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Biological hazards

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At the end of the course, you will be able to:

- ✓ Define biological agents in the context of occupational health
- ✓ Recognize routes of exposure
- ✓ Make a biological risk assessment
- ✓ Be familar with the prevention and control measures
- ✓ Connect environmental health challenges to the broader One Health and climate change perspectives.

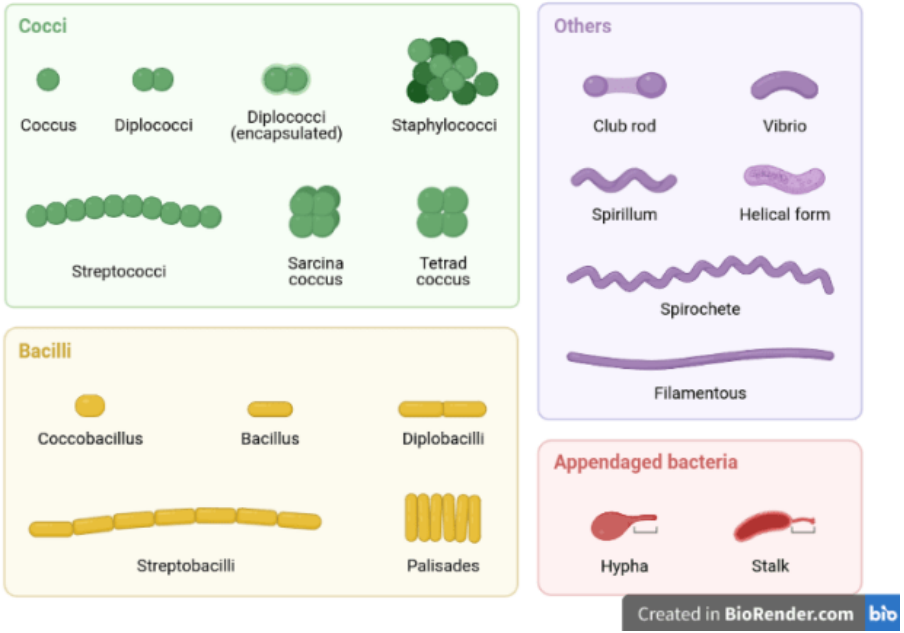
Definitions

Biological pollutants are living organisms or substances derived from living organisms that can adversely affect human health by causing

- infection,
- allergy or
- intoxication.

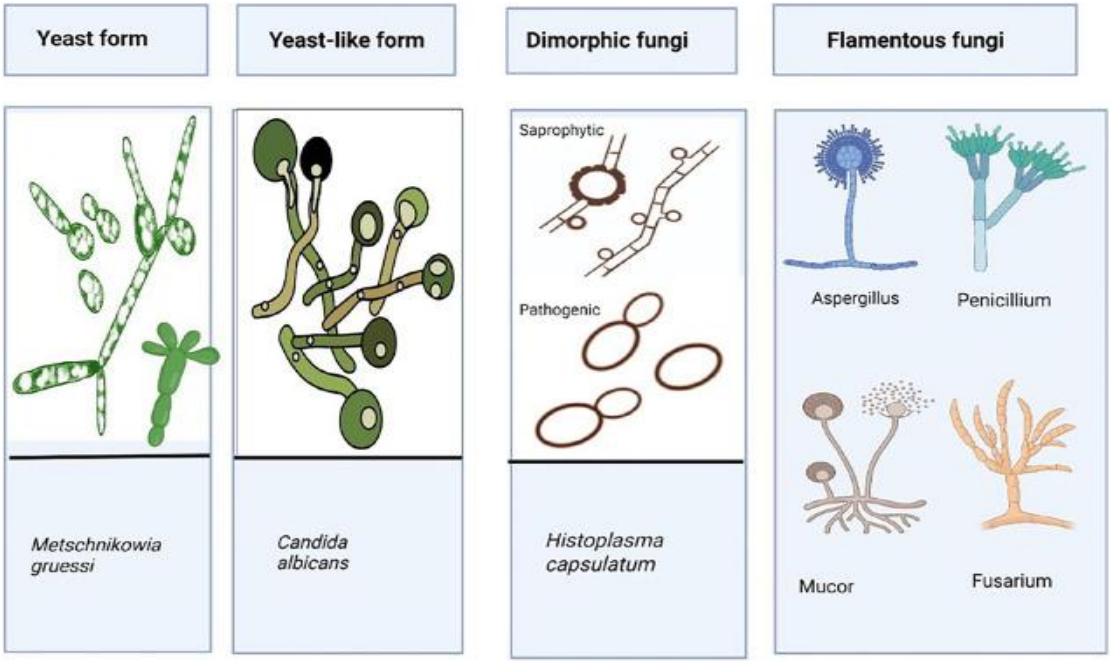
Biological agents

Bacteria (1 to 10 microns) lack a true nucleus and membrane-bound organelles. Their genetic material consists of a single circular DNA molecule located in a region called the nucleoid.



