

## Teachers' guidelines

**Title of the package:** ECOTOXICOLOGY

### Information about the package:

**Brief description:** The package covers issues related to toxins and their impact on ecosystems. The materials explain what biomagnification and bioaccumulation are, their consequences for organisms and potentially human health. The package discusses selected toxins, toxicity parameters, the concept of half-life and the effects of exposure to toxins, especially in arctic ecosystems.

**How does the package relate to STEAM education:** The package presents knowledge from various scientific disciplines using interactive educational materials. Their goal is to involve students in their independent search and understanding of the connections existing in the natural environment.

**Keywords:** toxins, toxicity, DDT, PCBs, mercury, methylmercury, food webs,

**Age:** 14+

**Didactical hours:** 2 hours

### Learning objectives:

Student:

- learns what toxins are, what their types are, how their toxicity is determined and how they work
- learns about the processes of bioaccumulation and biomagnification
- investigates the relationship between trophic level and exposure to toxins
- learns the history of Minamata disease, "mad hatter's disease"

### Content of the package:

Link to the package: <https://graasp.eu/s/otwe7l>

The package is divided into 5 sections:

#### 1. Section "Introduction"

A short video presentation on the types of toxins and how they work.

How is toxicity measured? Text with gaps to fill.

ANSWER KEY:

Project office: Księcia Janusza 64, 01-452, Warsaw, Poland [edu-arctic2.eu](mailto:edu-arctic2.eu) [edukacja@igf.edu.pl](mailto:edukacja@igf.edu.pl)

EDU-ARCTIC 2: from polar research to scientific passion – innovative nature education in Poland and Norway receives a grant of ca. 240 000 EUR received from Iceland, Liechtenstein and Norway under EEA funds. The purpose of the EDU-ARCTIC 2 project is to: enhance the knowledge about nature, geography, natural resources, political specificities concerning polar regions and increase awareness of environmental issues and climate change, increase of interest in pursuing STEM education and careers due to enhancement of knowledge about scientific research, and their place in the modern world, familiarizing young people with scientific career opportunities; introduce innovative tools by way of an e-learning portal and effective methods of teaching science in schools

LD stands for "lethal Dose". LD50 (median lethal dose) is the amount of a substance, given all at once, which causes the death of 50% of a group of test animals. The LD50 is one way to measure the short-term poisoning potential (acute toxicity) of substance.

Toxicologists can use many kinds of animals but most often testing is done with rats and mice. It is usually expressed as the amount of chemical administered (e.g., milligrams) per 100 grams (for smaller animals) or per kilogram (for bigger test subjects) of the body weight of the test animal.

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LC stands for "Lethal Concentration". LC values usually refer to the concentration of a chemical in air but in environmental studies it can also mean the concentration of a chemical in water.

According to the Organisation for Economic Cooperation and Development (OECD) Guidelines for the Testing of Chemicals, a traditional experiment involves groups of animals exposed to a concentration (or series of concentrations) for a set period of time (usually 4 hours). The animals are clinically observed for up to 14 days.

The concentrations of the chemical in air that kills 50% of the test animals during the observation period is the LC50 value.

Infographic "Paracelsus - Father of Toxicology" with the famous quote "Dose Makes Poison".

Students reflect on the relationship between this quote and the statements: TOOTHPASTE CAN BE LETHAL IF we used 33 tubes at once. 6 LITERS OF WATER DRUNK UP AT A TIME CAN BE LETHAL TO A HUMAN.

A graphic showing the LD50 values of various substances for humans. The students' task is to calculate the lethal dose of LD50 for people of different weight.

ANSWER KEY:

	ethanol	lead	nicotine	fructose
68 kg	476 g	155 mg	680 mg	272 g
82 kg	574 g	155 mg	820 mg	328 g
75 kg	525 g	155 mg	750 mg	300 g
46 kg	322 g	155 mg	460 mg	184 g

**Most toxic: lead.**

**Least toxic: ethanol**

Video material about the most lethal substances.

Link to the video material: <https://youtu.be/qd9oEhlyIKY>

The students' task is to solve a quiz ("true-false") based on the material watched.

