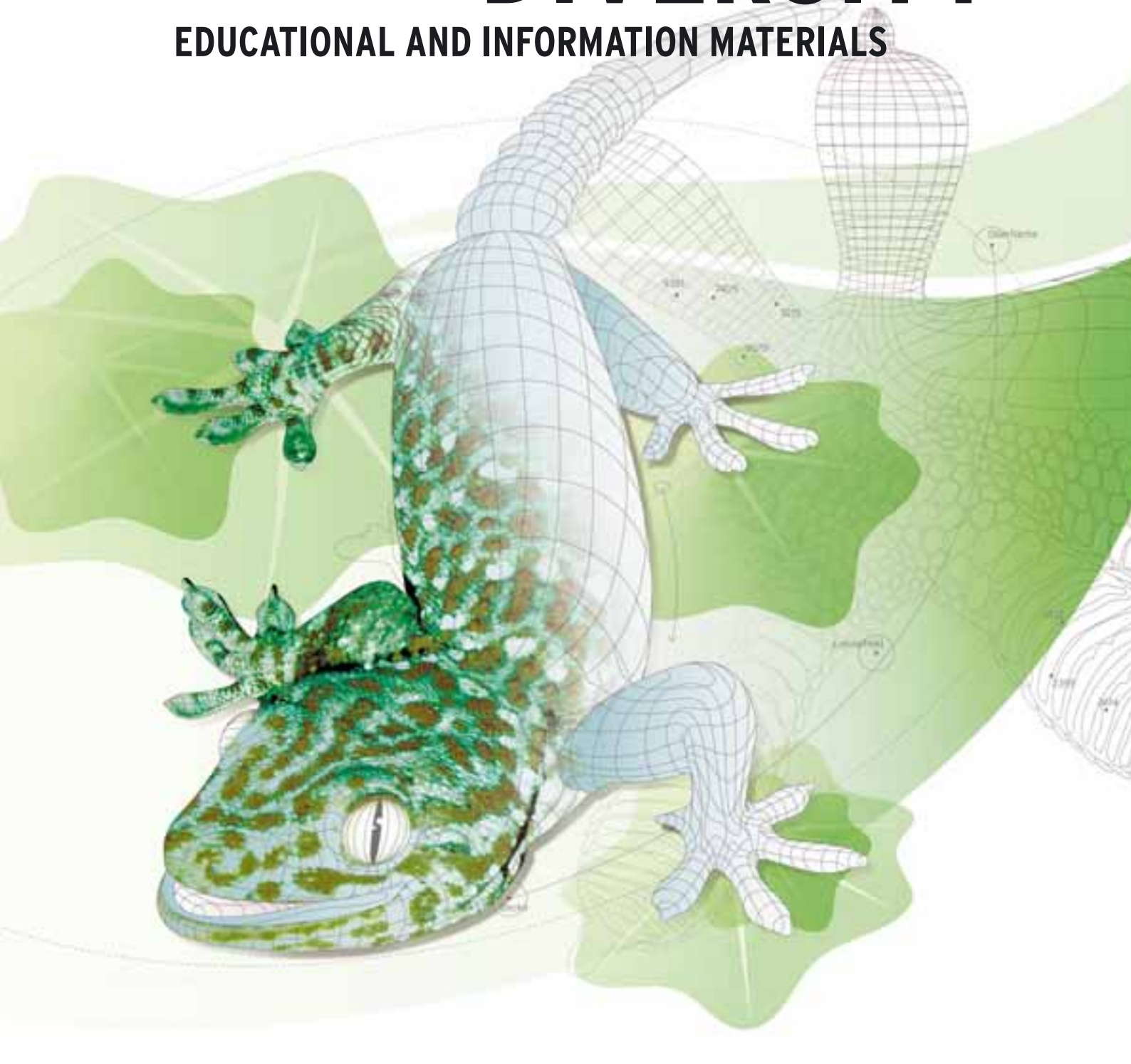
Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

BIOLOGICAL DIVERSITY

EDUCATIONAL AND INFORMATION MATERIALS



Note: This material was originally published in German and was designed for lessons for 12-16 year old pupils in Germany. It may therefore be necessary in some cases to adapt the worksheets to the situation in the countries where the material is to be used. To this end, the material is available for download free-of-charge on the Federal Environment Ministry's website at www.bmu.de/bildungsservice.

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EDUCATIONAL MATERIALS OF THE FEDERAL ENVIRONMENT MINISTRY

Under the banner "Building technical and scientific problem-solving capacities through environmental and conservation-related topics", the Federal Environment Ministry publishes educational materials on priority topics such as renewable energies, climate protection and climate policy, the environment and human health, water in the 21st century, land use, phasing out the nuclear power programme, etc. in conjunction with the publishing house Zeitbild Verlag and the Department of Educational Science and Psychology, Educational Future Science Section at the Free University of Berlin. The materials build on the most recent findings in the field of educational research and on the model programme, Education for Sustainable Development.

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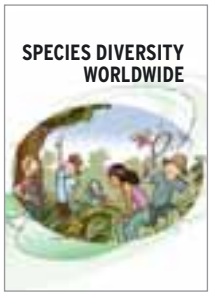
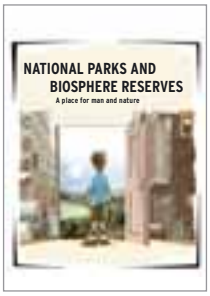
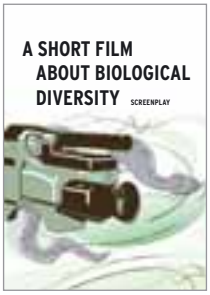






ONE NATURE • ONE WORLD • OUR FUTURE
UN Conference on Biological Diversity Bonn 2008

UN CONFERENCE ON BIOLOGICAL DIVERSITY GERMANY 2008

Environmental destruction and climate change are the two greatest challenges which we have to face in the next decades. It is becoming more and more evident that the deterioration of the natural foundations of life poses a severe threat to global economic development, social cohesion and ultimately to peaceful coexistence on Earth.

From 19 to 30 May 2008 Germany will host the 9th Meeting of the Conference of the Parties (COP) to the Convention on Biological Diversity. During these two weeks the international community under German chairmanship will discuss measures to combat the ongoing destruction of nature. Time is short, since at the World Summit in Johannesburg heads of state and government from all over the world jointly decided to achieve at least significant reductions in the rapid loss of biological diversity by the year 2010 (2010 biodiversity target).

The key international instrument for the conservation of biodiversity is the Convention on Biological Diversity (CBD) – one of the three international agreements adopted at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. The CBD is not a traditional species protection convention: it covers all aspects related to the conservation and sustainable use of biological diversity at three levels: habitats, species, and genes. The political focus is on the conservation and sustainable use of forests and marine ecosystems.

However, it also deals with a multitude of less “popular” habitats which are equally important for the global natural balance, such as drylands and inland waters. Moreover, the CBD has become a major platform for discussion of the relationship between the world trade regime and multilateral environmental agreements, and an important instrument for protecting the rights of indigenous communities. Equitable sharing of the benefits resulting from the use of genetic resources is another important goal of the Convention.

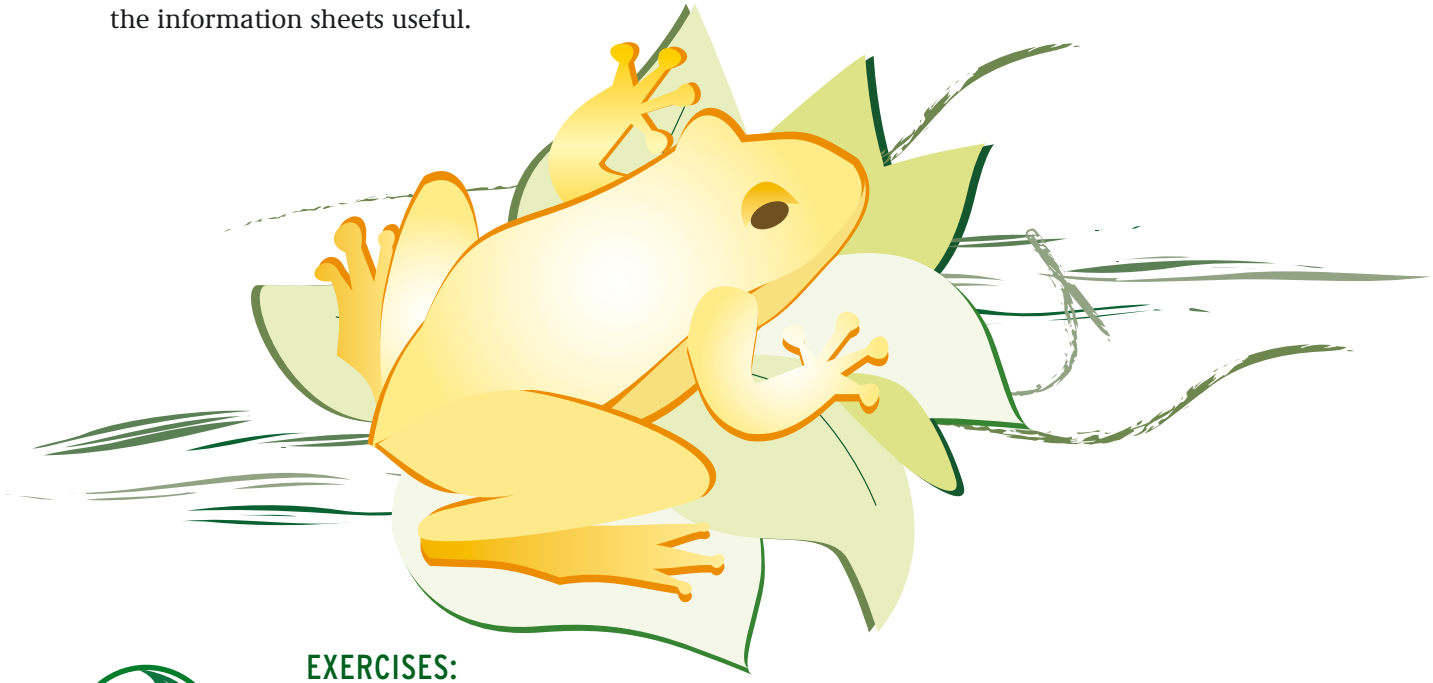
Every two years, the CBD, with about 190 Parties, holds meetings of the Conference of the Parties, which is the highest decision-making organ of the Convention. These UN meetings are attended not only by government delegations, but also by a broad range of environmental and development organisations. A total of around 4000 delegates and observers participated in the last meetings. About 5000 participants are expected for the upcoming meeting in Germany.

Further information: **www.bmu.de/english/nature/un_conference2008/aktuell/39655.php**

SPECIES DIVERSITY WORLDWIDE

THE TREASURE TROVES OF NATURE

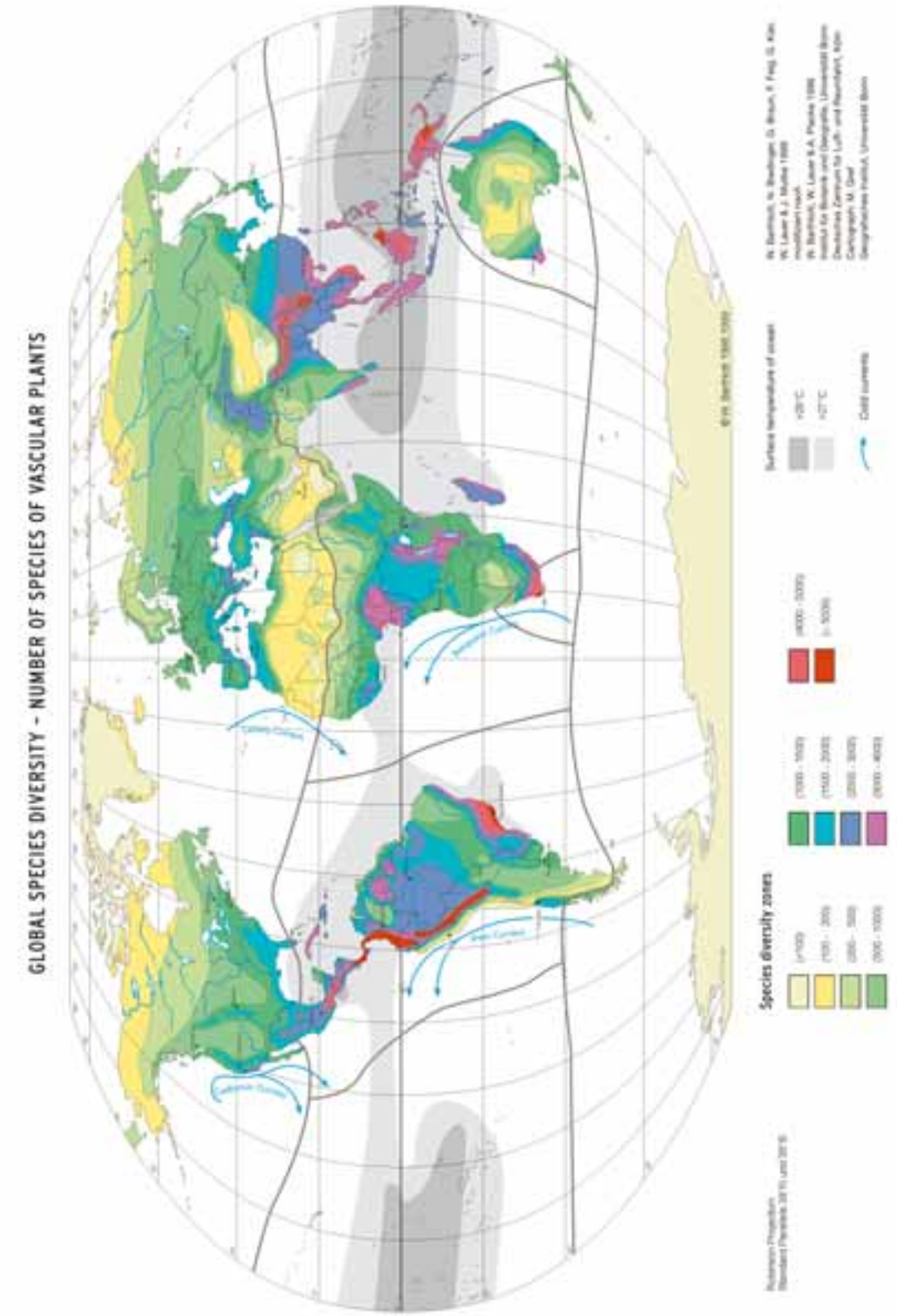
"Ever heard of the 'Queen of the Andes'?" Manuel asks his friends. They are in the bus on the way to the cinema. "I read about it in a magazine yesterday. Scientists are looking for plants and animals that can be used to help develop new medicines. They have found this potato in the Andes, in Peru. It's called 'Maca' – and it's not only highly nutritious, but is also supposed to be a cure for cancer! And scientists are trying to isolate a substance from the poison of tropical frogs that eases pain even better than opium without getting people addicted." "And how do they find these animals and plants?" asks an incredulous Viona. "In the treasure troves of nature, of course, that's where the chances are best, simply because there are so many different plants and animals there." "What treasure troves?" asks Aysche, "And what treasures?" "The treasure troves of nature means places where a great many different plants and animals live. In places like this it may be that an area no bigger than, say, Berlin is home to more species than live in the whole of Germany! And that's why there are such good chances of finding animals or plants which nobody knows and which could prove very useful," replies Manuel. "I wonder where the biggest treasure trove is for species diversity?" muses Aysche, and puts her money on the rainforests of Brazil. Now Viona and Felix join in the discussion. "Indonesia!", "Himalayas!", "Congo!" – each has a different suggestion. "I don't believe it can only be Brazil!" says Felix. Find out where the "treasure troves" are. You'll find the information sheets useful.



EXERCISES:

1. *Look at the map on Worksheet 1 (page 2). Name the five regions with the greatest species diversity on Earth. List them separately by continents. Does anything strike you?*
2. *Name the eight countries that belong to the five regions with the greatest species diversity. Describe the special geographical and natural features of these countries (e.g. climate, position, forests, deserts). Use your school atlas for the purpose.*
3. *What other regions display relatively great diversity of species?*
4. *Where are the species centres in Europe? Look on the map and write them down. Can you detect any geographical characteristic that they have in common?*

THE TREASURE TROVES OF NATURE – CENTRES OF SPECIES DIVERSITY

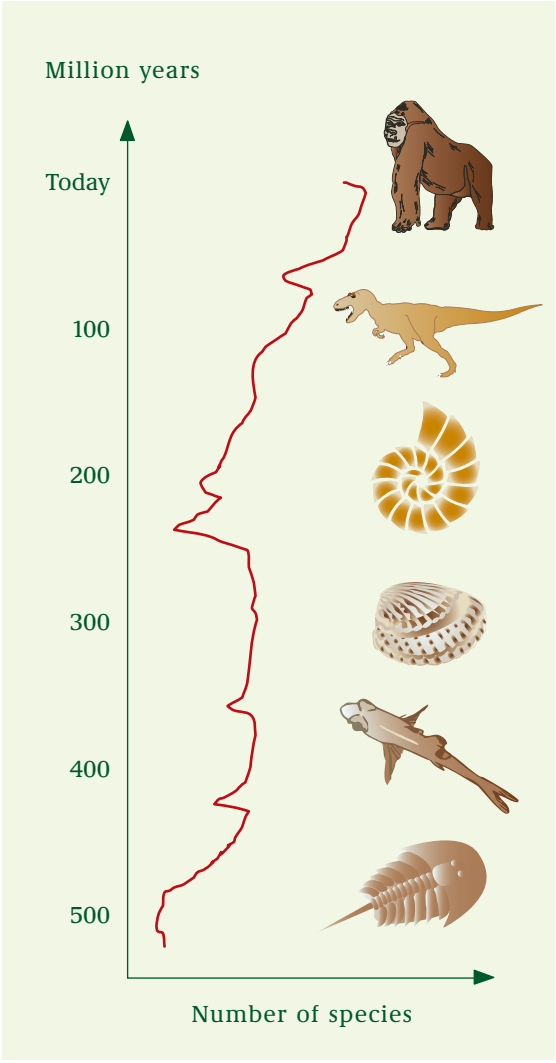


Five regions have been identified worldwide that have a top standing in the biodiversity rankings. They are followed by about ten more areas that stand out particularly because of the large number of different species. They are the home of nearly half of all known plant species and more than one third of all animal species. Most "treasure troves" are in the tropics. Many of the species centres are acutely threatened. Note: The map shows the species centres for the plant world (flora). The species centres for animals (fauna) have a similar distribution. The oceans also have their own "treasure troves". At http://stort.unep-wcmc.org/imaps/gb2002/book/viewer.htm you will find an interactive map showing you all the information you need, on animals and the oceans as well.

DOWN THE AGES...

