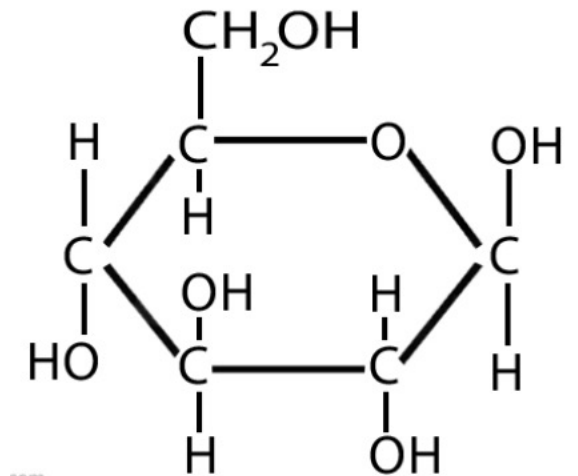


Ecology and Sustainable Development.

3. Ecosystem Functions and Human Impact:

3.1 Biodiversity.

3.2 Chemicals in the Environment.



3.1 Biodiversity.

- **Biodiversity:**

- Variation of life forms within a given ecosystem, biome or for the entire Earth.
- Many millions of distinct biological species, the product of four billion years of evolution.
- Flora and fauna diversity depends on climate, altitude, soils and the presence of other species.
- Biodiversity is extremely rich in the tropics and very low in polar regions.

- **Biodiversity hotspots:**

Region with a high level of endemic species.

- **Brazil's Atlantic Forest:** Contains roughly 20.000 plant species, 1.350 vertebrates, and millions of insects, about half of which occur nowhere else in the world.



Tamarin



Tapir



Biodiversity Hotspots.

- **Australia:** Separated from Supercontinent Gondwana (Africa, Asia) 100 million years ago.

Source: Terra X Phoenix 2023



Biodiversity Hotspots.

- **Madagascar:** High endemism since separated from mainland Africa 65 million years ago.



Biodiversity: Benefits.

- **Resistance of crops to diseases:**

- Monoculture, the lack of biodiversity, was a contributing factor to agricultural disasters, like the Irish Potato Famine of 1846 caused by a blight infection - *Phytophthora infestans* - (population reduced by 20%) or the collapse of the European wine industry in the late 1800s (caused by *Viteus vitifolie* - „Reblaus“).

- **Provision of food and drink:**

- Although about 80 percent of our food supply comes from just 20 kinds of plants, humans use at least 40,000 species of plants and animals.

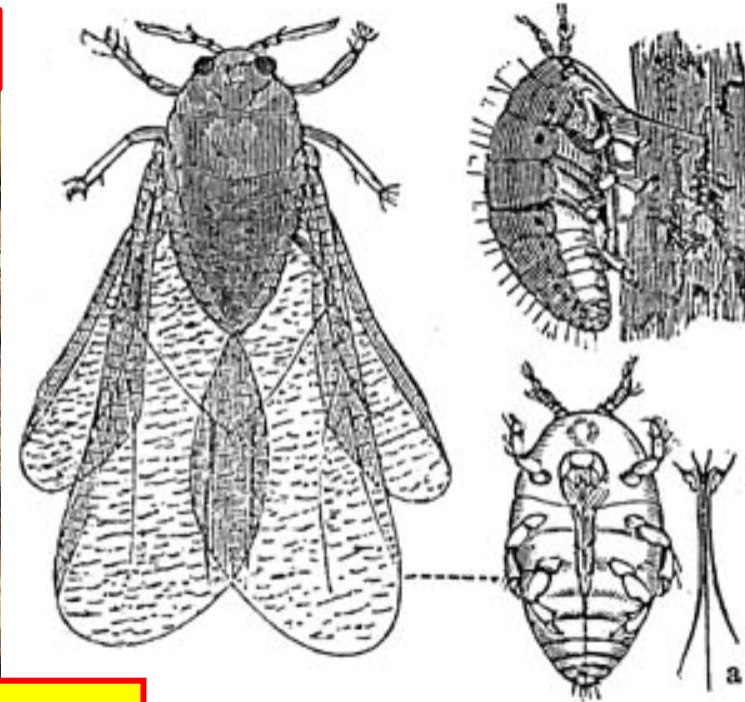
- **Provision of medicines:**

- About 40% of the pharmaceuticals used in the US are manufactured using natural compounds found in plants, animals, and microorganisms.
- Many drugs are also derived from microorganisms (penicillin from *aspergillus*, *penicillium* fungi).

Phytophthora infestans.



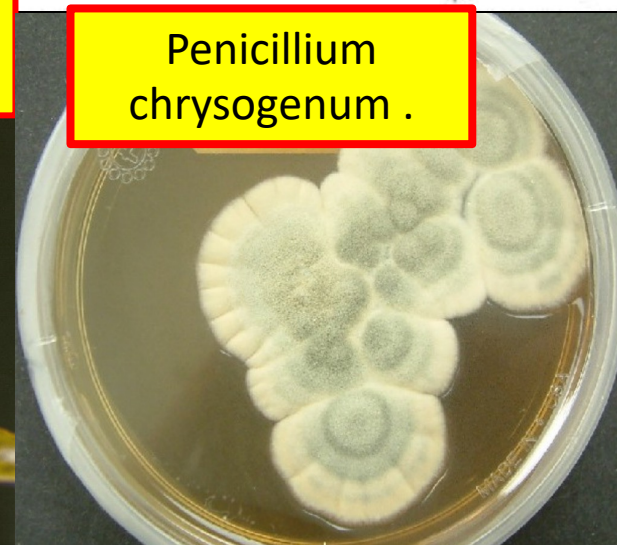
Viteus vitifolie.



*Aspergillus
Glaucus*



*Penicillium
chrysogenum* .



Biodiversity Benefits.

- **Provision of (industrial) materials:**
 - Building materials, fibers (wool, cotton, silk), dyes, resins, gums, adhesives, rubber and oil.
- **Ecosystem services:**
 - Biodiversity important in regulating the chemistry of our atmosphere and water supply.
 - Biodiversity is directly involved in recycling nutrients and providing fertile soils.
- **Intellectual value:**
 - Bionics – Nanotechnology
- **Leisure, cultural and aesthetic value:**
 - gardening
 - biodiversity has inspired musicians, painters, sculptors, writers.....
- **Intrinsic value of biodiversity:**
 - Philosophically it could be argued that biodiversity has intrinsic aesthetic and/or spiritual value to mankind.



Silk carpet of Ghom.



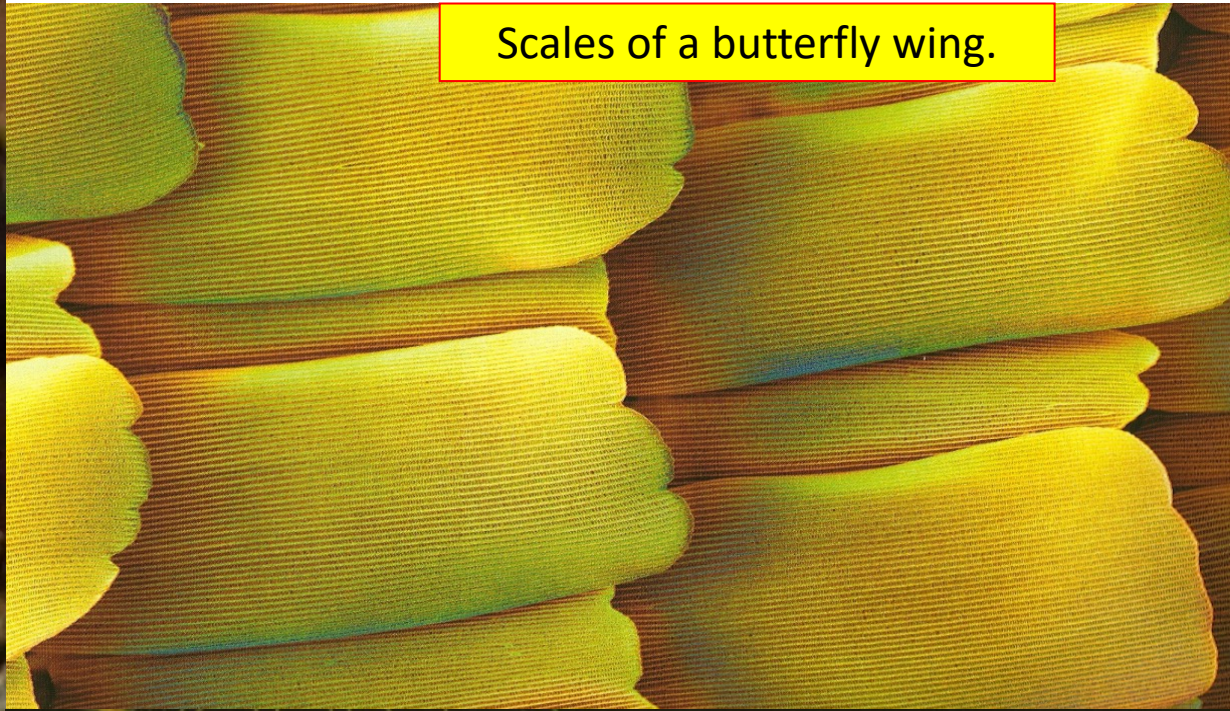
Dragon Fly – flight skills cannot be achieved by any helicopter.