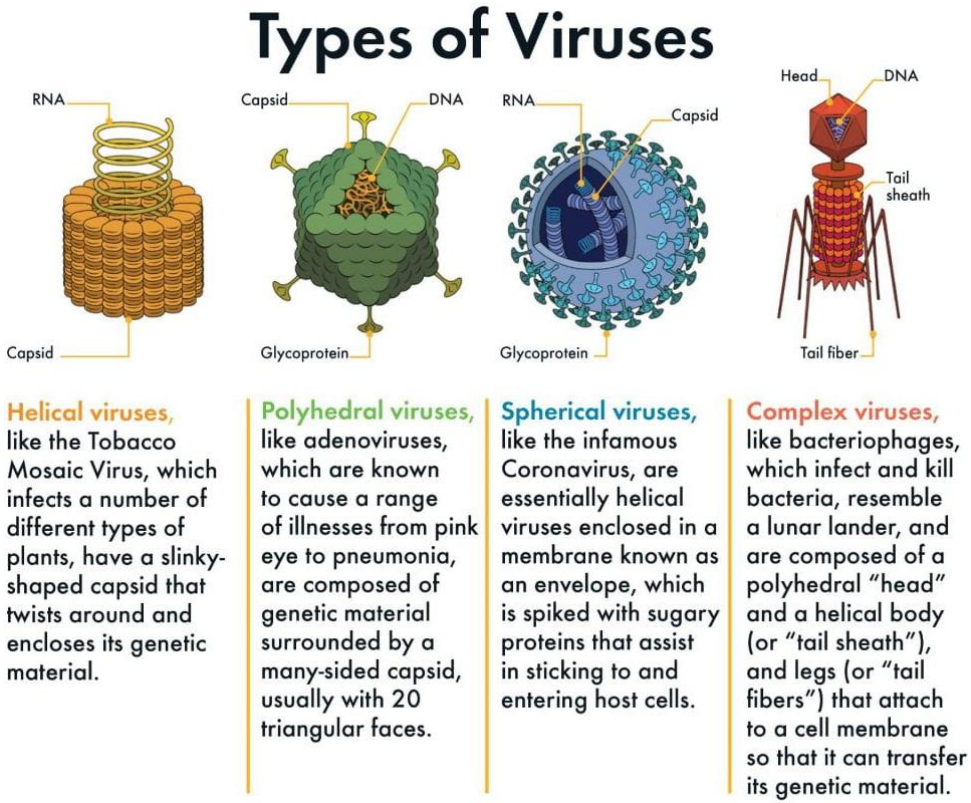
Biological agents

Fungi (1 to 100 microns)
eukaryotes that are characterized by the presence of chitin in the cell wall.



Biological agents

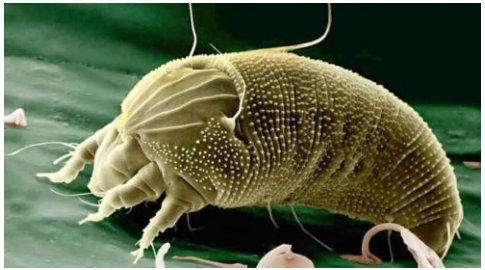
Virus (20 nm – 250 nm) are acellular infectious agents made of genetic material and a protein coat that requires a host cell to replicate



Biological agents

Protozoa (8–10 microns)
Toxoplasma gondii (toxoplasmosis)

Mites (200 micrometers to 3 millimeters)

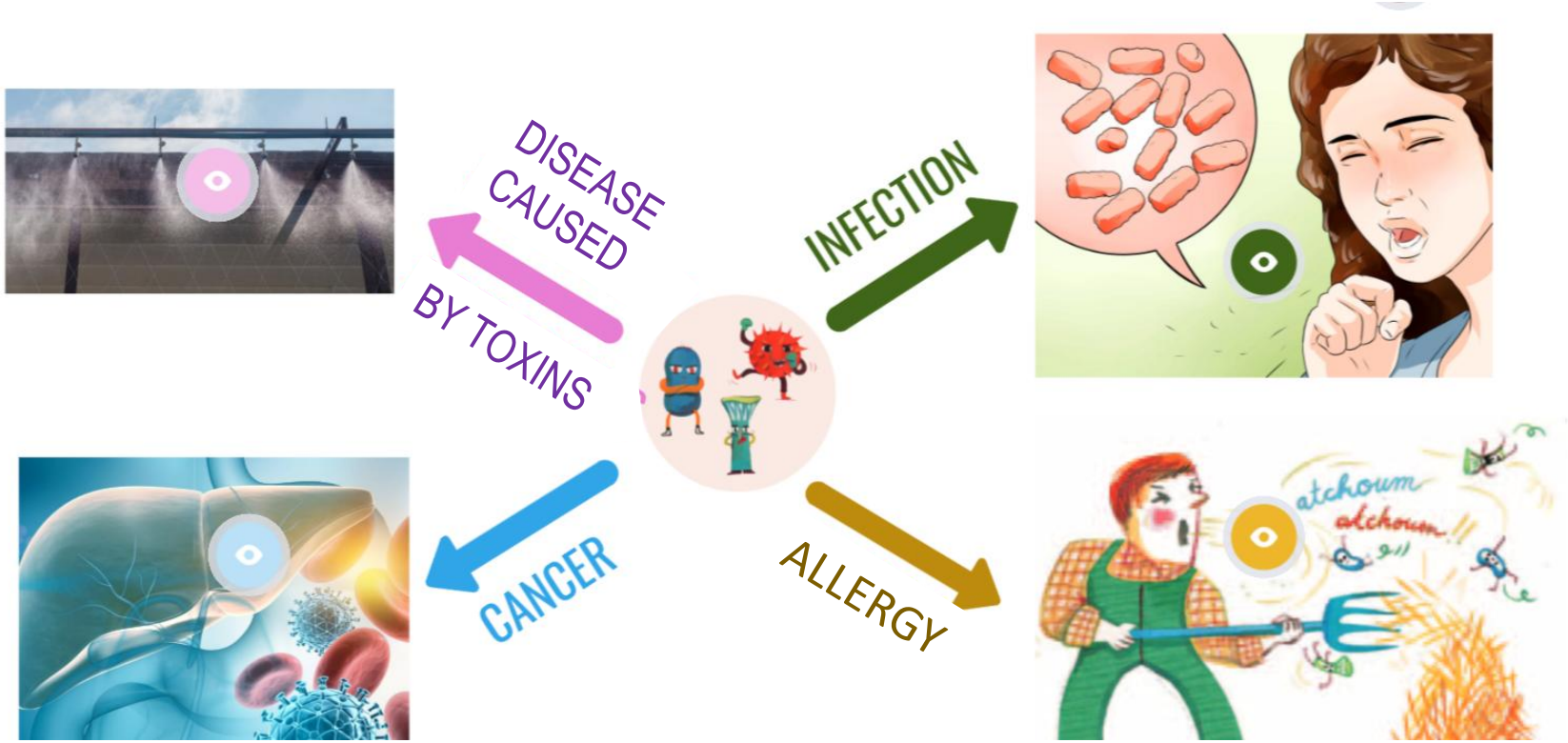


Biological agents are living organisms

Species specificity	•Whooping cough (*Bordetella pertussis*) in humans •Brucellosis (*Brucella spp.*) in ruminants and humans •Foot-and-mouth disease in cattle, goats, and sheep
Specific environmental conditions (humidity level, light, temperature)	*Legionella pneumophila* multiplies in fresh water at temperatures between 25°C and 45°C and at pH values between 5.6 and 9.6.
Nutritional requirements	Some bacteria feed on hydrocarbons and can be used for bioremediation, while others feed on organic or mineral matter.
Reproduction	Baker's yeast, *Saccharomyces cerevisiae*, doubles its population in 24 hours at 37°C. The bacterium *Escherichia coli* doubles its population in 30 minutes at 37°C.
Limited lifespan	Influenza viruses survive only a few hours in dried secretions. Pathogenic leptospires do not multiply in the external environment, but they can survive for up to six months in water or muddy soils with a slightly alkaline pH, very low salinity, and protected from sunlight.