Species diversity worldwide worksheet 2

Our planet is full of life – some scientists estimate that there are more than 10 million different species on Earth; others say there are as many as 100 million! That hasn't always been the case. Nearly 99 percent of all species that have ever existed are now extinct. But there are still more species living on our planet than in the billions of years of its history. We do not know exactly when life began, but about 500 million years ago there was a sudden dramatic increase in animal organisms. At that time life was confined to the oceans. 60 million years later there was a worldwide mass extinction. Whole families of species were wiped out. Life recovered, but in the millions of years since then there have been several cases of mass extinctions; the most recent, during the Cretaceous Period about 65 million years ago, put an end to the rule of the dinosaurs. No definite reasons are known for these ecological disasters: geological phenomena such as worldwide volcanic eruptions or cracks in the Earth's crust resulting in massive lava flows may be the answer, or possibly cosmic catastrophes such as a supernova or meteorite impacts, or maybe an abrupt climate change. A few species survived each of these catastrophic events, but the evolution of a new diversity of species took millions of years. Some biologists today believe there are signs of a sixth mass extinction, triggered by man's extensive interventions in the natural regime.



Source: National Geographic (2002)
Note: Not to scale as regards timing and number of species.

EXERCISE:

1. *When did the greatest diversity of species exist on Earth, and when the least?*
2. *Enter the five major mass extinctions of the past in the diagram.*
3. *Give at least five factors that could have caused the mass extinction of species.*
4. *What reasons do scientists see for extinction of species today? Give at least four reasons. What are the differences from previous mass extinctions? You can find information in your biology books, in encyclopaedi as or on the Internet.*

http://en.wikipedia.org/wiki/Extinction
www.wwf.org > Search:
www.worldwildlife.org > Search: Background to extinction of species

DIVERSITY OF SPECIES – A PRICELESS ASSET?

Species diversity worldwide worksheet 3

Aysche is fascinated by the idea of "treasure troves" – it sounds so exciting and adventurous. Finding natural remedies that are unknown today, almost like an archaeologist discovering a long-lost temple. "If there are so many different species in certain areas and the people there are poor, maybe they could make money that way. A cancer cure from the rainforest – that would be great, that would solve all their problems." "It's not as easy as that," says Manuel. "The first thing is to find the animal or plant. That's something the local people can help with, especially the healers who have long used nature as a pharmacy. But finding the active substance is extremely complicated and expensive. Most of these countries can't afford that, they're too poor." "Then they'll have to cooperate with companies from the rich countries," says Viona. "That would be good – if that kind of cooperation worked, everyone would benefit," says Manuel. "But unfortunately it often happens that such areas are almost entirely destroyed before anyone has the chance to discover anything." "Yes, sure, people fell the rainforest or burn it down because they need the money and sell the valuable wood, or because they need arable land for growing food. That's quicker than waiting for years for somebody to find something there that might be useful." "But you can only earn money like that once," objects Aysche. "How would it be if they earned money from the forest over a longer period and still had the forest later?" The friends start brooding over the possibilities: "Well – if I leased my rainforest ... say for medical research ... then every plant would really be worth something," says Felix. Viona butts in: "Should we only protect things that earn money? Animals and plants and nature as a whole also have a value that you can't put a price on. And we want our children and their children to be able to enjoy the beauty of nature. What's more, we don't know today what plants and animals might be of great benefit sometime in the future."

EXERCISE:

1. *There are various arguments that point to the value of great species diversity, and the need to protect it. Economic reasons, environmental, social/cultural, ethical/religious or aesthetic reasons (the beauty of nature). Read the text on Worksheet 3 and the texts on Information sheet 3. Which text belongs to which category of the reasons mentioned above? Classify them by writing the relevant category in the margin against each text (Note: One text might match more than one category of reasons!).*

PROTECTING SPECIES DIVERSITY – THE ROLE GAME

1. Schoolgirl aged 16, from Germany

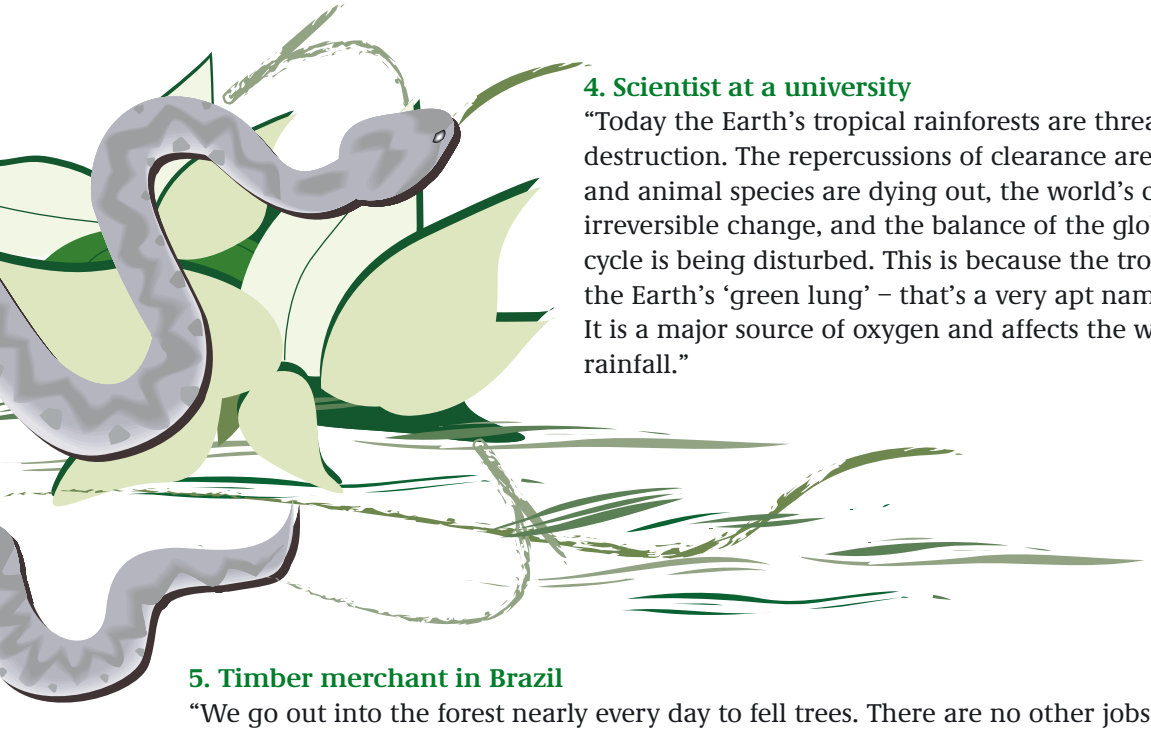
"Last year on 'Biodiversity Day' we investigated how many different plants and animals were living in and around our school pond. I would never have thought there were so many, it was unbelievable But the tropical jungles have a thousand times more species. And they are threatened with destruction, they need to be protected. Not only because of the beauty of nature, but also because they may be useful to us. Maybe someone will discover an important remedy in some animal or plant, e.g. a cure for leukaemia. If that jungle was destroyed, we wouldn't be able to use it any more."

2. Head of a community in New Guinea

"The important thing for me is that our community should get by all right. There is no work here; everyone is very poor. We clear a bit of forest, grow our food and gather anything we can use from the forest, for example by hunting or by gathering fruit. The many forest fires in recent years have been a problem. If people aren't careful when clearing patches of forest, the fire can quickly get out of control. Once a fire nearly burned down our village."

3. Research head of a pharmaceutical company

"We hope to discover substances that could help to develop new medicines for curing diseases like AIDS or cancer. Of course we have to make a profit – after all, we have a responsibility to our shareholders. The developing countries may have the areas with the greatest diversity of species, but these countries need our financial resources and our know-how to exploit the hidden treasure. We should therefore have free access to all bio resources."



4. Scientist at a university

"Today the Earth's tropical rainforests are threatened with total destruction. The repercussions of clearance are menacing: plant and animal species are dying out, the world's climate is at risk of irreversible change, and the balance of the global hydrological cycle is being disturbed. This is because the tropical rainforests are the Earth's 'green lung' – that's a very apt name for the rainforest. It is a major source of oxygen and affects the world's climate and rainfall."

5. Timber merchant in Brazil

"We go out into the forest nearly every day to fell trees. There are no other jobs here. We only cut out a few trees – mahogany or ebony, for example. Without timber felling, my workers would be forced to move to the big cities like Sao Paulo or Belo Horizonte. So it's better for them to cut down trees in Amazonia. People keep on saying that we are destroying the forest. But there are others who do much worse things, like the illegal gold diggers who poison the rivers with their mercury, and the settlers who burn down the forest."

EXERCISE (GROUP WORK):

1. *Use Worksheet 3 and Information sheet 3 to find out about the various arguments for conserving species diversity. Divide your class into five groups. Each group assumes one of the roles set out above. You will need to use your imagination. Information that may help you to understand the different standpoints of the role characters better can also be found on the Internet. Use a search engine like "Google", "Yahoo" etc. and search for pairs of key words such as "timber felling Amazon", "Medicines from the rainforest", "Village + rainforest". Try out different search terms or combinations of terms.*
2. *Try to identify as closely as possible with the selected role and collect arguments for the standpoint of your role. Write your arguments on a poster and note whether the reasons are of a social, environmental or economic nature.*
3. *After this preparation, each group has three minutes to present its position. Use your poster for this purpose.*
4. *After the presentations are over, each pupil assesses the arguments put forward. Use Worksheet 5 for this. If there is not enough space, copy the sheet.*
5. *Finally, find out which arguments meet with acceptance in the class and which do not. Draw up brief statistics on these results.*
6. *Choose a facilitator to run the discussion.*

WHY CONSERVE BIODIVERSITY?

Species diversity worldwide worksheet 5.1 assessment sheet

Environmental reasons

1. .....

☐ I agree ☐ I don't agree ☐ I don't know

2. .....

☐ I agree ☐ I don't agree ☐ I don't know

3. .....

☐ I agree ☐ I don't agree ☐ I don't know

4. .....

☐ I agree ☐ I don't agree ☐ I don't know

5. .....

☐ I agree ☐ I don't agree ☐ I don't know

Other reasons

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WHY CONSERVE BIODIVERSITY?

Species diversity worldwide worksheet 5.2 assessment sheet

Economic reasons

1. .....

☐ I agree ☐ I don't agree ☐ I don't know

2. .....

☐ I agree ☐ I don't agree ☐ I don't know

3. .....

☐ I agree ☐ I don't agree ☐ I don't know

4. .....

☐ I agree ☐ I don't agree ☐ I don't know

5. .....

☐ I agree ☐ I don't agree ☐ I don't know

Other reasons

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WHY CONSERVE BIODIVERSITY?

Species diversity worldwide worksheet 5.3 assessment sheet

Social/cultural reasons

1. .....

☐ I agree ☐ I don't agree ☐ I don't know

2. .....

☐ I agree ☐ I don't agree ☐ I don't know

3. .....

☐ I agree ☐ I don't agree ☐ I don't know

4. .....

☐ I agree ☐ I don't agree ☐ I don't know

5. .....

☐ I agree ☐ I don't agree ☐ I don't know

Other reasons

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WHY CONSERVE BIODIVERSITY?

Species diversity worldwide worksheet 5.4 assessment sheet

Ethical/religious reasons

1. .....

☐ I agree ☐ I don't agree ☐ I don't know

2. .....

☐ I agree ☐ I don't agree ☐ I don't know

3. .....

☐ I agree ☐ I don't agree ☐ I don't know

4. .....

☐ I agree ☐ I don't agree ☐ I don't know

5. .....

☐ I agree ☐ I don't agree ☐ I don't know

Other reasons

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WHY CONSERVE BIODIVERSITY?

Species diversity worldwide worksheet 5.5 assessment sheet

Aesthetic reasons

1. .....

☐ I agree ☐ I don't agree ☐ I don't know

2. .....

☐ I agree ☐ I don't agree ☐ I don't know

3. .....

☐ I agree ☐ I don't agree ☐ I don't know

4. .....

☐ I agree ☐ I don't agree ☐ I don't know

5. .....

☐ I agree ☐ I don't agree ☐ I don't know

Other reasons

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What does “biodiversity” mean?

Biodiversity is a contraction of the term “biological diversity”. It means not only the variety of ecosystems or habitats, but also the variety of different species within a region.

What is a species?

A species is a group of living organisms which can interbreed and which, due to heredity, have more similarities with each other than with individuals of other species. Species can be broken down further into subspecies, breeds, varieties or forms. Several species can be grouped in a genus. Some 2 million species have been described to date, though it can be assumed that this represents only a fraction of all existing species. Estimates put the total number of species on Earth considerably higher. The most extreme estimates are as high as 117.7 million species, but the most common figures are between 13 and 20 million species.

What are endemic species?

These are plant and animal species that only occur within a specific area and are not found anywhere else in the world. This makes the area in question even more worth protecting. If it is badly damaged or even destroyed, and with it the endemic species that live there, there is no substitute – the species are irreversibly extinct. A good example of this is the Moa, a huge flightless bird that used to live in New Zealand, or the Tasmanian Wolf, a marsupial that was wiped out by the European settlers. Endemic species are frequently found on remote islands, in narrow mountain valleys or inaccessible mountain regions. Well-known examples include the Galapagos Islands off the coast of South America, Madagascar, Australia, New Zealand, Pacific islands or the mountainous regions of the Andes, Caucasus and Himalayas.

The Earth’s treasure troves

The tropical rainforests with their immeasurable diversity of species are the treasure troves of the Earth. They are home to two thirds of the animal and plant species that live on land. A wealth of creatures are found on or around every tree: moulds and fungi, insects, birds and mammals. Well over one thousand different species of fish swim in their streams and rivers. We do not even know many of the plant and animal species that live there. These treasure troves, however, are of great importance for stabilising the climate and for regulating the Earth’s water balance.

A very good overview of these treasure troves, including several interactive maps, can be found at: http://stort.unep-wcmc.org/imaps/gb2002/book/viewer.htm ; the site is in English and can be strongly recommended! Try out the different buttons in the menu on the right: “Terrestrial biodiversity”, “Marine biodiversity” etc. They will show you the worldwide distribution of the treasure troves of nature. “Humans and biodiversity” shows you where mammals or birds are endangered, or where the Earth’s main wilderness areas are situated. It’s worth trying everything out.

The “hot spots”

Biologists use the term “hot spots” to describe those treasure troves where endemic species occur in particularly large numbers and which also run an acute risk of destruction. A very good overview of the hot spots – including an interactive map – can be found at www.biodiversityhotspots.org > Interactive Map (highly recommended!).

Central America

Costa Rica and Panama

These two countries form the land bridge between North and South America. This geographical peculiarity means that the two countries form a region with the greatest density of plant and animal species in a small space. There are 850 bird species here, more than in Canada and the USA together, about 1,200 species of butterfly – ten percent of all the world's butterfly species –, plus 237 species of mammals, including all six cat species found on the American continent, a wealth of amphibian and reptile species, and more than 130 species of freshwater fish. More than 12,000 plant species are known to date, and a great many others have yet to be investigated. Costa Rica is a land of mountains and green valleys, of dormant and active volcanoes. Rainforest and cloud forest, dry areas and mangrove swamps are found here, as are untouched beaches on the Atlantic and Caribbean coast and high mountain areas. Panama, to the south of Costa Rica, is like a bottleneck between the two continents. The remarkable feature of the jungles of Panama is the incredible diversity of species within a very small area. Not only does this apply to the number of animal species, but the region is among the world's record holders when it comes to the diversity of tree species as well. The reasons for this biodiversity: not only do two oceans – Atlantic and Pacific – meet here, but it is also the link between North, Central and South America.

South America

The tropical Andes – Colombia, Ecuador and Peru

The tropical part of the Andean range with its western slopes to the Pacific and its eastern slopes to the Amazon lowlands is one of the Earth's centres of biological diversity. Here nearly 15 percent of the world's plant species are concentrated on an area of barely 2 percent of the Earth's land surface. As well as the large number of flowering plants, birds and mammals, this is also the home of the greatest diversity of amphibians (e.g. frogs, toads, salamanders). Unfortunately very many of the species in this region are acutely threatened with extinction. The main reasons for this are increasing human settlement, and also hunting – especially for mammals like the jaguar or ocelot, or large birds like the beautiful parrot species of the red-fronted macaw or the blue-and-yellow macaw. This natural paradise is also threatened by timber felling or slash-and-burn cultivation, mining and the search for oil.

Amazon lowlands – Colombia, Ecuador, Peru, Venezuela, Guyana, Surinam, Brazil

The rainforest of the Amazon region is also referred to as the world's treasure trove of species, and is the Earth's biggest rainforest. It is biologically the richest wilderness on Earth apart from the island of Borneo. It is home to more than 40,000 plant species, some 30,000 of which do not occur anywhere else in the world. No other wilderness approaches this biological diversity. The average population density of the Amazon region is only one person per square kilometre. The diversity of insect species is particularly striking. There can be more than 40,000 species on an area the size of a football pitch! But the group of insects that puts all others right in the shade is the beetles. About 24,000 species of beetle are known to date in the whole of North America, whereas in the Amazon rainforest scientists count about 20,000 species on one hectare (100 m × 100 m)! On a single tree in the Amazon jungle, scientists found 95 different species of ant. In the whole of Germany, by contrast, there are only 105 species of ant. On one hectare of rainforest in Ecuador, botanists have identified 456 tree species (there are only 30 in the whole of Germany)! Also famous are the large wild animals like the giant anaconda, jaguar, caiman, river dolphin or the giant otter. But the Amazon jungles are shrinking all the time: 17,000 square kilometres are lost every year. The impacts of major road projects (e.g. Transamazonica) are particularly serious. These facilitate settlement, followed by timber felling. The tree fellers do the rainforest a lot of harm. As a rule the trees are felled

for the coveted hardwood they yield, and the rest is burned off and used as arable land. But the soil does not remain fertile for long. The peasants and livestock farmers move on, and more forest falls victim to the chainsaws. Major dam projects are another problem. Because the differences in height are only slight, it is necessary to flood huge areas. The result: vast amounts of land are lost, and extreme climatic events can be expected. The trees rot in the water, producing methane and other greenhouse gases.

The Atlantic coastal forests of Brazil
The region covers a long strip along the Atlantic coast from Salvador da Bahia right down to Porto Alegre. It consists mainly of mountain ranges reaching up to 2,700 m, characterised by great differences in climate. Whereas the north tends to be dry, the rainfall – and hence also the vegetation density – increases considerably towards the south.
Around Rio de Janeiro and southwards to Porto Alegre there used to be evergreen tropical forests with very great diversity of plant species in a very small space. Most of the species are not found anywhere else. Unfortunately, large portions of these coastal mountain rainforests have been cleared in the last 100 years and used for agricultural purposes. It is estimated that only about 5 to 7 percent of the original vegetation is left.