Natura Magistra est: Bionics – Nanotechnology

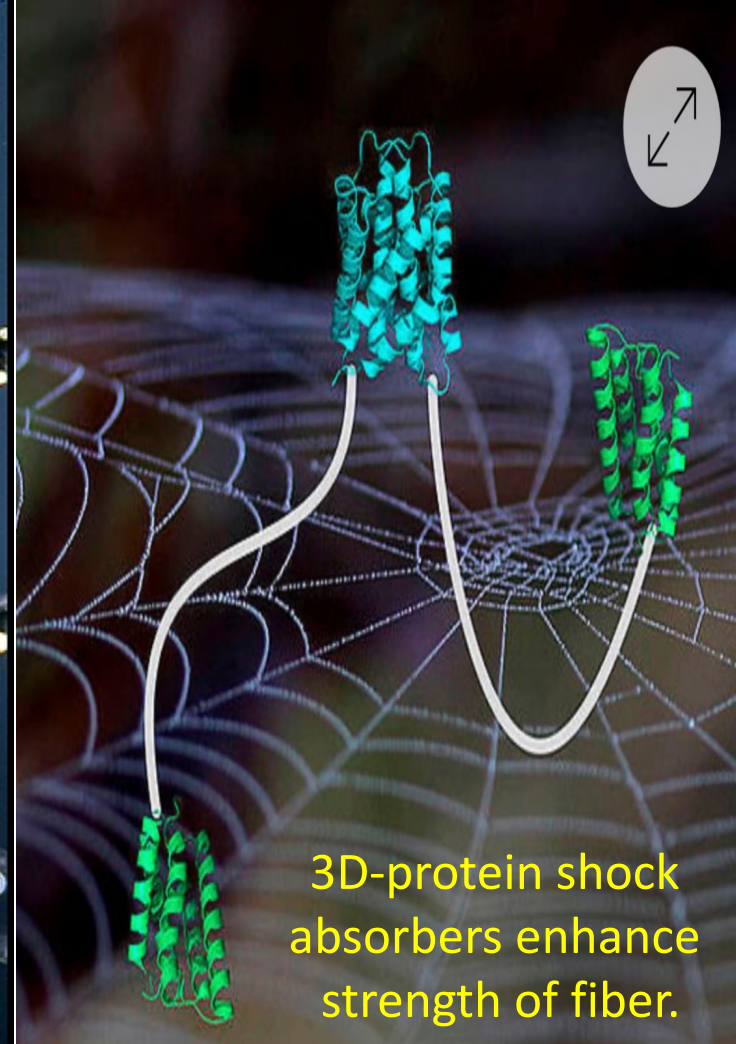
Eye of a bee.



Scales of a butterfly wing.



Natura Magistra est: Bionics – Nanotechnology.



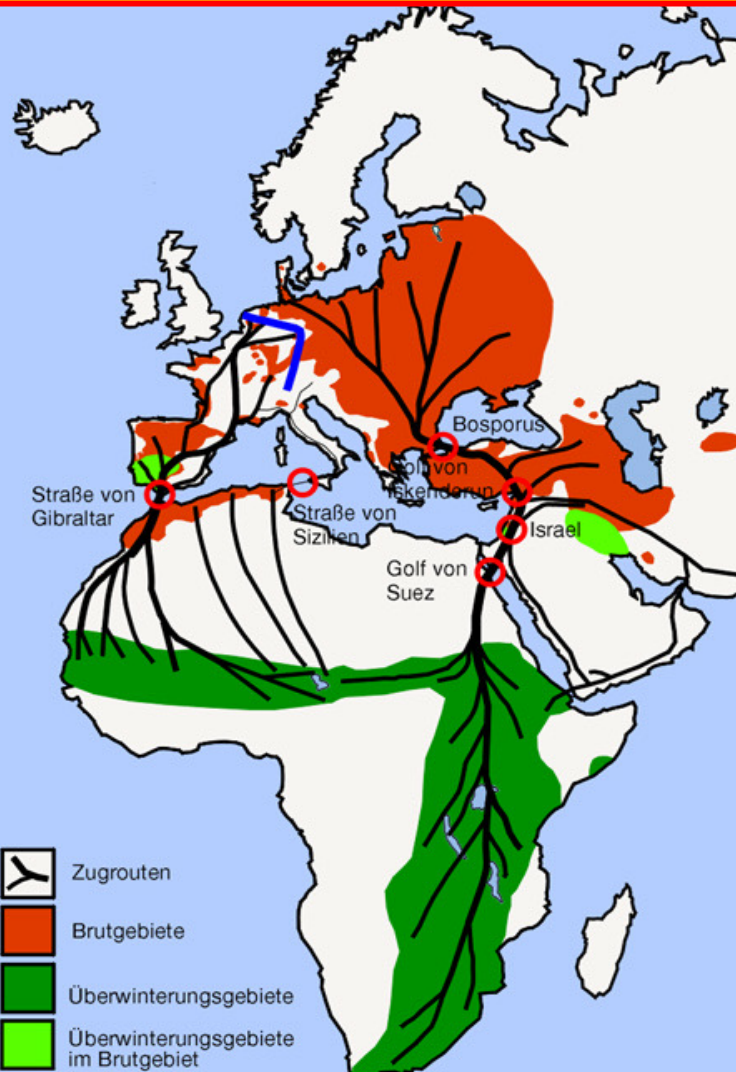
3D-protein shock absorbers enhance strength of fiber.

Ultra high strength nanomaterials: fibers of a spider net.

Source: A. Meckes, N. Ottawa:
Die phantastische Welt des Unsichtbaren, GEO Verlag 2003

Natura Magistra est: Orientation Skills.

Storks fly up to 10.000 km into Africa and return in spring to the same nest.



Hawk flying from South Africa to Finland: 10.000km in 42 days.

Nature - an Inspiration for Artists.



Marc Chagal 1972



Henri Matisse 1905

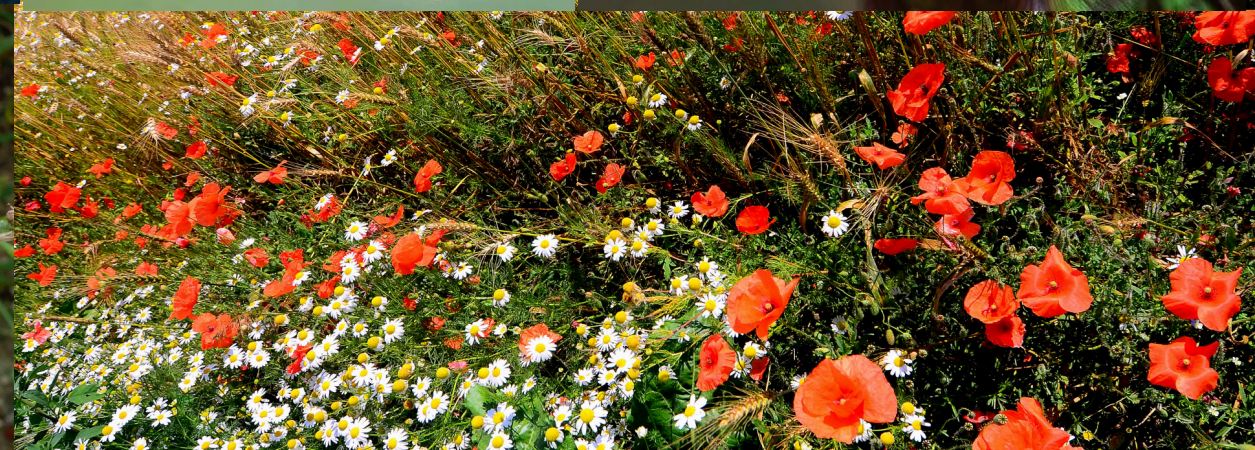
Amazing Nature: Aesthetics.