The effects on health

4 Types of Risks



Risk of Infection

Mechanism: Entry and subsequent multiplication of a biological agent in the body

Examples: Influenza, Hepatitis B, Leptospirosis, Tuberculosis

Host specificity
Route of entry
Mode of transmission

Si Route of penetration = Mode of transmission ⇒ Contamination

Quantity of biological agents
Host immune status ⇓

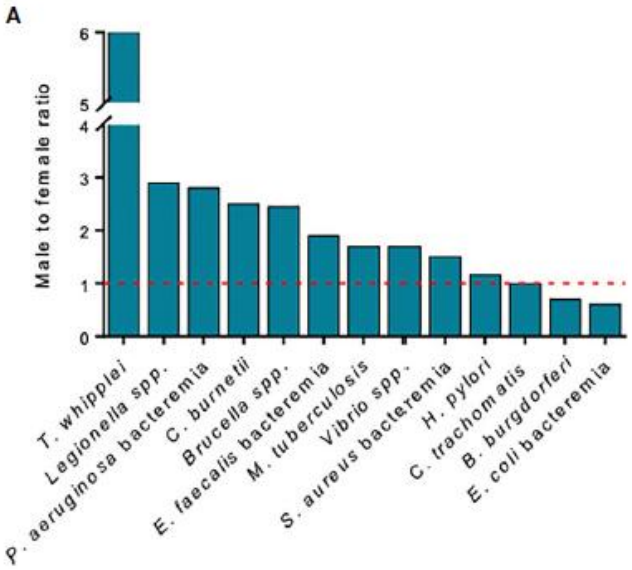
Development of an infection

Immunity and infection

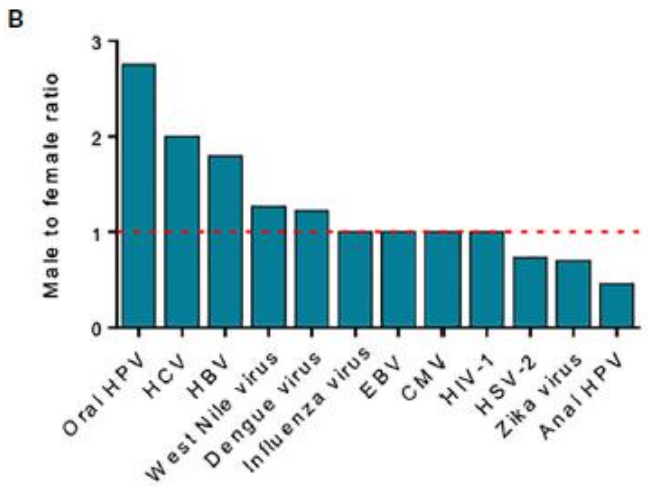
- Development of immunity (previous exposure)
- Acquisition of immunity (vaccination)
- Decrease in immunity – opportunistic infection