Africa

Lowland rainforests in the Congo basin – Cameroon, Gabon, Equatorial Guinea, Republic of the Congo, Zaire
The Congo basin is the location of the second-largest continuous system of rainforests on Earth after Amazonia. They extend from the coastal countries of Cameroon, Gabon, Equatorial Guinea and the Republic of the Congo, via the Central African Republic and the Democratic Republic of the Congo, to Uganda, Ruanda and Tanzania. The biological diversity of the region is unparalleled: the Congo rainforests are home to more than 400 mammal species, e.g. forest elephants and forest buffalo, bongo antelopes and okapis – over a quarter of all mammal species in Africa, including more than 20 species of primates and three species of apes (gorillas, chimpanzees, bonobos) – plus over 1,000 species of birds and probably more than 10,000 plant species. Many species are endemic – in other words, they do not live anywhere else in the world. The forests of the Congo Basin form the basis for the life of millions of people. The biggest threats to the forests of the Congo Basin are commercial forestry, illegal hunting, expansion of farmland, and mining.

Asia

Borneo
The island of Borneo, which belongs largely to Indonesia (Kalimantan) and in the extreme north to Malaysia (Sarawak and Sabah) and the Principality of Brunei, is the home of some of the oldest and most valuable rainforests on Earth. Tropical plants and animals are found here in impressive variety and beauty. And new species are being discovered all the time. To date, more than 20,000 species are known in the whole of Borneo. There are more species of woody plants growing on a single hectare than there are in the whole of Europe. Since prehistoric times people here have been living in harmony with nature (stone-age cultures). In the north-east of Borneo is the Kayan Mentarang national park. With 1.4 million hectares, the area of Schleswig-Holstein, it is the largest protected area of rainforest in Indonesia – and one of the most unspoiled in the world. The number of flowering plants must be a record. Mammals too are well represented, with more than 100 species: the Sumatra rhinoceros, sun bear, proboscis monkey, Asian elephant, rhinoceros bird, Bengal cat, clouded leopard, gibbons and the bateng, one of the largest wild cattle in the world. One world-famous species is the orang utan, the “man of the forest”, one of the world’s four species of

hominid apes. This is their last refuge. About 15,000 people live in the region; the forest provides them with everything they need to live. Kayan Mentarang, like most rainforests, is threatened largely by commercial interests: Even today, uncontrolled swathes are being cut into the forest close to the boundaries of the national park to produce timber. The recurring political unrest in Indonesia is also a threat to this natural paradise. The region is highly endangered.

Papua New Guinea

New Guinea is the world's largest tropical island, and has the highest mountains. The island is divided into Irian Jaya in the west, which belongs to Indonesia, and Papua New Guinea in the east. The diversity of the ecosystems and the extraordinary fauna of the island are unique, especially in the eastern part, Papua New Guinea. Here is the home of Queen Alexandra's birdwing (the world's largest butterfly). The mountain forests are particularly rich in endemic marsupials, birds, insects and flowering plants. The biggest threats come from timber felling, road construction, shifting cultivation, and the expansion of arable and livestock farming, particularly in the Indonesian region of Irian Jaya in the west. In Papua New Guinea the precious ecosystems are still relatively stable and intact.

THE DISCUSSION

Here you can read a small selection of articles and statements published in recent years on the subject of biological diversity.

Knowledge and the environment

"Today we know, without surveying the world again, that we can no longer shift our social and ecological problems to the future. We have to act quickly because the threat of irreversible ecological damage forces us to, and because a loss of biodiversity not only impoverishes us, it also threatens our existence. For economic reasons alone we must act more quickly than in the past. Not only because biodiversity and "natural" riches are not mere luxuries to be confined to the biosphere reserve, but because they are the foundation for all economic activities. The more we have to share fossil raw materials and energy sources with the people in today's developing countries and emerging economies – and who would deny these people growth and prosperity? – the more important natural and renewable raw materials become. But if they are to be permanently available we cannot in future afford the increasing destruction of species and loss of biodiversity. Anyone who wants to use enzymes and microorganisms in industrial biotechnology and genetic engineering for process technology and materials engineering must have a prime interest in the preservation of biodiversity."
German Environment Minister Sigmar Gabriel, excerpt from speech to the Humboldt University, Berlin, February 2006

Accepting responsibility for creation

"Not only human, but also animal and plant life and inanimate nature deserve our appreciation, respect and protection. Reverence for life presupposes that life is a value, and that it is therefore a moral obligation to preserve this value. Mankind has a responsibility to look after its environment. This requires consideration, self-discipline and self-control. Reverence for life is not confined to human, animal and plant life, but in the wider sense to "inanimate" nature as a habitat, with its elements of life (water, soil, air) and its functional cycles. These should not be thought of as dead objects, but as part of the living conditions of mankind and its fellow creatures. One important task in preserving creation is protecting biological diversity. The diversity of creation is a reflection of the splendour of God, and it is an indispensable precondition for global ecological stability. Many plant and animal species are threatened by numerous environmental stresses or have already disappeared. We must desist from illusions about our power over creation and must humbly acknowledge the boundaries of our own freedom of action and our own limitations. We must say goodbye to the belief in unlimited growth and never-ending progress, and must base our approach on the criterion of life and what serves the interests of life."
Joint declaration by the Council of the Protestant Church in Germany and the German (Catholic) Bishops' Conference, 1985

A whole world in the hothouses

"Plant species diversity and human civilisation are inseparably entwined. Plants serve as a basis for food, building materials, remedies and stimulants, as input for the cosmetics, clothing and paper industries, and as elements of our traditions and mythology. In spite of this importance, plant species are currently being lost faster than ever before. Botanical gardens house a representative selection of this plant diversity. To mark World Food Day, selected examples are used to illustrate the many facets of the links between plants and people. Plants have always been a deciding factor in human history. But plant diversity should not be seen solely in terms of economic wealth. Plant diversity should be regarded as a basis for the cultural diversity that has always brought people together."
Press release on special guided tour, Botanical Garden Munich-Nymphenburg, 2004

Bolivia: Ecotourism to bring money and visitors

In this South American country there are national parks that extend from the valleys of the Amazon basin to the highest mountain regions. For example, one park has 800 different bird species, while another is home to eleven percent of all the world's animal and plant species. The country is too poor to maintain the large national parks properly. Now the authorities are pinning their hopes on tourists. The aim is to interest the 400,000 international visitors who come to Bolivia every year in the country's wealth of natural diversity. One of the successful showcase projects is run by the local indigenous community. More than 1,000 visitors came last year and brought a profit of 25,000 dollars. Half the profit goes to the families who look after the visitors. The rest goes into community health and education programmes. Not only could the project bring prosperity to the population, but it could also help to ensure conservation of biological diversity.
www.pressetext.de 2005

The jungle of New Guinea as a source of medicines

Two US scientists are searching the jungles of New Guinea for new miracle cures for tuberculosis, cancer, AIDS and other diseases. An environmental protection organisation is supporting the project to the tune of four million dollars, as this could make it possible to protect the island's rich rainforests from felling for timber. Through this project, however, the scientists are seeking not only to advance the search for new remedies, but also to get the local people to do something to preserve the rainforest. They promise them a lucrative deal if they grow various medicinal plants on a home basis. The researchers want to find out about traditional native medicine and investigate plants that the indigenous people have been using for thousands of years. Although the area of Papua New Guinea is only about one percent of the total land mass of the Earth, the inland's rainforests are home to about five percent of all the world's animal and plant species. The scientists are excited about the biological diversity of the island, but warn that there could be an ecological disaster: illegal felling is rapidly decimating the rainforests.
www.pressetext.de, 2004, ICBG Program, National Institutes of Health, USA

Only biodiversity can save people

One aim of the United Nations is to halve poverty on the Earth by 2015 and to combat diseases such as malaria and AIDS. An expert study has come to the conclusion that this can only be achieved if the diversity of species – biological diversity – is preserved . There are two disturbance factors in this system: firstly, trade in animals is increasing, and secondly, people are penetrating further and further into previously untouched regions. There is a good deal of evidence that a direct connection exists between species diversity and human health, the scientists say. A report prepared for the UN criticises the fact that important points have not been investigated in the fight against poverty. In many cases important functions performed by intact nature have been disregarded. Two thirds of the world's poor live in the country and are highly dependent on natural resources. Biodiversity is absolutely essential, the experts conclude. People should make intelligent use of the diversity of nature. Healthy ecosystems ensure the existence of ecological services. These include, for example, the prevention of soil erosion or the protection of drinking water. Scientists keep on calling for a "hands-off principle" for regions where little research has been carried out.
www.pressetext.de, 2005, World Resources Institute (WIR), Institute for Ecology and Nature Conservation, University of Vienna

Healthy coral as protection from tsunamis

A recently published study once again draws attention to the importance of healthy coral reefs. It states that healthy reef systems are capable of withstanding the force of tsunamis. For years now, the Earth's coral reefs have been under great pressure. The reef areas are constantly overfished, sometimes even using dynamite, and coral material is broken off for building purposes. Another

factor is the pollution of coastal waters by wastewater. All these factors weaken the coral's resistance to flood waves. But the cycle of reef destruction has now come round to affecting humans. In the Hikkaduwa reef region of Sri Lanka, for example, which is a maritime protected area, scientists have found that healthy reefs in the coastal region give rise to less destruction than reefs that are already damaged. The efforts to conserve reefs worldwide are by no means easy. Investment running into the billions is needed to improve the wastewater situation alone. The Green Coast Project has been launched to protect life in the coastal regions from tsunami damage. The aim is to make the coastal regions of Indonesia, India, Sri Lanka, Malaysia and Thailand safer. The project involves reforesting mangroves, cleaning up coral reefs, protecting fishing grounds, and restoring inland waters close to the coast. It cooperates with local governments and communities. As well as its function of providing protection from flood waves, the project also has economic benefits: A healthy environment makes a region much more attractive for tourists.
www.pressetext.de, 2006, World Conservation Union (IUCN), Green Coast Project

UN ecosystem study: Impoverished nature makes people poor

The Earth's biological diversity is dwindling faster and faster. According to a UN report, however, the loss of biodiversity also has serious implications for mankind, because a reduction in the number of species means an increase in human poverty, reports the science magazine Nature. In the past 50 years, people have done more harm to biological diversity than ever before. In the past century alone, the rate of extinction due to human activity was a thousand times higher than with natural selection. If this trend continues, human life will also be threatened. Only a planet rich in species can guarantee adequate supplies of food for its inhabitants, says the United Nations report. "Everyone on this planet depends on biological diversity," says one expert. For example, more than 70 percent of the world's population are dependent on traditional medicines. Felling the forests destroys this resource. The researchers have therefore made a monetary assessment of the value of ecosystems. For example, they have calculated that one hectare of intact mangroves in Thailand is worth more than 1,000 dollars in the long term. The reason: mangroves are a "nursery" for many species of fish. Intact mangroves therefore provide food for people, protect the coast and attract tourists on a sustainable basis. Mangrove forests that are cleared for intensive use lose value in the long term and are therefore put at only 200 dollars per hectare.
www.pressetext.de, 2005

Between nature and culture – people, food, biological diversity

Since the United Nations Conference on Environment and Development (UNCED) in Rio in 1992, "biodiversity" has become a firmly established term for a broad public. Many of the crop plants that have become part of our everyday life originate from developing countries. Wheat, rice, maize, sorghum, millet, sugar cane, potatoes, which today provide food for over three quarters of the world's population, have been grown for thousands of years in their countries of origin and differentiated into innumerable varieties. Plant species diversity and human civilisation are inseparably entwined. The exhibition seeks to arouse interest and curiosity about other societies and their cultures, including their eating habits. At the same time it aims to make people aware of the thousands of years of interdependence between peoples and the cross-fertilisation of their cultures. Preserving diversity means safeguarding the future of humanity. Take a tour with us through the variety of forests, fields, gardens and meadows that our world has to offer. You will be amazed at what arable and livestock farmers worldwide have achieved down the millennia through their work, know-how, ability and skill. And – biological diversity is attractive. The aesthetic and moving photos in the exhibition speak for themselves.
Text of invitation to exhibition, InWEnt Educational Centre Feldafing, 2005

Nature more efficient than technology

For a long time technology was too primitive to pursue designs drawn from living organisms: "Only with today's polymer chemistry, microelectronics and complex computer calculations might it be capable of making progress in this direction," says Bernd Lötsch, biologist and director general of the Vienna Natural History Museum, in his lecture on bionics – the future technology that learns from nature – at the opening of the special Bionics Exhibition in his museum. Lötsch also stressed that direct application of natural models has hitherto been confined to a small number of classic cases. These include gliding, streamlining, the sharkskin effect and the lotus effect. There are striking examples when one compares the human eye with a television camera, bat or dolphin sonar with technical ultrasonic location, siphon swimmers with jet propulsion, airborne seed with parachutes, and insect or sea urchin pincers with remote-controlled gripper arms in the field of robotics. The scientist also objects to claims that technology can achieve greater efficiency than nature. "The bioluminescence of a glow-worm, at 58 to 60 percent light yield, is considerably more efficient than any technical light source, and several times more efficient than any fluorescent tube." Lötsch also emphasises that we cannot do without bionics if we want to solve the problems of the future. "We therefore regard bionics and the reassessment of the value of organic aspects in our culture as a long overdue swing of the pendulum in a new direction. In future we will urgently need biodiversity so that we can learn from as many different species as possible, about natural substances, technical solutions, for medicines and agricultural breeding. And that is not trying to create a myth."
www.pressetext.de, 2001

Biodiversity atlas goes online

The United Nations Environment Programme (UNEP) has compiled an interactive atlas of the biological diversity of our planet. It seeks to show which regions of the Earth are particularly rich in species. The interactive atlas also offers an insight into the history of our environment, and shows that since 1850 man has changed roughly half the Earth's surface. If destruction continues at this pace, UNEP estimates that every two years we will lose an important natural remedy that could protect mankind from serious diseases or possibly even cure such diseases. The organisation reckons that only about one percent of the estimated 250,000 tropical plants have been tested for their pharmaceutical effects. Another factor that must not be underestimated, according to a UNEP spokesperson, is the fact that 80 percent of the people who live in developing countries are dependent on natural remedies obtained from nature. The environmental organisation calculates that in the USA alone some 56 percent of the 150 most widely prescribed medicines, accounting for sales of around 80 billion dollars, come from nature. The atlas also describes those zones of the Earth that are most threatened by destruction. They include the rainforests of the Congo basin, the tropical rainforests of Southeast Asia, and parts of Amazonia.
www.pressetext.de, 2005

Respect for life is all-important

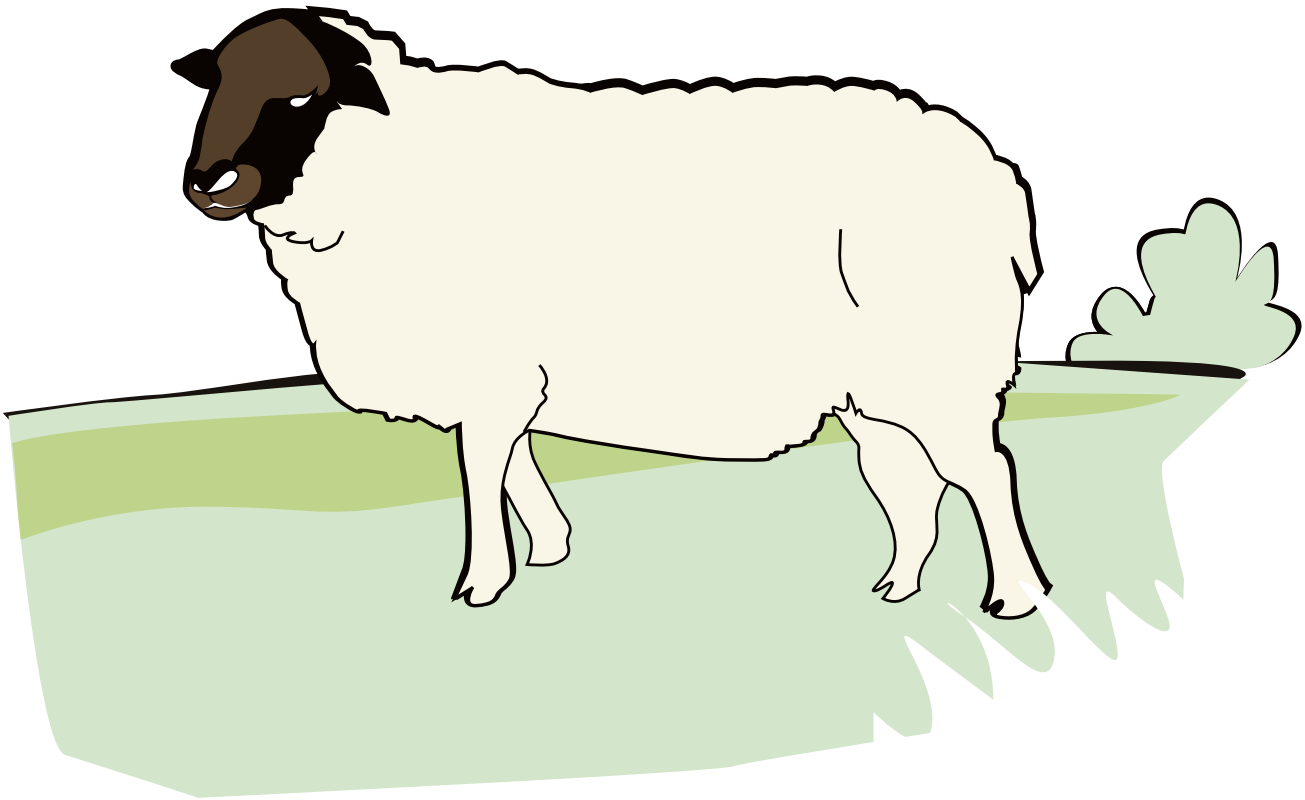
Jainism is a religion based in India that originated about 1,500 years ago. Today Jainism has about 6 million believers, about 3.5 million of them in India. Its followers are strictly forbidden to kill any form of life. Jains have an exclusively vegetarian diet. They sweep the ground in front of their feet to avoid treading on ants. They are not farmers, because the plough could injure or kill worms. A Jain has absolute respect for all life – that is the supreme commandment of this unusual religion.