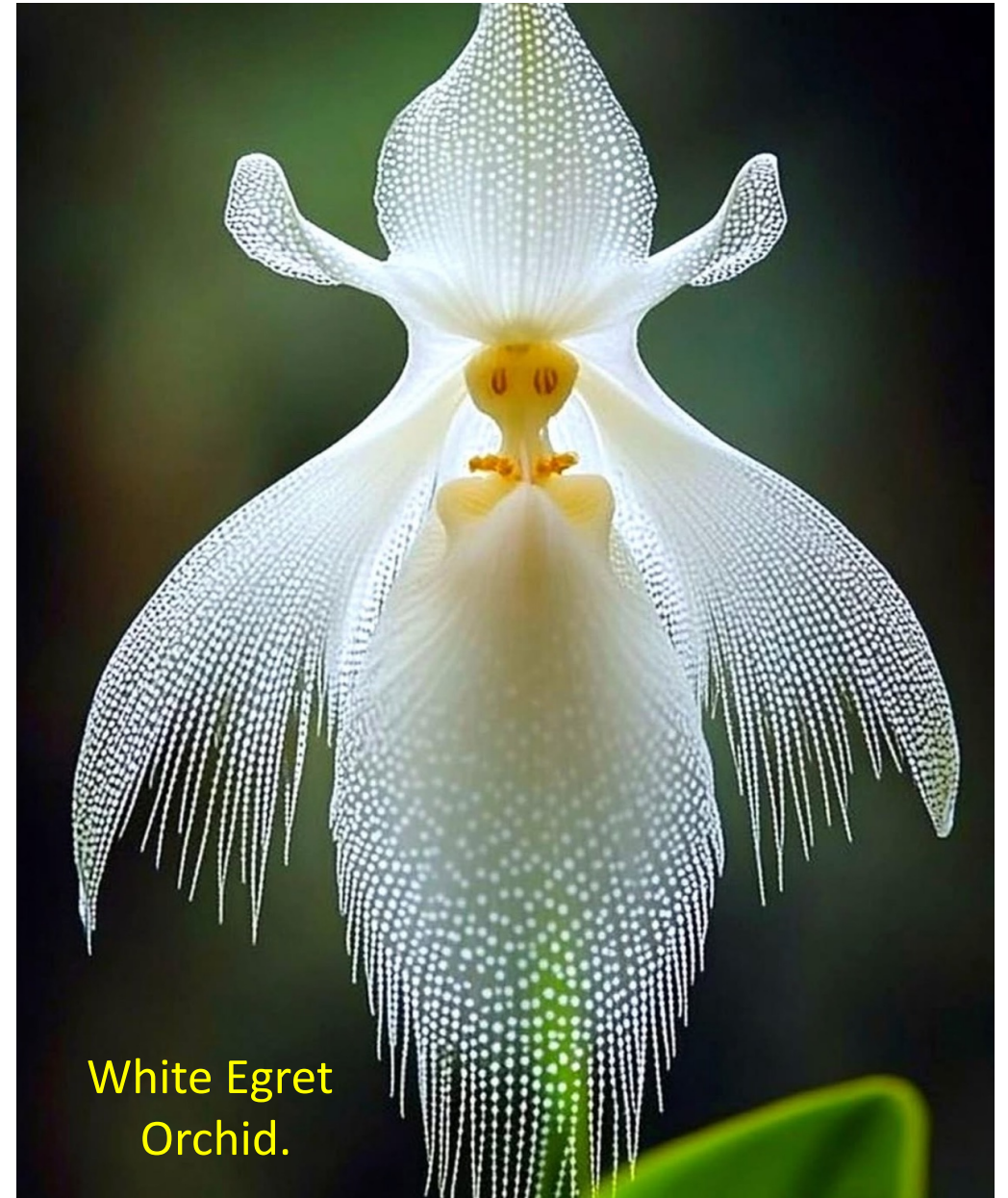
Tanagra Darwini
Rio de La Plata
Beagle Expedition 1831-36



Heliodoxa Aurescens
Tarapoto, Peru



Amazing Nature: Aesthetics.



Amazing Nature: Adaptability.



During the cold winters, the Alaskan Wood Frog becomes a frog shaped block of ice. It stops breathing, and its heart stops beating. When Spring arrives the frog thaws and returns to normal going along its merry way. *Source: Facebook 2024*



Leopard with
perfect disguise.

Amazing Nature: Adaptability.

- Efficient protection against enemies:



Armadillo:

Body covered with large bony scales and which rolls itself into a ball when it is attacked.

Blue hairy frogfish:

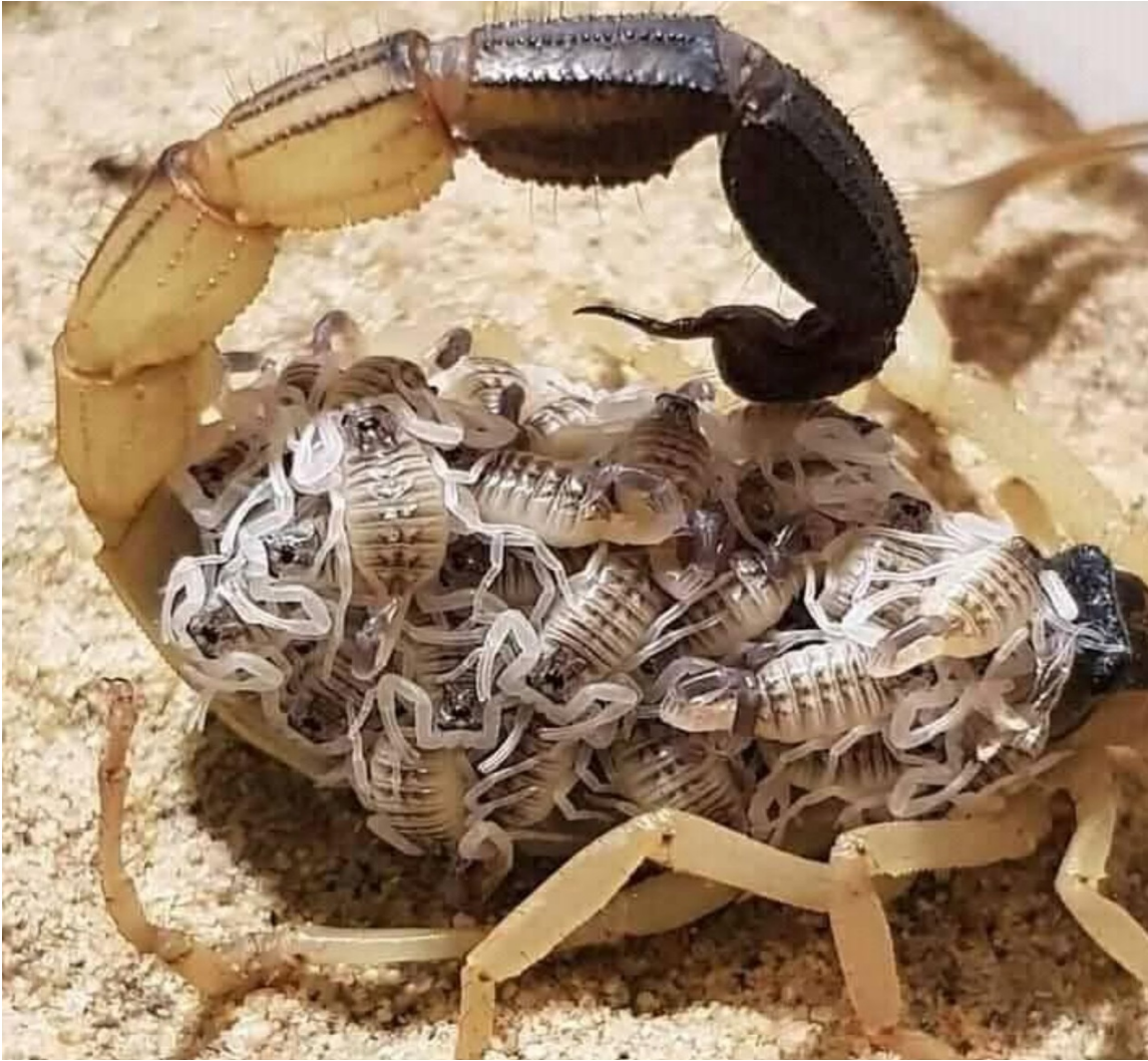
Shows an extraordinary blend of adaptation and survival strategies.



Source: Facebook 2024

Amazing Nature: Family Life.

Source: Reddit PythiaPhemonoe, Facebook 2024

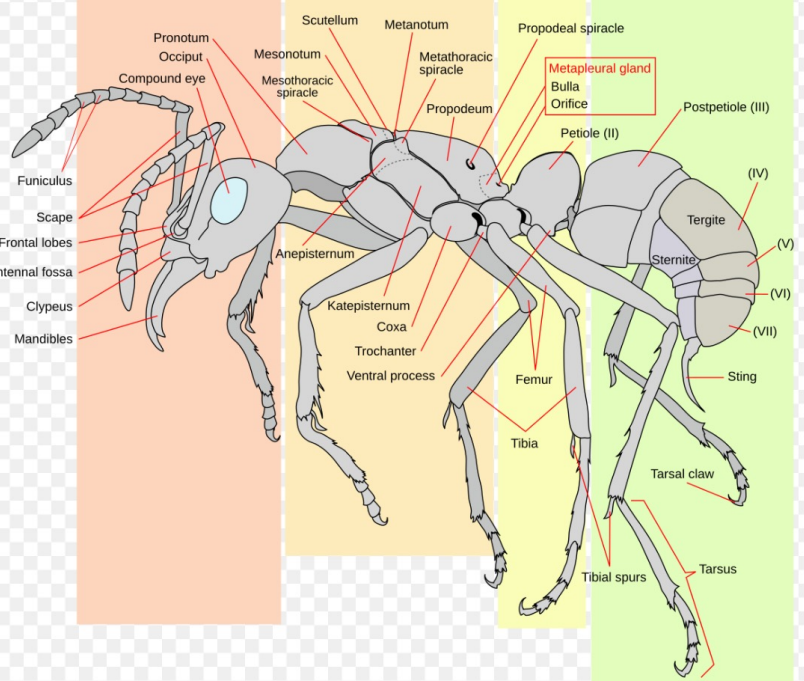


Scorpion mother carrying babies on her back.
A scorpion can have 100 babies in a single
brood born alive.



