

# Environmental medicine

## Lecture 4



# Dangers of food contaminants and their effects on health

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- Food contaminants are unwanted substances present in **food**, which can be of:
- biological,
- chemical,
- or physical origin.
- Their presence in food can pose various risks to human health.



# Dangers of food contaminants and their effects on health

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- A food contaminant is any substance that is **not intentionally added** to a food
- but which is nevertheless present in it, either as a **residue of treatment and handling during production** (agriculture, breeding, veterinary medicine), or during **preparation** or during **conservation**.



# Dangers of food contaminants and their effects on health

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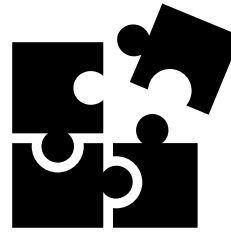


- Food poisoning is a pathological condition caused by **microbial, chemical, and/or physical contamination**, or by **food additives**.
- Accidents often result from **poor hygiene** or **errors** during **food preparation** and/or **storage**.



# Dangers of food contaminants and their effects on health

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- Food poisoning can cause **digestive problems** such as **diarrhea and abdominal pain**.
- In the most **serious cases**, food poisoning requires medical attention and **possibly hospitalization**.





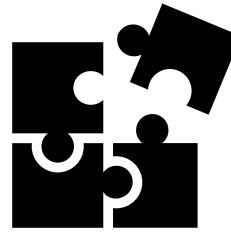
# Dangers of food contaminants and their effects on health

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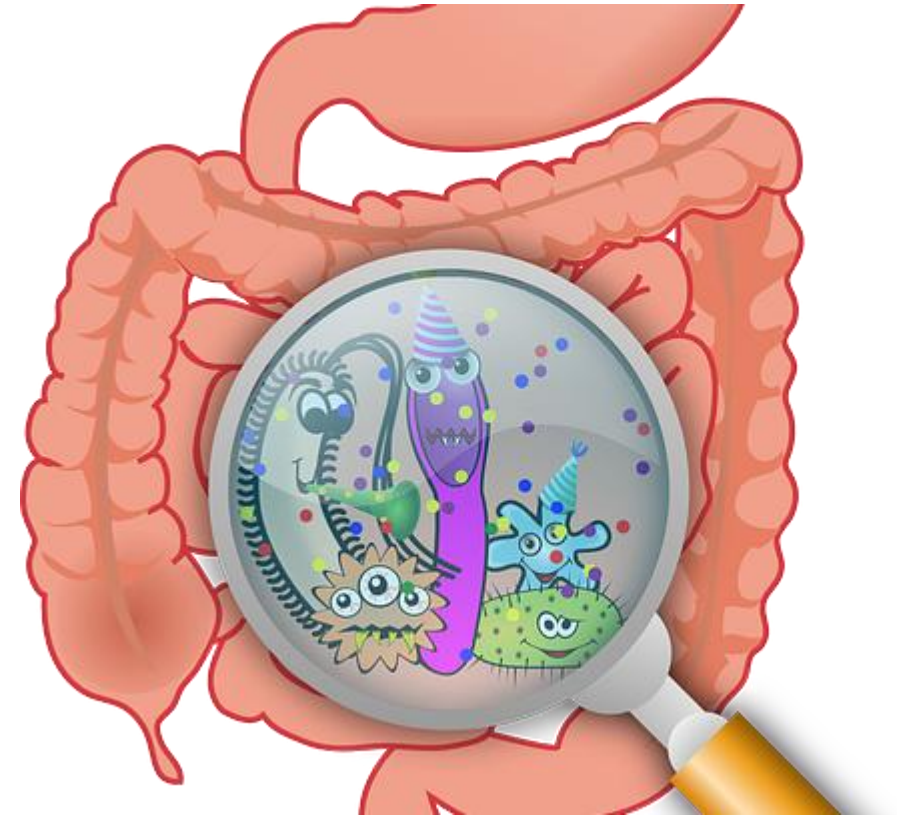


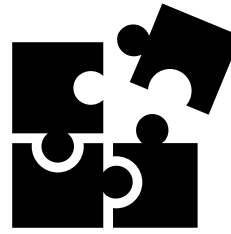
- In general, **maximum residue limits, maximum concentrations, guidelines, standards** and tolerances are limits established to **minimize potential risks** to human health from **excessive exposure to chemical residues** and **contaminants** in food.





## Microbial contaminations





# Microbial contaminations

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- **Food Poisoning**
  - Food poisoning results from the **ingestion of a toxin already present in the food** before it is consumed.
  - Microorganisms produce **toxic substances or toxins** that can easily **diffuse into food**.
  - Food poisoning occurs when these pre-formed **toxins**, secreted by **bacteria or molds**, are **ingested**, leading to adverse health effects.

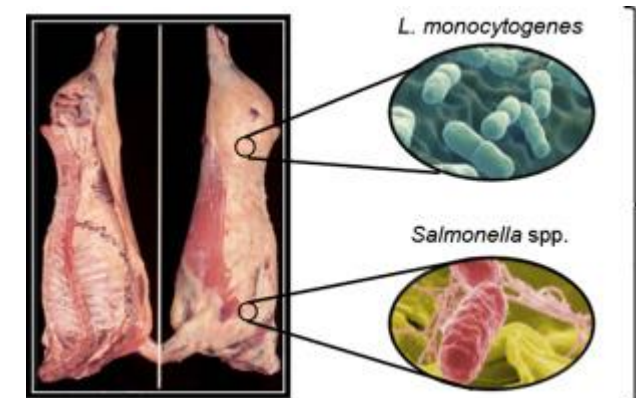




# Microbial contaminations



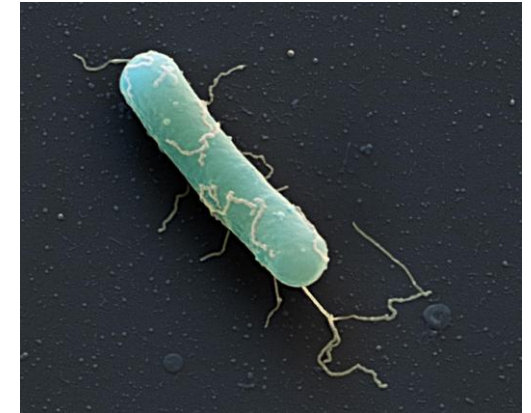
- **Pathogenic Microorganisms:**
- Pathogenic bacteria such as *Salmonella*, *Escherichia coli* (*E. coli*), *Listeria monocytogenes*, and *Campylobacter* can **contaminate food** and cause serious **gastrointestinal infections**.
- These infections can manifest with **digestive symptoms** such as diarrhea, vomiting, fever, abdominal pain, and, in the most **severe cases**, **sepsis and death**.



# Microbial contaminations



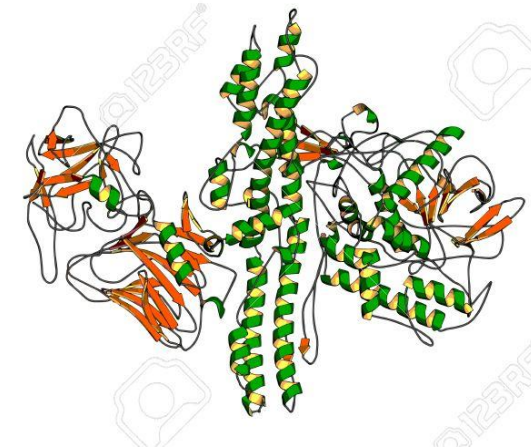
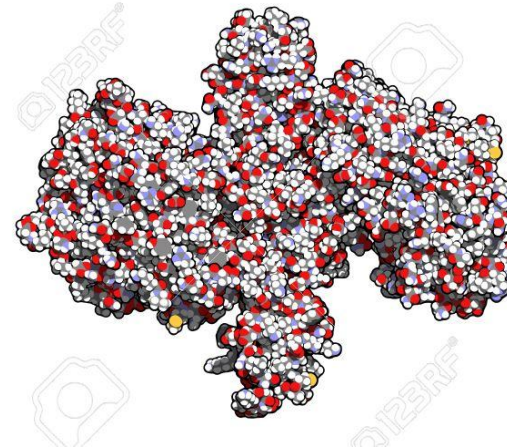
- **Food Toxins:**
- For example, **botulinum toxin** produced by *Clostridium botulinum* can cause **life-threatening** food poisoning.
- Symptoms of food poisoning from toxins include **muscle paralysis, blurred vision, difficulty breathing, and muscle weakness.**



# Microbial contaminations



- **Food poisoning**
- The microorganism multiplies in the food and **excretes toxins** and **toxic metabolites**.
- In fact, the **pathogenicity** is due to the action of the infectious **microorganism** and **its secreted toxin**.



# Microbial contaminations

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- **Food poisoning or intoxication – Mycotoxins**
- Molds are **filamentous microscopic fungi**.
- Due to their heterotrophy, they contribute, along with other decomposing microorganisms, to the **biodegradation and recycling of organic matter**.





# Microbial contaminations



- **Food poisoning or intoxication – Mycotoxins**
- Certain molds are **intentionally used** to enhance the organoleptic properties of food products, such as *Penicillium roquefortii* and *P. camembertii*, which contribute to the **flavor and texture of various types of cheese**.

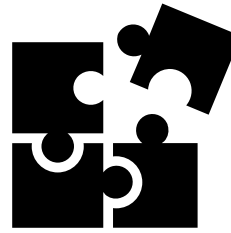


*Penicillium roquefortii*





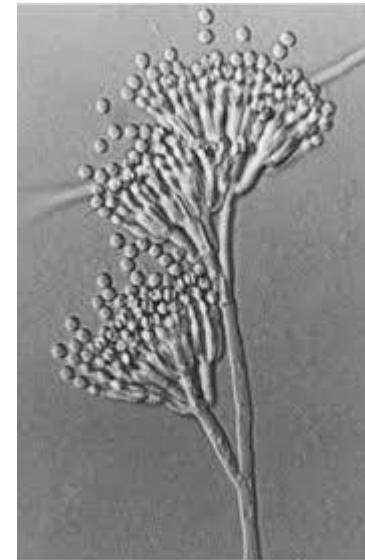
# Microbial contaminations



- **Food poisoning or intoxication – Mycotoxins**
- Others are used in biotechnology for the production of **enzymes** (*Aspergillus niger* for the production of **protease and pectinase**), **organic acids** (production of **citric acid and gluconic acid** by *Aspergillus* and *Penicillium*), or **antibiotics** (production of penicillin by *P. chrysogenum*).