Prevalence of infections according to sex

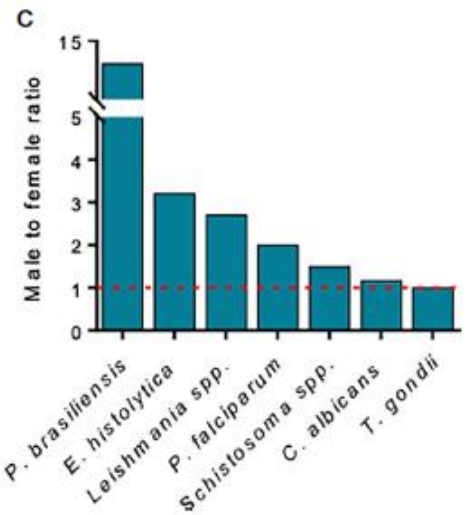
Bacterial



Viral

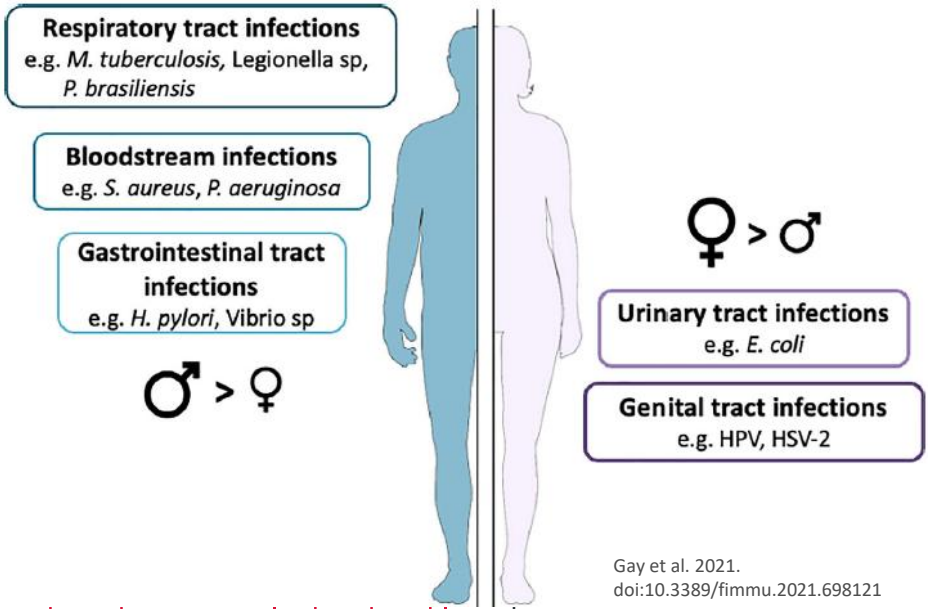


Parasitic and fungal



Gay et al. 2021.
doi:10.3389/fimmu.2021.698121

Prevalence of infections according to anatomical characteristics



Gay et al. 2021.
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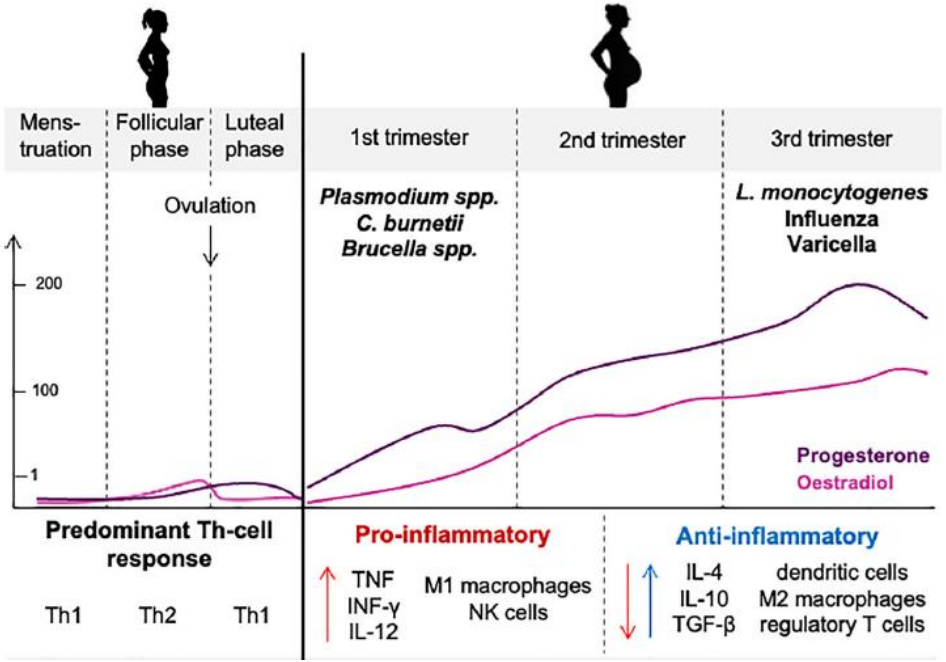
Evolution of susceptibility to infections



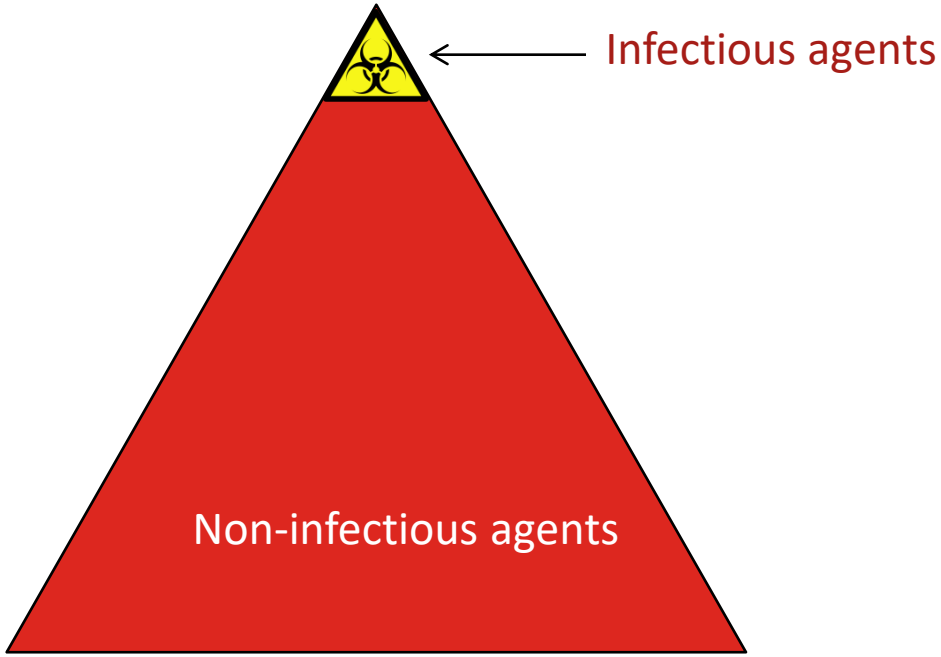
The increase in hormone levels during pregnancy contributes to the immune system changes necessary for a successful pregnancy, but it also increases women's susceptibility to infectious diseases.

Pregnant women are:

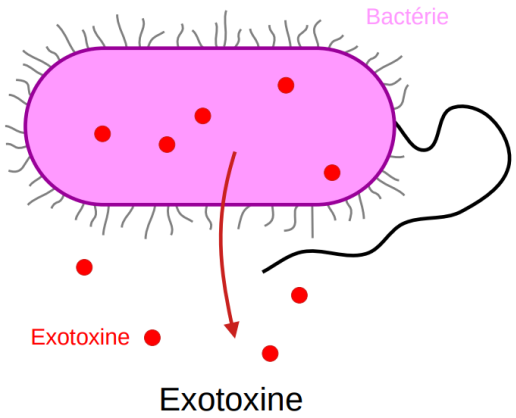
- 7 times more likely to be hospitalized,
- 2 times more likely to die from influenza virus,
- 3 times more likely to develop severe dengue as well as fatal *Plasmodium falciparum* infections than non-pregnant women.

Gay et al. 2021.
doi:10.3389/fimmu.2021.698121v

Infectious vs. Non-infectious

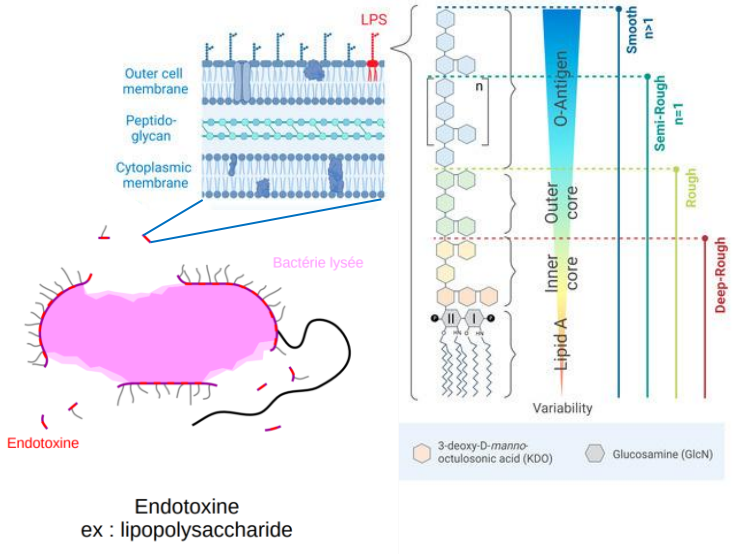


Toxic risks



	Exotoxin
Species that produce the toxin	○ Some species of gram-positive and gram-negative organisms
Method of release	○ Actively secreted
Gene location	○ Plasmid or bacteriophage
Toxicity level	○ High toxicity
Vaccines	○ Available for some toxins in the form of toxoids
Properties	○ Heat-labile
Examples	○ *Vibrio cholera* ○ *Diphtheria* ○ *Salmonella* ○ *Shigella* — Enterotoxins ○ *Clostridium tetani* ○ *Clostridium botulinum* — Neurotoxins