Sandhill Crane

Amazing Nature: Insect Societies.



Social ants cooperate and collectively gather food.

Ladybugs gathering on a tree branch helping to control pests like aphids (Blattläuse).



Amazing Nature: Special Creatures.

Sea Dragon.



Spiny flower mantis.



Tiger Beetle.



Peacock spider.

Tropical rock lobster.



Blue admiral butterfly.



Anomalocaris.

Amazing Nature: Miracles of Nature.

Fact Finder Hub



The tiny tardigrade can survive in space, extreme heat, and freezing cold!

**Coelacant
(Quastenflosser):**
A piece of living
evolution - 360
million years.



Crossopterygiformes

Biodiversity: Elimination of Biological Species by Human.

- **Anthropogenic evolution:**

- Led to extinction of species thousands of years ago.
- Homo sapiens was (is) an „ecological mass murder“ (Y. N. Harari)

- **Discovery and colonization:**

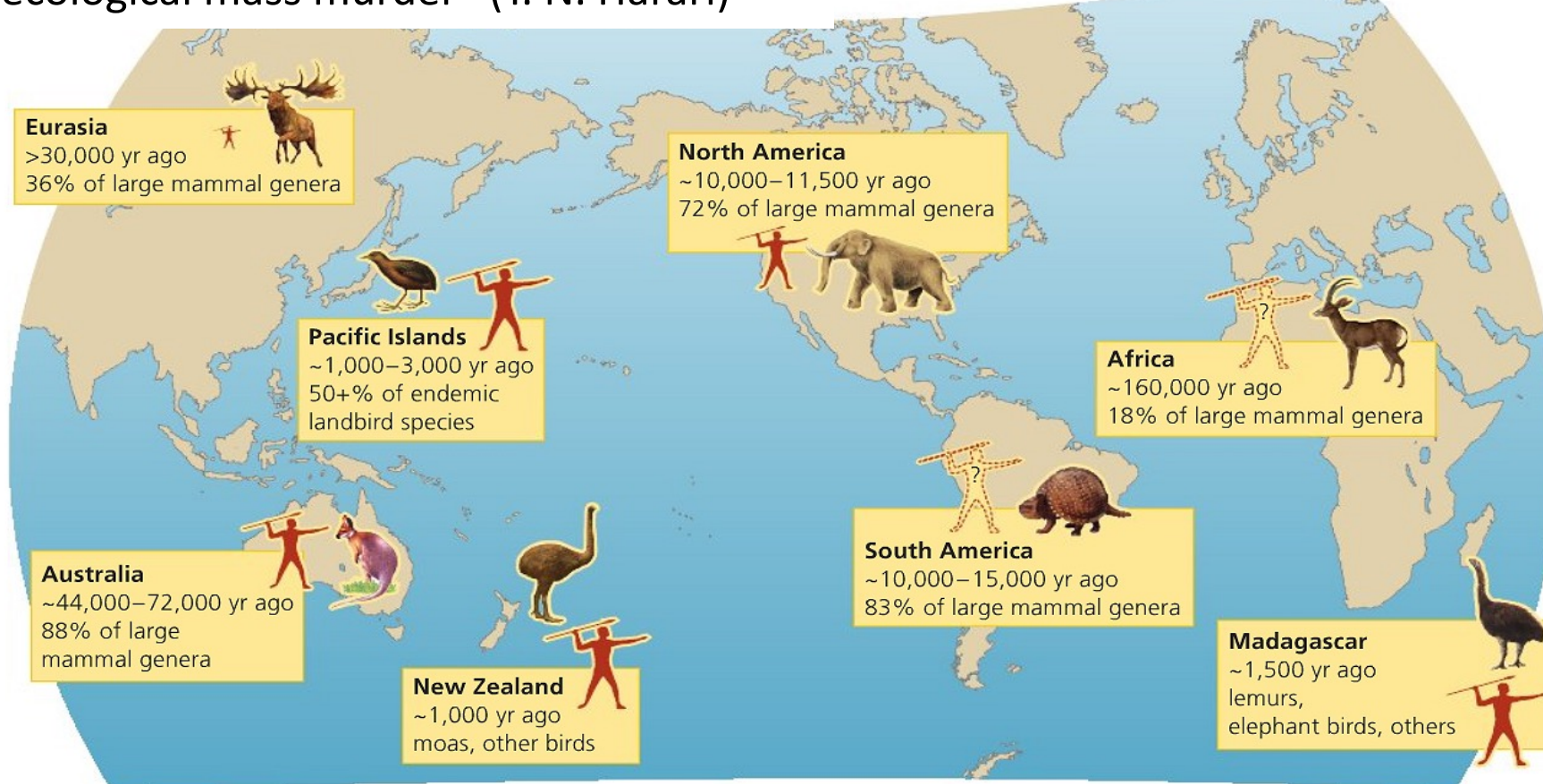
- Extinction of many bird species on remote islands and introduction of foreign species by man starting 500 years ago.

- **Industrialization:**

- Industrialization and change of land use beginning in the 19th century: Scientists estimate that during the last century, between 20,000 and two million species have become extinct.

- **Persistent threats from human activities:**

- Land change activities.
- Environmental pollution: atmosphere, soil and water.
- Agricultural application of fertilizers, pesticides.
- Climate change.
- Hunting and fishing.



Human arrival and the extent of extinction. *Source: Withgott and Brennan 2008*

Biodiversity: Extinct Species.



Moa were flightless birds native to New Zealand. The largest species reached 3 m.



The **quagga** is an extinct subspecies of the plains zebra, which was once found in great numbers in South Africa's Cape Province.

Biodiversity: Endangered Species.

International Union for the Conservation of Nature (IUCN): 2018 assessment report lists 28.000 species identified as threatened out of 105.000 species evaluated using the IUCN Red List criteria.



Hedgehog.



Sumatra
Tiger.



White headed Vulture.

Biodiversity: Endangered Species.



White Rhino, Kenya, only 2 animals left,
individually protected by park rangers.

Photo: Matjaz Krivic, Facebook 2023

Whale Shark

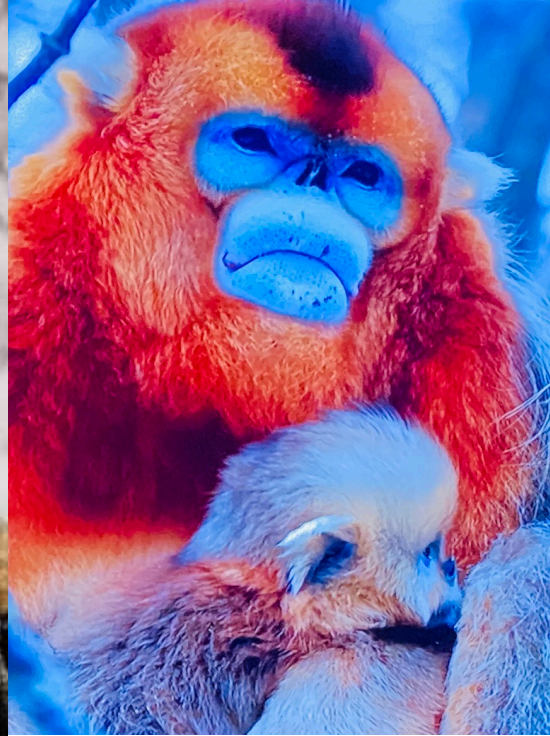


Biggest fish on earth – length 20 m.

Biodiversity: Endangered Species.



Siberian Tiger.



Orang Utang
(Malaysia)



Gold Snub Noses (China)



Biodiversity: Endangered Species.



By 2080 the Arctic polar ice will probably be gone.



Cheetahs: fastest animal, speed up to 130km/h.

- The conservation of biological diversity has become a global concern and is addressed in the **Convention on Biological Diversity**, which is an international treaty of 1992 (Rio), signed by 196 parties with main goals: conservation of biodiversity, sustainable use of its components and fair sharing of such resources.

Biodiversity: Existing Species.

Numbers of species (Chapman 2009):

Earth's ecosystems contain an estimated 10 million species, of which 1,8 million have been documented.

- **300.000 plant species** , including
 - 120.000 fungi
- **1,5 million animal species**, including
 - **65.000 vertebrates:**
 - 31.000 fish,
 - 6.500 amphibians,
 - 8.700 reptiles,
 - 10.000 birds,
 - 5.500 mammals.
 - **1,4 million invertebrates:**
 - 1 million insects
 - 90.000 mollusks,
 - 50.000 crustaceans,
 - 150.000 bacteria.