*P. chrysogenum*



# Microbial contaminations



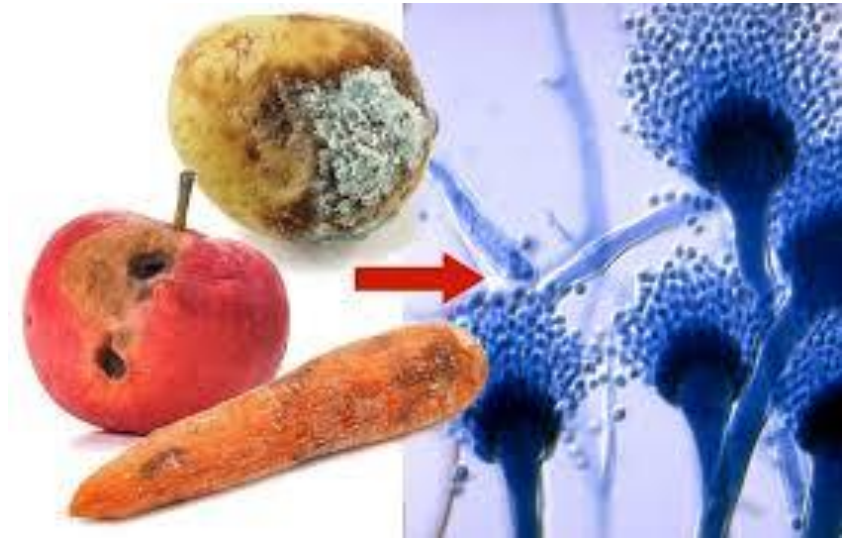
- **Food poisoning or intoxication - Mycotoxins**
- Despite these beneficial effects, fungal contamination of food intended for humans or animals is responsible for **numerous economic and health problems**.
- Indeed, the **unwanted growth of mold** can alter the **appearance of food products**.



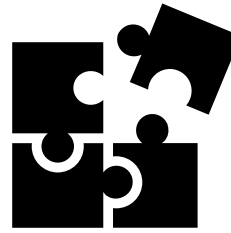
# Microbial contaminations



- **Food poisoning or intoxication – Mycotoxins**
- Fungi, known as **toxigenic fungi**, can produce **secondary metabolites** during their growth on food.
- These metabolites could also be involved in serious health problems, such as the **risk of food poisoning (mycotoxicosis)** due to the presence of mold toxins called **mycotoxins**.



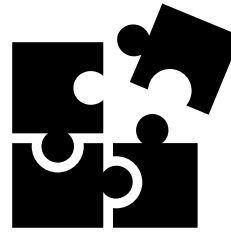
# Microbial contaminations



- **Food Intoxication or Poisoning – Mycotoxins**
- The term mycotoxin comes from the Greek "mycos," meaning **mushroom**, and the Latin "toxicum," meaning **poison**.
- It refers to **secondary metabolites produced by microscopic filamentous fungi** or molds toward the end of their exponential growth phase and **has no biochemical significance for fungal growth** and development, nor for competition.

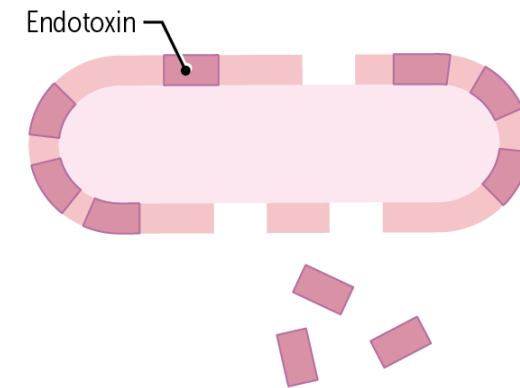
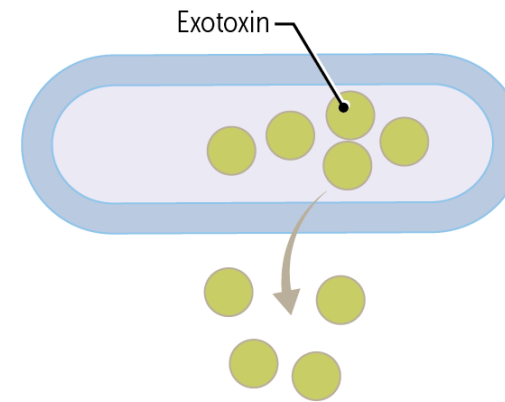


# Microbial contaminations



- **Food poisoning or intoxication – Mycotoxins**

- Mycotoxins are **exotoxins**.
- They **diffuse** into the food.
- They are **thermostable** in a non-aqueous environment.
- They **persist** there after the fungus is destroyed.
- The **same mycotoxin** can be produced by **different fungi**.
- These **toxins** are **secreted** in very small quantities.

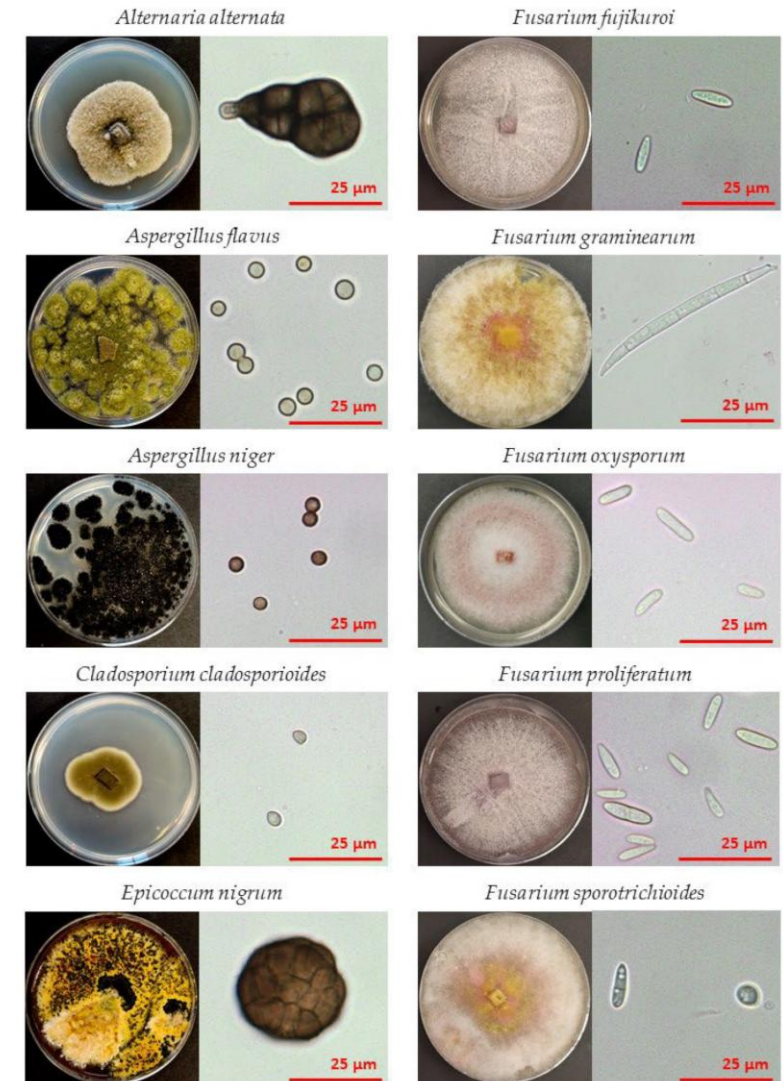




# Microbial contaminations



- **Food poisoning or intoxication – Mycotoxins**
- The **main toxigenic fungi** that produce mycotoxins belong mainly to the genera **Aspergillus**, **Claviceps**, **Alternaria**, **Penicillium**, and **Fusarium**.

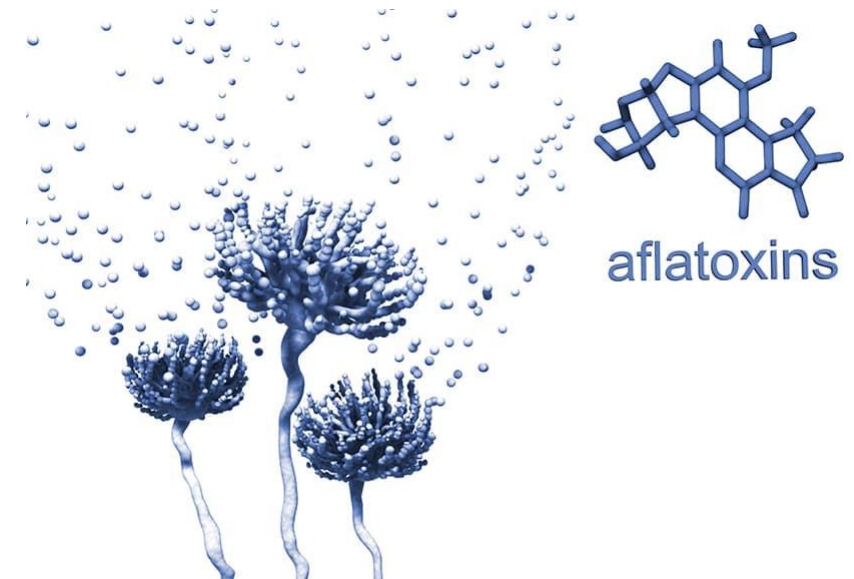


# Microbial contaminations

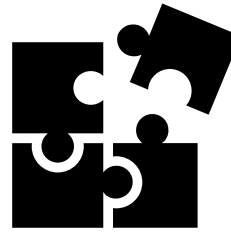
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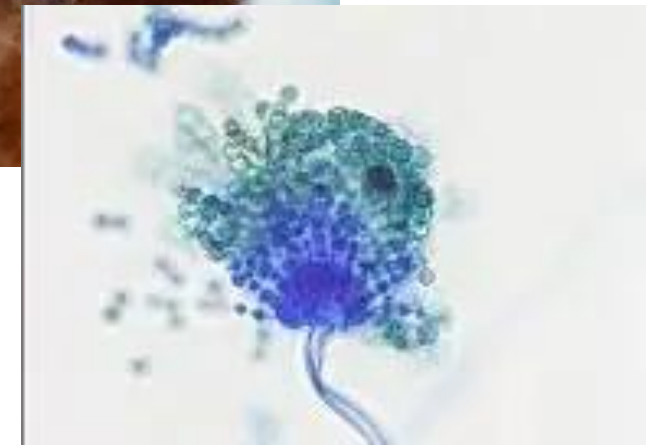
- Food poisoning – Mycotoxins
- Aflatoxins
- Aflatoxin is a mycotoxin that thrives in warm, humid environments.
- It poses a significant health risk to both humans and animals due to its potent carcinogenic properties.



