goal of being able to practise living democracy, and the criteria for sustainable social, economic and environmental development. The pursuit of human rights, within a framework of democratic structures and in the interests of sustainable development, represents three over-arching educational objectives which form guidelines for defining competencies. These statements are of no small importance. After all, the OECD is also responsible for the PISA studies; and in 2006 these surveyed pupils' competencies in the natural sciences.

The competencies that children and adolescents should possess if they are to be able to act in the interests of sustainable development are subsumed in Germany under the term Gestaltungskompetenz. Gestaltungskompetenz denotes the ability to identify problems of non-sustainable development

and apply knowledge about sustainable development. In other words, being able to draw conclusions about environmental, economic and social developments and their interdependence from analyses of the present and studies of the future, and to use them as a basis for taking, understanding and implementing decisions that permit the realisation of sustainable development processes.

This general description of Gestaltungskompetenz displays close relations to the definition of "scientific literacy" which underlies the PISA studies – including the 2006 study which investigated young peoples' competencies in the field of natural sciences. It reads as follows: "Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity. " Both competence definitions are concerned with findings, knowledge, understanding phenomena and actions, and taking decisions that affect the environment. Above and beyond this, Gestaltungskompetenz focuses specifically on problem-solving skills and the ability to take proactive and future-oriented action.

In all, Gestaltungskompetenz comprises eight individual competencies. Placing them in the context of scientific and technical findings and problems, as presented in this large package of materials, results in the following picture:

1. **The competence to think in a forward-looking way,** to cope with uncertainty and with fore casts, expectations and designs for the future – for example, with regard to the future use of renewable energy sources – is the individual competence to look beyond the present. The crucial factor is being able to grasp the future as something that is open and capable of being shaped with the aid of innovative technologies, and to develop various action options from current situations on the basis of this attitude. Forward-looking thinking and acting makes it possible to consider potential future developments – such as climate change – and to discuss the opportunities and risks associated with present and future developments, even if these are unexpected. At the level of learning goals, this means:

- The pupils are familiar with various methods of future research into (non-) sustainable development (e.g. energy scenarios; species reduction forecasts). They are able to use the methods in group work. They can assess and describe the strengths and weaknesses of the methods.

- The pupils are able to select the various methods of future research appropriately for problem areas of environmental change and applications of environmental technology that have not yet been dealt with in lessons.

- The pupils can reproduce the main statements of various future scenarios and forecasts, for example on climate change, especially with regard to environmental risks, poverty and non-sustainable global economic developments. They are sufficiently familiar with associated action recommendations and strategies to be able to reproduce them in their threads of argument.

- On the basis of material and information sources provided on non-sustainable or problematical developments – e.g. with regard to landscape depletion due to settlement-related measures – the pupils can work together in projects to design and visualise positive scenarios of technical, social, environmental and economic change, and can present them in verbal and pictorial form both logically and on the basis of value judgements and imaginative components.

2. **The competence to work on an interdisciplinary basis.** Problem areas of non-sustainable development and perspectives of viable future changes can no longer be coped with by a single technical discipline or using simple action strategies. They can only be handled by cooperation between multiple technical disciplines, different cultural traditions and aesthetic, cognitive and other approaches. The development of suitable abilities is indispensable for identifying and understanding system contexts and dealing appropriately with their complexity. Such abilities are fostered by problem-oriented interlinking of natural and social sciences, innovative technical knowledge and planning strategies, and imaginative thinking and innovative access facilities. This presupposes interdisciplinary, i.e. cross-subject, learning. This leads to the following learning goals:

- The pupils can describe complex situations with the aid of integrated analytical methods from the natural and social sciences.

- With the aid of creative methods, normative criteria, personal value judgments and research-oriented learning, the pupils can work on problematical non-sustainable development situations – e.g. biodiversity reduction – in a way that permits their transformation into models of sustainable development – e.g. as illustrated by biosphere reserves.

- When presented with problem situations – e.g. the threat to fresh water from inputs of environmental toxins – the pupils can analyse them to see which technical disciplines, information sources and actors need to be consulted to permit appropriate analysis and countermeasures.