Toxic risks



Endotoxine
ex : lipopolysaccharide

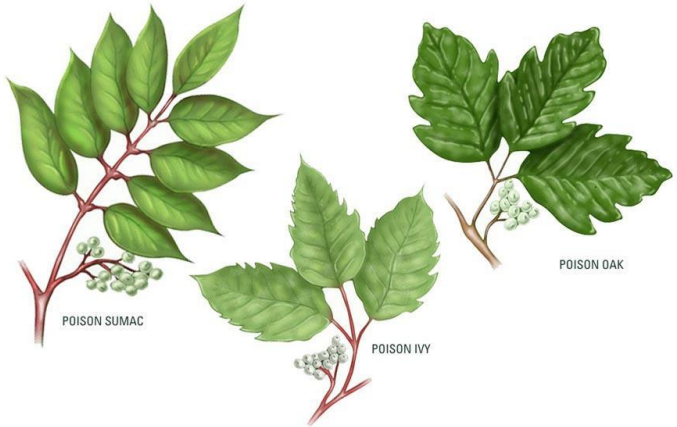
	Endotoxin
Species that produce the toxin	○ Gram-negative organisms ○ Listeria
Method of release	○ Bacterial cell lysis or fragmentation
Gene location	○ Bacterial chromosome
Toxicity level	○ Low toxicity
Vaccines	○ No vaccines available
Properties	○ Heat-stable
Examples	○ *Neisseria meningitidis* ○ *Escherichia coli* ○ *Pseudomonas*

Massive exposure through inhalation of contaminated dust
Symptoms similar to influenza, including fever, myalgia, and one or more respiratory symptoms.

Toxic risks

Direct contact

GIANT HOGWEED



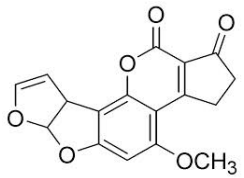
Manifestations:

Occupational cancers

Cancer = a malignant tumor formed by the uncontrolled multiplication of cells

Agents responsible for liver cancer:

Viral infection: Hepatitis B virus (HBV)
Exposure to mycotoxins: Prolonged exposure to aflatoxins can promote cancer development.



Cancer risk and occupational exposure to aflatoxins in Denmark:
Daily intake for workers via the respiratory route of approximately 170 ng
Liver cancer and for cancers of the biliary tract increased by two- to three-fold
significance after a 10-year latency

Allergic Risks

Allergy = a person's hypersensitivity to a substance present in the environment that is harmless to the majority of people.

In the **workplace**, biological agents that cause sensitization are mainly transmitted **via the respiratory route**.

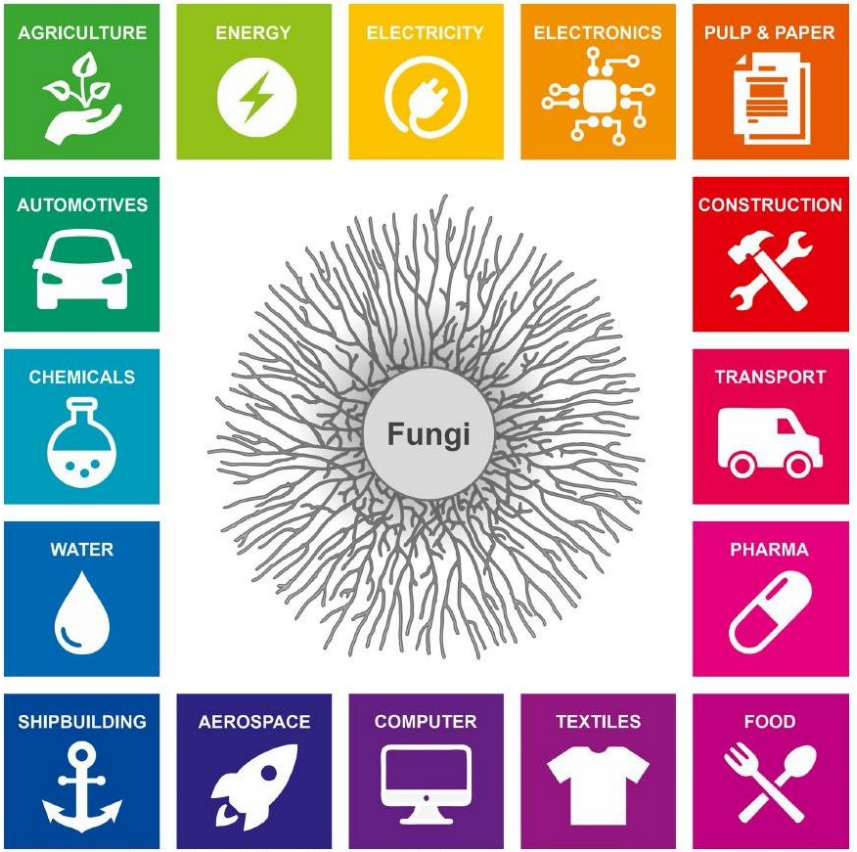
Manifestations:

- Rhinitis
- Asthma
- Hypersensitivity pneumonitis

Occupational allergies

Bacteria: Enzymes like subtilisins in detergents or impurities like grain weevils in flour.
Fungi: Spores and metabolites from molds or fungi used in industry.