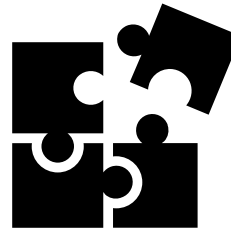
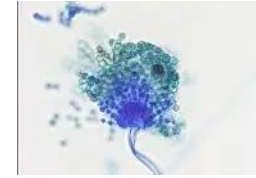
# Microbial contaminations



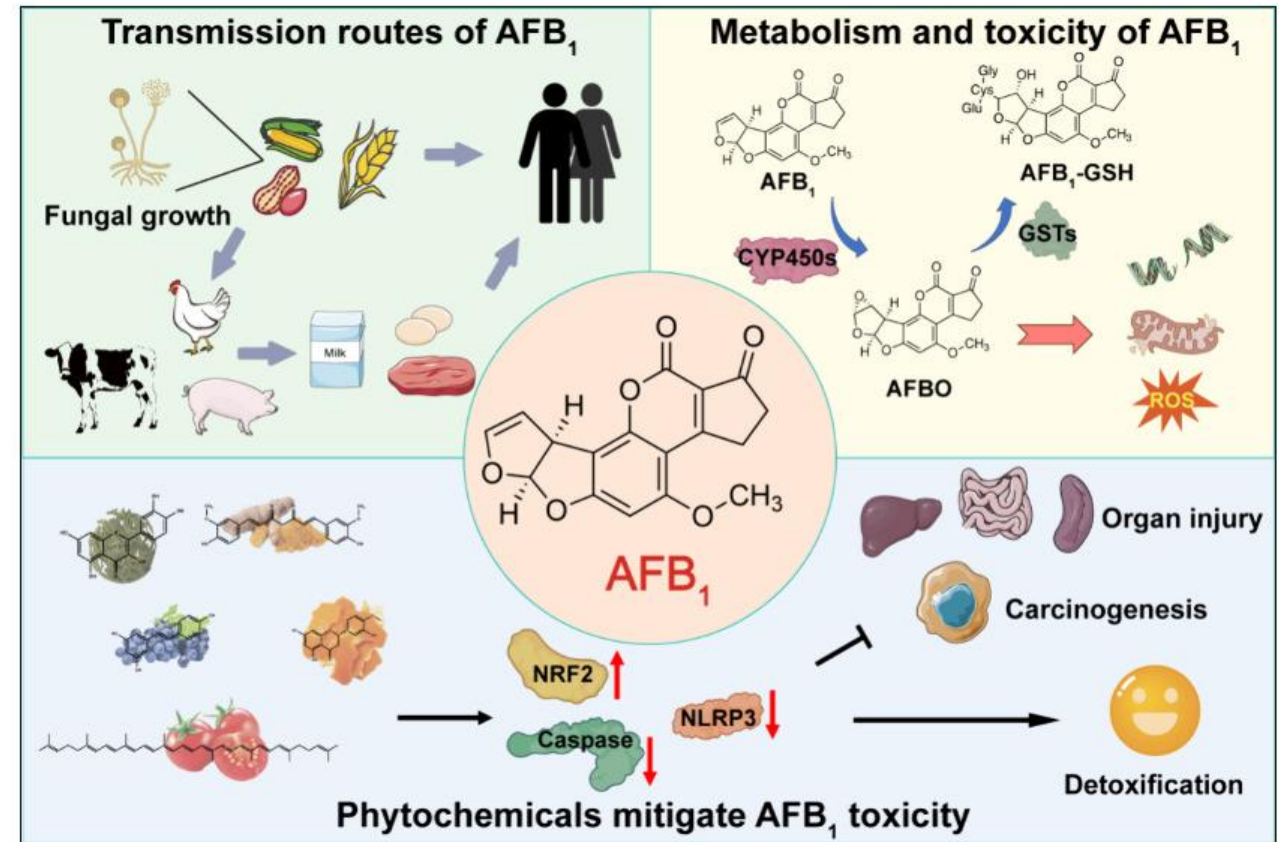
- Food poisoning – Mycotoxins
- Aflatoxins
- Aflatoxins are a group of 18 structurally similar compounds (a combination of a coumarin and three furans).
- They are produced by *Aspergillus flavus*, *Aspergillus parasiticus*, and *Aspergillus nomius*, of which four major compounds have been isolated.



# Microbial contaminations



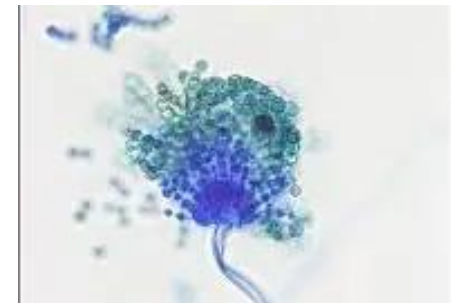
- **Food poisoning – Mycotoxins**
- Aflatoxins are among the most potent naturally occurring **carcinogens known**.
- Chronic exposure, even at low levels, can cause:
  - liver damage,
  - immune suppression,
  - and cancer, particularly hepatocellular carcinoma (liver cancer).







- **Food poisoning – Mycotoxins**
- **Acute aflatoxin poisoning (aflatoxicosis)** can result from consuming large amounts and may lead to:
  - Severe liver damage
  - Vomiting
  - Abdominal pain
  - Edema
  - Convulsions
  - **Coma** or death in extreme cases

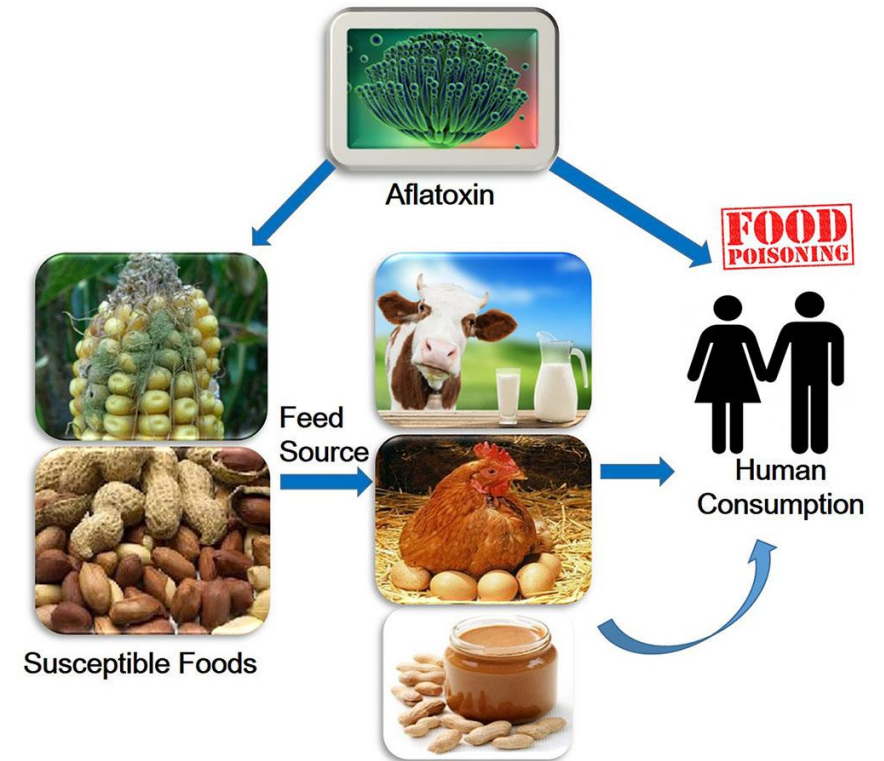




# Microbial contaminations



- **Food poisoning – Mycotoxins**
- **Aflatoxin contamination** is a serious **global food safety issue**, particularly in developing countries.
- Monitoring, awareness, and **good agricultural and storage practices** are essential to reduce exposure and protect public health.

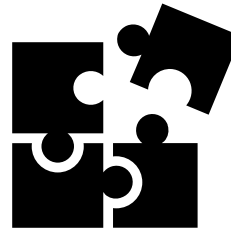


# Microbial contaminations



- **Food poisoning – Mycotoxins**
- **Aflatoxins** can occur in foods such as **groundnuts**, **tree nuts**, **maize**, **rice**, **figs** and other **dried foods**, **spices**, **crude vegetable oils** and **cocoa beans**, as a result of fungal contamination before and after harvest.
- Store food in **cool**, **dry**, and **well-ventilated areas**
- Use **sealed**, **clean**, and **mold-free** containers





# Food additives



# Food additives



## Food additives

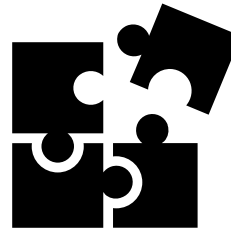
- Food additives are **intentionally added** in small quantities to a food during its preparation to ensure **better preservation or to compensate for the loss of sensory qualities**.
- They can be of **natural origin** (mineral, plant, or animal), derived from the processing of natural substances, or obtained **synthetically**.

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# Food additives



- Generally, **natural molecules** are often **too fragile or too expensive** for **industrial production**.
- They therefore give way to **synthetic products**.





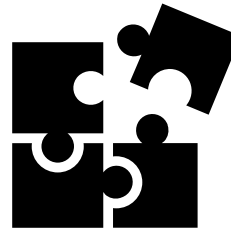
# Food additives



- The term "**additive**" refers to **any substance that is not a normal constituent** (ingredient) of food and whose intentional addition serves a **purpose** that can be categorized into three categories: **technological, organoleptic, and nutritional**.
- Their use is regulated and **limited to a maximum** concentration of **1%**, except in a few special cases.

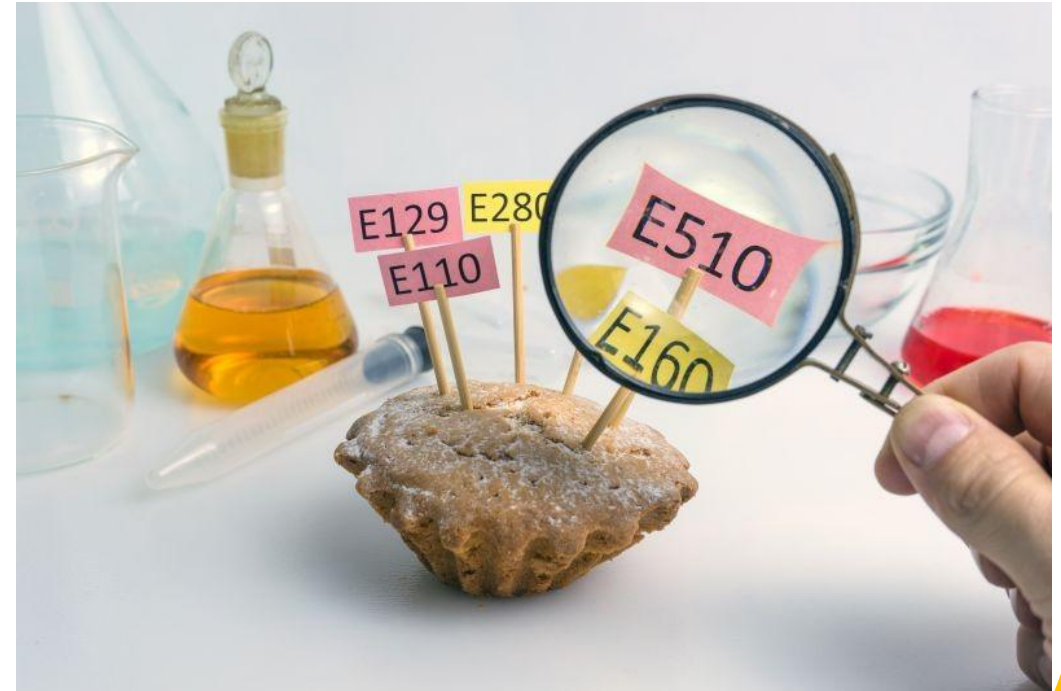


# Food additives



For a food additive to be used in the **European Union**, it must **have authorization**, systematically based on a prior **assessment of the risks** associated with its use.