3. **The competence of cosmopolitan perception, transcultural communication and cooperation.** Gestaltungskompetenz implies the ability to grasp and localise phenomena in their world wide context of links and interactions. This competence focuses on perceptions that broaden contexts and horizons. Because a regional or national point of view is too narrow to permit orientation in a complex global society, perception and assessment horizons need to be expanded in the direction of a global approach. For example, a Central European view of freshwater reserves and use is totally different from the viewpoint of nations and peoples in arid or semi-arid regions. In terms of learning goals, this means:

- The pupils can describe relations between global climate change, resource consumption, pollutant inputs, economic ramifications and the social situation in developing countries on the one hand, and national pollutant inputs and resource consumption on the other.

- The pupils are able to familiarise themselves independently with other cultures' views and arguments regarding individual aspects of sustainability, and to assess and use these views and arguments in their own arguments, descriptions and assessments of situations. For example, what is the significance of exporting old cars and old clothes to Africa?

- They are also able to describe, with the aid of examples, the impacts that their own actions and those of their surroundings (school; region) have on resource consumption, pollutant inputs and equitable distribution at a supra-regional level and over long periods. To this they can apply a concept for calculating flows of materials.

- The pupils are familiar with methods of presentation and treatment that reflect different interests and problems from the viewpoint of various cultures and philosophies. What arguments do developing countries put forward when they are called upon to invest in environmental technology or to reduce pollutant emissions? In this connection the pupils can make a conscious change of perspective, identifying and assessing important points in the perspectives of different cultures, and using them in the interests of communication and understanding.

4. **Participation competence.** The ability to take part in shaping sustainable development processes is of fundamental importance for future-oriented education. There is a growing need to take part in decisions and a growing interest in helping to shape the world in which we live – at least in our culture: Involvement in decisions and self-determination at work, in civil society (and not just when it comes to planning leisure time) – are acquiring increasing importance for an emphatically independent way of life. This implies the following abilities:

- The pupils have the ability to draw up, together with their fellow pupils, teachers and non-school partners, joint sustainability objectives – for example, with regard to species protection or the use of renewable energy. They are able to stand up publicly with others in support of their joint objectives.

- The pupils can appreciate divergent positions of individuals, groups and nations on individual aspects of sustainability – e.g. regarding the designation of nature conservation areas and the protection of certain species. Together with their fellow pupils and other actors, they are able to turn conflicts and controversies into constructive suggestions for solution

- On the basis of practical activities, the pupils display the ability to engage regularly with others in environmental, economic or social fields of sustainability. This may relate to reducing energy and water consumption, advocating waste avoidance, or propagating gentle tourism or ideas for sustainable homes in the future.

5. **Having planning and implementation competence means** being able to assess action workflows with regard to the necessary resources and their availability from a sustainability point of view, to design cooperation networks, to allow for side-effects and possible surprise results, and to cater at the planning stage for their potential occurrence. Relevant learning options discuss feedback, delayed consequences and time lags of the kind familiar from the damage to the ozone layer or inputs of environmental toxins into water, and offer a corresponding repertoire of methods. Implementation competence comprises the actual interest in pushing action beyond the intention and planning stage – for example commitment to the installation of a photovoltaic system on the roof of the school. The pupils should therefore be able to do the following:

- The pupils can use sustainability criteria to estimate the resources (e.g. heat energy, water, office materials, cleaning and polishing agents) necessary for services, production or the ongoing operation of a facility (e.g. the school) and make optimisation proposals on this basis.

- Within planning processes, the pupils are able to cope with surprise effects, uncertainties and necessary modifications by reacting appropriately to such effects and situations and readjusting the planning processes – e.g. rising consumption as a result of dwindling commitment on the part of pupils, shortfall on savings targets due to cold winters.

- In this context the pupils are familiar with the phenomena of feedback, late consequences, and delayed occurrence of problem situations. For instance, they can name examples and can describe and critically assess forms of reaction and anticipation that are practised by the economic and political world in this context. The different reactions by various nations to climate change analyses provide a number of good examples.

- The pupils are in a position to implement a project successfully on the basis of their acquired planning competence. In this respect they undertake activities by developing planning processes into action concepts and taking them to the action stage either independently or in concert with others. Saving resources, propagating new heating technologies and using environmentally friendly materials provide numerous opportunities for action here.

- They are able to present the results of their sustainable planning processes to different external groups (parents, teachers, citizens in a pedestrian zone, younger pupils) in a manner appropriate to the individual groups.