Blue whale under a boat.
30m long, 150 tons.



15.000 species of ants
(20.000 billion ants globally),
weight 10 mg.

The Variety of Fungi.



Trametes Versicolor.



Mycena roseoflava.



Lycoperdon
Prismae.



Buchenschleimröbling.



Trichterling.



Mycena subcyanocephala.

The Variety of Frogs.



The Variety of Birds.

Eastern
Bluebird



Toucan.



Kingfisher.



Short Eared
Owl.



Eagle Owl.



Hummingbird.



Cuckoo.

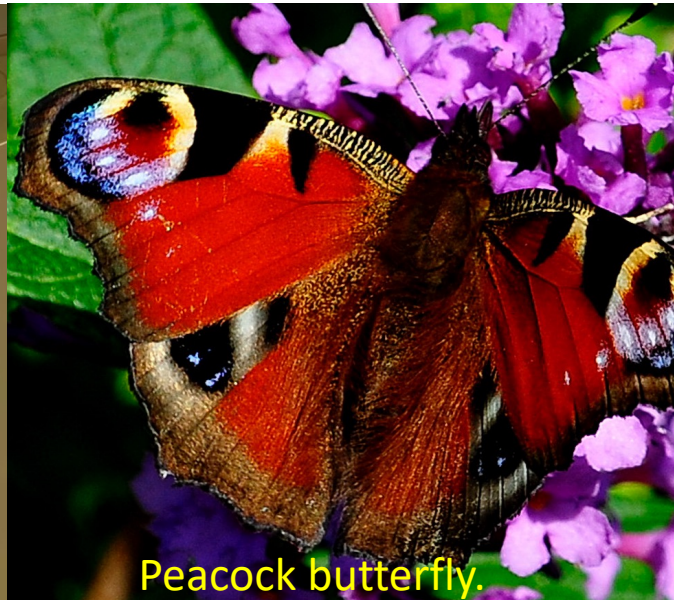
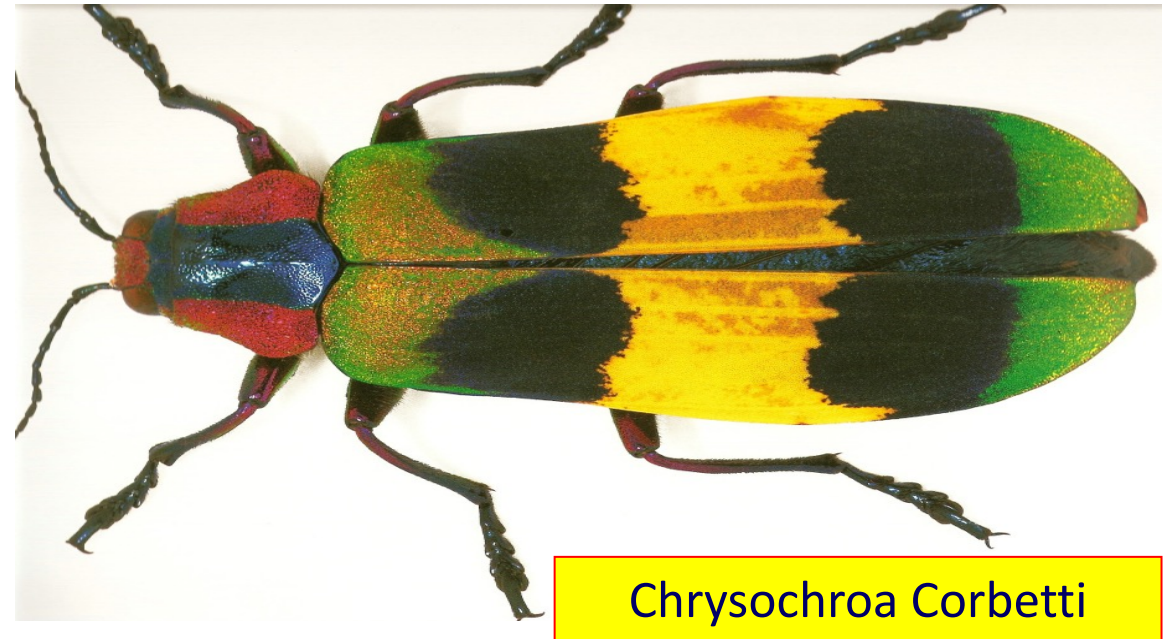


Crimson
Sunbird.



American
Avocet.

The Variety of Insects.



The Amazing Microstructure of Insects.



Beetle's foot
under microscope.

IGOR SIWANOWICZ



Spider eyes.

Biodiversity: Extraordinary Species.



Luminescent micro-frog: size 1-3 mm



Dracula orchid (Affenorchidee)

Biodiversity: Extraordinary Species.



Source:
Facebook,
National
Geographics 2024

American Eagle: Herald animal of the USA



Albatross: largest bird, capable of spending years in the air, during their first 6 years of life they are flying over the ocean before coming to land to mate, capable of travelling more than 10,000 km in a single journey and circumventing the earth in just 46 days.

Biodiversity: EU Red List.

- **European Red List of endangered species (IUCN criteria):**
 - 15% of Europe's 2.313 mammal species
 - 13% of Europe's 1.000 bird species
 - 9% of Europe's 440 butterfly species
- **Strict protection regime for certain animal species**

Arctic Fox

Beaver

Canarian Butterfly

Lynx

Biodiversity: Strict Protection of Predators?



17.000 brown bears in EU.



Difficult coexistence: 19 groups of wolves in Austria killed 1.000 sheep (2022)



Biodiversity: EU Strategy.

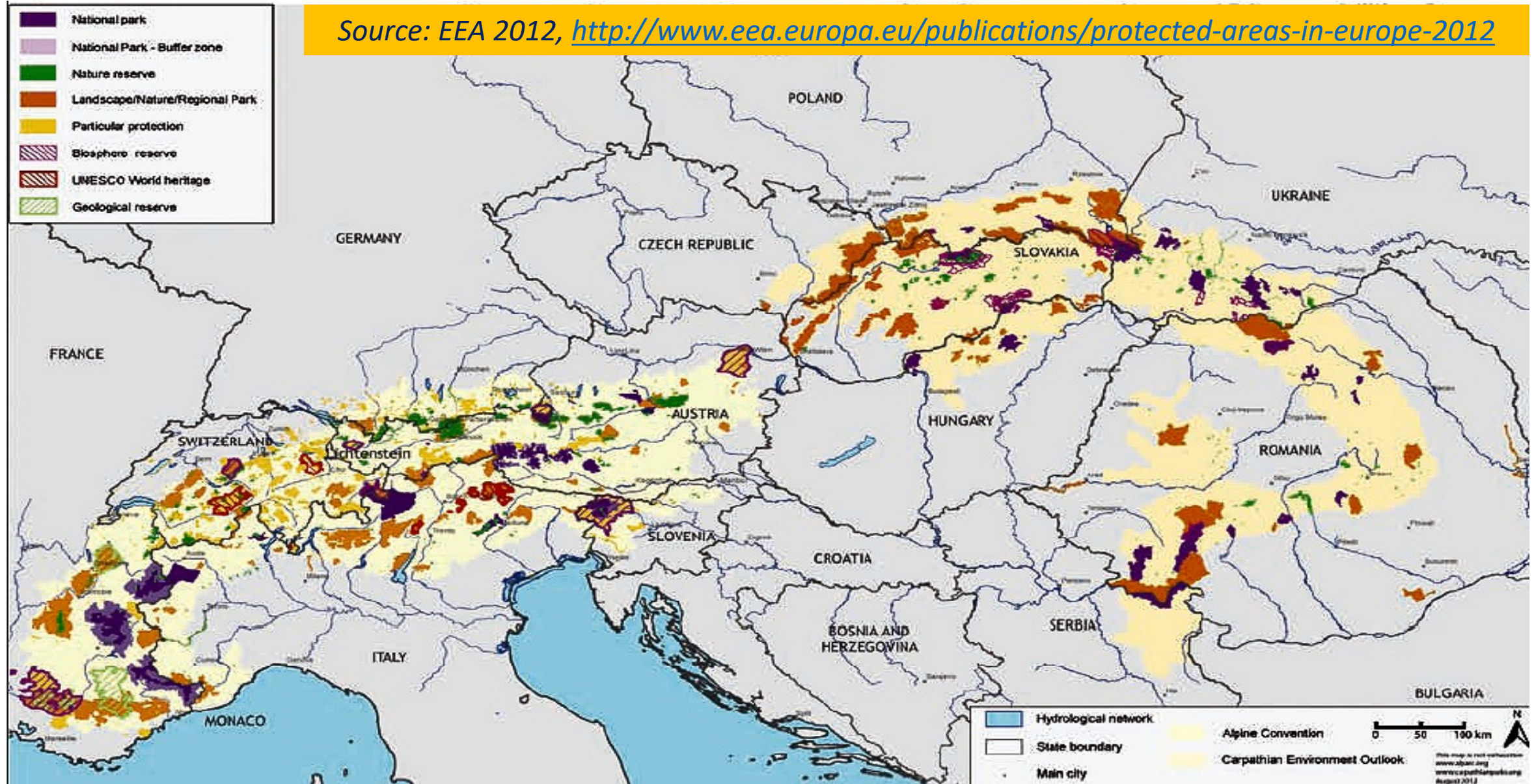
- **EU Biodiversity Strategy (1998, updated 2010 and 2022):**
 - to halt the loss of biodiversity by better protection and restoration of ecosystems and sustainable agriculture, forestry and fisheries.
- **Natura 2000 areas:**
 - Conservation of natural habitats and of wild fauna and flora generating Special Areas of Conservation (SAC)
 - 18% of EU territory are Natura 2000 areas.