This **independent assessment** is carried out by the **European Food Safety Authority (EFSA)**.



# Food additives

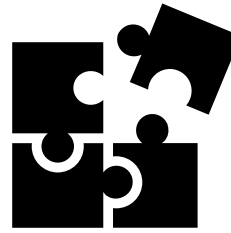
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The **manufacturer** or **user** of a food additive is required to immediately transmit to the Commission **any new scientific or technical information** likely to influence the **safety assessment** of that additive.



# Food additives

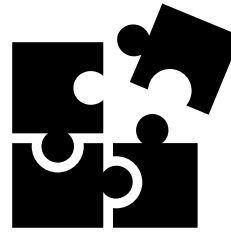


When food additives are **sold mixed together** and/or with other food ingredients, they carry on their packaging or container the list of all the ingredients in **descending order of their weight percentage**.

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# Food additives

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Functional classes of food additives in foodstuffs and food additives in food additives and enzymes:

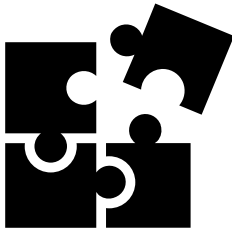
colorants, sweeteners, preservatives, antioxidants, acidifiers, acidity regulators, antifoaming agents, bulking agents, emulsifiers, melting salts, flavor enhancers, foaming agents, gelling agents, glazing agents, humectants, modified starches, packaging gases, propellants, stabilizers, flour treatment agents.





# Food additives

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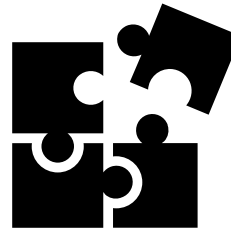


**Colorants** are substances used to **add or restore color** in foods.

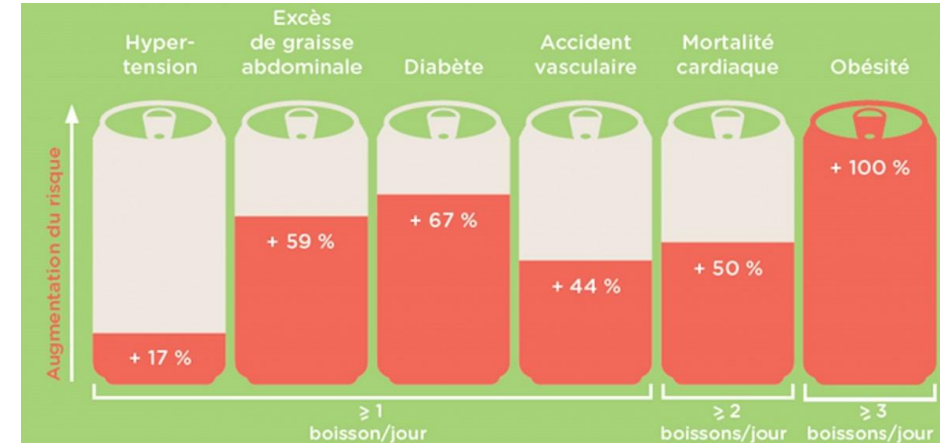
They may be **naturally occurring** food components or **derived from other natural sources** that are not typically consumed as food on their own and are **not commonly used as primary food ingredients**.



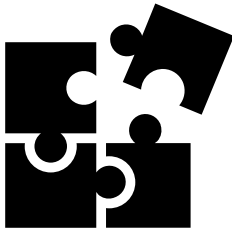
# Food additives



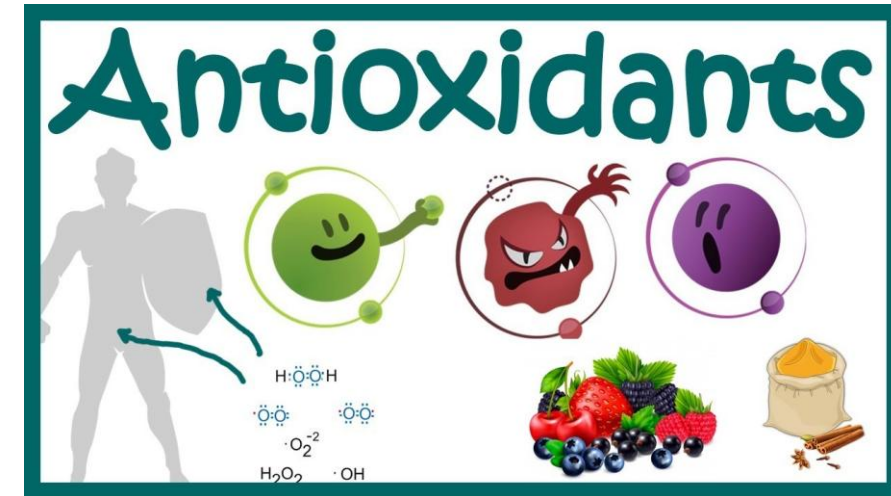
**"Sweeteners"** are substances that are used to impart a **sweet flavor to foods** or are used in table sweeteners.



# Food additives

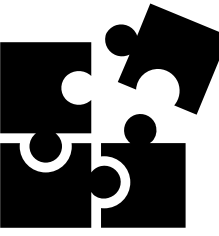


**Antioxidants** are substances that **extend the shelf life** of foods by **protecting** them from deterioration caused by **oxidation**, such as rancidity of fats and **changes in color**.



# Food additives

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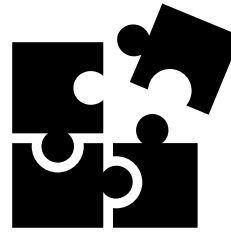


“**Acidifiers**” are substances that **increase the acidity** of a food and/or give it a tangy flavor.



# Food additives

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**Anti-caking agents** are substances added to food products to **prevent the formation of lumps**, ensuring a **free-flowing texture**.

These compounds work by **absorbing excess moisture** or by coating particles to **reduce their tendency to stick together**.

They are commonly **used in powdered and granulated foods such as salt, powdered sugar, flour, and spice blends** to maintain consistency and ease of use.





# Food additives

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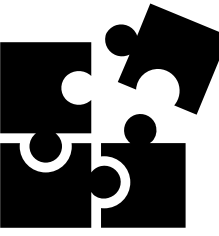


**Emulsifiers** are substances which, when added to a foodstuff, allow the homogeneous mixture of two or more immiscible phases, such as oil and water, to be achieved or maintained.



# Food additives

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"**Melting salts**" are substances that **disperse the proteins in cheese**, resulting in an **even distribution of fat** and other components.



# Food additives

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**Firming agents** are substances that make or **keep fruit and vegetable tissue firm or crisp**, or that, when combined with gelling agents, form or firm a gel.



# Food additives

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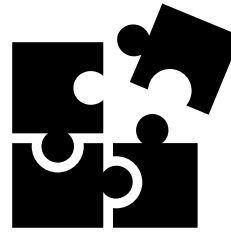


“**Foaming agents**” are substances that allow the **homogeneous dispersion of a gaseous phase** in a liquid or solid foodstuff.



# Food additives

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“**Modified starches**” are substances obtained by means of one or more chemical **treatments of food starches** which may have been subjected to **physical or enzymatic treatment**, and which may be made **more fluid by acid or alkaline treatment or bleached**.





# Food additives



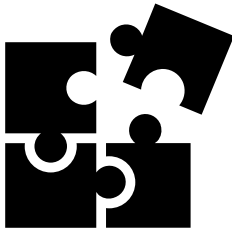
**"Stabilizers"** are substances that, when added to a food, help maintain its physicochemical state.

Stabilizers include substances that maintain the homogeneous dispersion of two or more immiscible substances in a food, and substances that stabilize, preserve, or intensify the color of a food.



# Food additives

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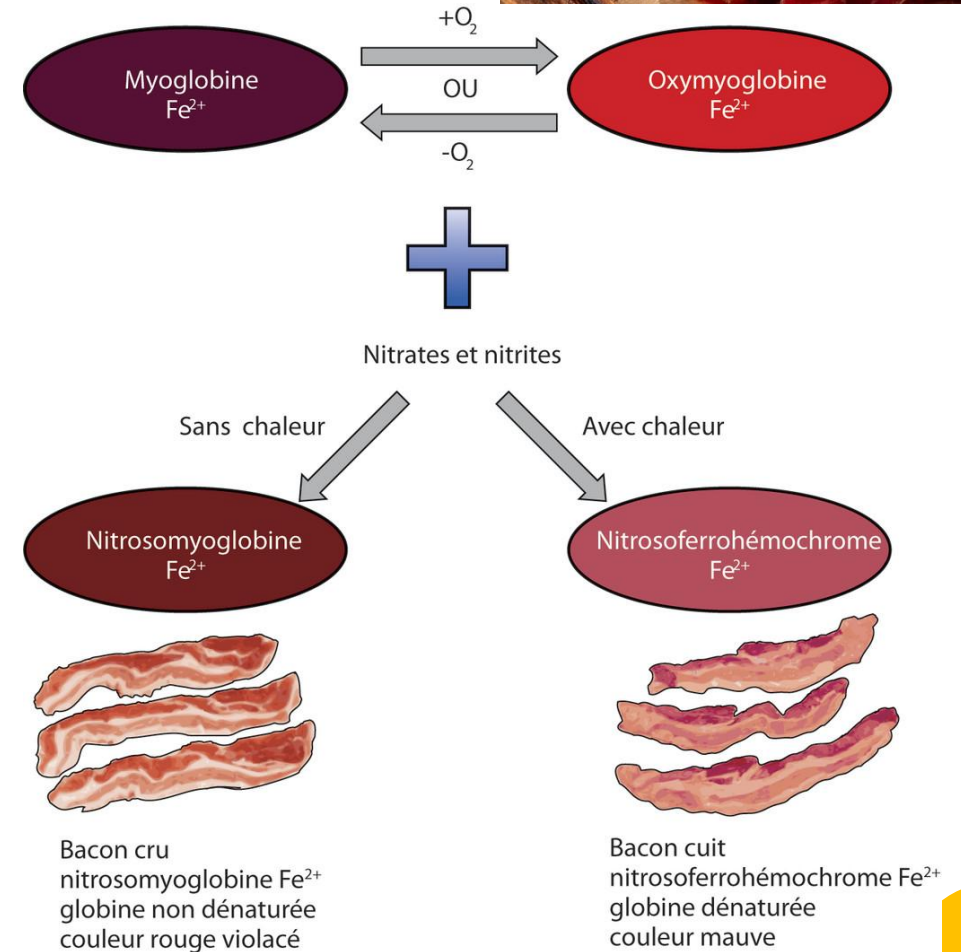


**"Preservatives"** are substances that **extend the shelf life** of foodstuffs by protecting them from spoilage caused by microorganisms and/or protect them against the growth of pathogenic microorganisms.