6. **Capacity for empathy, sympathy and solidarity.** All sustainability concepts set out to achieve greater equity, which always involves a balancing transfer between rich and poor, advantaged and disadvantaged, and seeks to minimise or abolish oppression. This is not just a matter of morals. It also involves the will to exploit scientific and technological potential. This in particular has frequently not been the case in the past. Many new ideas for environmentally friendly technologies are not used because of short-term economic considerations or long-established habits. The ability to stand up for greater equity and the use of innovative potentials makes it necessary to develop a certain empathy, a kind of global “togetherness”. Education for sustainable development therefore aims to develop individual and collective action and communication competence in a spirit of worldwide solidarity. It provides the motivation and empowerment to find viable joint solutions to joint problems and to make a considered stand for greater equity. This starts with collecting for a solar cooker that can be used by families in semi-arid areas with little fuel wood, and continues with support for whaling rules that conserve whale populations while acknowledging the traditional whale catching rights of indigenous peoples. This includes the fol lowing examples:

- The pupils are able to express their empathy for animal protection, species-appropriate livestock farming, conservation of endangered species and ecosystems, and biological diversity.

- They can argue in favour of local and regional measures designed to combat non-sustainable developments – for example reduction of land take for settlement purposes – and for sustainable changes in socio-economic and natural living conditions, for instance by advocating greater use of wind energy, biosphere reserves and equitable water resources management in arid and semi-arid areas of the Earth. They express their emotional attitudes to the relevant circumstances.

- The pupils can describe, both with rational arguments and with emotive approaches, the situation of people who live in poverty, who lack adequate medical or other care, who are oppressed, or who have little or no access to education. Thanks to their knowledge of innovative technologies and sustainable management of resources, they are able to discuss action options for improving the situation.

- They are able to argue in favour of the interests of such people with the aid of international treaties and conventions, such as the Framework Convention on Climate Change or conventions on species protection, by reference to religious or ethical standards and values, and by making use of existing scientific and artistic works.

7. **The competence to motivate themselves and others.** Getting to grips with the concept of sustainability, breathing life into it and developing viable and satisfactory everyday lifestyles requires a high degree of motivation to change oneself and encourage others to do the same. Education for sustainable development sets out to develop the motivational drive we need if we want to lead a fulfilled and responsible life even under the complex conditions of an increasingly interdependent world. Being able to motivate oneself and others means knowing about action options. In other words knowing innovative environmental technologies, resource-conserving lifestyles, nature-friendly forms of mobility and economic activity, and being able to argue in favour of their use. What does this mean when translated into learning goals?:

- The pupils can cite activities and learning progress from their work on sustainability issues, such as “Renewable Energy Sources”, “Biological Diversity”, “Regional Utilisation and Threats”, which motivate them to put into practice and supplement the knowledge, problem-solving strategies and action concepts they have acquired.

- The pupils can demonstrate to others their commitment, problem-solving abilities and factual knowledge in relation to sustainable development processes and the identification of non-sustainable developments by informing them, say at exhibitions and other presentations about the use of fuel cells, wind energy, solar technology and the implications of the growing consumption of oil for energy production.

- In the course of their learning, the pupils display increasing expectations about their own effectiveness with regard to the possibility of implementing strategies for sustainable development processes. This means, for example, that after working on Renewable Energy Sources for some time they should be more convinced than before that it is possible for them to make a contribution to the “energy revolution”.

8. The competence to engage in detached reflection about individual and cultural models.
Identifying and critically appraising one's own interests and wishes, localising oneself in one's own cultural context, or actually adopting a well considered stance in the debate on global equity calls for the competence to engage in detached reflection about individual and cultural models. This is partly a question of perceiving one's own behaviour as culturally conditioned, and partly of getting to grips with social and societal models. For example, there are socially favoured lifestyles (the ideal of a detached house out in the country; air travel to one's annual holiday destination; a car of one's own; solarium-tanned skin) which are problematical from the point of view of health and sustainability. What kind of abilities and skills should pupils possess in connection with this individual competence?

- The pupils are able to give a structured description and assessment of their lifestyles and their local and family environment in the light of the perspective of people and living conditions in developing countries. This can for example be done by comparing land take for housing, differences in interest in repairable equipment, or misgivings about the use of environmentally harmful chemicals. Against this background, the pupils show their ability to describe the limits of their own lifestyles and the extent to which they can be generalised.

- The pupils are able to identify and describe the intentions associated with their lifestyles in terms of their consequences for the environment and for social equity. Suitable issues for this include topics from the complex "Biological Diversity", and also reflections about leisure interests, clothing fashions, interest in the protection of animals and in mobile phones free from "electromagnetic smog".