ANSWER KEY:

Lead paint is responsible for approximately 500,000 deaths each year – TRUE

1. Fugu fish contains haemotoxins - FALSE – it contains neurotoxins
2. Cyanide is more lethal than sarin - FALSE, Sarin is 26 times more deadly than cyanide
3. Cyanide is in the seeds of apples - TRUE, Consumption of 150 seeds can kill a person
4. Fugu is the most poisonous animal on the planet - FALSE, the most poisonous animal is the leaf walker frog
5. Mercury can cause hair and teeth loss – TRUE

## 2. Section "Inquiry"

Students match the description of the toxin with its name / picture.

ANSWER KEY:

DDT - chlorinated hydrocarbon, used as a pesticide

PCB - still present in old electrical appliances

Mercury (Hg) - In the past, an essential ingredient in many different medications, such as diuretics, antibacterials, antiseptics, and laxatives.

Presentation (pdf) presenting the history and harmfulness of substances: DDT, PCB and mercury.

The student calculates how much DDT remains in the soil after a certain period of time (assumed half-life is 15 years, amount released in 1955 = 40% \* 16,000 tons.

ANSWER KEY:

	Production in 1955 released into the soil
Remains in 1955	16 000 t
Remains in 1970 roku	8 000 t
Remains in 1985 roku	4 000 t
Remains in 2000 roku	2 000 t
Remains in 2015 roku	1 000 t

Students observe illustrations of bioaccumulation and biomagnification.

LINK TO ONLINE VERSION: <https://view.genial.ly/5fb6828d9e38cb0d1a1a1704/game-action-environmental-cycles>

Students match the terms to the definition (open quiz, possible answers - BIOACCUMULATION, BIOMAGNIFICATION, ABSORPTION, BIO-CONCENTRATION, BIO-AVAILABILITY

ANSWER KEY:

The tendency of pollutants to concentrate as they move from one organism to another. Increase in the concentration of pollutants from one link to another at each trophic level. Pollutants are not metabolized, and after ingestion of an organism containing the pollutant, they pass onto the predator.

BIOMAGNIFICATION

It occurs in the body, where the concentration of a substance accumulates in the tissues and is absorbed faster than removed. This process often occurs in two ways simultaneously: by consuming contaminated food and by absorbing directly from water.

## BIOACCUMULATION

It is a natural survival process as the organisms gather the necessary nutrients - proteins, vitamins, etc.

## BIOACCUMULATION

The ingress of a chemical into the body, e.g. by breathing, swallowing or absorbing it through the skin, regardless of its subsequent storage, metabolism and excretion.

## ABSORPTION

A specific process of bioaccumulation whereby the concentration of a chemical in the body becomes higher than the concentration in the air or water around the body.

## BIO-CONCENTRATION

The ability of substances to pass through the body's cell membrane.

## Bioavailability

Students match features to processes (BIOACCUMULATION, BIOMAGNIFICATION, COMMON FEATURES)

## ANSWER KEY:

BIOACCUMULATION: Toxins are absorbed faster than eliminated, Accumulation within an organism

BIOMAGNIFICATION: Organisms at a higher trophic level are more vulnerable, Increase in concentration between trophic levels

COMMON FEATURES: Toxins are absorbed, the concentration increases with time

Students fill in the gaps in the text "Toxins in the Arctic".