# Food additives

- **Nitrites and nitrates** are often used in **meat preservation** and, more rarely, in fish canning. They **inhibit the growth** of *Clostridium botulinum*.
- They can also help **stabilize the color of meat products** by **complexing with myoglobin**.

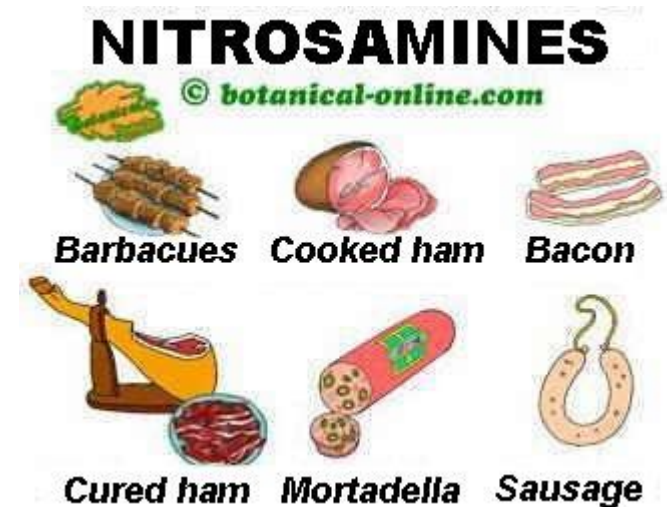


# Food additives



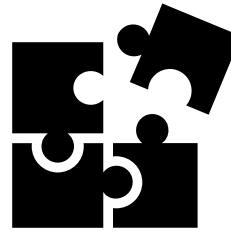
## Formation of Nitrosamines

- In the body (especially in the **acidic environment** of the stomach) or **during high-heat cooking** (like frying or grilling), **nitrites** can **react with amines** from proteins to form **nitrosamines**.
- **Nitrosamines** are **carcinogenic**, meaning they can increase the risk of cancers, especially colorectal, stomach, and possibly pancreatic cancers.

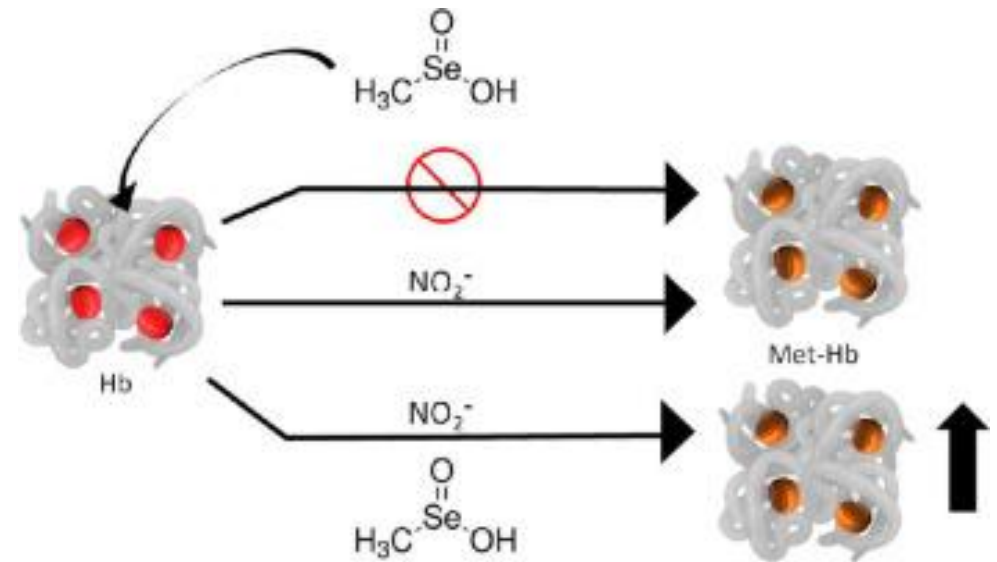


**Long-term effects:** The combination of nitrites with molecules containing amine groups leads to the **formation of nitrosamines**.

# Food additives

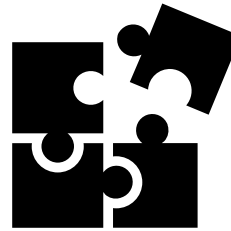


- Toxicity is due to the **met-hemoglobinizing effects of nitrites**.
- Methemoglobinemia is defined as the transformation of **myoglobin into methemoglobin**.



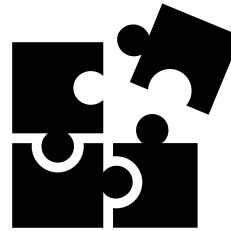
- Toxicité aiguë: DL50= 75-100 mg/kg.





# Pesticide residues



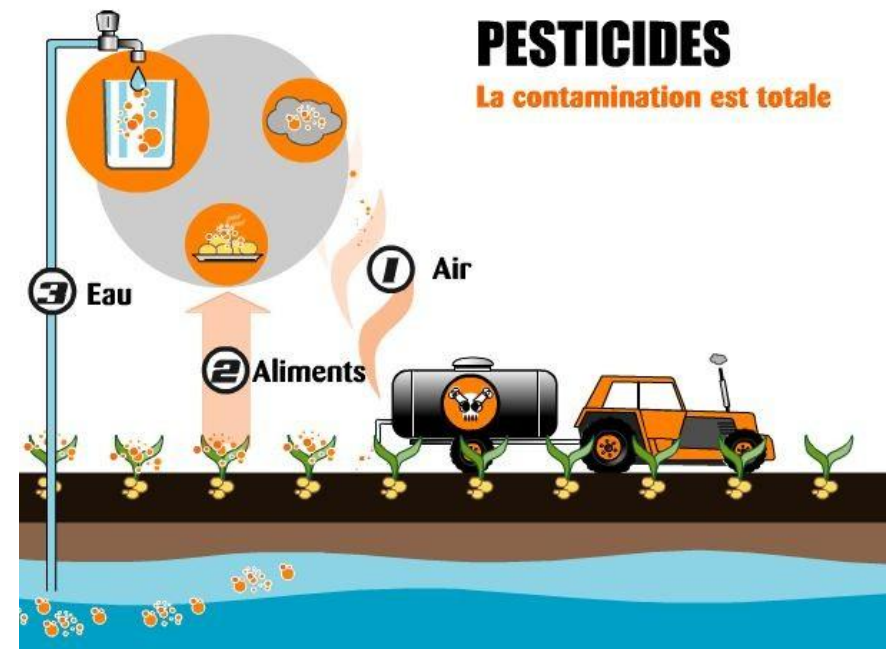


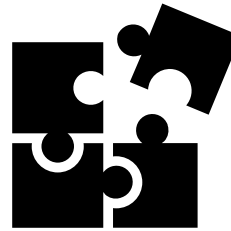
# Pesticide residues

Pesticide residues (fungicides, herbicides, insecticides)

Are **chemical substances**, or mixtures of substances, presenting **toxic risks**, which may remain in **food intended for humans or animals** following phytosanitary treatments carried out either during the **growing season or after harvest**.

Residues may also **include substances derived through degradation or conversion**, through chemical reactions, or impurities.





# Pesticide residues

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- The level of these residues in food is often determined by **regulatory agencies** in many countries.
- Population **exposure** to these residues most often occurs through the **consumption of pesticide-treated food** products.



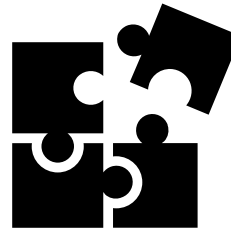
# Pesticide residues

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- Many of these chemical residues, particularly **derivatives of chlorinated compounds**, are **prone to bioaccumulation** which can lead to harmful levels in the body and the environment.





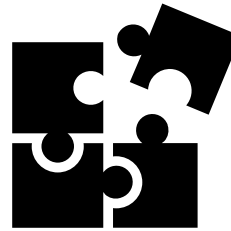
# Pesticide residues

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- Persistent chemicals can accumulate in the food chain and can be detected in products as diverse as meat, poultry and fish, vegetable oils, nuts, and various fruits and vegetables.

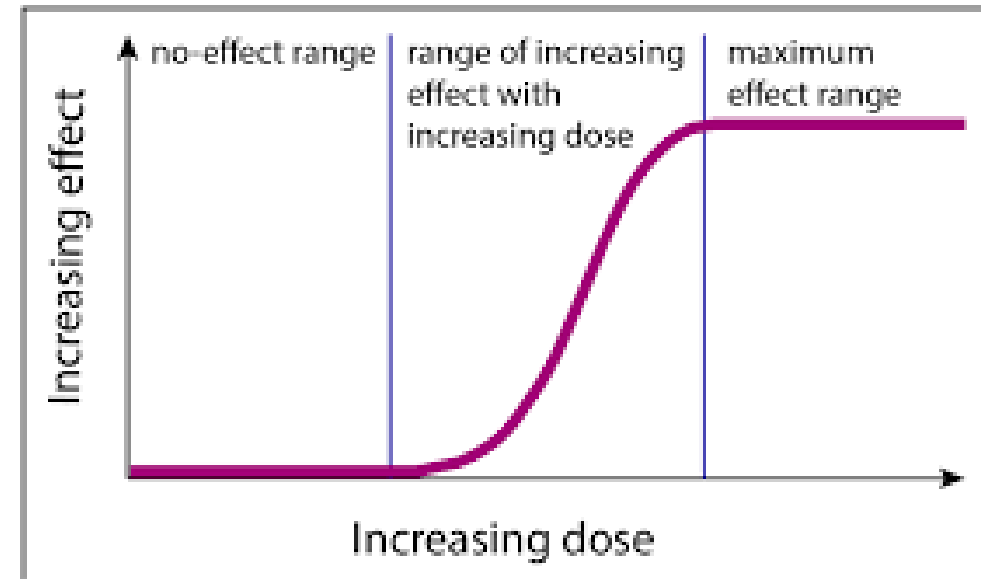






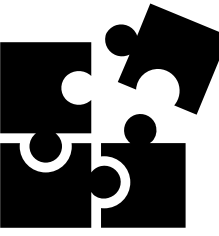
# Pesticide residues

Their effects can be **immediate or short-term** (acute effects) after short-term exposure (a few minutes, hours, or days).