- They are able to analyse their designs for the future – for example the kind of homes they want, their ideas about mobility, use of leisure time, travel destinations – from the point of view of social equity, consideration for the freedom of action of future generations and their potential environmental impacts, and can cite action options for reducing the resulting friction between sustainability and designs for the future. It goes without saying that it cannot be the objective of every project or every lesson to teach all these individual competencies. They define the background against which the content should be chosen and discussed and the teaching methods selected. It will of course be necessary to specify the individual competencies in more detail, particularly in relation to the material taught. This is done in the following material under the heading of "Learning Goals".

Bibliography

· OECD (Ed.), DeSeCo Strategy Paper. An Overarching Frame of References for a Coherent Assessment and Research Program on Key Competencies. www.statistik.admin.ch/stat_ch/ber15/deseco/deseco_strategy_paper_final.pdf

To help teachers use these materials on Biodiversity in schools, the Education Service can provide general information about learning goals and the way the material fits into the existing syllabus, as well as pointers on educational standards in science. This will help teachers identify the contexts in which they can use the topics, project suggestions and worksheets. The material also takes account of the standards for geography drawn up by the DGG (German Society for Geography), since many aspects of Biodiversity have clear links with geography.

Biodiversity, the variety of landscapes, biotopes, biocenoses and ecosystems, is of vital importance for the existence of humans, animals and plants. Ethical, aesthetic and economic factors point to the need to protect, conserve and even expand the diversity of ecosystems. Even those who do not acknowledge an intrinsic right of all living things or who do not value the beauty of nature, even those who do not attach any (monetary) value to nature or to individual plants and animals, have no option but to safeguard biodiversity. This necessity is a simple consequence of the dependence of all living things – including human beings – on the diversity of ecosystems.

For this reason, biodiversity is of the utmost relevance for present and future generations, and learning about it is an indispensable part of our education. This is not just a matter of acquiring additional information in the sense of "dull knowledge". The aspects of biodiversity presented here directly affect young people in their everyday life: the variety of the living world in their immediate vicinity, forms of landscape use and the design of urban areas are important for them, as is the opportunity to learn from the sustainable and efficient solutions created by nature (from the durability of a spider's web, through the aerodynamics of birds, to self-repairing structures). It is only natural in this context that the issue of whether an ecosystem and its diversity should be preserved gives rise to conflicts of use and is the subject of learning-oriented confrontation.

Grasping and explaining the complexity and "ingenuity" of the functioning of ecosystems and survival strategies of animal and plants is necessary to arrive at a deeper understanding of ecosystems and appreciate nature's "inventions". Making efficient use of resources, nature has often produced solutions that humans can learn from.

Learning goals (in brief)

Biodiversity and bionics have met with a broad response in scientific and technical broadcasts in the mass media. In technological research, bionics is regarded as a promising combination of biology and technology. The science of robotics adapts motion sequences of animals, architecture puts the statics of plants and animals to good use, the food industry employs preservation methods adapted from nature. Today the attention focused on biodiversity is primarily concerned with preserving the gene pool for plant and animal breeding, for medicine, and also for "gentle tourism". The demand for accurate knowledge and exploratory research is particularly great in both sectors. The material provided here illustrates the function of biodiversity, how it can be analysed and preserved, and what risks and conflicts of use can arise. The set on "Bionics" is experimental in approach and indicates the opportunities offered by "learning from nature" for innovations and solutions in the technological field. The material is also designed to foster interest in discovery-based learning.

Points of contact with the syllabus (in brief)

Biodiversity as a topic is firmly established in the syllabus for junior secondary level in two main forms: in biology and in geography. Particularly at national level – as dealt with in Set 2 – biodiversity is closely connected with biology. By contrast, the discussion of the international aspects of biodiversity has strong connections with geography.

As a rule, a variety of ecosystems are dealt with in biology from age 12 onward. In this context attention is paid not only to the functioning and importance of ecosystems, but also to the threats to them and the importance of the diversity of biocenoses. The links with chemistry are more difficult. Nevertheless, the topic of "chemistry and the environment" is firmly established in this subject area. From age 13, this looks at air, soil and water pollution by harmful substances (nitrates, phosphates, pesticides, alkalis, salts etc.).

Geography in particular has established close links with sustainability in recent years. It takes an extensive look at anthropogenic influences on ecosystems, interest in using nature, conflicts of use etc. during all years of the junior secondary stage. This offers ideal opportunities for cooperation with biology or with ethics and politics.