March-Thaya-Wetlands of 150 km² are habitat for many protected species.

Biodiversity: Large Alpine and Carpathian Protected Areas.

Source: EEA 2012, <http://www.eea.europa.eu/publications/protected-areas-in-europe-2012>



EU Biodiversity Strategy for 2030/2040: Renaturalisation of European Land.

EU Nature Restoration Law for Improvement of Degraded Ecosystems (2024):

- **Goal:** to increase biodiversity, reduce the risk for natural disasters and achieve the climate mitigation and adaptation goals.
- Legislation contains binding restoration targets for specific habitats and species.
- Restoration measures should cover at least 20% of the EU's land and sea areas by 2030, and ultimately all ecosystems in need of restoration by 2050.
- Measures should aim at Green Cities, agriculture with high biodiversity features, increase of number of pollinators.....defined in national implementation plans.

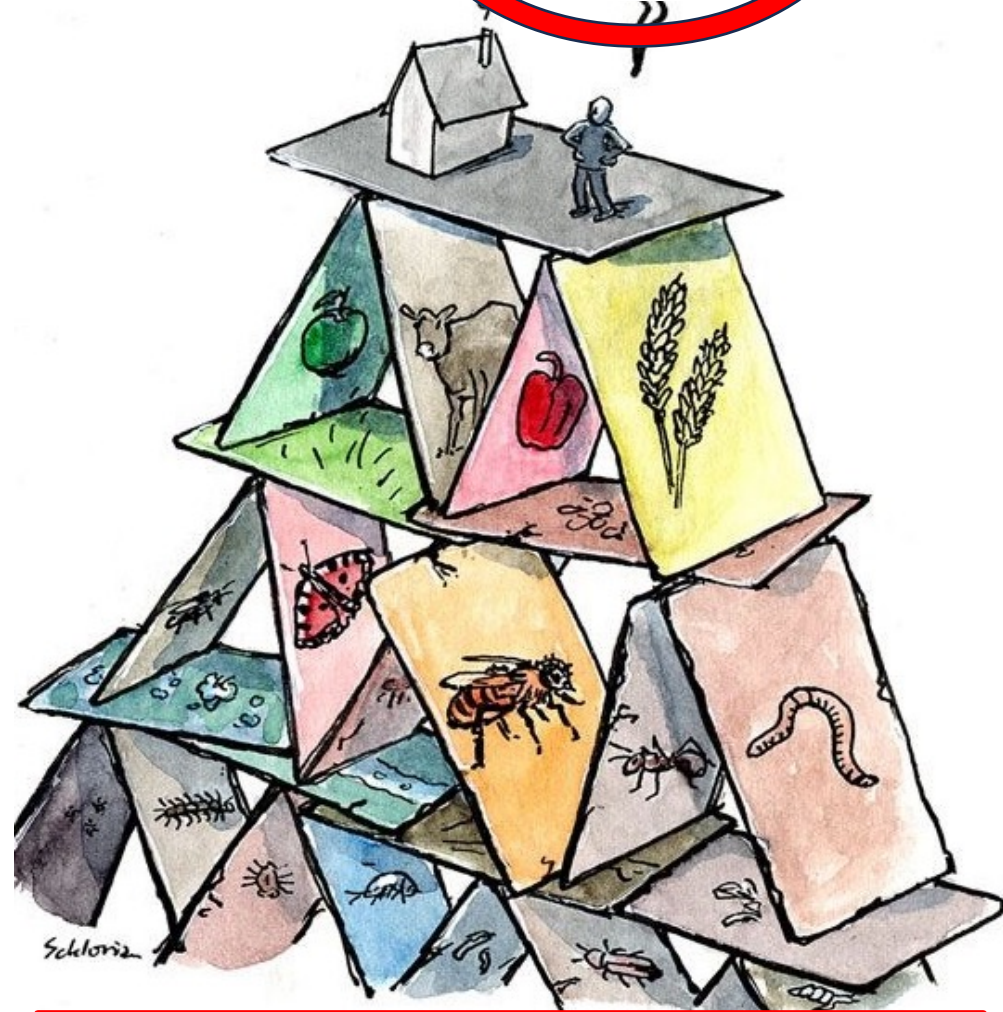


Tagliamento, IT.

Specific targets:

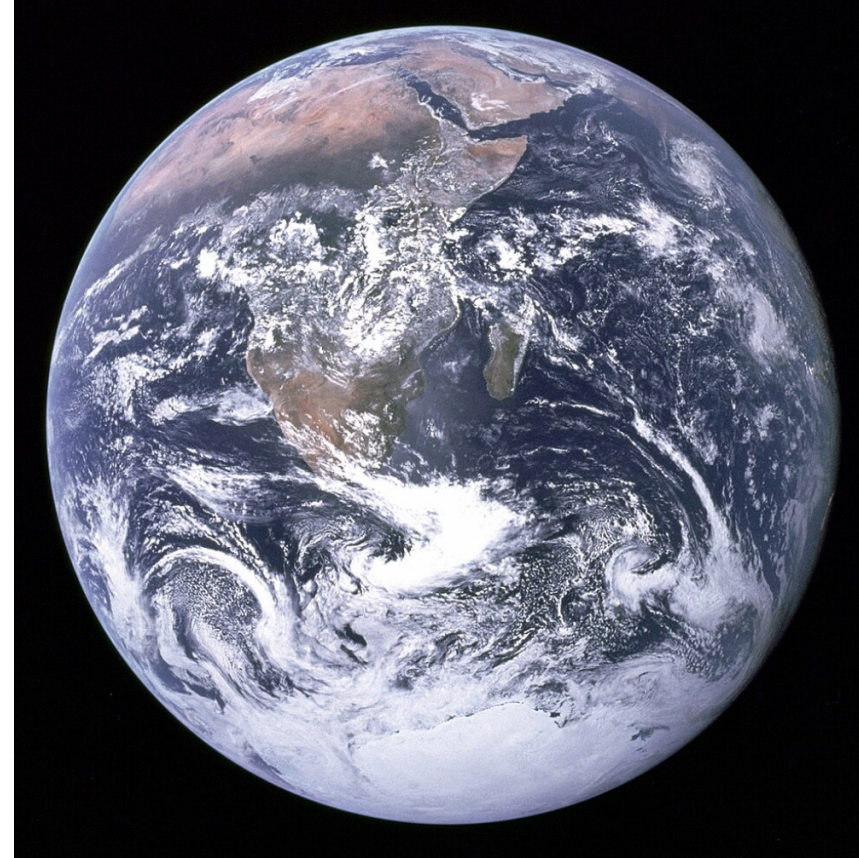
- 30% of land and coastal areas should be protected.
- Plant 3 billion trees.
- 25.000 km free flowing rivers.
- Reduce pesticide use by 50%.
- Reduction of application of fertilizers by 20%.
- 25% of agricultural area for ecological (bio-food) production.

*„I couldn't care
less about the
loss of
biodiversity!“*



The Pyramid of Life.

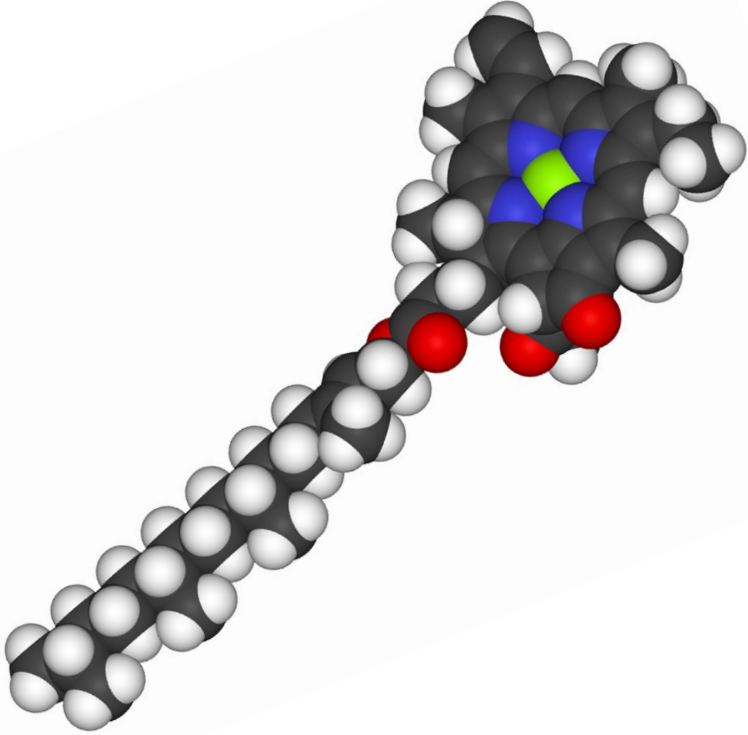
Biodiversity: Holistic Approach.