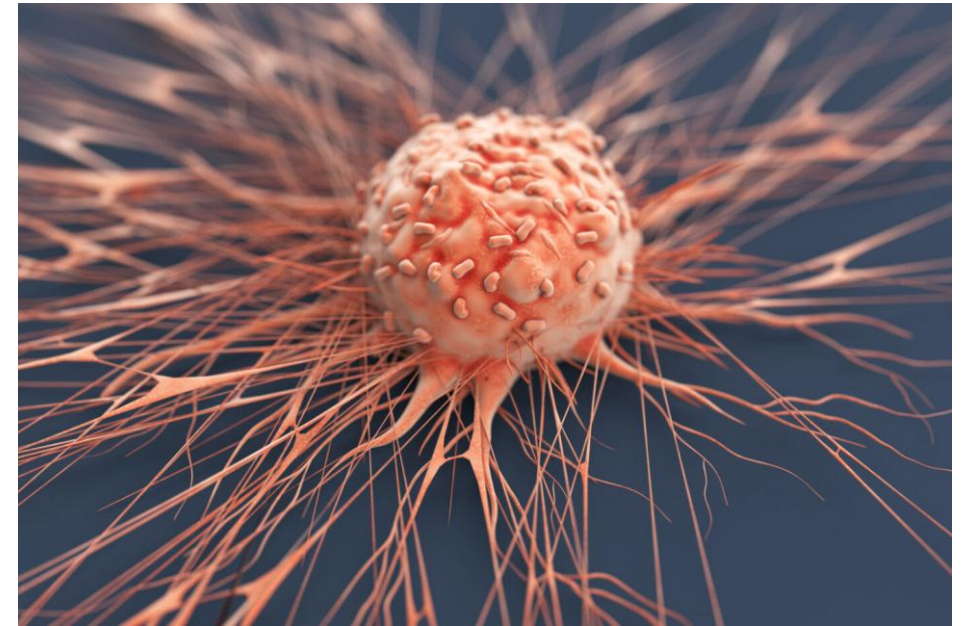


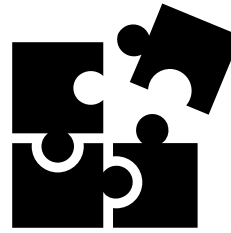
# Pesticide residues

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Chronic effects can occur following repeated ingestion of low doses of pesticides and can cause liver, prostate, and blood cancers, as well as fertility problems and neurological problems.





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## Veterinary drug residues



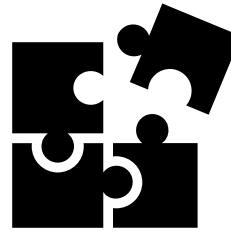
# Veterinary drug residues



- **Veterinary medicine** is an **essential tool** for protecting animal health and welfare.
- By maintaining the health of production animals, it helps ensure their productivity and guarantee the safety of animal-derived foods.



# Veterinary drug residues



## Veterinary Drug Residues

It therefore also contributes to **preserving public health** by participating in the **prevention and control** of animal diseases transmissible to humans.

**Veterinary drugs** can be **antibiotics**, **antiparasitics**, or **anabolic steroids**.

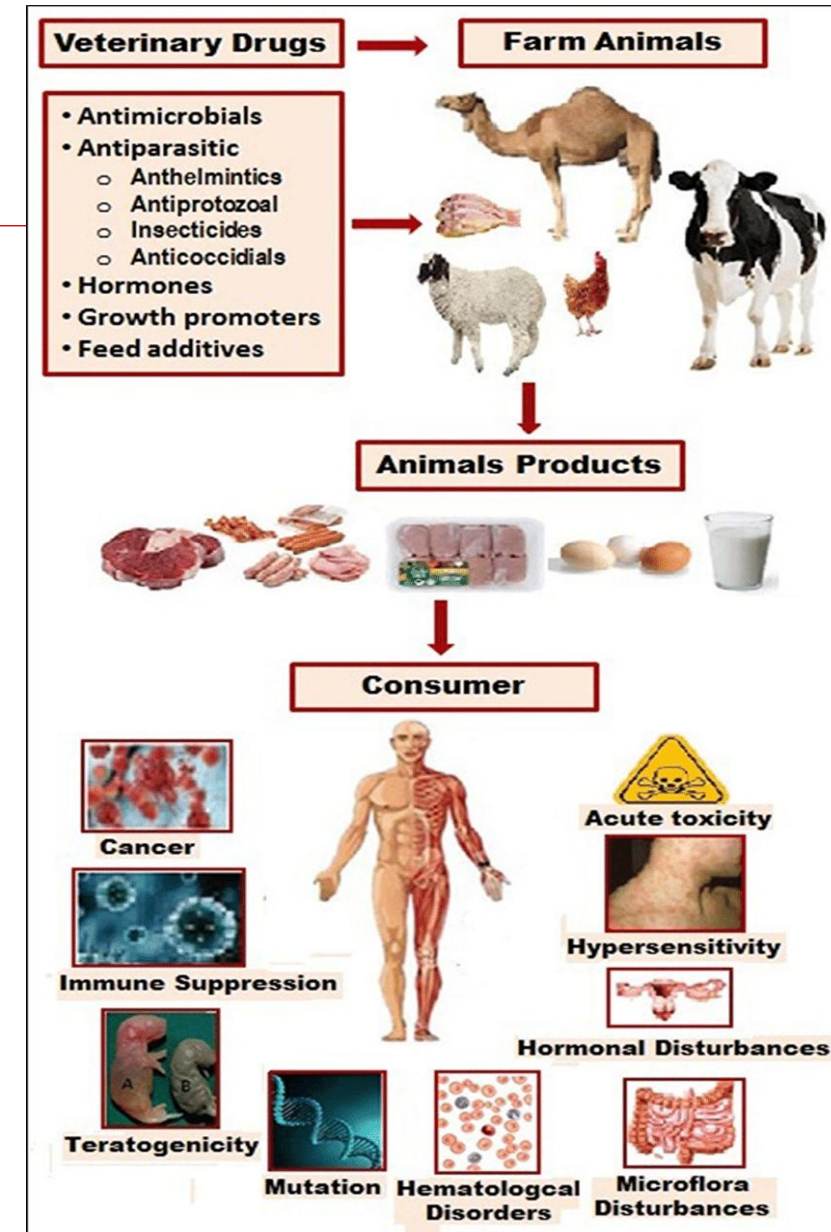
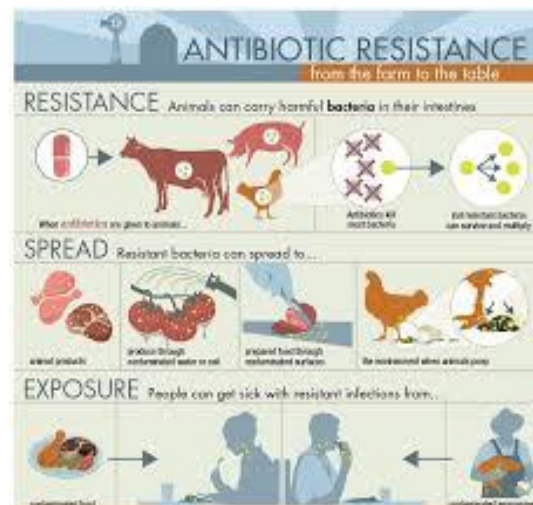


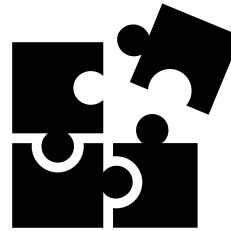


# Veterinary drug residues

## Veterinary Drug Residues

To fully fulfill its role, it must meet **quality, efficacy, and safety criteria** for both the **treated animal and the consumer**, when it comes to drugs intended for production animals.



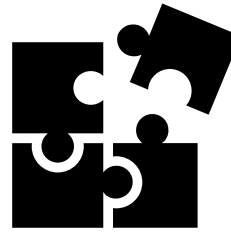


# Heavy metals



# Heavy metals

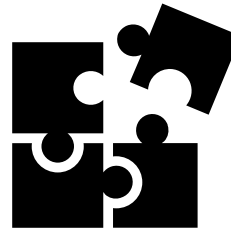
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Heavy metals are naturally occurring elements.

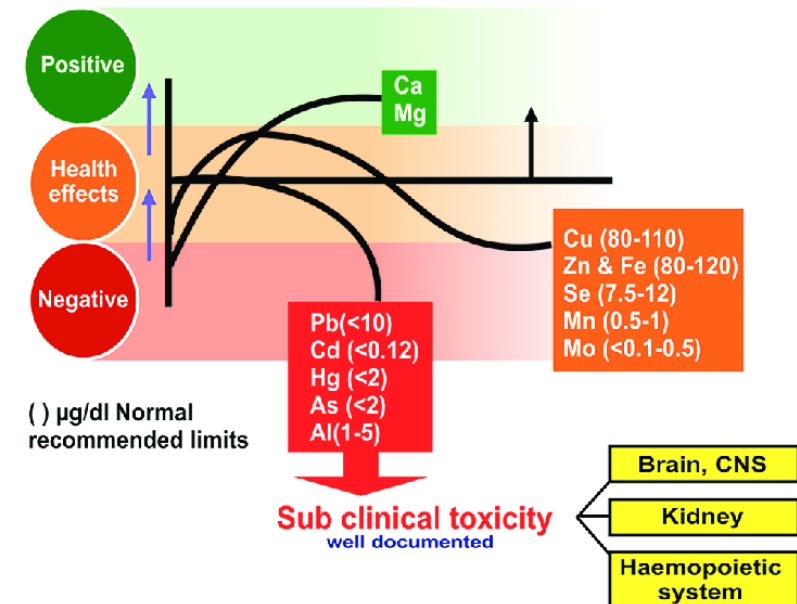
They are found in the air, water, soil, sediment, and consequently in plants, animals, fish, and all elements of the human diet.





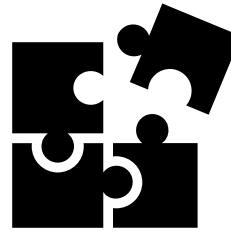
# Heavy metals

- **Essential:** Elements essential for metabolism: Cu, Zn, Fe, Mg, Mn, Ni, Mo, etc.
- They are important in the metabolism of carbohydrates, lipids, proteins, etc., enzymatic reactions (dehydrogenases, etc.), oxidation-reduction reactions, etc.
- **Excessive concentrations of heavy metals**, even essential ones, are **toxic** to living organisms.