All in all, there are thus close links between this material and the biology and geography syllabuses, and also to some extent with the syllabuses for technology and physics: Bionics has links with physics/technology. We would nevertheless like to draw special attention to the fact that we see the topics in a "scientific literacy" context. In other words we pursue an integrated scientific competence approach that creates close links between nature, environment and society and, in the case of biodiversity, focuses on the anthropogenic factors influencing ecosystems.

WHAT DO SCIENTIFIC EDUCATION STANDARDS FOR THE INTERMEDIATE-LEVEL SCHOOL CERTIFICATE SAY ABOUT "BIOLOGICAL DIVERSITY"?

The scientific education standards of the KMK (standing conference of the ministers of education of the federal German states) make numerous references to "Biological Diversity". These, however, are found not under the terms "Biodiversity" or "Bionics", but in connection with "Ecosystem" and "Sustainability".

The links with geography are particularly important in the case of biological diversity because of the close interconnections between natural science and social science aspects. Bionics also has connections with physics, and with "technology" (for which no education standards exist). In some federal states, biological diversity is also declared to be a learning item in the syllabuses for interdisciplinary teaching (e.g. in Brandenburg). Similarly, some syllabuses in the field of science/technology also contain references to bionics (e.g. in Hamburg).

Four key areas for the biodiversity complex can be identified in the syllabuses for junior secondary-level natural sciences, geography and technology:
1. Functioning and importance of ecosystems
2. Relations between man and environment in areas of different types and sizes
3. Future-oriented technologies and techniques
4. Environmentally and socially acceptable lifestyles and management approaches

Safeguards for and threats to biological diversity are determined by human use of land. It is therefore logical to make the topic of "consequences of land use and land depletion" one of the key areas of the confrontation with biological diversity. However, since separate teaching material on "land depletion" is being developed as part of this series, this is not the dominant aspect here. The focus is rather on the function of biodiversity and on conflicts of use.

The first set provides material on "Bionics". There are four reasons why the connection between biology and technology is worth stressing in the context of biodiversity. Firstly, little mention is made of bionics in syllabuses to date. References can be found in the subjects of Work Study / Technology, Physics (especially in the field of mechanics), and in plans for interdisciplinary teaching. Secondly, this material is intended to make bionics "accessible" for environmental education purposes, since – as mentioned above – it is a future-oriented field of research with promising application potential. Thirdly, bionics is an important aspect of biodiversity, since many species and breeds have a highly specialised way of life. In a spirit of responsibility for future generations it is therefore of the utmost importance to conserve biological diversity, since we do not know today what benefits we will be able to derive in future from "learning from nature". Fourthly, bionics offers numerous opportunities for experimenting and inventive activities. This is a – frequently neglected – field of school learning, the relevance of which is constantly being stressed today.

Set 2 concentrates on biological diversity in the strict sense with its focus on biosphere reserves and national parks. It illustrates with practical examples how and why species diversity needs to be conserved in large ecosystems and how it is nevertheless possible for biotopes to be used for human economic activity. On the basis of the knowledge acquired about the Rhön Biosphere Reserve and the conflicts of use that arise there, the pupils should be able to plan the establishment of a conservation area themselves, having regard to numerous interests. This creates a link to the topic of "ecosystems", which is of central importance in biology, and also to geography, where the functional and systemic interplay of natural and anthropogenic factors is just as important as the impacts of land use and organisation on the environment, the economy and the social structure.

Set 3 of Biological Diversity points out even more clearly than Set 2 the conflicts of use and especially potential uses in relation to the economic exploitation of ecosystems and species diversity. The tropical rainforest and its regions with particularly great diversity of species form the starting point for the reflections and subsequent role-play game concerning conflicts of use in a tropical rainforest area. Here there are links to biology and geography of the kind seen in Set 2. However, the links with politics/business studies and ethics/religion are even stronger in this set, since it addresses human geography systems and structures (settlement areas, economic globalisation, developing countries – industrialised countries).

The intermediate-level standards of the KMK for Chemistry, Biology and Physics are binding for all federal German states. Since they serve as the rules for future measurement of your pupils' performance, the following remarks set out to clarify how the material on "Biological Diversity" is related to the educational standards. The KMK's intermediate-level education standards for Biology do not use the terms "biodiversity" or "bionics". The term "ecosystem" is used instead. As a result, there are numerous links with biology. In the field of technical knowledge, the material provided creates links with the following thematic areas:
a) Analysing the function of organisms in the ecosystem,
b) Describing the cycle of substances and the flow of energy in an ecosystem,
c) Outlining the interactions between living beings and the other spheres of the Earth, and
d) Describing the changes in an ecosystem over time.