NATIONAL PARKS AND BIOSPHERE RESERVES

A place for man and nature

THE RHÖN BIOSPHERE RESERVE

Viona meets Aysche on the way to school. “Have I told you that I’m doing my work experience in the ‘Black Mountains’?” Aysche looks bewildered. “What does that mean?” she asks her friend. “The Black Mountains are in the Rhön region, in the area where the German states of Hesse, Thuringia and Bavaria meet, and I’ve got a place there at the nature conservation station. My uncle helped me to get it. He does advertising for the local tourist board. ‘The Rhön is fine,’ is their slogan ...” “... if only the people would leave the Rhön alone,” scoffs Manuel, joining them suddenly. “Oh, that’s enough of your silly jokes,” says Viona. “It’s great there, I’ve already seen some photos. It’s a lonely region, and they not only want to conserve the beautiful countryside, but also create jobs for the local people. That’s why there’s a kind of conservation area – the Rhön Biosphere Reserve – and that’s where I’m going for my work experience. There are some areas where nobody is allowed to go. There it’s almost like being in the jungle, but in other places they breed sheep and earn money from tourists and sport enthusiasts.” “What kinds of sports enthusiasts?” asks Aysche in disbelief. “Glider pilots, mountain bikers and climbers,” replies Viona. “The Rhön is famous for them. But I think one of the most important things is the Rhön sheep, which has a certain claim to fame there.” “A herd of sheep in a nature conservation area? That can’t be right, the sheep will graze everything they find,” says Manuel. “What kind of protection is that?”

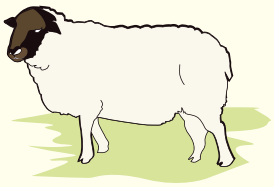


THE RHÖN SHEEP

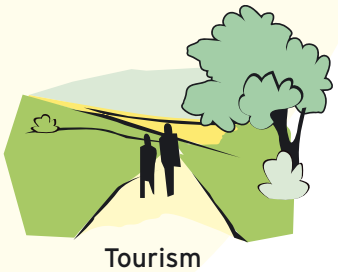
For a very long time the Rhön sheep was a widespread farm animal in the Rhön area. It was adapted to the barren region, and sheep farming moulded the cultural landscape, especially where no other form of land use was possible. Where sheep – or goats – graze, no trees and bushes grow and the countryside remains open. About 150 years ago, the Rhön sheep began to disappear, because artificial fertilisers and modern machinery made other uses possible on land where sheep farming had previously been the only option. There was also increasing competition from imports of lamb from Australia and New Zealand. As the sheep disappeared, so did the associated characteristic landscape in the Rhön. Sheep farming became uneconomic, and many shepherds gave up. Only through the efforts of committed individuals was this breed saved from extinction. In 1988 nature conservation associations started the "Rhön sheep project", which was a success. The Rhön sheep was rediscovered as a regional speciality. The sheep owners are able to obtain high prices thanks to high quality, short delivery distances and fresh organic meat, although it yields about one third less meat than other breeds. Today there are once again enough animals grazing the upland pastures and rough grazing land, and thereby helping to preserve the rare plants and animals that are characteristic of the Rhön. Thus an almost extinct farm animal is now protecting other species from extinction. In addition to this ecological value, there are quite a number of businesses, from shepherds through abattoirs to restaurants, that profit from direct marketing of the Rhön sheep and thereby safeguard jobs. Also, the Rhön sheep has acquired a kind of cult status – a whole region identifies with "its sheep". Today the Rhön sheep is an advertisement for the Rhön, and therefore makes a contribution to tourism.


Farming


Butcher


Rhön sheep


Inns


Tourism

EXERCISES:

1. *Assess the benefits of the Rhön sheep from various points of view. Distinguish between economic, environmental and social aspects.*
2. *The sheep is the central focus here. What are the individual relationships? Label the diagram with arrows and explain (e.g. sheep provides meat).*

HOW DOES ONE PLAN A CONSERVATION AREA?

On a weekend cycling tour, Viona tells her friends all about her work experience. “I was actually allowed to help plan a new conservation area,” she proudly tells them. “With maps and large-scale site plans – it was really professional. It certainly wasn’t easy. The task was to protect several pairs of black storks that nest and breed there every year, but at the same time allow people to spend their leisure time there. I told you how popular the region is with leisure sports enthusiasts.” “And how did you manage it?” Felix is curious to know. “I can show you when we get home. I’ve brought back some material as a souvenir of my time there.”

EXERCISE:

Take a careful look at the map on Worksheet 4 and try to plan an ideal conservation area. Try to find a compromise between use by man and nature conservation interests. In the table on Worksheet 3 you will find the conditions for such a conservation area as found by Viona, Felix, Aysche and Manuel in their research.

Tip: Use different colours or hatching to distinguish the different roads and paths. You can also – as in national parks and biosphere reserves – draw in zones that are allowed to be used and zones that are protected.

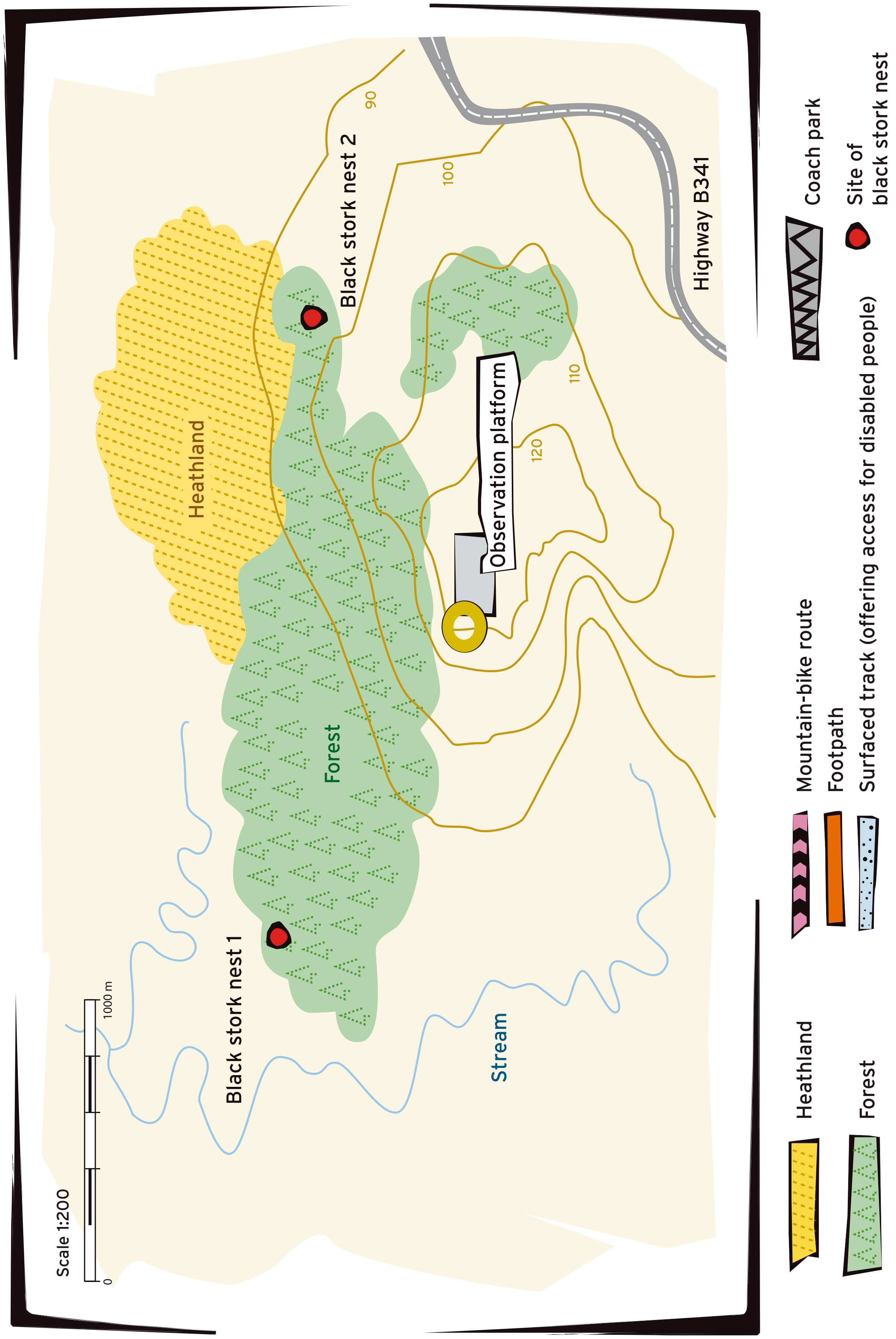
IMPORTANT: Find out more about the differences between national parks and biosphere reserves. Use Information sheets 1 to 3 for this purpose.

HOW DOES ONE PLAN A CONSERVATION AREA?

The table provides you with all the information you need for planning the conservation area. Apart from the restrictions set out here, you are free to design your conservation area how you like.

use	needs
Wild animals	Every year there are two breeding pairs of black storks. The storks are very shy. They take flight when any threat appears within about 500 metres. In other words, no people should get closer to them than this during the breeding season.
Farm animals	Herds of sheep should be able to graze on the heathland. The sheep pastures must be fenced off to stop the sheep straying into other parts of the countryside. For this reason the footpath can only cross the grazing area at its boundary.
People **a) Arrival/ Roads/ Parking**	A surfaced road is needed to reach the area. The road runs from the local highway to the conservation area. It should be as short as possible to minimise the amount of land sealed by asphalt. It must be twice as wide as the footpaths. No bridges are permitted. Parking space must be provided for visitors and should accommodate two buses and about 35 cars.
b) General	Within the conservation area there should be a visitors' platform with a good all-round view. The platform must be planned so that it does not extend too far into the conservation area. Next to the platform there should be a small kiosk selling food and drinks.
c) Hikers	A circular footpath should run along beside the stream for a short while as far as the observation platform. The path does not have to be surfaced. As much shadow as possible would be pleasant, as most visitors come during the high summer. The footpath should permit a round tour.
d) Access for disabled people	A surfaced path leading to the observation platform is needed for this special group of visitors. It must be suitable for wheelchairs. The gradient of this path should be as low as possible.
e) Leisure/Sport	A neighbouring sports club would like to create a mountain bike track with as much gradient as possible. For safety reasons, this track must not be used by hikers. Ideally this should be a closed circuit, i.e. the track leads back to the starting point.

PROTECTING BIODIVERSITY – AN OVERVIEW



NATIONAL PARKS AND BIOSPHERE RESERVES – TWO SOLUTIONS FOR BIOLOGICAL DIVERSITY

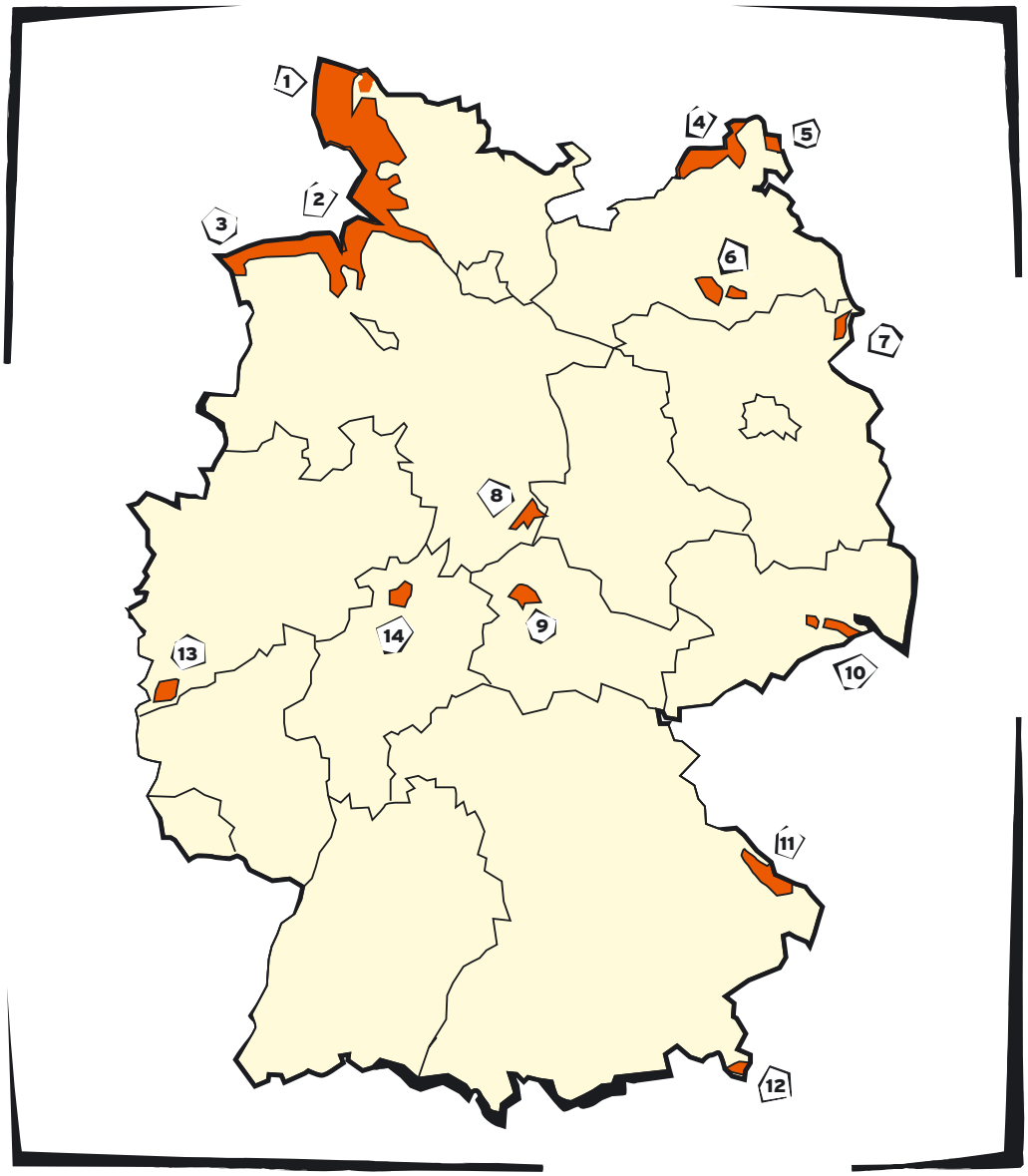
National parks are the oldest existing major protected areas. In 1872 the Yellowstone National Park in the USA became the world's first national park. About 100 years later, the Bavarian Forest National Park was established as the first major protected area in Germany. It was followed by more national parks, including some in Eastern Germany after reunification. Today there are a total of 15 national parks in Germany. Here nature is left to itself, and people are kept out as far as possible to avoid disturbing the flora and fauna.

In other words: No forestry or farming, no roads, little or no access for humans. The forest is left to its own devices. Nobody clears away the fallen trees – a paradise for animals that are particularly shy or need unspoiled natural habitats. On the other hand it is possible to visit national parks – certain peripheral zones are open to visitors. But the core zones are taboo – even scientists need a special permit here.

Biosphere reserves are a relatively new idea. In 1970 UNESCO launched the "Man and the Biosphere" programme to promote more nature-friendly use of the environment and hence also a new model of "conservation areas". Whereas no human use is permitted in national parks, in biosphere reserves it is actually part of the strategy: the focus is on humans. This is because these cultural landscapes took shape as a result of human activities, usually a specific kind of farming. These landscapes are maintained in biosphere reserves – together with their wild fauna and flora and often typical farm animals (in many cases threatened by extinction), traditional regional farming methods or other environmentally friendly forms of management. The reserves are intended to demonstrate what is possible on an environmentally friendly basis: the aim is to practise farming, forestry and other uses in a particularly sustainable and nature-friendly way.

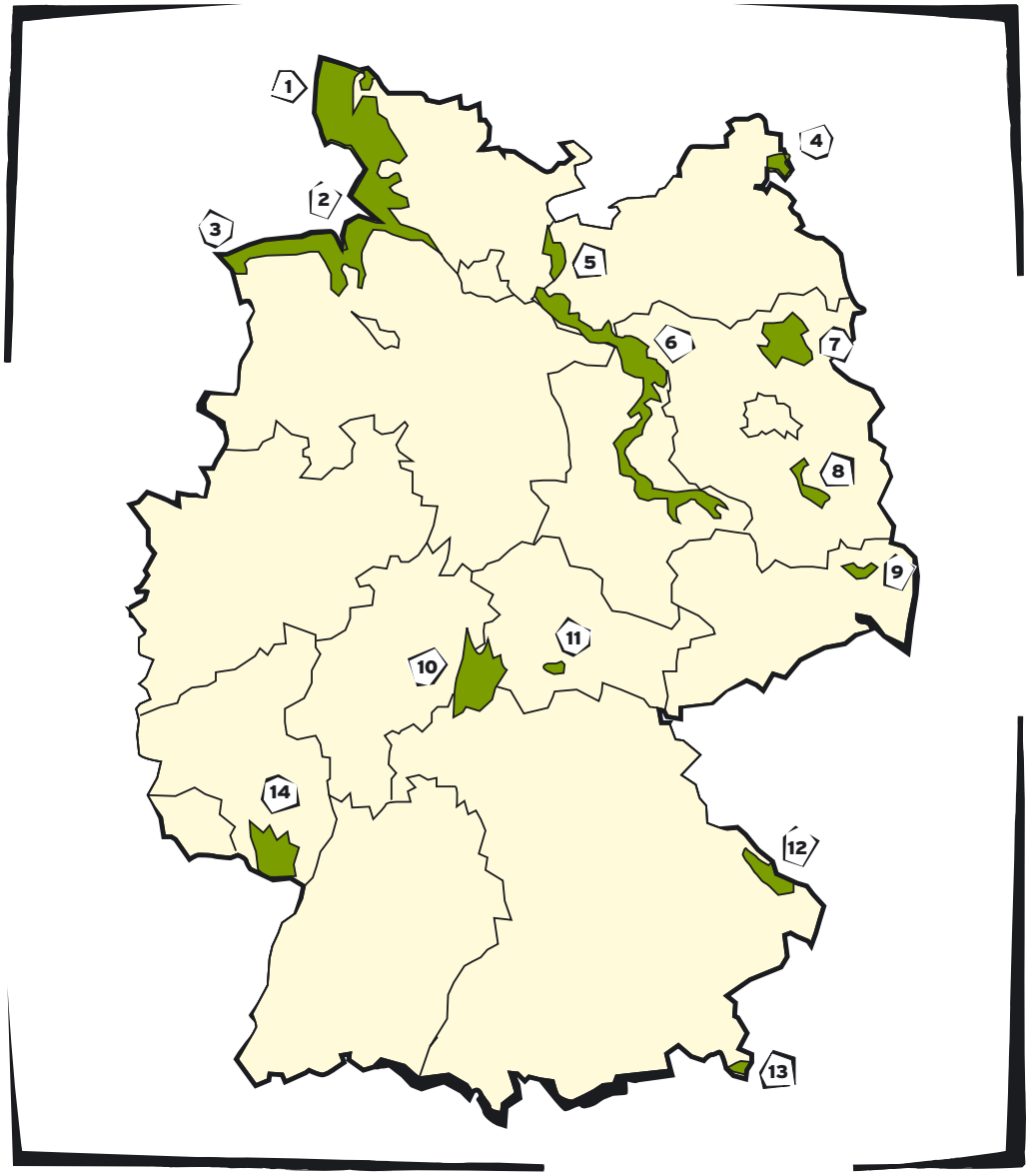
Thus the two conservation strategies complement each other: National parks as conservation areas for unspoiled nature, and biosphere reserves as areas for sustainable quality use of nature by man.