# Heavy metals

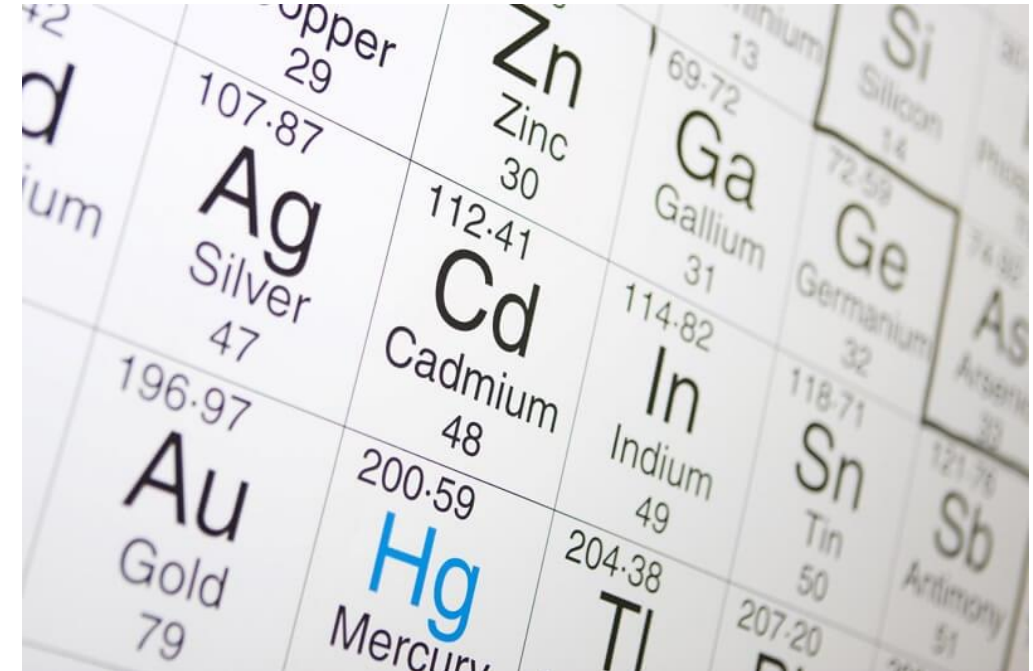
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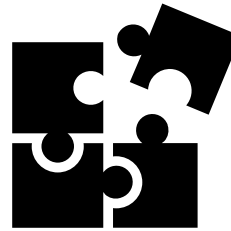
Toxic heavy metals are pollutants with **toxic effects** on living organisms even at low concentrations.

This is the case for **lead (Pb)**, **mercury (Hg)**, and **cadmium (Cd)**.

Their toxicity develops through **bioaccumulation** along the food chain.







# Heavy metals

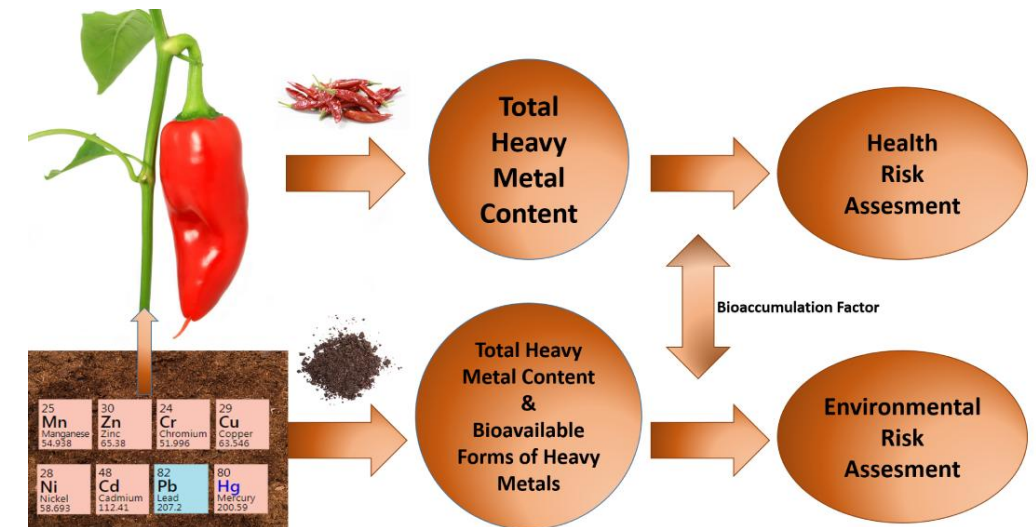
- Heavy metals have both **natural** (erosion, eruptions, forest fires) and **anthropogenic** (fertilization, petrochemicals, vehicle engines) origins.
- They accumulate in living organisms and food chains.



# Heavy metals

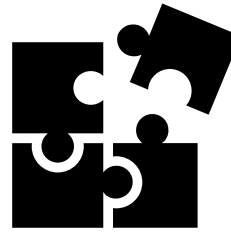


- One of the characteristics of **metal toxicity** is their ability to **form complexes**.
- Their **toxicity** also varies depending on the **dose and duration of exposure**.
- **Short-term exposure to high concentrations** causes acute symptoms, while **long-term exposure to low concentrations** causes chronic disorders.



# Heavy metals

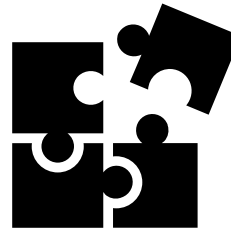
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- The main dangers of toxic heavy metals:

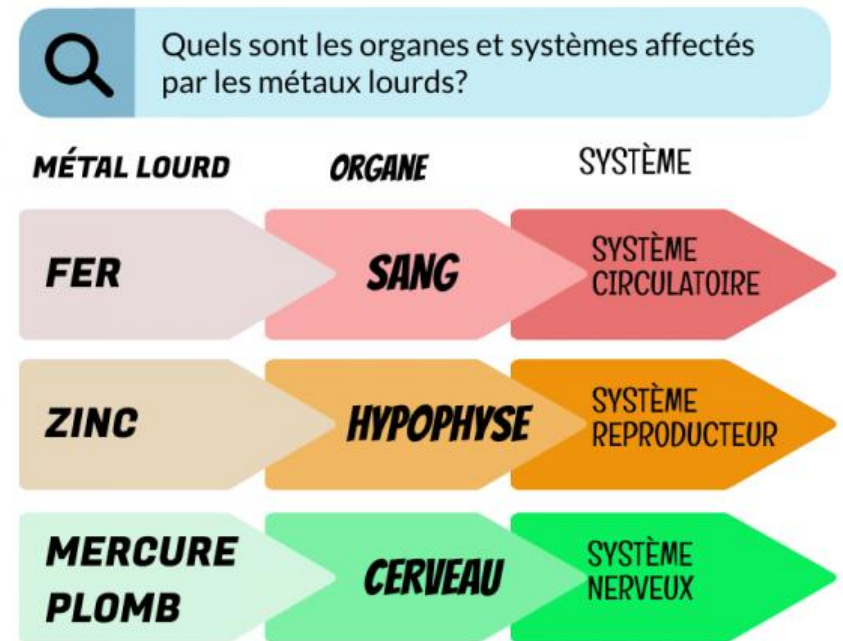
They replace or **substitute essential minerals**, **alter the genetic code**, produce **free radicals**, **neutralize amino acids** used for detoxification, cause **allergies**, and **damage nerve cells**.



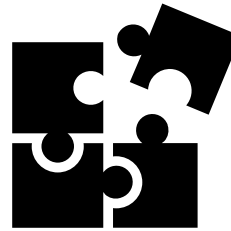


# Heavy metals

- Heavy metals are primarily stored in the bones, liver, kidneys, and brain.
- In humans, they can affect the nervous system, kidney, liver, and respiratory functions.
- Some, such as cadmium, arsenic, nickel, and chromium, are carcinogenic.
- They can also cause Alzheimer's disease, Parkinson's disease, autism, and other diseases..







# Persistent organic pollutants (POPs)

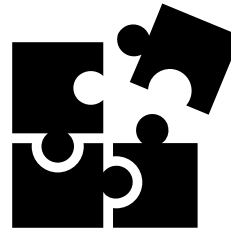
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## Dioxins and polychlorinated biphenyls (PCBs)





# Persistent organic pollutants (POPs)

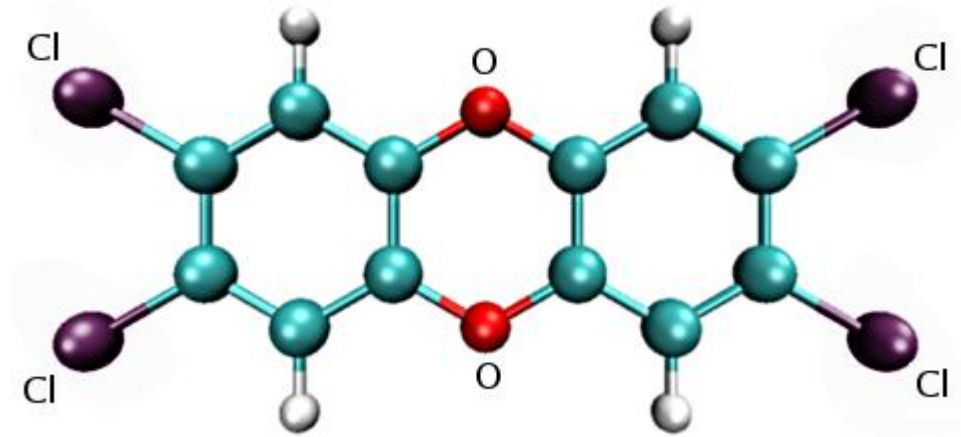


## Dioxins and polychlorinated biphenyls (PCBs)

Are chemical substances that are particularly toxic to humans and the environment.

They are **persistent organic pollutants** (POPs), i.e., toxic substances that **accumulate in living organisms** and are no longer eliminated.

These pollutants are thought to cause **adverse effects on reproduction** (risk of **endocrine disruption**) and possibly **carcinogenic effects**.



# Persistent organic pollutants (POPs)



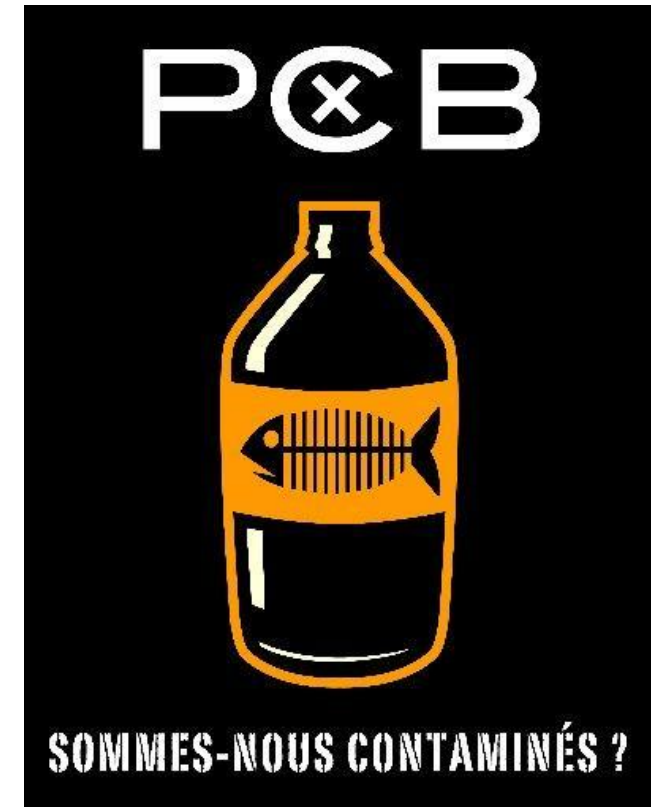
- Dioxins are products of **incomplete combustion of organic substances** (waste, cigarettes, etc.) and **industrial substances** (metallurgy, etc.).
- They are very **persistent and highly toxic** at very low concentrations. They cause **chronic toxicity**.
- Chronic dioxin toxicity, **still poorly understood**, is thought to cause **damage to the immune, endocrine, nervous, and reproductive systems**.