In the field of knowledge discovery, moreover, the pupils should be able to explain dynamic processes in ecosystems with the aid of model concepts and assess the information value of a model. For example, the education standards for biology state that the pupils should learn to describe and assess the impacts of human interventions in an ecosystem – not least from the point of view of conservation of nature and its use by humans. And finally it is important to discuss action options for environmentally sound and nature-friendly participation in the interests of sustainability.

The intermediate-level education standards for physics do not display very strong links with the package of material. Bionics is not specifically discussed. In the competence area "Assessment", however, the pupils are to compare and assess "alternative technical solutions, taking account of physical, economic, social and environmental aspects". These materials help the pupils to acquire technical knowledge in this context. Physical knowledge discovery processes are also discussed (perceive, classify, explain, examine, construct models). In addition, pupils acquire communicative competence when they have to make a factual and audience-oriented presentation of the results of experiments with possibilities of adapting mobility systems from nature.

LEARNING GOALS

Most people are hardly aware how important biodiversity is for securing the existence of mankind and maintaining our freedom of action. Even the idea that we can learn from nature is seen more as an appeal than as the highly complex scientific and technical achievement that is really is. It took the rise of the young science of bionics to demonstrate the opportunities for learning. The first comprehensive learning goal associated with this material is therefore to make clear the potential uses of nature at the interface between biology and technology.

This involves more than acquiring technical knowledge about adhesive forces (for example in connection with self-cleaning surfaces, Velcro-type fasteners and other applications). Pupils should experiment and search for ways of putting natural problem-solving strategies to technical use (for example in the field of mobility).

Biodiversity is generally regarded from the point of view of the conflicts of use that can occur. This makes sense, since ecosystems are among the standard topics in biology lessons. This means it is possible to build on knowledge acquired by the age of 12. The aim here is not only to acquire knowledge about divergent interests (of nature conservation, tourism, industry etc.), but also to identify and manage conflicts. Attention should also be focused on typical regional biotopes and biocenoses.

Pupils should also acquire planning skills in which conflicts of use play an important role. In this way pupils can learn that in the field of sustainability the balance between economics, the environment and social matters often involves compromises and suboptimal solutions. On the one hand these learning goals should be discussed on the basis of a national example, but on the other hand a global example should be used to make it clear what ethical problem situations can arise when the interests of individuals, organisations and businesses in industrialised countries are set against the often difficult living conditions of people in the developing countries.

What competences can pupils acquire as they tackle the topic of biodiversity?

- Pupils not only analyse the complex interactions of biotope and biocenosis in ecosystems, but against this background they can also grasp, assess and communicate the phenomenon of biodiversity with the aid of interdisciplinary methods of analysis from the natural and social sciences (for example, registering environmental, economic and social aspects with regard to biosphere reserves).

- Pupils can analyse the problems they are posed – e.g. the conflict between nature conservation and human use of areas in biosphere reserves – to see what technical knowledge, information paths and actors they need to consult to be able to analyse conflicts appropriately and integrate them in planning processes.

- Pupils are able to state the interests and activities of individual actors (e.g. businesses, state establishments, non-governmental organisations and scientists with regard to using the biodiversity of the tropical rainforest), describe their objectives and assess the expected or perceivable effects of their actions.

- Pupils can use sustainability criteria to argue in favour of conserving biodiversity and preserving individual species and breeds in view of their specialised capabilities and their degree of adaptation to their individual environment in the interests of bionics.

- Pupils know how to anticipate and handle conflicts in planning processes (e.g. for a biosphere reserve) by taking an active approach to planning.

- As a result of their knowledge of the basic principles of bionics, they are able to work autonomously to investigate solutions to technical problems on the basis of models in nature, and to present simple suggestions for solutions.

- Pupils are able to explain the many and various reasons for the destruction of biodiversity and the arguments in favour of its conservation. With the aid of scientific knowledge, ethics and aesthetics, and economical and medical arguments they can present a case for the protection of complex ecosystems, adopt a position of their own and express their own opinion.

- Pupils can cite activities and learning processes from their work on "biodiversity" which motivate them to put into practice and supplement the knowledge, problem-solving strategies and action concepts they have acquired.

- They are in a position to reflect on their everyday life and their lifestyle in the light of their importance for biodiversity.