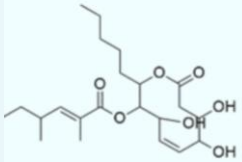
Industries profiting from the metabolic capacities of filamentous fungi



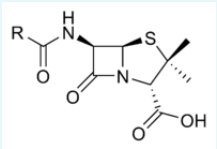
Meyer *et al. 2020*
https://doi.org/10.1186/s40694-020-00095-z

Fungal metabolites

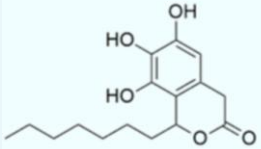
Antibiotics



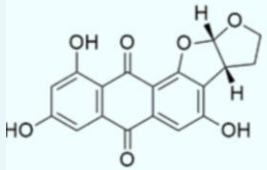
Phomol



Penicillin

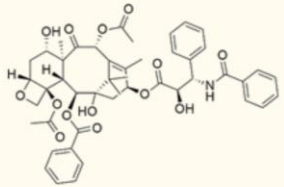


Cytosporone D

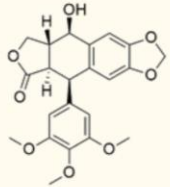


Isoversicolorin C

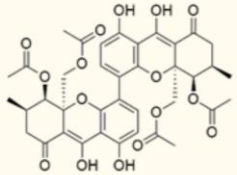
Anticancer



Paclitaxel

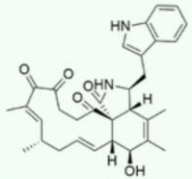


Podophyllotoxin

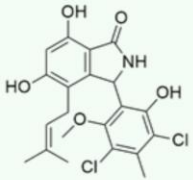


Phomoxanthone A

Antifungal

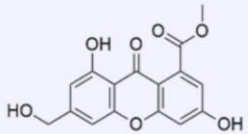


Chaetoglobosin G

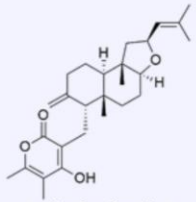


Pestalachloride A

Immunosuppressants

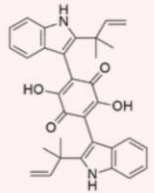


Conioxanthone A

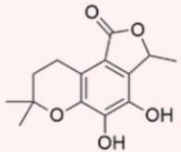


Subglutinol A

Antiviral



Hinnuliquinone



Fuscinarin

Occupational allergies

Bacteria: Enzymes like subtilisins in detergents or impurities like grain weevils in flour.

Fungi: Spores and metabolites from molds or fungi used in industry.

- **Baker's asthma:** Inhalation of airborne **alpha-amylase** dust, especially from fungal sources, is a major cause of occupational asthma among bakers.

- **Contact dermatitis:** Direct contact with alpha-amylase powder can cause skin reactions.

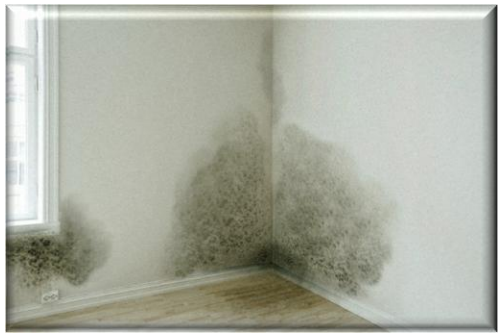
Plants: Pollen or components from flours like wheat, rye, or barley.

Arthropods: Dust and body parts from mites and insects.

Animals: Dander, bodily fluids, and other proteins from animals.

Allergens

(molds, pollen, faeces, urine, animal hair and saliva)

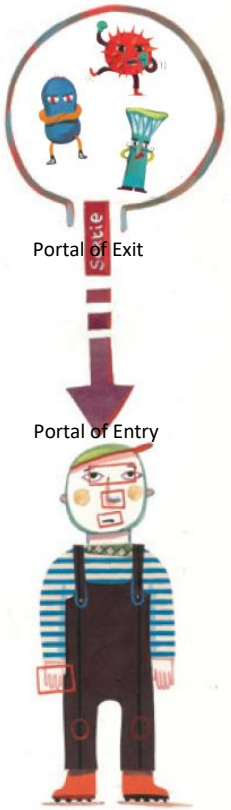


Swiss population suffering of allergy:

- 20% to pollen
- 6% to house dust mites
- 1 to 10% to molds
- 4% to cats and 3% to dogs

Biological Risk Assessment

Transmission Chain



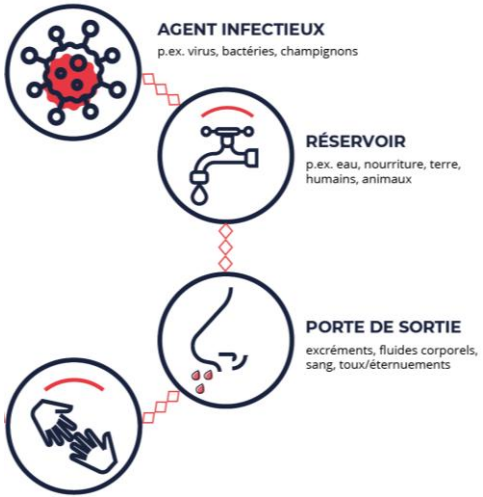
Reservoirs:
Human,
Animal,
Environment: building, water, waste, soil

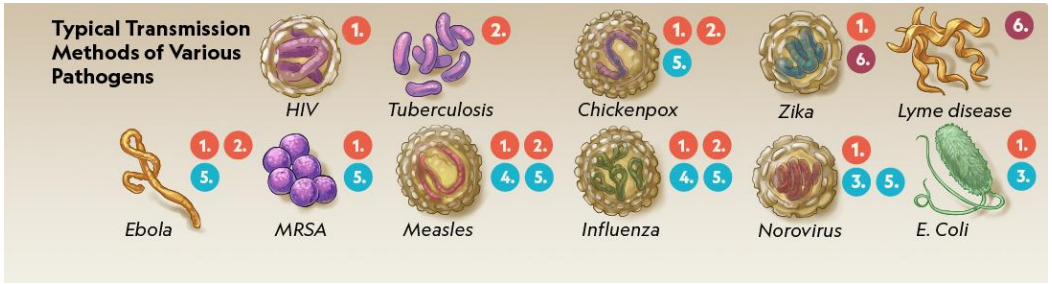
Transmission routes:
inhalation,
ingestion,
contact with skin or mucous membranes,
inoculation

Host factors:
immunity,
specific conditions such as pregnancy or immunosuppression

Approach to Biological Risk Assessment:
- Search for the presence of reservoirs
- Identify exposing activities