DDT and PCB, two well-known **organochlorinated** compounds, have been detected in the **tissue** of animals that live in the Arctic or Antarctic all year round. These molecules are ingested at the bottom of the food chain and gradually make their way up, until they are found at elevated **concentrations** in the largest predators, such as polar bears and humans. Biologists are now beginning to record the health effects on individuals at the upper end of the food chain, with cases of low **fertility**, immune deficiency, disruptions to the endocrine system, **genetic** mutations being seen. These effects may endanger the survival of some polar species. Among the main threats currently hovering over the poles, the long-distance transport of contaminants from industrial or agricultural areas to the polar regions is of particular concern. In the Arctic, various ice **core** samples extracted from the Greenland Ice Sheet show that the effects of industrial pollution have already been felt for about a century. Today, particles of soot, nitrogen and sulphur dioxide (acid rain), **pesticides** (PCBs, DDT, etc.), heavy metals, radioactive isotopes, etc. can be detected in measurable quantities in the air, snow, sediment and water of the polar regions. This is particularly true in the **Arctic**, where many pollutants from the **northern** hemisphere are collected (also as the result of river runoff). Of all the many pollutants released into the environment by human activity, **persistent** organic pollutants (POPs) are among the most dangerous. POP with the worst reputation is DDT. DDT's stability, persistence and widespread use, especially in developing countries, have all contributed to the fact that residues of the compound are now found as far afield as the polar environment, for example, in polar bears in the Arctic. The harmful effects on the **eggshells** of birds, was highlighted clearly by scientists in the 1970s. This led to strict restrictions on the use of DDT and ultimately to its almost total ban. Despite this, the presence of **DDT** can still be detected in food all over the world. PCBs (polychlorinated biphenyls), also POPs, are used to manufacture transformers, condensers, plastics and paint additives. PCBs include about 200 different products, all highly toxic even in low doses. Studies have demonstrated their sterilising immunosuppressant effects on many species in the animal kingdom including seals and whales in the polar regions. Because they are highly stable, POPs persist in the environment for several years or even decades. This allows them to circulate across the entire globe via a process called the "**grasshopper**" effect - an often seasonal phenomenon in which successive evaporations and deposits enable transportation following atmospheric currents. In the Arctic, for example, pollutants come essentially from two sources: the east and west coasts of North America in winter (big cities and industrial regions) and from central Europe in summer (industry and power stations of the former Soviet Bloc, among others). The ice ecosystems at both the North and South Poles have been particularly affected by POPs that find their way into the food chain through land plants and marine plankton and filtering organisms that absorb the nutrients in the water column. They are then eaten by **fish**, accumulating in their adipose tissue (fat). POPs are extremely persistent and highly lipophilic, so that they end up becoming concentrated in the adipose tissue of animals higher up the food chain, where they can reach levels up to several tens of thousands of times higher than in the surrounding environment. POPs climb up the food chain from fish to birds and finally reach the large marine mammals (as well as humans) at the top of the food chain, at increasing concentrations. The traditional diet of Arctic peoples is based on hunting and fishing, which means that the **accumulation** of POPs and mercury in the food chain has an effect on human health. Due to their migration, birds also spread POPs that they have ingested throughout the entire land-based ecosystem, sometimes several thousand kilometres from their original source. Pollution in the Arctic is of particular concern at the top of the food chain, where heavy metals and other pollutants are found in polar bears, belugas, orcas, etc. Scientists from the environmental protection organisation WWF have shown that **orcas** (killer whales) are now the most polluted predator in the Arctic.

## ANSWER KEY:

LINK TO ONLINE ACTIVITY: <https://learningapps.org/watch?v=prc27vckt20>

Based on the picture, the students name the process- BIOMAGNIFICATION and explain why it is harmful to the polar bear.

EXPLANATION: The polar bear is the apex predator in the Arctic, as a result of biomagnification, the concentration of toxins in its body is the highest. Toxins such as DDT or PCB can affect min. on fertility, the endocrine system, which endangers the bear population.

### 3. Section "Research"

Video material about MINAMATA disease. Students answer 3 open-ended questions based on the film they watched.

#### ANSWER KEY:

1) what toxin was causing Minamata disease.

**Mercury in the form of methylmercury.**

2) what system in the body was being attacked?

**The nervous system.**

3) how did the toxin enter the human body?

**With food intake (fish).**

Activity: the students match the name of the organism to the picture and indicate which fish / seafood are safe to eat in terms of mercury contamination.

Answer key:

Video presentation on toxins in the Arctic and the effects on food toxicity.