OVERVIEW OF NATIONAL PARKS IN GERMANY



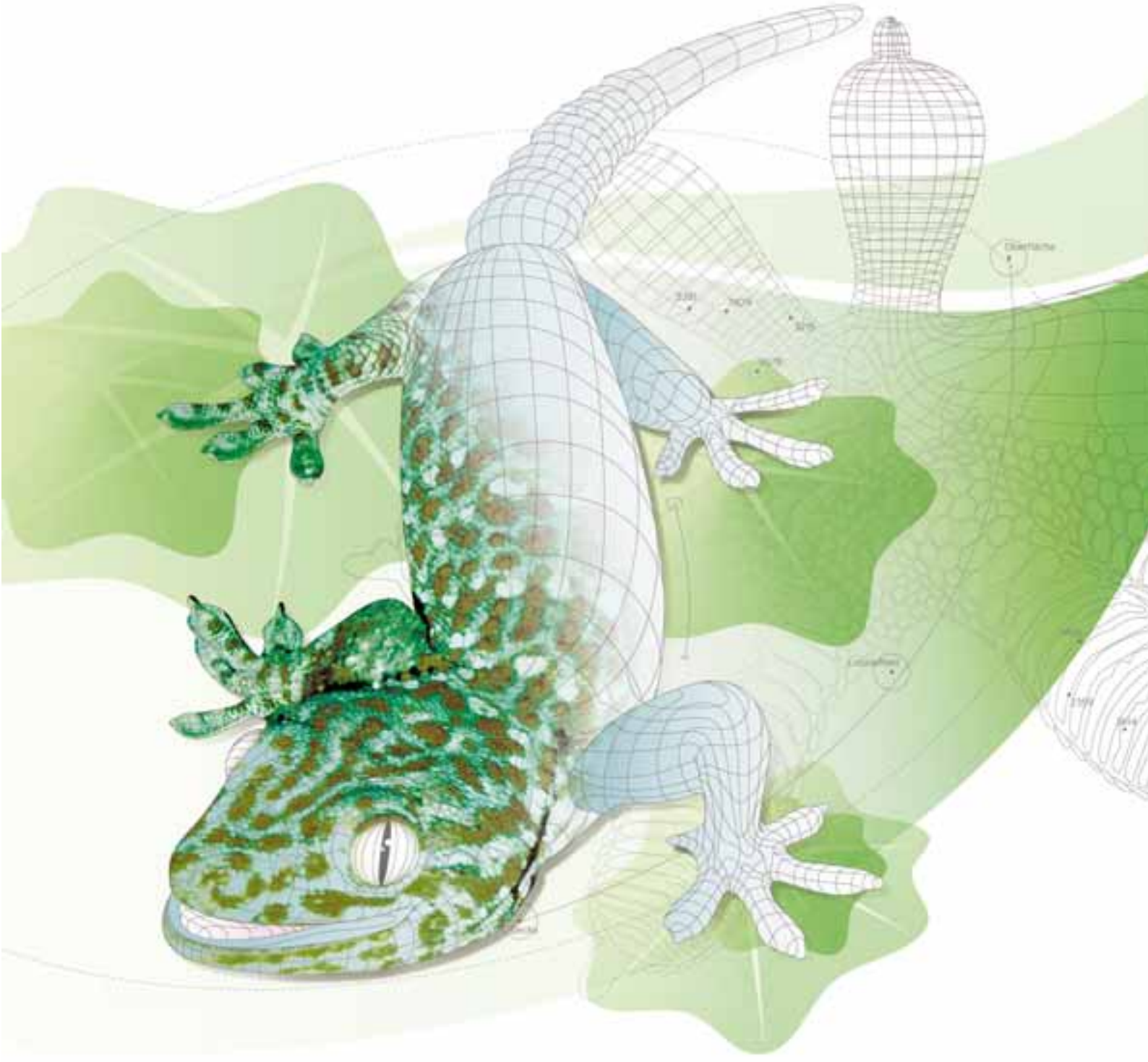
1. Schleswig-Holstein Wattenmeer National Park (also biosphere reserve)
2. Hamburg Wattenmeer National Park (also biosphere reserve
3. Lower Saxony Wattenmeer National Park (also biosphere reserve)
4. West Pomeranian Boddenlandschaft National Park
5. Jasmund National Park
6. Müritz National Park
7. Lower Oder Valley National Park
8. Harz National Park
9. Hainich National Park
10. Saxon Switzerland National Park
11. Bavarian Forest National Park (also biosphere reserve)
12. Berchtesgaden National Park (also biosphere reserve)
13. Eifel National Park
14. Kellerwald-Edersee National Park

OVERVIEW OF BIOSPHERE RESERVES IN GERMANY

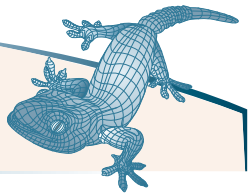


1. Wadden Sea and Hallig Islands of Schleswig-Holstein
2. Wadden Sea of Hamburg
3. Wadden Sea of Lower Saxony
4. Rügen
5. Schaalsee
6. Flusslandschaft Elbe
7. Schorfheide-Chorin
8. Spreewald
9. Oberlausitzer Heide- und Teichlandschaft
10. Rhön
11. Vessertal-Thüringen Forest
12. Bayerischer Wald
13. Berchtesgaden Alps
14. Palatinate Forest

HIGH-TECH FROM NATURE

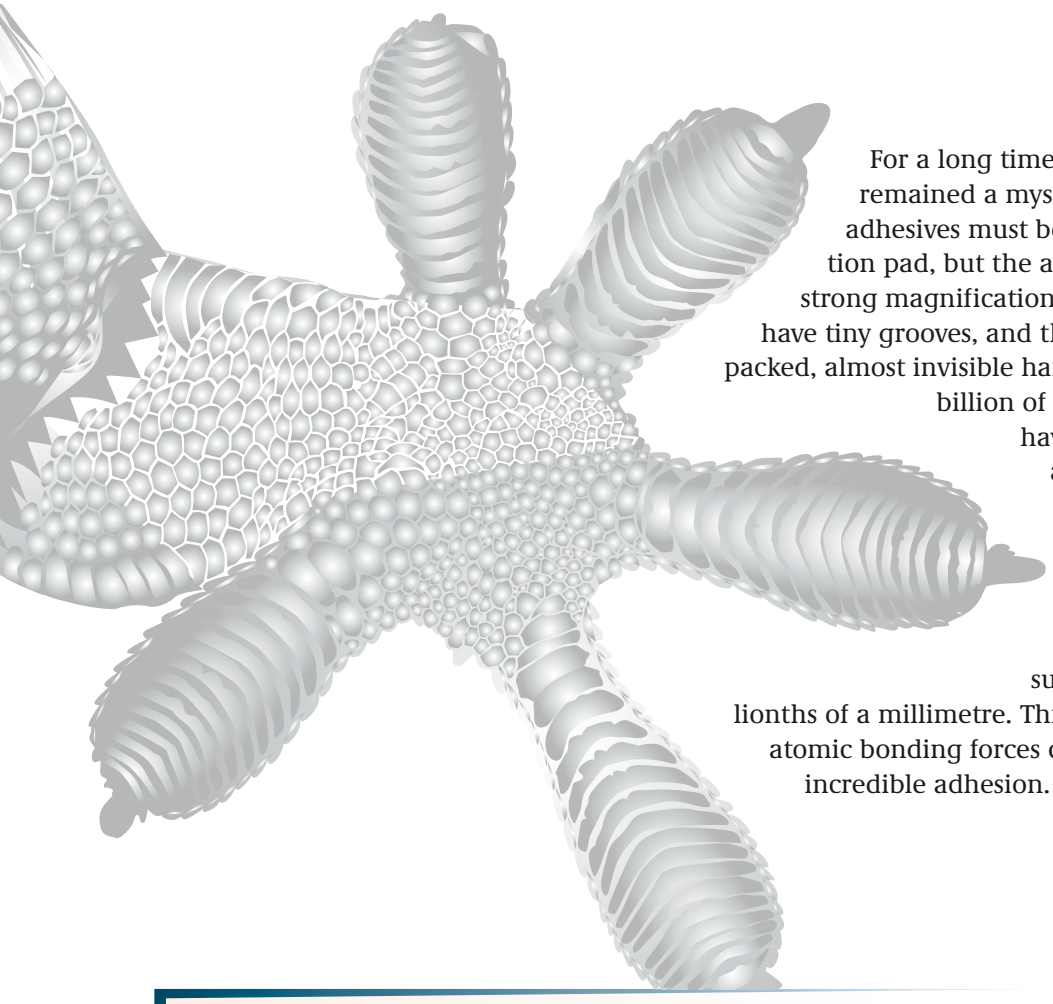


THE HAIRY SECRET OF THE GECKO



High-tech from nature worksheet 1

"I would like a gecko as a pet!" Viona whispers to Manuel. "It would deal with the spiders and insects in every corner." It's the last lesson, and Biology is really interesting today. In fact it's absolutely amazing what great achievements evolution has produced over millions of years. Geckos, for example: small reptiles with incredible climbing skills that can even run around upside down on the ceiling to catch their prey, which makes them popular with people as "home cleaners".



For a long time the gecko's climbing skills remained a mystery. At first people thought adhesives must be involved, or a kind of suction pad, but the answer is different. Under strong magnification, a gecko's foot proves to have tiny grooves, and these in turn contain densely packed, almost invisible hairs. Each foot has about one billion of these minute hairs. They have the property of being able to cling to any surface – whether coarse rock or very smooth glass. The ends of these tiny hairs are so small that the gap between them and the surface is only a few millionths of a millimetre. This is a distance at which atomic bonding forces can act, which explains this incredible adhesion.

EXERCISES:

1. *A gecko's foot sticks well, and so do adhesives. What is the difference between the normal kind of adhesive that you use and the gecko's foot? Explain it in your own words. You can find information about adhesives in an encyclopaedia or by searching for "adhesive" on the Internet.*
2. *If it were possible to use the gecko's unique capabilities for the benefit of people, what possible applications can you see? Make a list.*
3. *What raw materials and resources would this save?*

GREAT ACHIEVEMENTS OF NATURE

High-tech from nature worksheet 2

What is Bionics?

Bionics combines Biology and Technology. In bionics, experts in the fields of biology, technology, engineering and design work together, identifying possible applications for solutions that nature has created in the course of evolution. In a second step they apply this special property in a technological context. It is not a matter of making a faithful copy, but rather of finding inspiration in nature.

Cat's paws for motorists?

Velvet paws as a model for car tyres? Cat's paws spread out when "braking", which means they apply more force to the ground than when walking normally. This principle can be applied to tyres as well. The tyre spreads out considerably, bringing more rubber into contact with the asphalt. This reduces the braking distance by more than 10 percent, which can make all the difference between life and death in emergencies, especially under wet or snowy conditions.

Cycling without a puncture kit

A rainforest liana has the unique ability to ensure the speedy healing of cracks in its stem. A few minutes after the split has occurred, special cells arrive on the scene. They multiply and seal the split, and subsequently become woody. This restores the strength of the stem so that it cannot break apart. German researchers have now developed a plastic foam that can be applied inside bicycle tyres. If the tyre is punctured by a nail, the foam expands into the hole and seals it.

Seeing in the dark

The "fire-loving" jewel beetle deliberately flies to forest fires in order to lay its eggs on the freshly burned site. It has a special organ with infrared sensors that can detect heat radiation. Artificial IR sensors made by man (e.g. in satellites or night vision devices) require complicated and expensive cooling so that they can distinguish heat sources from the surroundings. But these beetles have an IR sensor that manages without this additional cooling and is nevertheless extremely sensitive. German scientists have succeeded in developing an IR detector that works in the same way as the beetle's sensor. They are now carrying out laboratory tests on a fire alarm based on this principle.

The penguin principle

Thanks to the ideal streamlining of their bodies, penguins can swim at high speeds under water and use surprisingly little energy in the process. Unlike fish or dolphins, penguins do not use their bodies to propel themselves forward. They use their wings to move under water. Apart from slight oscillations, their bodies remain almost rigid. This makes penguins particularly interesting for bionics specialists because submarines, planes or airships are also built with a rigid body. The idea is to make these penguin-shaped in future. This could save a lot of energy and substantially reduce pollutant emissions.

EXERCISES:

1. *Read the texts. Explain in your own words what bionics means.*
2. *Think of other possible uses for the examples described.*
3. *Imagine you have to design an environmentally friendly means of transport. What models in nature can you think of? Think of things like swimming, flying, crawling etc. Who has the best ideas? Collect the ideas in your group and make a list of them. You can find information and ideas on the Internet, e.g. under: www.biokon.net/bionik/beispiele.html.en*

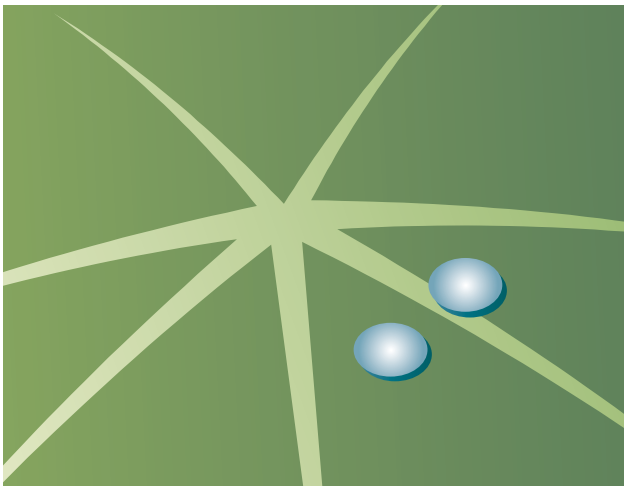
THE DIRT SIMPLY RUNS OFF ...

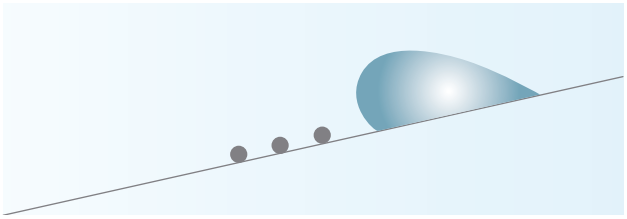
High-tech from nature worksheet 3

Manuel wants to go to the cinema with his friends. The only problem is that his bicycle badly needs a clean after yesterday's ride through the mud. But time is short. And now the others are already waiting at the door. "Hi Manuel, it's time to go," says Felix. "I have to give my bike a quick clean – I can't go with it like that," says Manuel, and the thought crosses his mind: "If only the bike would clean itself!" For Manuel it's still a dream, but it's already being used in thousands of practical applications. Self-cleaning surfaces, a principle copied from plants. It's known as the Lotus Effect® – a brilliant example of bionics.

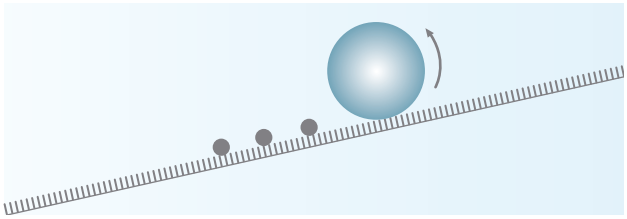
The Lotus Effect®

The leaves of the lotus plant have a rough surface with tiny bumps and a layer of wax. When water runs over it, the water droplets roll off the surface, taking any dirt with them. That leaves the leaf clean again.





On plants with a smooth surface, the particles of dirt have a large area in contact with the leaf, so they stay clinging to it.



On the lotus plant, the dirt has virtually no contact with the surface of the leaf. The water droplets, which maintain a completely spherical shape, take the dirt with them.

EXERCISES:

1. *Describe the Lotus Effect®. Use the infosheet to help you.*
2. *Today it is possible to copy the Lotus Effect® by technical means. Consider where one could productively make use of this effect.*
3. *Consider what raw materials this might save on a sustainable basis.*
4. *A tricky question: Where does it does not make sense to use products with the Lotus Effect®, and why not? Think of the basic principle of the Lotus Effect®!*

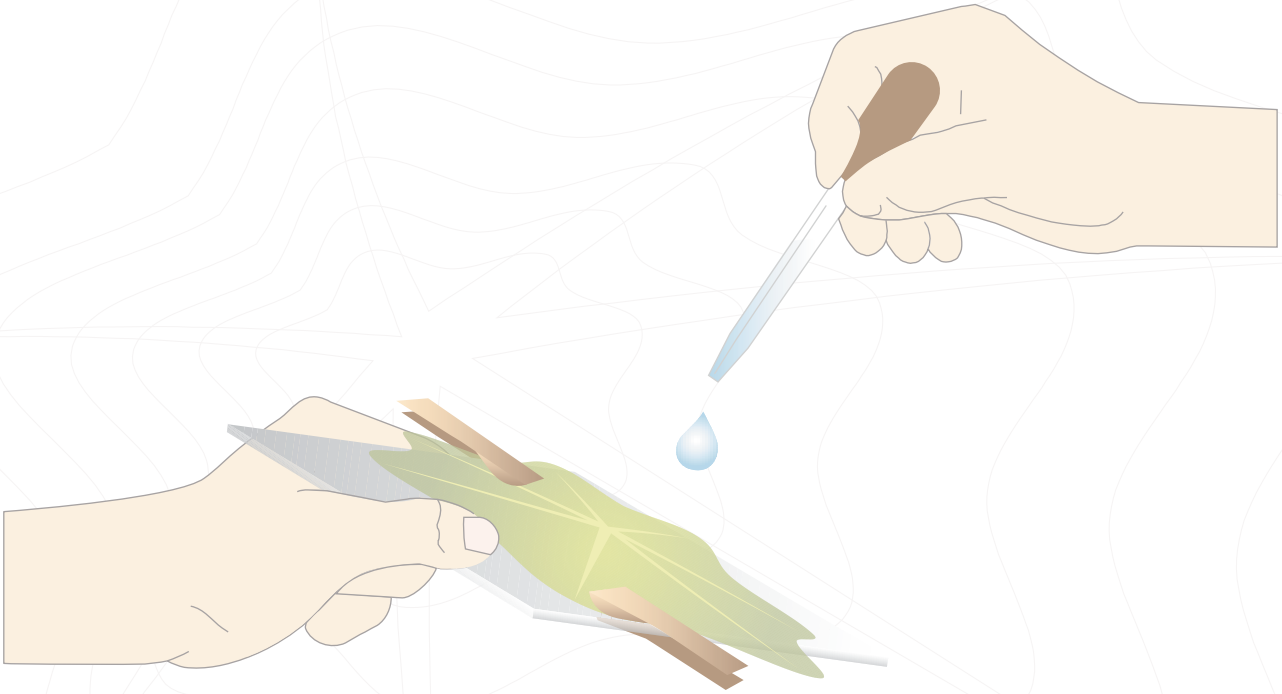
THE EXPERIMENT

"The Biology project week starts tomorrow," Aysche says to Felix, "And I haven't done any preparation at all. What's it all about, anyway?" "Experiments, experiments," says Felix, "That's what they say. We'll probably have to investigate the Lotus Effect®. That could be quite interesting. I find it more interesting doing experiments than having to read up everything in books."