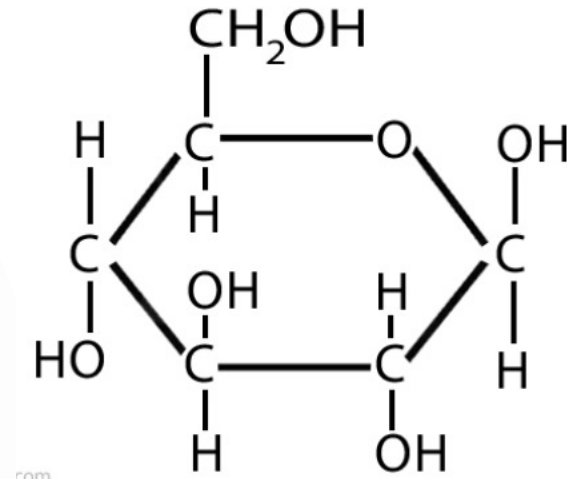
Gaia paradigm: formulated by James Lovelock and Lynn Margulis in the 1970s proposes that living organisms interact with their inorganic surroundings on Earth to form a synergistic and self-regulating complex system that helps to maintain and perpetuate the conditions for life on the planet.

3.2 Chemicals in the Environment.

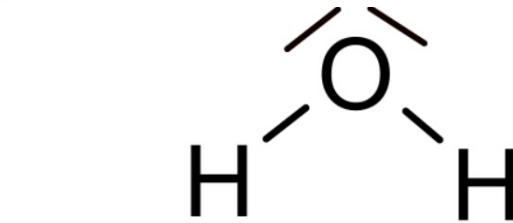
- A **chemical substance** is a material with a definite chemical composition.
- Presently 200 million chemical compounds are known and registered by Chemical Abstracts Services (USA) and assigned a CAS registry number.
- Chemical substances have systematic names („IUPAC“ nomenclature) and sometimes an empirical name.



Chlorophyll – catalyst in photosynthesis

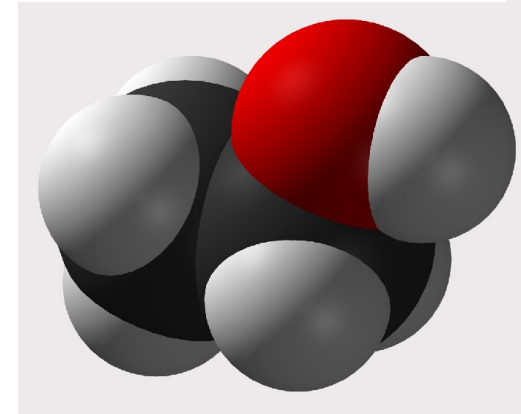
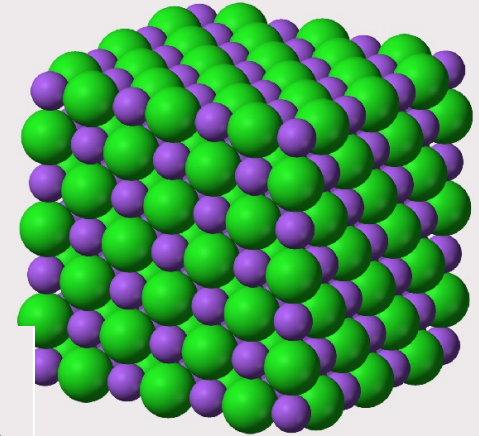


6-(hydroxymethyl)oxane-2,3,4,5-tetrol,
empirical name glucose.



Dihydrogenmonoxide,
empirical name water

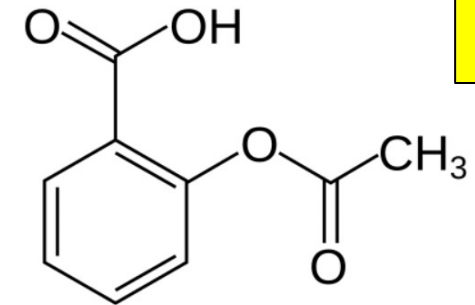
Sodium chloride
(NaCl)



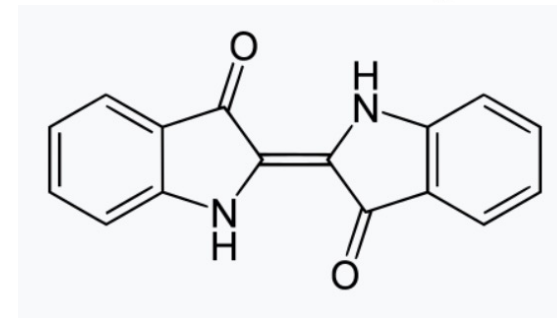
Ethanol
(C₂H₅OH)

Chemicals in the Environment.

- **Industrial production of chemicals:** 100.000 different chemical compounds, volume 400 million tons globally.
- **Most important products:**
 - Polymers and plastics, (polyethylene, polypropylene, polyvinyl chloride, polyethylene terephthalate, polystyrene, polycarbonate....).
 - Pharmaceuticals (aspirine, antibiotics, insuline, blood pressure regulators...).
 - Petrochemicals (gasoline, diesel, kerosine).
 - Food components (sugar, salt, aroma substances, starch, vitamins.....).
 - Colors (indigo, azo-compounds, antrachinon.....)
 - Fertilisers.
 - Plant protection chemicals (pesticides...).
- **Leading companies:**
 - The leading producer countries are China, EU, USA and Japan.
 - Largest chemical companies BASF, Dow, Shell, Bayer, INEOS, ExxonMobil, DuPont, SABIC, Aventis, Novartis, Mitsubishi, SINOPEC, China Petroleum Corporation, China National Chemical Corporation.
 - Global market value of chemical industries: 6.000 billion EUR (2023).
 - Production of chemicals is a key industry for Europe.



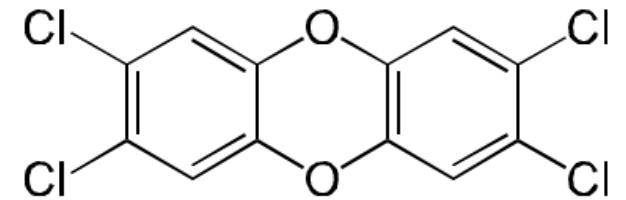
aspirine



indigo (blue)

Chemicals in the Environment: Relevant Substances.

- **The most important chemical substances in relation to the environment are:**
- **Fertilizers:** containing - in varying proportions – mainly compounds of nitrogen, phosphorus, potassium, calcium, sulfur, magnesium required for plant growth, but major source for input of nitrogen and phosphorous into water systems (eutrophication).
 - Annual use close to 100 million tons (50 million tons nitrogen).
- **Plant protection chemicals** (pesticides....): enable good yield in agriculture, but are toxic compounds.
 - Annual use 2,5 million tons.
- **Detergents:** necessary household chemicals, but phosphate input to water systems (eutrophication).
- **Waste materials:** from human consumption and industrial processes:
 - Plastics as such (in the oceans).
 - Residues in processing of waste: heavy metals (like Cd, Cr, Pb....., dioxins).
 - Polychlorinated Persistent Organic Pollutants used for various purposes, stable because of high chlorination of molecules (e.g. PCBs) with bioaccumulation potential.
- **Pharmaceuticals and agropharmaceuticals:** necessary for human and animal health, but possible endocrine disruption.



2,3,7,8-Tetra-chloro-dibenzo-dioxin.