Identify the hazard = identify the reservoir

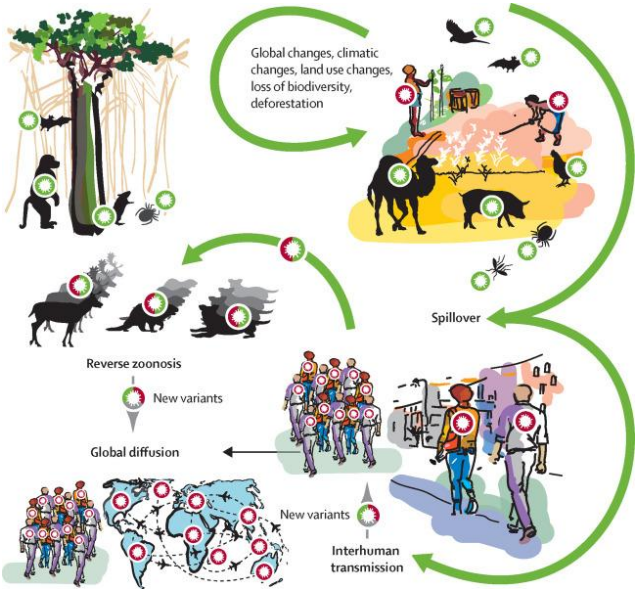




Emergence of a zoonotic disease

For a new pathogen to become a threat to human populations, the following are required:

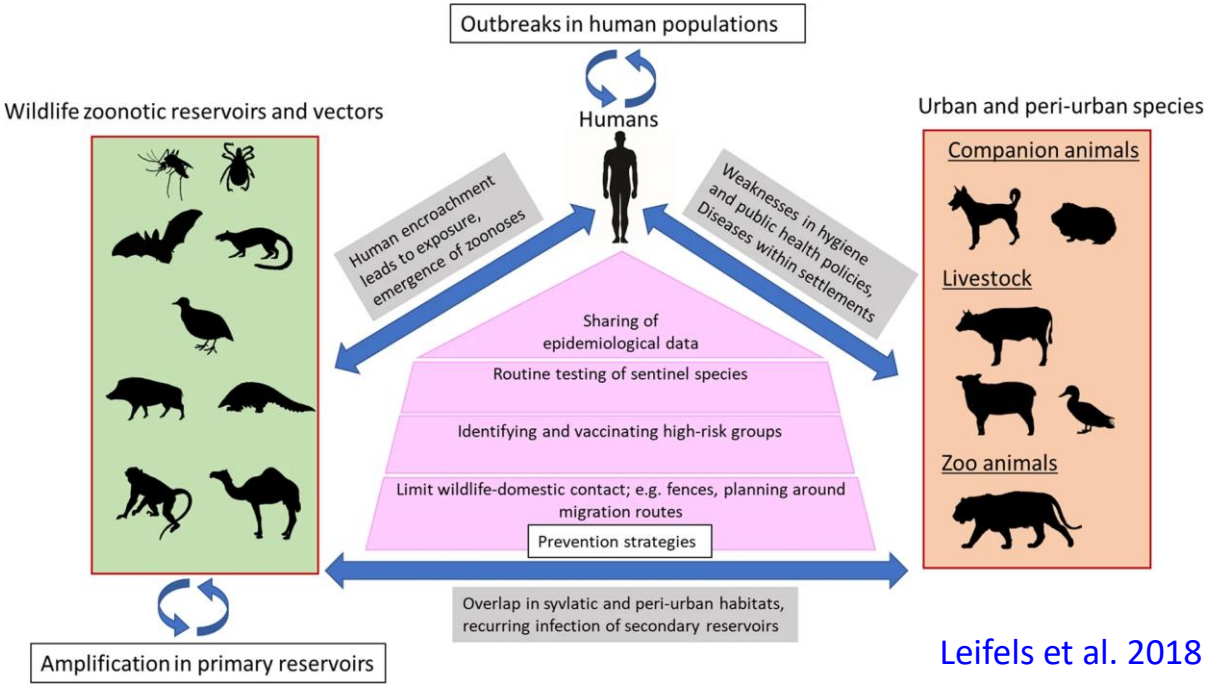
1. Contact between humans and the animal reservoir



2. The pathogen must possess—or develop—the ability to transmit from human to human

3. Expansion of the pathogen's geographic range beyond the initial zone of zoonotic transmission

Identify the hazard = identify the reservoir



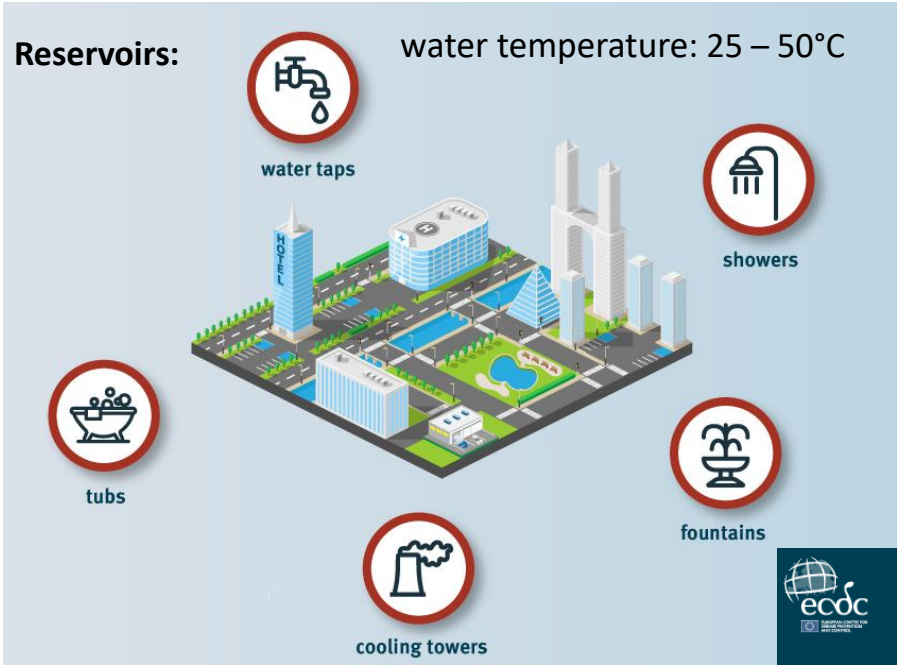
Leifels et al. 2018

- COVID-19
- Rabies
- *Salmonella* infection
- West Nile virus infection
- Q Fever (*Coxiella burnetii*)
- Anthrax
- Brucellosis
- Lyme disease
- Ringworm
- Ebola