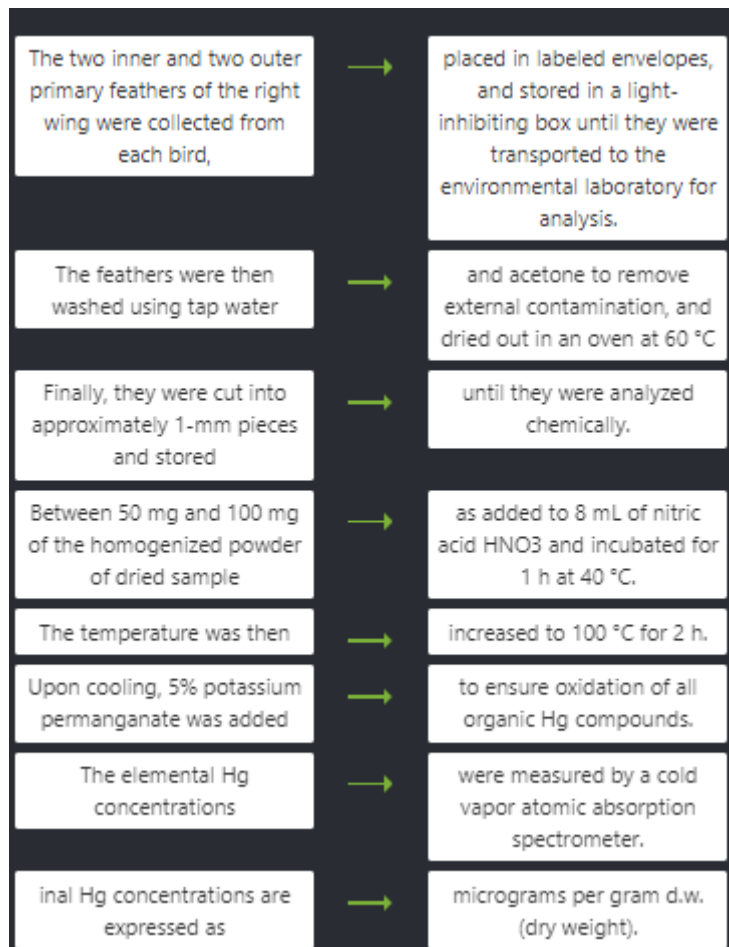
LINK DO PREZENTACJI: <https://view.genial.ly/5fb7c1ac0525e10d26a931a7/presentation-toxic-food>

Exercise - experiment with birds.

The students match the sentences to form the description of the experiment.

LINK TO ONLINE EXERCISE: [https://www.educaplay.com/learning-resources/7754752-studying\\_levels\\_of\\_mercury.html](https://www.educaplay.com/learning-resources/7754752-studying_levels_of_mercury.html)

ANSWER KEY:



Students answer questions about what kind of toxin was tested in this experiment.

SOLUTION KEY:

1) What kind of toxin was tested in this experiment

The content of MERCURY was tested in the experiment

2) what part of the body was sampled from and why

Feather samples were collected because mercury (and other toxins) accumulates in the feathers / hair, and it does not require interaction with birds.

3) why the samples were washed with impurities on their surface,

The samples are washed to remove contaminants from their surfaces that do not result from ingestion of the toxin by the bird.