You can do the same as Aysche and Felix and carry out your own experiments on the Lotus Effect®. The aim is to compare various artificial and natural surfaces and see how good their self-cleaning properties are.

THE EXPERIMENT

Work in your groups to perform the experiments. Each group is given a measuring beaker filled with water, a pipette, five artificial surfaces and two or three leaves of different plants. You can use clothes pegs or large paper clips to fix the leaves to a piece of cardboard so that they stay flat.



EXERCISES:

Observation experiment, Group 1:

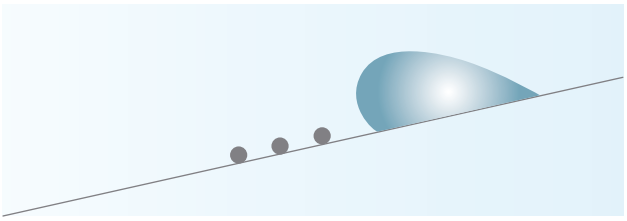
1. *Hold all surfaces at an angle of between 20 and 45 degrees to the table or floor. Check the angle with a protractor.*
2. *Before the experiment, estimate which of these surfaces will repel water better.*
3. *Use the pipette to drip roughly equal amounts of water onto the surfaces. Note which surfaces the water runs off easily and which it tends to cling to.*
4. *Look at the shape of the droplets on the surfaces – what differences are there?*
5. *Try to find an explanation for this behaviour.*

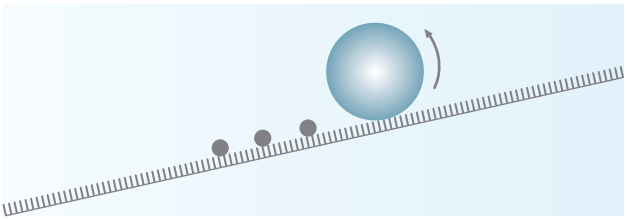
Observation experiment, Group 2:

1. *Dust the surfaces with flour, dust, fine sand, ash.*
2. *Which of these surfaces do you think will repel the dirt better?*
3. *Now drip roughly equal quantities of water drop by drop (like rain) onto the surfaces. Note what happens and which surface gets cleaner.*
4. *Repeat the experiment with other kinds of "dirt", e.g. honey, sugar, even commercial water-soluble adhesives of the kind you use at home!*
5. *Try to find an explanation for this behaviour.*

Physical basis of the self-cleaning experiment
Smooth surfaces are not always easier to clean than surfaces with a rough microscopic structure. Many plants use nano structures to help rain wash off the dirt. Particles of dirt or pathogens (mould) either block off the sunlight, thereby preventing optimum photosynthesis, or they can give rise to plant diseases – good reason to get rid of them as quickly as possible.

To this end, plants use not only their cell structure, but also wax crystals of regular shape on their surface. These give the surface a micro and nano structure that ensures the water droplets cannot cling to it, since wax is hydrophobic and repels water. Instead, the surface tension in the droplet is so strong that it pulls the droplet together and stops it spreading on surfaces with such a structure. This can also be seen from the "swollen" shape of the droplets, whereas droplets on glass surfaces, for instance, tend to look much flatter.





When a droplet runs over the surface of the leaf, it can easily take up dirt particles and rinse them off, because most dirt – like the substances used in the experiments in Group 2 – is easily removed by water. Typically, one can observe that there is no trace of dust left along the path followed by a droplet.

It may be possible in the lesson to demonstrate this by a simple experiment, e.g. by destroying the wax layer on one half of a cabbage leaf by wiping it off with a cloth. In this case the self-cleaning effect does not function nearly so well on the half with the wax layer removed.

Tip: A variety of plants can be used for the experiment: nasturtium leaves, all types of Brassica (cabbage, kale), poppy leaves (cultivated varieties have larger leaves), tulip leaves, and numerous aquatic and wetland plants such as bulrush, lotus etc. However, cabbage leaves are recommended here because of their size.

A SHORT FILM ABOUT BIOLOGICAL DIVERSITY

SCREENPLAY

A SHORT FILM ABOUT BIOLOGICAL DIVERSITY – SCREENPLAY

THE EARTH'S TREASURES

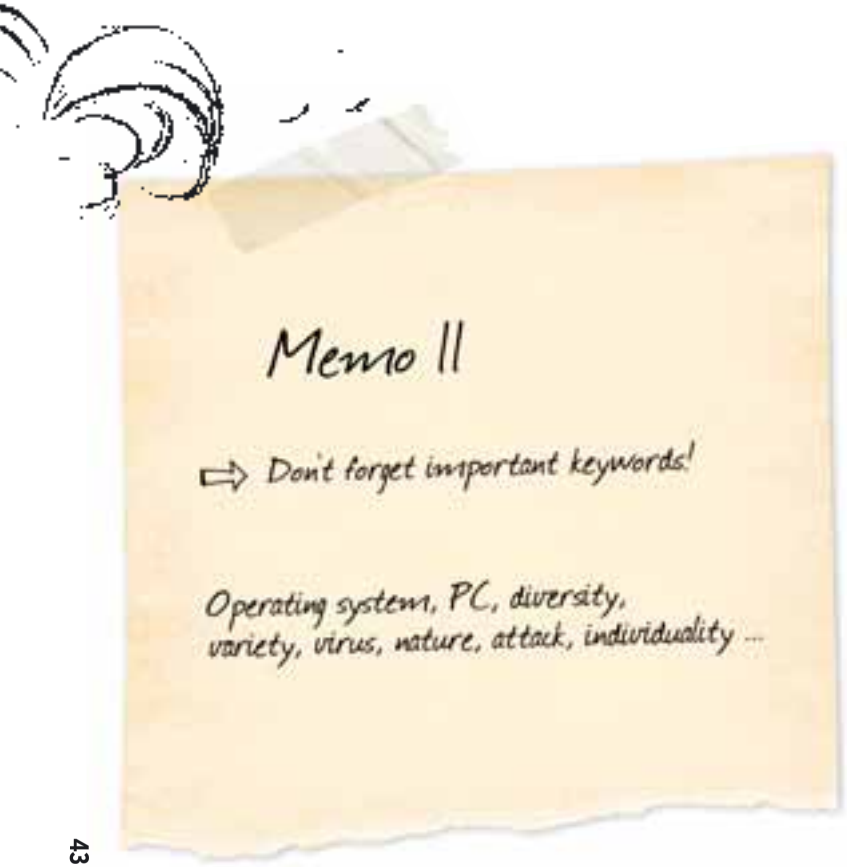
Aysche, Viona, Felix and Manuel want to make a short video on biodiversity for a school project. The four friends are hard at work drawing up a shooting schedule and a draft screenplay. Luckily, Manuel's older sister is very good with computers and can help them create difficult sequences, like the initial scene, with a suitable computer programme.

Take I: Initial scene

A long travelling shot, tracking in towards the Blue Planet from somewhere in the solar system.

EXERCISE
Describe how you think the scene could be continued.

The four friends are sitting in Viona's room and wondering how the screenplay should go on after the initial scene. Manuel is mumbling quietly to himself: "Diversity, diversity ... what's the point of it all?" Turning to his friends, he says: "We could do without all that. When I think of all the creepy-crawlies and midges. Much too much diversity to my mind." "Well then, look at the PC in front of you," says Aysche, "and remember the last virus onslaught in the Internet" ...



Take II: Indoors/daytime

The scene is a huge office, with dozens of people sitting at computers. Suddenly a red warning light comes on and an alarm siren sounds. General chaos breaks out, people are all talking at once and rushing here and there and looking helpless. Some of them are frantically typing at their keyboards, others are unplugging their computers at the mains.

EXERCISE

What do computers, their operating systems, viruses and worms have to do with species diversity? How could the scene continue? Give your imagination free rein!

Aysche is trying hard to find a scene that shows how nature serves as a model for new technical inventions. Felix is thinking of his favourite sport, free climbing. He would like an invention that enabled him to negotiate overhanging rocks safely. Like a fly running upside down on the ceiling. But that's still a dream for the future.

But there is something that already exists today – a self-repairing bicycle tyre. The model was a species of liana that grows in tropical rainforests.

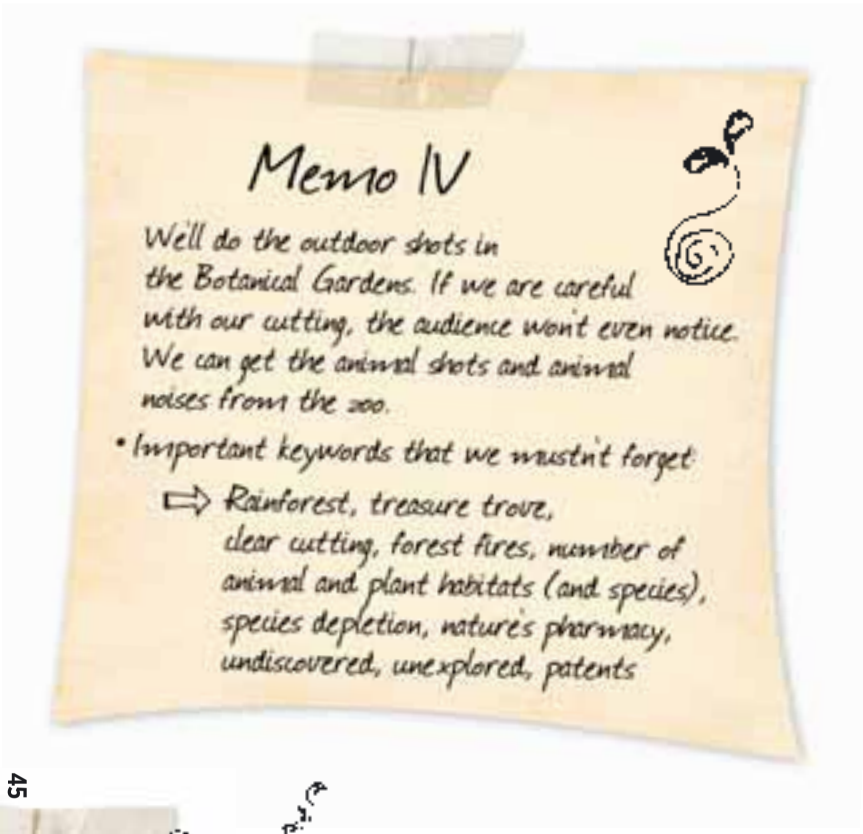
Take III: Outdoors/daytime

A 15-year-old girl is fiddling with her bicycle. Two school friends come round the corner. ”Hey, what's up? We wanted to go to the pictures, didn’t we?" says one of them. "I won’t be long, it’s a puncture again,“ replies the girl.

EXERCISE

How could the scene continue? Give your imagination free rein and write the rest of the scene. Have you a few ideas of your own about things we could copy from nature?

The four friends are keen to do something about the world's treasure houses. But those are far away in the Earth's tropical rainforest belt. The friends discuss what to do. Finally Viona says: "I would like to have gone to Ecuador, but it costs far too much to get there. And wild horses wouldn't drag me to Borneo or New Guinea. They say there are still head-hunters there, maybe we'll end up as shrunken heads!" "Rubbish," says Aysche: "Those are just old horror stories. That's a thing of the past. But we could bump into bio-pirates" ...



Take IV: In the jungle/daytime

A group of biologists armed with nets are combing the rainforest in search of unknown plant and animal species. At the front of the group is the expedition leader. He turns round and talks to the man behind him. "I hope we find the hidden valley the medicine man was talking about. He told me this was the only place you can find this rare liana. That would be a real breakthrough in pharmaceutical research." His colleague replies: "Let's just hope those bio-pirates don't get there first!" ...

EXERCISE
How could the scene continue?
Give your imagination free rein and write the rest of the scene. !

LEARNING / COMPETENCE CHECK

Fit for Pisa?

Question 1: Biological diversity

Our Earth is home to a wide variety of species and habitats. They include micro-organisms, sheep and whales, dandelions and sequoias, tropical forests, heath land, river meadows, lakes, oceans and deserts. All this is biological diversity. Animals and plants form communities, known as biocenoses. We humans cannot live without plants and animals. We form a community with them. We are part of this biological diversity. Plants, animals and humans need an environment to live in, and they help to shape this habitat, also known as a biotope. The biotope is characterised, for instance, by the nature of the soil, the water quality, the surface structure of the terrain, and the climate. A community and its habitat form an ecosystem. There are countless ecosystems of widely varying size. A puddle of water and the organisms that live in it are an ecosystem, but so is a desert, a stream or a forest and the organisms that live there. Biological diversity is usually defined in terms of the variety of different species. It is easy to measure: the more species live in a specific setting, the greater its biological variety. The diversity of species also provides information about the state of the ecosystem. There are also great differences in the relationships between the plants and animals. They support each other, they compete to use resources, and they eat each other.

EXERCISES

1.1 What information about the function of biological diversity can you find in the text?

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1.2 What does the text say about ecosystems?

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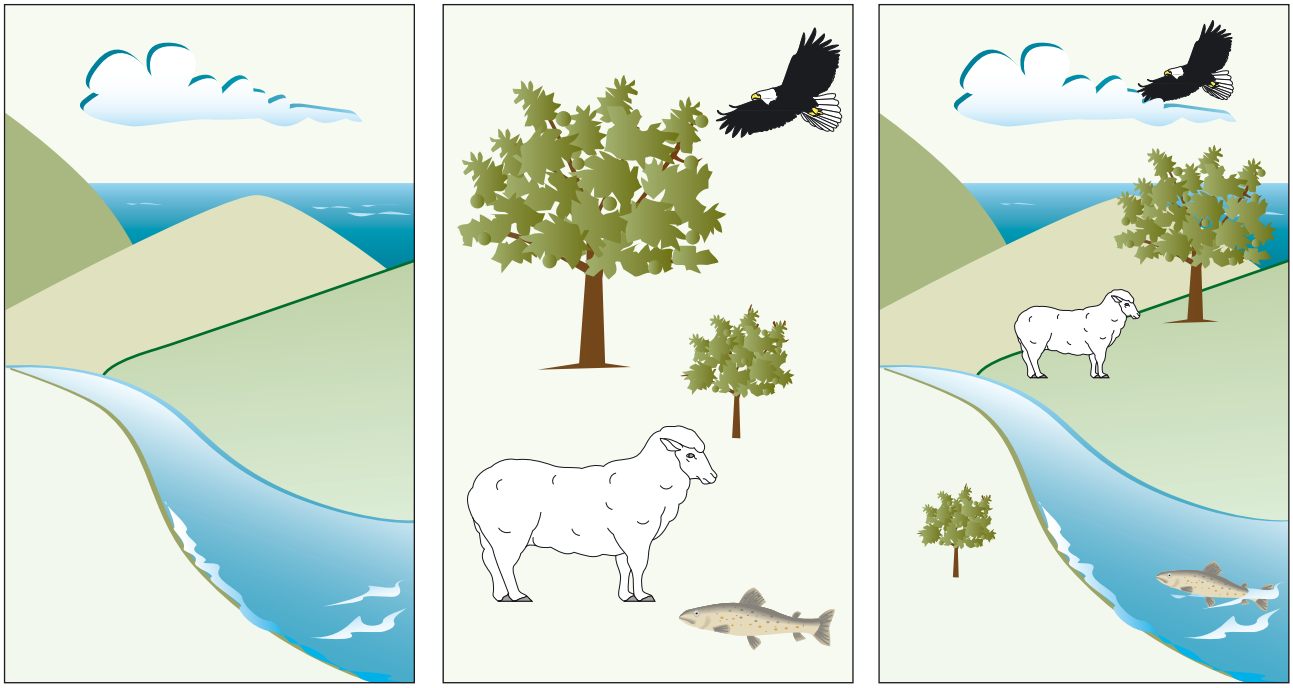
QUESTION 2: Are organisms dependent on each other?

2.1 (a) Assign the correct terms to the three pictures: biocenosis, ecosystem, biotope.

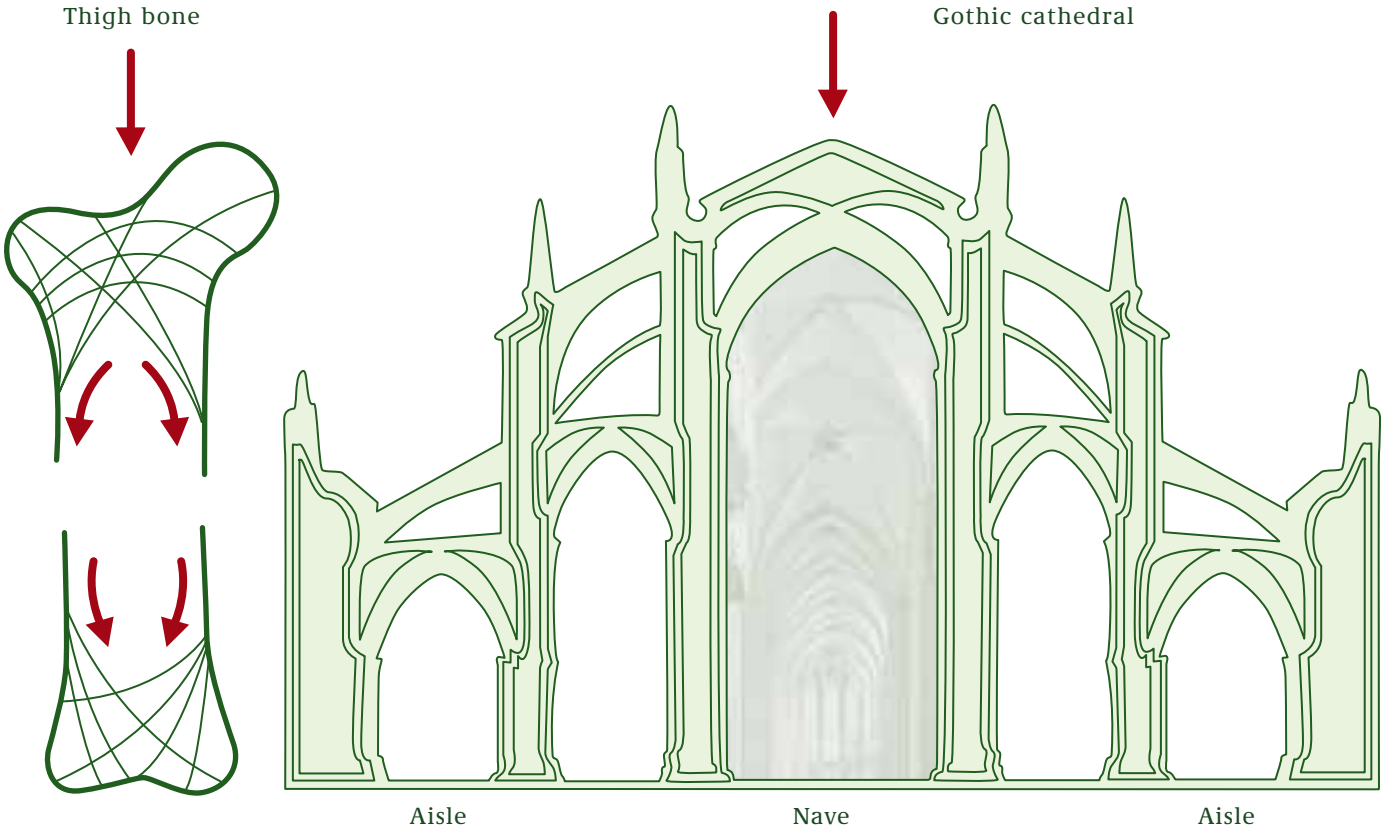
2.1 (b) To demonstrate the interdependence of plants and animals, draw arrows in the middle picture. Be careful to indicate which animals and plants are dependent on each other and which are not.