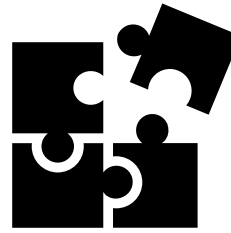
# Persistent organic pollutants (POPs)



- Dioxins are suspected of causing cancer.
- Stable and highly soluble in fats (lipophilic), dioxins accumulate in soils, contaminating plants, the animals that feed on them, food (fish, seafood, dairy products, etc.), and ultimately humans.
- They are stored in fatty tissue and concentrate in the body throughout life.



# Persistent organic pollutants (POPs)

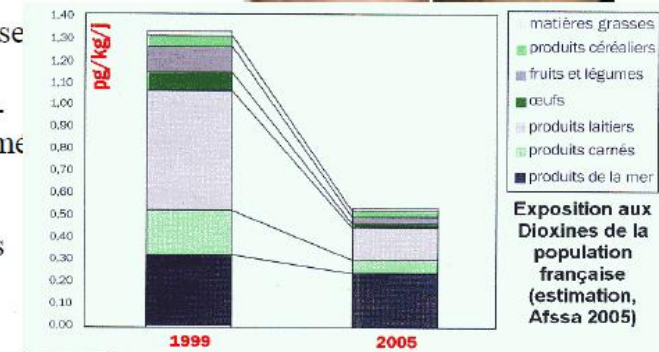


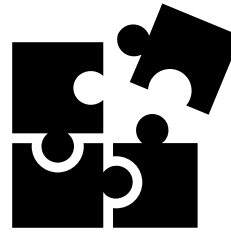
- PCBs (polychlorinated biphenyls) or pyralenes are substances closely related to dioxins.
- PCBs, form a family of 209 aromatic organochlorine compounds derived from biphenyl.
- PCBs are toxic and ecotoxic, even at low doses, as endocrine disruptors.



## Dioxines (et PCB)

- Empoisonnement criminel en 2004 de Viktor Iouchtchenko
- LMR très basses (2pg/g gras de viande, 4pg/g gras du lait, 10 pg/g poisson)
- Normes sur fumée incinérateur (0.1 pg/m<sup>3</sup>)
- L'exposition baisse régulièrement
- Danger probablement très surestimé en raison de la sensibilité des animaux modèles

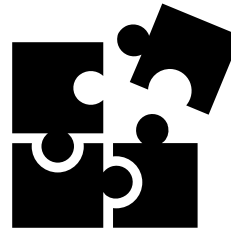




# Residues from packaging materials







# Residues from packaging materials

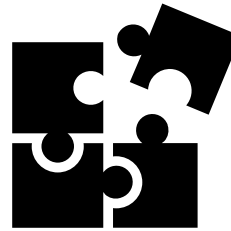
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- Container-content interaction can affect the organoleptic and nutritional qualities of foods, as well as consumer safety.
- This refers to the phenomenon of migration of hazardous chemical substances from the container to the contents.
- Materials must be inert to the food to limit the migration phenomenon.



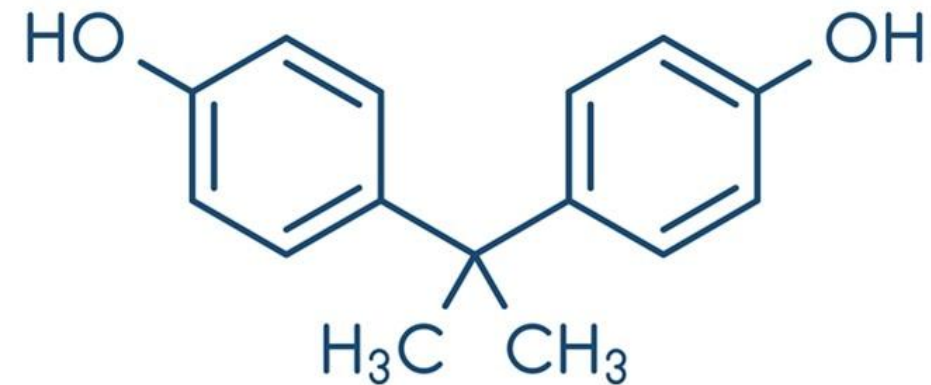
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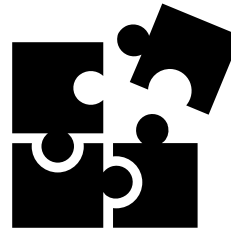


## Packaging Material Residues

**Bisphenol A (BPA)**, a mixture of phenol and acetone, a **primary component of plastic** packaging, is strongly suspected of being a **dangerous endocrine disruptor** for both animals and humans.



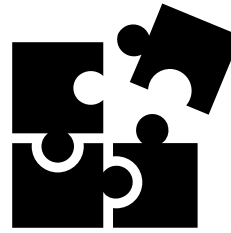
bisphenol A



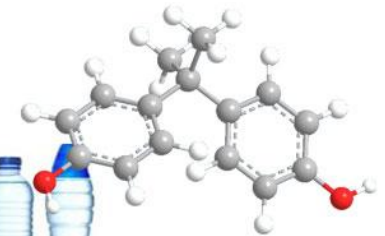
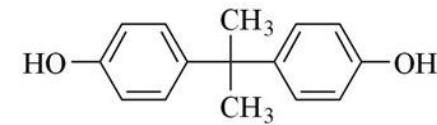
## Packaging Materials Residue

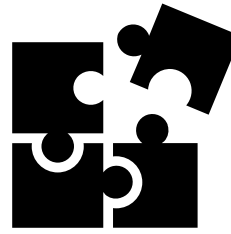
- Present in many packaging materials. Bisphenol A is present in a **wide variety of packaging** (inside cans, some baby bottles, cans, plastic bottles, water containers, and dental amalgam).
- According to INRA, **BPA can migrate from these plastics and resins into the food** they contain.
- It is found in the **urine, blood, and amniotic fluid of a large majority of the European population.**"





- **Bisphenol A (BPA):** BPA has been linked to adverse health effects, including hormonal disruption, reproductive problems, developmental problems in children, and increased cancer risks.

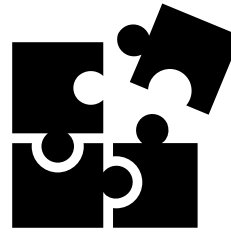




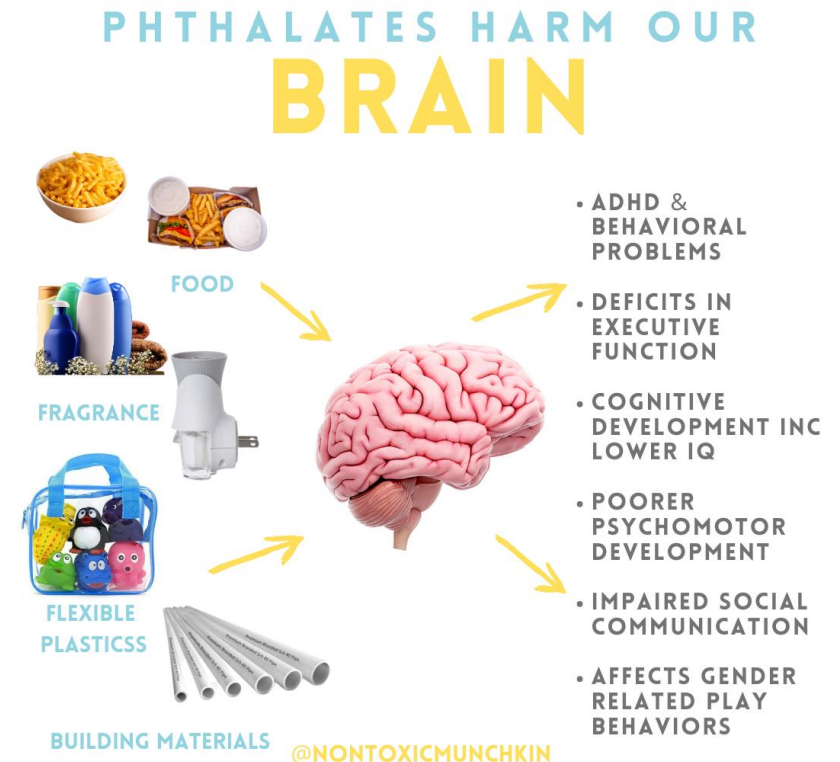
- To minimize exposure to toxic substances in packaging, it is recommended to **choose packaging certified as BPA-free, phthalate-free**, and free of harmful chemicals.
- It is also advisable to choose **packaging made of glass, stainless steel, or natural materials** whenever possible, and to **limit the use of plastic packaging**, especially for **hot or fatty foods**.





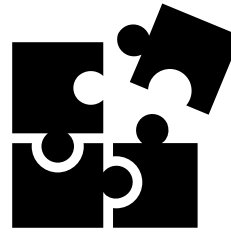


- **Phthalates:** Phthalates are chemicals added to plastics to make them softer and more flexible.
- They are often used in food packaging, particularly in plastic films and coatings.
- Phthalates can migrate from packaging into food and have been linked to adverse health effects, including hormonal disruption, developmental problems, and reproductive harm.



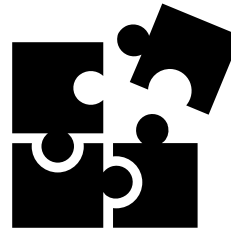






Aspect	Modern diet	Mediterranean
Fats	High in saturated and trans fats (e.g., from fast food, processed snacks)	Rich in healthy fats, especially olive oil (monounsaturated) and omega-3s (from fish)
Carbohydrates	Refined, high-glycemic index (white bread, sweets, sodas)	Complex carbs from whole grains, legumes, vegetables
Proteins	Red and processed meats	Moderate intake of fish, poultry, and plant-based proteins (like legumes)
Sugar and salt	High in added sugars and sodium	Low in added sugars and salt, uses herbs and spices for flavor





Health outcome	Modern diet	Mediterranean
Obesity and diabetes	High risk due to overconsumption of processed, sugary foods	Lower risk, supports better glycemic control
Cardiovascular health	Associated with high cholesterol, hypertension	Proven to reduce cardiovascular disease risk
Inflammation	Often promotes chronic inflammation	Has anti-inflammatory properties