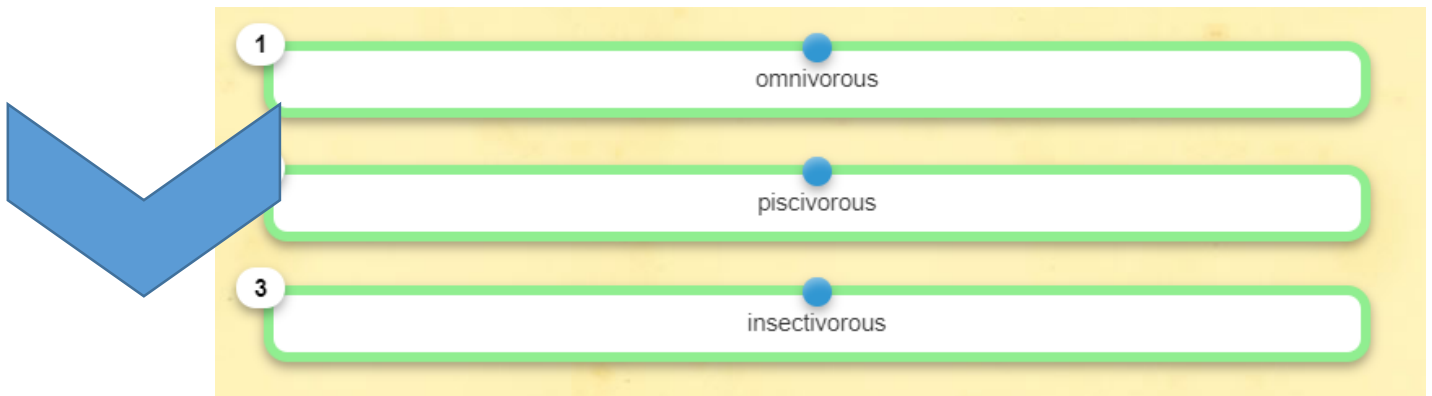
4) why were the samples dried?

The samples are dried to prevent mold and to standardize the results (mercury dry weight).

Graph from the research article:

Students determine the nutrition feeding habits of studied species and rank them in order from highest to lowest mercury concentrations.

ANSWER KEY:



#### 4. Section „Activities“

Students conduct a scenario-based experiment using different colored dry cup beans (recreating the food chain), modeling the biomagnification, and note the results in a table.

Students take the "Millionaires" quiz, summarizing information from the package.

LINK TO ONLINE QUIZ: <https://learningapps.org/watch?v=pvpo5jion20>

#### 5. Section „Wrap-up“

Students summarize the information they have learned - the main ecotoxicological information that they would like to keep after class.

Students recreate a food web based on the given items.

### Technical tips for teachers

#### 1. Inquiry

"Name the frame" - dragging terms to specific places in the picture - terms are numbered from top to bottom.

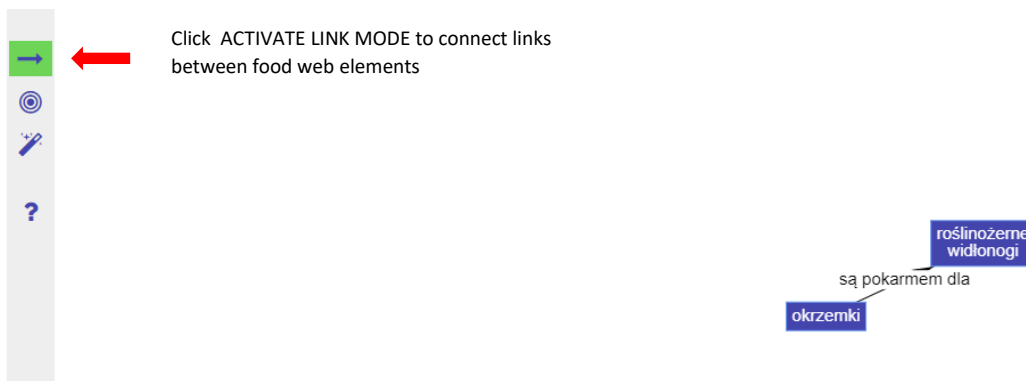
Fill in the gaps in the text - when filling in online, click on the gap and select the correct word from the drop-down list. To validate, click the blue icon in the lower right corner.

Presentation and longer materials are not fully displayed on the screen - you have to scroll them using separate scroll bars (or with the mouse wheel on hover).

Links to external sources are not free from personalized ads, therefore it is recommended to use your browser with an ad-blocking application, e.g. adblock plus.

## 2. Summary

Graasp app: „CONCEPT MAPPER”



External resources, links and references:

### Article:

Mercury kills arctic foxes

<https://www.bbc.co.uk/news/science-environment-22425219>

### Videos used in the package:

What is the deadliest substance on Earth?

<https://youtu.be/qd9oEhlyIKY>

Japan's ominous dancing cats and the disaster that followed.

<https://youtu.be/0Yhaei1S5oQ>