Source: Das Biobuch 7. & 8. Schuljahr, Diesterweg, Frankfurt a. M. 1995, p. 179

QUESTION 3: What do bones and cathedrals have in common?

Bones can withstand great stresses. Would you have thought that a cow's thigh bone could bear the weight of a whole car? How is that possible? The little beams, or trabeculae, in the thigh bone (shown here as black lines inside the bone) run in certain directions. They ensure even distribution of the pressure on the bone. This structure absorbs the forces acting on the bone. Similar structures are found in architecture, as in the following diagram of the structure of a Gothic cathedral.



EXERCISES

3.1 Draw arrows in the diagram of the cathedral to indicate the direction and nature of the forces acting on it, using the drawing of the thigh bone as a model.

3.2 Why were the aisles added on each side of the central nave?

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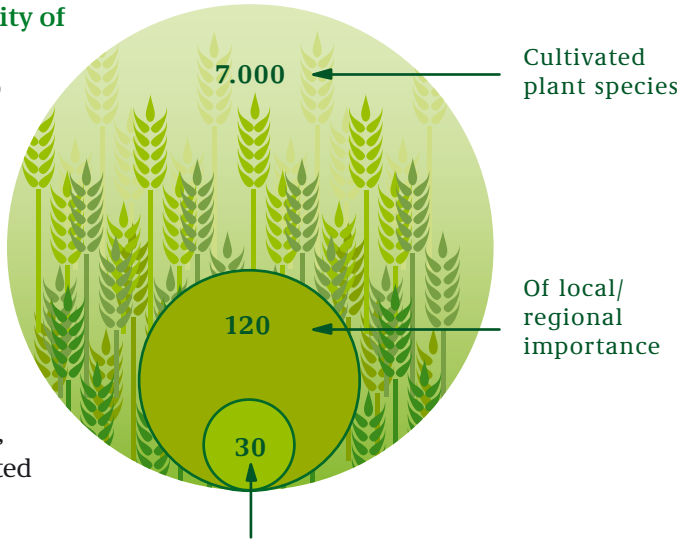
Question 4: Why should we preserve the diversity of cultivated plants?

Worldwide, there are an estimated 300,000 to 500,000 species of higher plants. Some 250,000 of these have been described. Of these plants, about 30,000 are edible, and 7,000 are regarded as cultivated plants (not counting ornamental and forestry plants). Cultivated plants are used to provide food for humans. 120 are only of regional or local significance, but are of great importance there as food crops. Others grow only in specific places. 30 cultivated plants supply 90% of the world's food. Four species – rice, wheat, sugar and maize – account for 65% of the cultivated plants used for the world's food.



Source: FAO, 1996

As the diagram shows, only a small proportion of cultivated plants are really used by the agricultural sector.

EXERCISES

4.1 Give as many reasons as you can why we should preserve the variety of cultivated plant species.

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4.2 How can we preserve the cultivated plant species that are used rarely or not at all?

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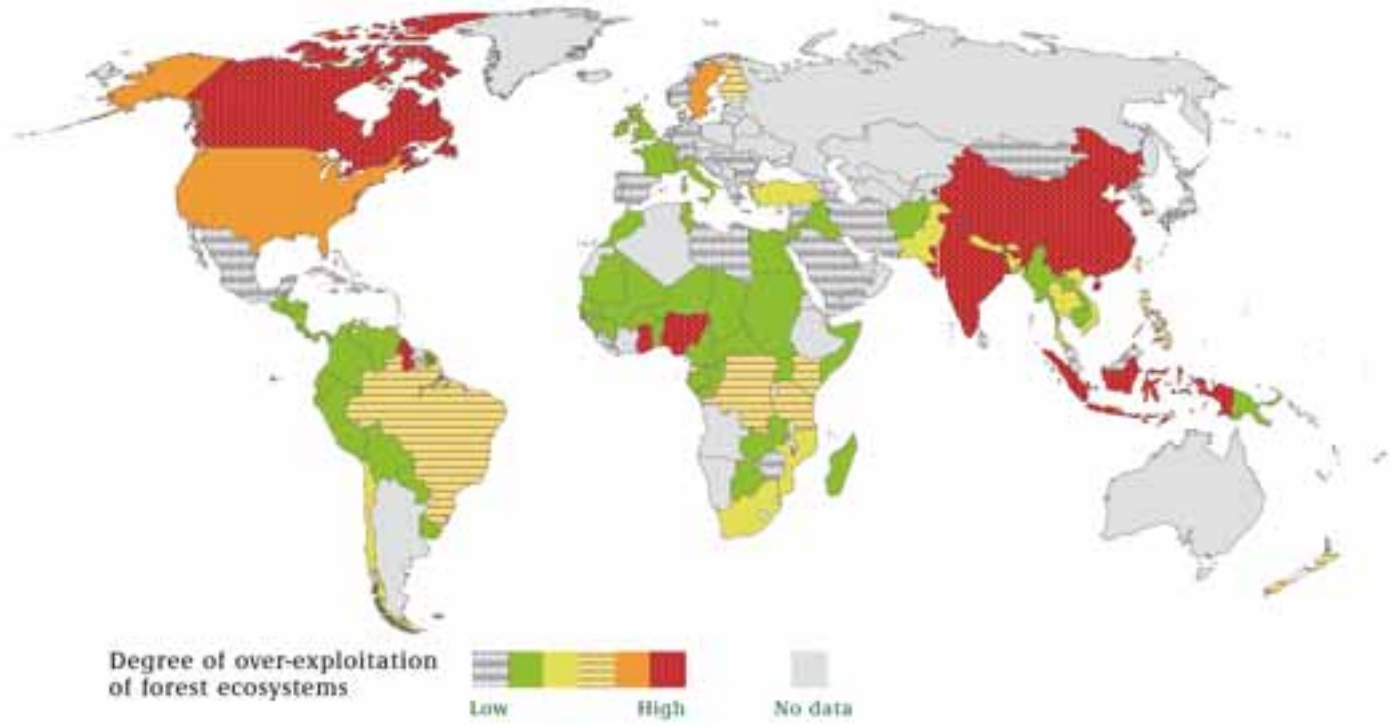
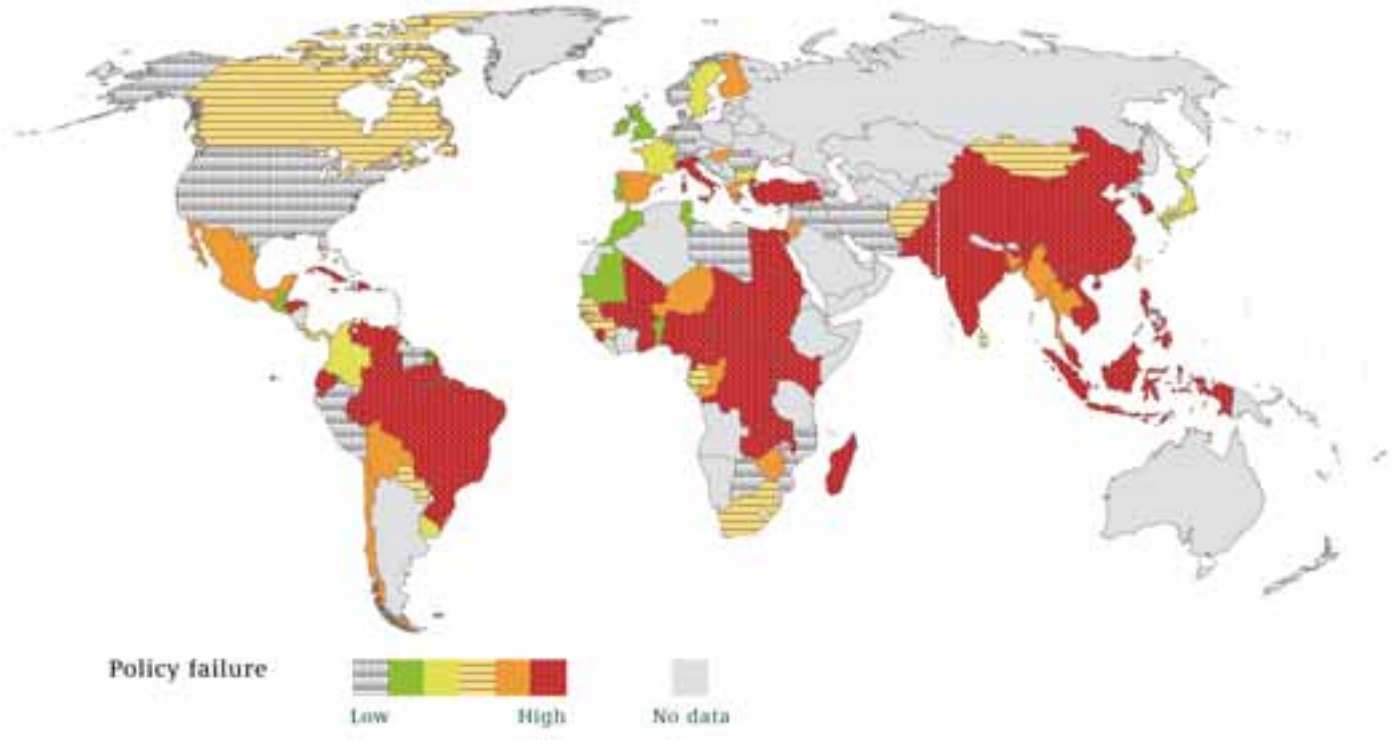
Question 5: Why does nobody stop over-exploitation of biological diversity?

In many parts of the world, forests are being felled faster than they can grow again.
That is why forests are disappearing very quickly in certain countries. This is called over-exploitation.
Map 1 shows the degree of over-exploitation.





Source of diagrams: WBGU (German Advisory Coucil on Global Change), Annual Report 1999 - Summary for Policymakers: World in Transition – Conservation and Sustainable Use of the Biosphere; www.wbgu.de/wbgu_jg1999_ultra_engl.html · World map: © cartogis, 2004

EXERCISES

5.1 Compare the two maps and name five countries where you think there was little chance of stopping over-exploitation of forest ecosystems at the time of recording the data (which was before 1999). You can use your atlas to help you identify the countries.

5.2 Imagine you belong to an organisation that is trying to combat over-exploitation of tropical rainforests. You have the opportunity to advise the government of a developing country on what action to take to prevent over-exploitation. What measures would you suggest? State at least three measures and give reasons.

HOW FIT ARE YOU AND YOUR PUPILS FOR PISA?

The Education Service expressly offers information primarily on scientific, geographic and social studies topics. The aim is to give pupils modern scientific skills, with a view to enabling them to play a responsible, understanding and active part in today's and tomorrow's society. This corresponds to the competencies tested at international level within the framework of the PISA test. In line with this, test questions have been developed for the Education Service which are designed to allow teachers to assess the competence level attained by their pupils. The competencies to be acquired are varied and demanding. The materials on this topic aim to develop the pupils' proactive skills (see **www.blk.de/Info-rundgang/Gestaltungskompetenz.php**). Our ideas today as to what constitutes a high-quality, practice-oriented, situation- and problem-appropriate basic scientific education (i.e. giving pupils scientific literacy), generally makes a distinction between the following fields, in which competencies can be categorised:

- Scientific concepts and principles
- Methods of scientific investigation and scientific ways of thinking
- Ideas as to what is special about sciences
- Ideas as to the relations between science, technology and society (understanding of the "Science Business" in a social, economic and ecological context)
- Attitudes to and value-based decisions on the application of science and on nature as part of our living world.

The central facets of scientific literacy are:

Scientific processes – These are ways of thinking and working used by science (e.g. recognising that a problem can be tackled on a scientific basis, drawing appropriate conclusions on the basis of data and findings, being able to explain something to others on the basis of scientific arguments, being able to make predictions on the basis of data, interrelations and events).

Scientific concepts and subject matter – The topic fields and fields of application in which science offers facts and findings (e.g. forces and motion, evolution, the immune system).

In our modern understanding of science, the fields of application are considered to be very important. After all, the knowledge acquired is to be used in situations outside the classroom or laboratory. A distinction is made between individual, local or municipal and global importance.

Five competence levels are distinguished:

Competence level I:
Nominal scientific literacy
Pupils are able to draw conclusions on the basis of everyday scientific knowledge and can reproduce simple factual knowledge.

Competence level II:
Functional scientific literacy on the basis of everyday knowledge
Pupils are able to apply everyday scientific knowledge in order to make predictions or offer explanations. They can refer to scientific information in order to draw conclusions and assess these.

Competence level III:
Functional scientific literacy with application of scientific knowledge
At this level pupils are able to use scientific concepts in order to explain phenomena and make predictions. They are able to decide which questions can be scientifically explored.

Competence level IV:
Conceptual and procedural scientific literacy
Pupils can identify and articulate additional information which they need in order to make valid conclusions. They can use relevant data in their chain of arguments and can communicate these. They can make use of elaborated scientific concepts to express predictions and offer explanations.

Competence level V:
High-level conceptual and procedural scientific literacy
Pupils can work with conceptual models and can systematically analyse experiments. They can take account of several different perspectives and argue in terms of one specific target group.

Competence levels IV and V differ in terms of the complexity, precision and systematic approach needed to resolve the problems set. In the 2000 PISA Test of scientific literacy, 60% of questions were multiple choice and 40% open format tasks. We have not chosen the same breakdown here, since multiple-choice questions are easy to produce and this is common practice. We have thus chosen to concentrate more on open-format questions.

For every topic area covered by the Education Service, questions are drawn up and classed in line with the above competence levels. This categorisation is based on assumptions of plausibility and is not intended to be taken as a gold standard. It should be seen as a suggestion, which teachers can and should adapt on the basis of their own experience. This also applies to the degree of difficulty involved in the exercises and the number of possible answers to some questions. In future, the Education Service plans to take into account concrete feedback from teachers with respect to the questions and exercises set. We would also like to point out the following:

1. In the PISA Test in 2000, German fifteen-year-olds (across all forms of secondary school) were clustered at the upper end of competence level II. Only 3.4% achieved competence level V, while 26% attained only competence level I (another 26% attained competence level II, 20% reached competence level III and 24% managed competence level IV).

2. It is not possible to cover every aspect of basic scientific literacy in one block of exercises. Several exercises would be needed for each aspect.

3. The individual questions contained in the exercises also require pupils to find and use information and skills that are not covered by these materials on biodiversity. This is customary and necessary when classifying competences in order to avoid too restrictive a link to the curriculum.

QUESTION 1

Intention of question:
Locate information, reproduce simple factual knowledge contained in the text – this corresponds to Competence Level 1.

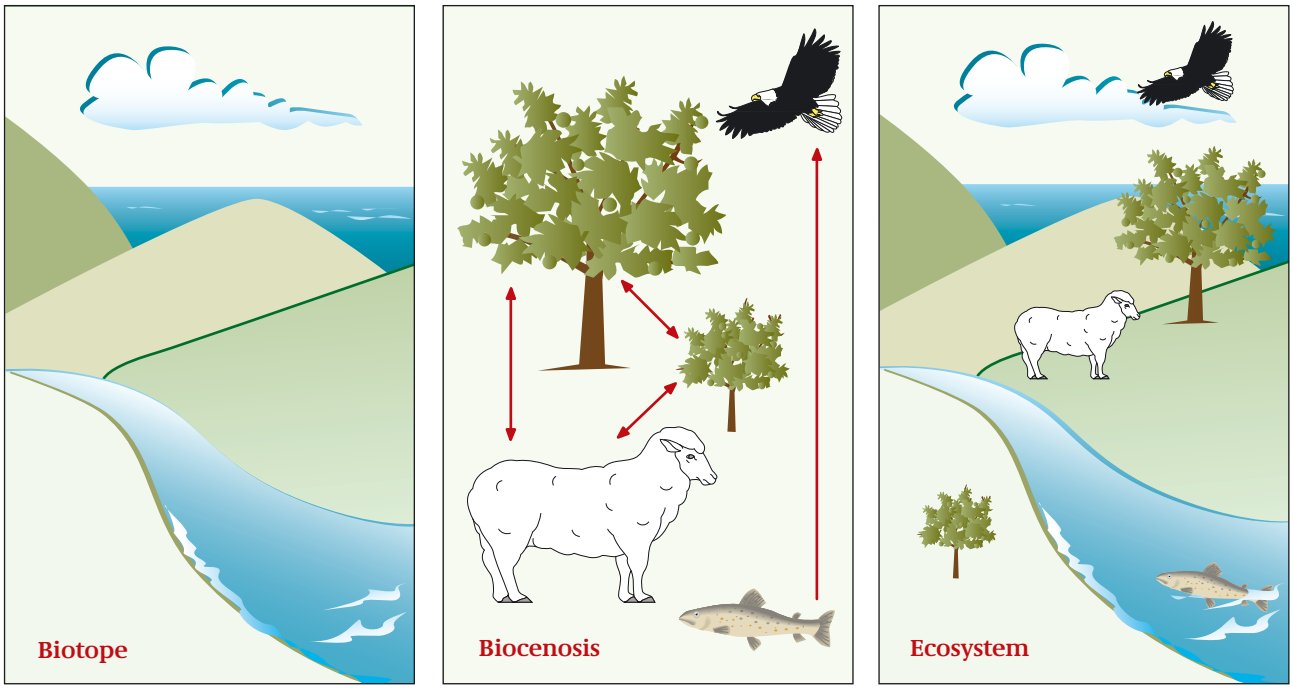
1.1 Correct answer:
Plants, animals and humans cannot live on their own. Biological diversity secures the life of the individual species.