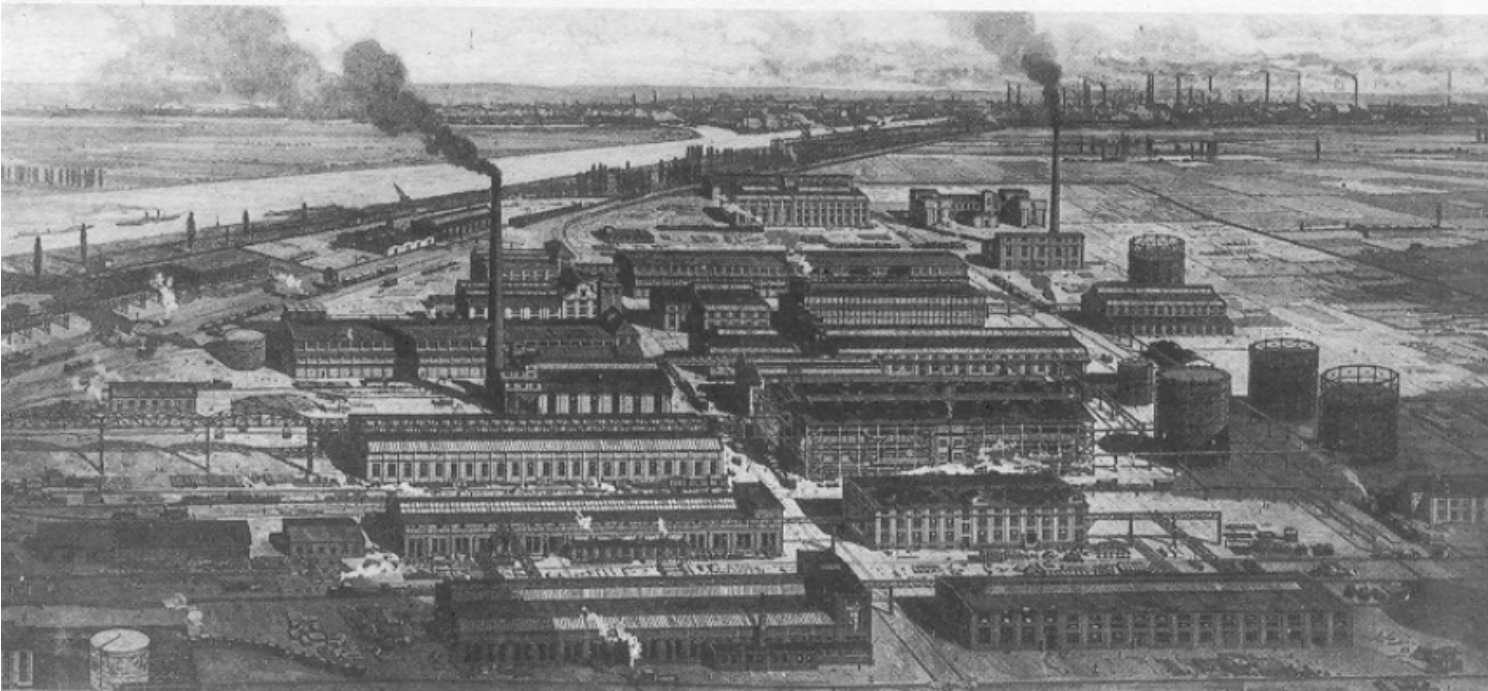
Chemicals in the Environment: Risk Assessment.

- **Registration and authorization for placing on the market:**
 - All chemical compounds entering the environment have to be registered at a proper authority which authorizes their use, including “chemicals of concern” potentially causing negative effects for organisms (like pesticides).
 - USA: the US Food and Drug Administration – FDA
 - EU: National Competent Authorities, or European Chemicals Agency – ECA, based in Helsinki (under the REACH legislation).
- **Risk assessment and classification of chemicals:**
 - The US FDA registry contains some 5.000 substances classified as somehow toxic.
 - For all data the bibliographic source is listed. The studies are not evaluated in any way. Liability rests with the producer/distributor of the chemicals.
 - Six types of toxicity data are included in the registry:
 - primary irritation (acids, NaOH, O₃, chlorine, nitrogen oxides...)
 - mutagenic effects (dixins, PAHs, As, Ni, Cr...)
 - reproductive effects (pesticides, PCBs, Phtalates, DDT....)
 - tumorigenic effects (benzene, PAHs, oxymetholone, tobacco.....)
 - acute toxicity and multiple dose toxicity (potassium cyanide, dimethyl mercury, acrolein.....).

Chemicals in the Environment: Fertilisers.

- **Haber-Bosch Process:**

- Developed 1910 ammonia (NH_3) is produced through a high temperature (400°C /high pressure 300bar) reaction between hydrogen (from natural gas) and atmospheric nitrogen: $\text{N}_2 + 3\text{H}_2 = 2\text{NH}_3$
- In the Haber-Bosch Process developed 1910 ammonia (NH_3) is produced through a high temperature (400°C)/high pressure (300bar) reaction between hydrogen (from natural gas) and atmospheric nitrogen:
$$\text{N}_2 + 3\text{H}_2 = 2\text{NH}_3$$
- NH_3 is used to produce nitrogen fertilizers, mostly in the form ammonium nitrate and urea.



Factory of BASF for production of NH_3 in Oppau (1914).

- Production 100 million tons of nitrogen fertilisers per year.
- The growth of the world's population to its current figure has only been possible through intensification of agriculture associated with the use of fertilizers.
- That fertilizer is responsible for sustaining one-third of the Earth's population, but overfertilisation is considered a severe environmental problem.

Chemicals in the Environment: Pesticides.

- A **pesticide** is a substance or mixture of substances used for controlling the damage caused by a pest.
- Application of pesticides in agriculture is necessary since large fractions of a crop can be destroyed by pests.
- The application of pesticides in agriculture began in the 1940s.
- Pesticide use has increased 50-fold since 1950.
- Seventy-five percent of all pesticides in the world are used in developed countries, but use in developing countries is increasing.



A cropduster spreading pesticide.

- **Major classes of pesticides:**
 - Bactericides for the control of bacteria (phenylmercuric acetate.....)
 - Fungicides for the control of fungi (thiabendazole.....)
 - Herbicides for the control of weeds (glyphosate)
 - Insecticides for the control of insects (DDT, atrazine.....)
 - Molluscicides for the control of slugs and snails (niclosamide, iron-III-phosphate.....)
 - Nematicides for the control of nematodes (chitin oligo/polysaccharide..)
 - Virucides for the control of viruses (povidone iodine....)

Chemicals in the Environment: Pesticides

- **Regulations:**

- To use a pesticide, it must be approved by a government agency.
- UN's Food and Agriculture Organization (FAO) adopted an International Code of Conduct on the Distribution and Use of Pesticides in 1985.
- The UN Codex Alimentarius Commission seeks to create uniform standards for maximum levels of pesticide residues among participating countries.
- In the European Union an extensive legislative framework is in place controlling the use of pesticides in food and feed (Regulation 396/2005 of EP and Council on maximum residue levels of pesticides in or on food and feed of plant and animal origin): Maximum allowable concentration in drinking water: 0,1 ng/L.

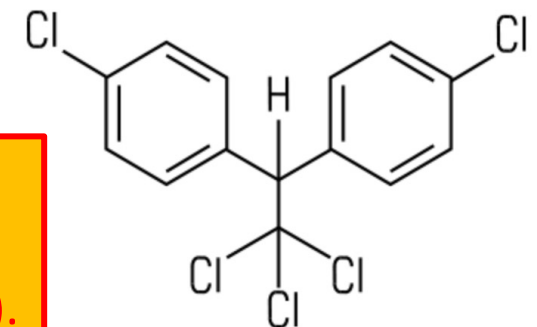
- **New pesticides with lower impact on the environment:**

- Modern pesticides are chemicals which rapidly decay after application, e.g. organophosphorus compounds (residence time a few weeks only.)

„Old“ pesticides like DDT have residence times up to years in soil and water due to their extraordinary chemical stability.

But: successful in wiping out malaria in India (6 million annual deaths in the 1960s).

DDT
1,1,1-Trichlor-2,2-bis(4-chlorophenyl)ethane





Pesticides – Environmental Effects on Bees?

- In recent decades there was a dramatic reduction in the number of honey bees in the U.S. (and to a lesser extent Europe) and a decline in the number of colonies maintained by beekeepers.
- Colony collapse disorder (CCD) is a phenomenon in which worker bees abruptly disappear.
- Major suspected causes are the enhanced use of pesticides and spreading of infections of bee hives by the *Varroa Destructor mite*.
- Colony collapse is economically significant because many agricultural crops worldwide are pollinated by bees.



Pesticides – Environmental Effects on Bees?



Life with bees.



Life without bees.



Moving spring bees from South Carolina to Maine for blueberry pollination.

Contribution of insect pollinators to agricultural output:
200 billion \$/year.

Source: J. Settele, UFZ Leipzig 2010

Pesticides: Controversies about Toxicity.

- **Glyphosate** developed by Monsanto chemist John Franz in 1970 is a broad-spectrum herbicide.
- It is an organophosphorous compound with short residence time killing weeds.
- It is the pesticide used for growing genetically modified soy (Monsanto Round-Up-Ready) which makes up more than half of the global soy harvest.
- In regions where glyphosate is forbidden growing GM-soy is not possible.
- Monsanto brought it to market for agricultural use in 1974 under the trade name Roundup.
- Glyphosate is one of the most used herbicides, with a global application of 600.000 tons per year.
- WHO, FAO, European Chemicals Agency, European Food Safety Agency, and the German Federal Institute for Risk Assessment have concluded that there is no evidence that glyphosate poses a carcinogenic or genotoxic risk to humans (more than 1.000 studies evaluated).
- The International Agency for Research on Cancer (IARC), affiliated with the WHO, has made claims of carcinogenicity in research reviews but the IARC has been heavily criticized for its assessment methodology.
- Due to a political initiative triggered by several NGOs the EP voted to ban glyphosate in 2017, but the European Council approved use until 2028.
- Austria forbids the application of this pesticide as of 1 Jan. 2020.