1.2 Correct answer:
a) An ecosystem is characterised by the reciprocal interaction of plants and animals (as communities or biocenoses) and the surroundings in which they live (habitat or biotope).
b) There are countless ecosystems of varying size.
c) The state of an ecosystem can be seen from its diversity of species.
d) In an ecosystem the organisms support each other, they compete to use the resources, and they eat each other.

QUESTION 2

Intention of question:
The first aim is to check whether the pupils associate each picture with the correct term.
The second step is to see whether they can explain one of the pictures without being given any help.
This corresponds to Competence Level II.

Correct answer:



Source: Das Biobuch 7. & 8. Schuljahr, Diesterweg, Frankfurt a. M. 1995, p. 179

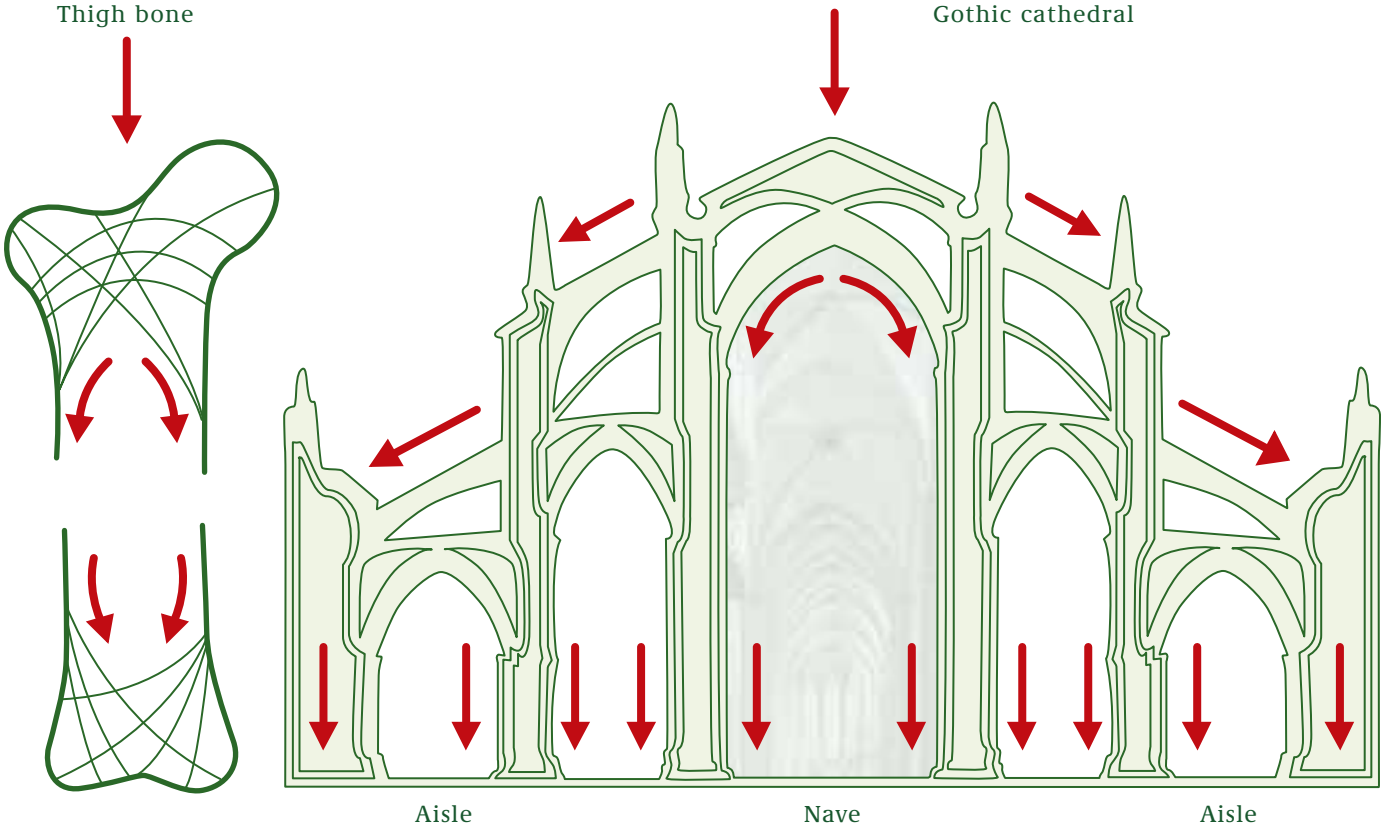
The sheep feeds on plants. Its excrement fertilises the soil. This supplies the soil with nutrients that are broken down by organisms in the soil and taken up by plants. The nutrients enable the plants to grow. By grazing, the sheep ensure that new shoots of trees and bushes are kept down. As a result, the ecosystem is preserved as heath land. The young chestnut tree can only originate from the seed of the large tree. And this reproduces through its seed. The bird of prey (fish eagle) eats the fish. It is at the top of a food pyramid. The arrow points in one direction only: from the fish to the eagle. An arrow from the tree to the eagle should also be accepted as an answer: this may be intended to indicate that the tree is used for nesting. Incorrect answers: missing double arrow between sheep, young and old tree.

QUESTION 3

Intention of question:

The aim is to establish whether the pupils can accurately describe scientific concepts regarding the direction of action of forces. and whether they can predict what might happen if one failed to take account of the forces applied.

Correct answer:



3.1

Note: For the correct answer it is important that the pupils draw the curved arrows under the roof and in the aisles as curved arrows.

3.2
The aisles absorb the forces exerted by the roof. With their buttresses and turrets they bring about a downward deflection of the lateral shearing forces acting through the arches. If the aisles were not there, the nave would fall apart.

QUESTION 4

Intention of question:
The aim is to test whether the pupils can develop and formulate chains of argument from the data provided. The question checks whether they can use an advanced form of words und complex cause-and-effect chains to explain the situation. This corresponds to Competence Level IV.

Correct answers:
4.1
a) Should environmental conditions change, we need to be able to fall back on the diversity of cultivated plant species in order to adapt to new situations.
b) Food security is threatened in future if biodiversity is lost.
c) Variety is more likely than a lack of species diversity to secure biodiversity (ecological performance).
d) We do not know what natural and active substances plants might possess (e.g. medicinal benefits).
e) Diversity is a value in itself (aesthetic and ethical aspects).
f) The diversity of cultivated plants goes hand in hand with knowledge about methods of cultivation. (Local) know-how would be lost if the species were no longer grown.

4.2
There are two possibilities:
a) Conservation in nature through systematic re-establishment of growing as a cultivated plant or through protection of existing stocks (in situ conservation) and
b) Conservation in collections, for example botanical gardens and seed banks, or collection of the plant DNA (ex situ conservation).

(Source of model answers: WBGU (German Advisory Coucil on Global Change), Annual Report 1999 - Summary for Policymakers: World in Transition – Conservation and Sustainable Use of the Biosphere: **www.wbgu.de/wbgu_jg1999_ultra_engl.html; especially p. 86 contd.**)

Note: The pupils do not have to present the reasons in the same structure as shown here. The more individual aspects are stated, the better the achievement.

QUESTION 5

Intention of question:
The aim is to ascertain whether the pupils can work with conceptual models (loss of biodiversity as a result of economic interests and policy failures) and are in a position to show how one can systematically arrive at reliable scientific statements. They must select various perspectives in which they name economic and political factors that reduce biodiversity.

Correct answers:

5.1

China, India, Indonesia, Malaysia, Ghana, Nigeria, Canada, Sweden, Brazil, Democratic Republic of Congo, Kenya, South Africa, Turkey, France, Pakistan, Thailand. The answer is obtained by establishing a correlation between the degree of over-exploitation and the severity of policy failures. The countries named above can be mentioned here. China, India and Indonesia, and also Ghana and Nigeria, are the most important countries to name. The best marks should be awarded for citing them.

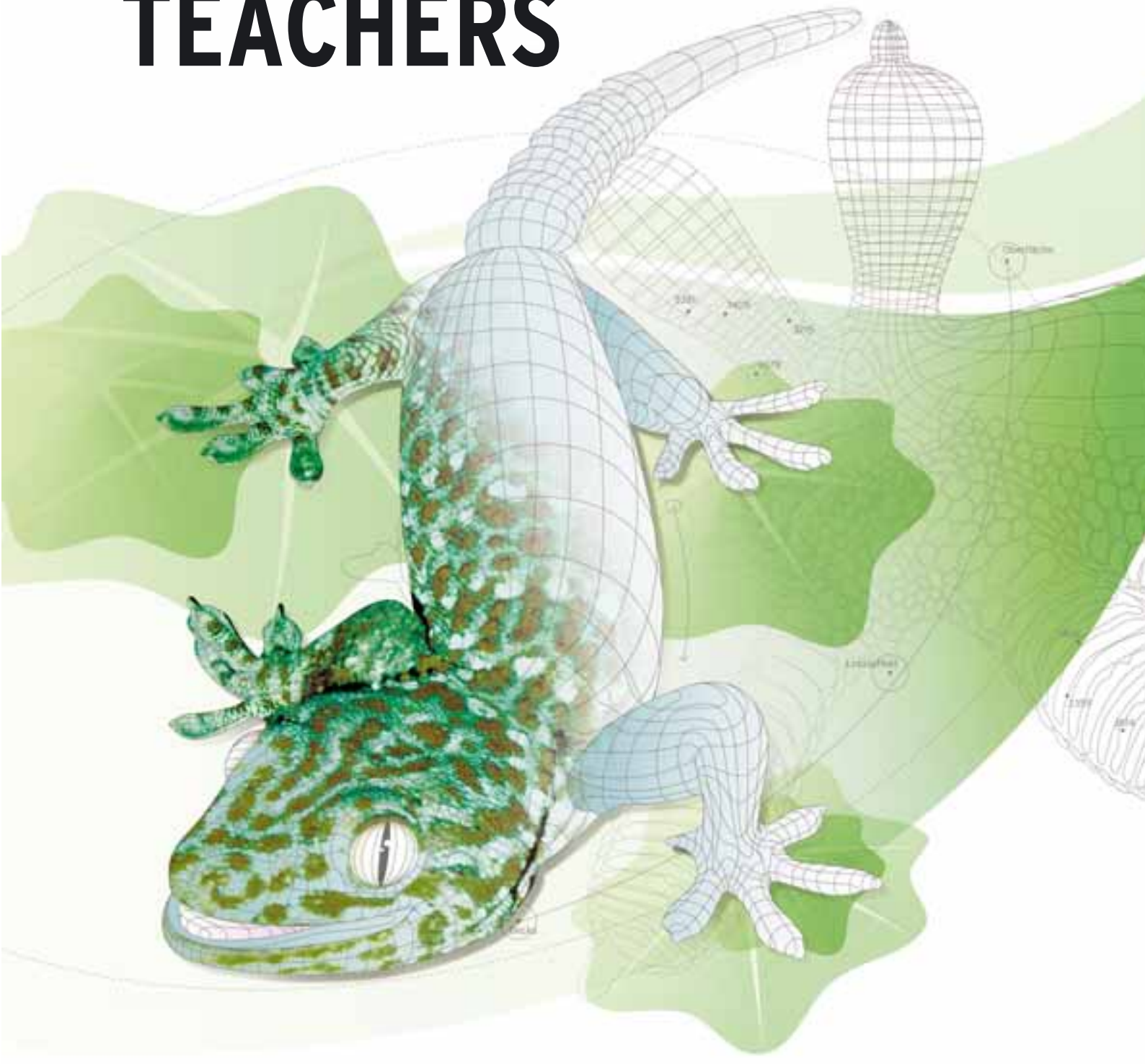
5.2

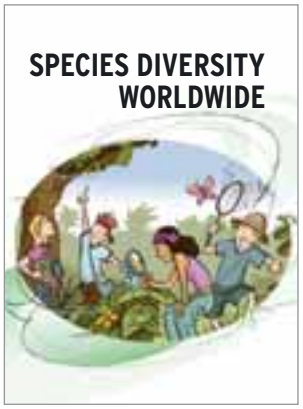
a) Governmental regulatory measures such as
- Binding laws and forest conservation programmes (incl. promotion of plantation wood production), because they offer not only sanction options, but also incentives (through assistance);
- Fixed quotas for felling quantities, because this permits an optimum ratio of felling to new growth;
- Defined felling areas, because this means the felling is not "wild" and is easier to control. It also permits better protection of areas requiring special protection;
- Reforestation measures and action plans, because they can at least partially offset existing damage;
- Supervision by forestry institutions, because laws and conservation programmes are only effective if control and sanctions actually take effect;
- Designation of usable land for farmers and potential settlers, and provision of support in the form of knowledge, infrastructure, micro credits, seed etc., because this makes it possible to prevent uncontrolled settlement and clearance and to achieve permanent use of certain areas.

b) Commitment on the part of non-governmental organisations
- Cooperation between local authorities etc. and (national) lobby groups to prevent timber felling, because they display strong honorary commitment, provide assistance with controls and can generate international attention
- Strengthening local groups who advocate conservation of biodiversity, practise traditional forest uses etc., because their knowledge and interests frequently run contrary to over-exploitation.

Note: Pupils can give other answers than those suggested here. What is important is not only their plausibility, but also the expected effectiveness of the measures.

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

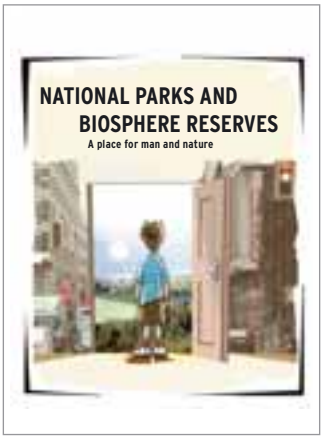
MATERIALS

- **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.

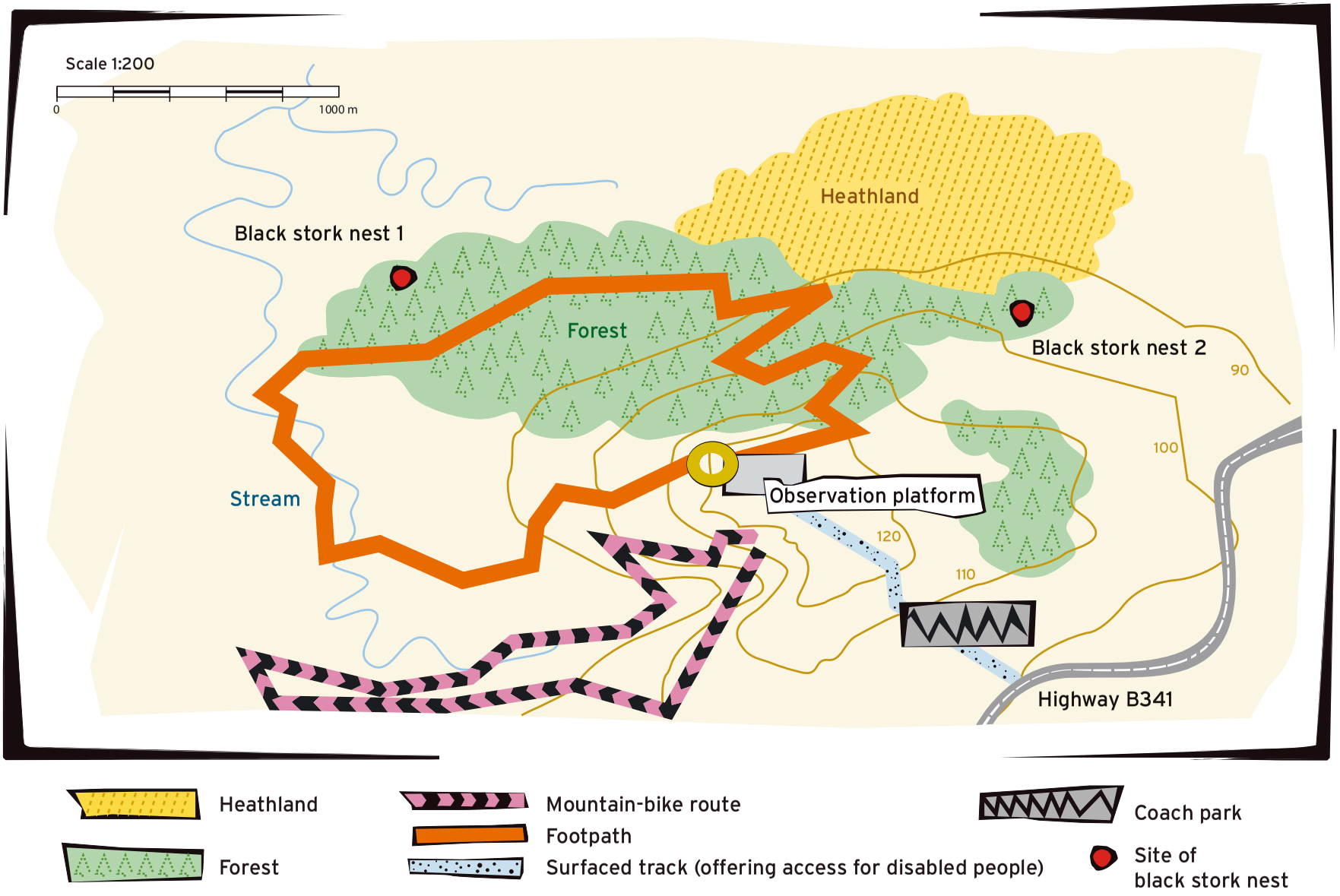
Other action options
What can the pupils do with their newly acquired knowledge? Particularly the biosphere reserves in Germany offer a wealth of opportunities for pupils of all ages to play an active role. For example, they can help to design teaching paths, participate in the Junior Ranger programme 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

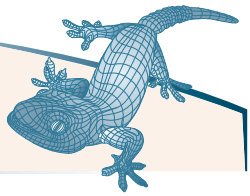
METHODS

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

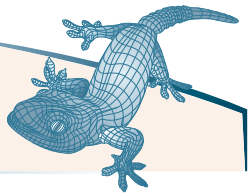
SUGGESTED APPROACH

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).

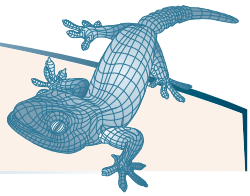


In depth: Work Phase 2 (experiments, Worksheets 3 and 4):

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.

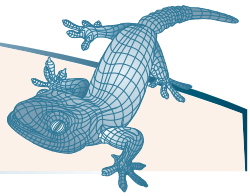
Worksheet 2:

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.

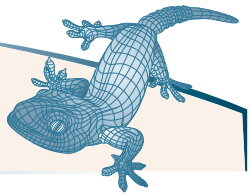
Tasks 4 and 5: The plant surfaces have a micro and nano structure that ensures the water droplets cannot cling to them. This results in strong surface tension which pulls a water droplet together on such a surface structure and keeps it almost spherical. On the artificial surfaces, e.g. glass, the droplets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

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