Identify the hazard in Built Environment

Microorganism	Common Sources in Built Environments	Main Health Effects / Diseases
Mycobacterium tuberculosis	Airborne in enclosed, poorly ventilated spaces	Tuberculosis
Streptococcus pneumoniae	Airborne droplets in crowded or poorly ventilated areas	Pneumonia, otitis, meningitis
Streptococcus pyogenes	Contaminated surfaces, airborne droplets	Pharyngitis, scarlet fever, skin infections
Legionella pneumophila	Hot water systems, cooling towers, humidifiers	Legionnaires' disease (severe pneumonia)
Pseudomonas aeruginosa	Damp surfaces, biofilms in water systems	Respiratory and wound infections, especially in hospitals
Aspergillus fumigatus	Ventilation systems, construction dust, damp walls	Allergies, aspergillosis (lung infection)
Staphylococcus aureus	Human skin, surfaces, door handles, hospital equipment	Skin infections, wound infections, pneumonia, sepsis

Risk of Exposure to *Legionella*

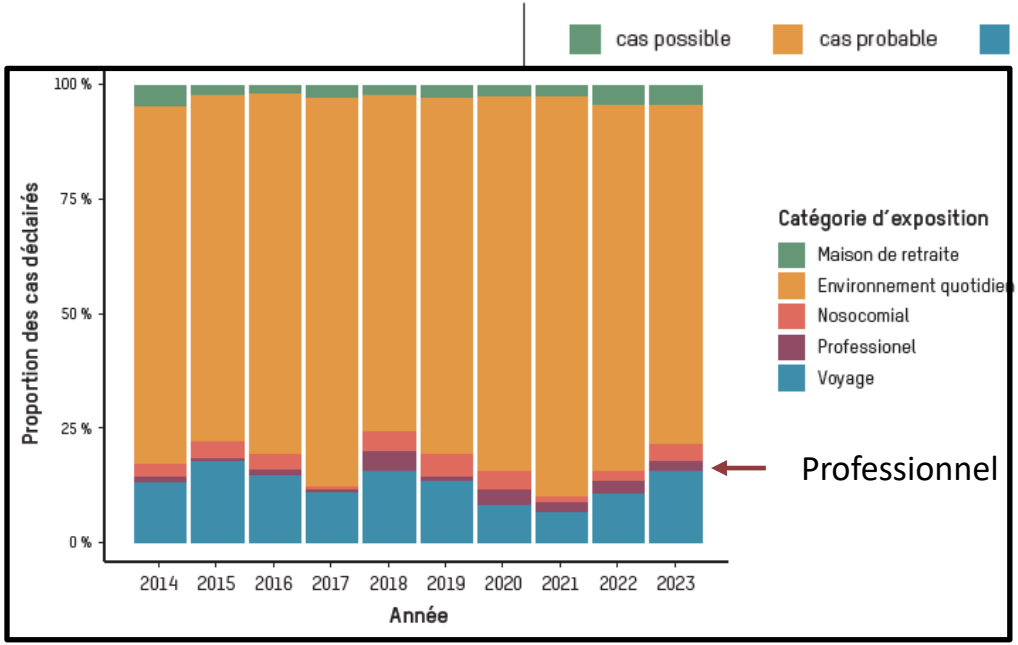


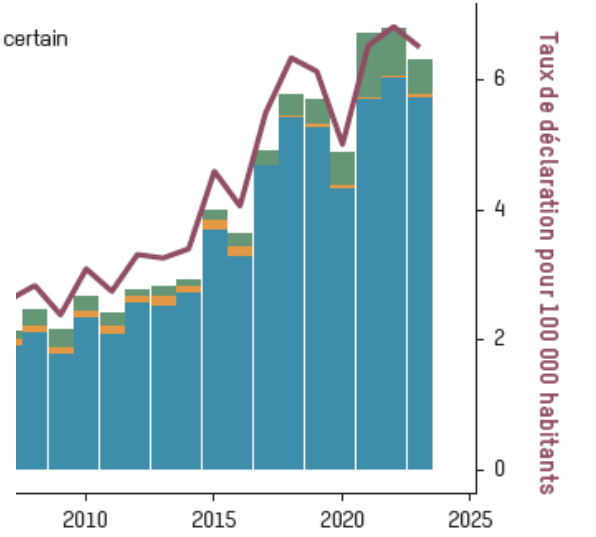
Transmission:
Emission of bioaerosols from a water reservoir contaminated by *Legionella*, through:
spraying,
bubbling, or
high-pressure impact on a surface.

Diseases:
Pontiac fever
Legionellosis (Legionnaires' disease)

At-risk populations:
Over 50 years old
Smokers
Individuals with weakened immune systems, or
Those under immunosuppressive treatment

An increase in the number of Legionnaires' disease cases





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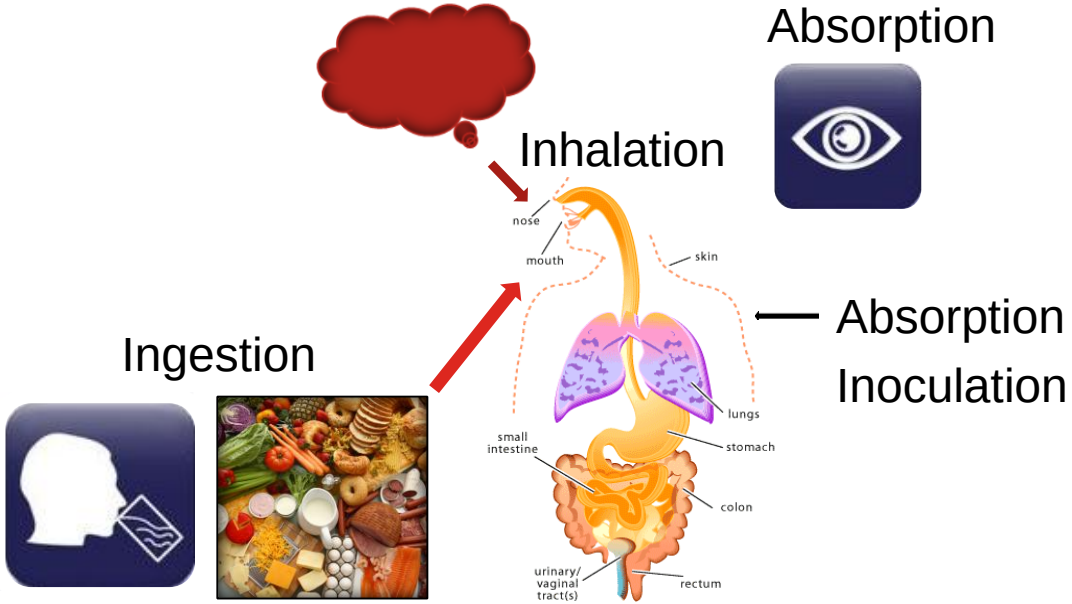
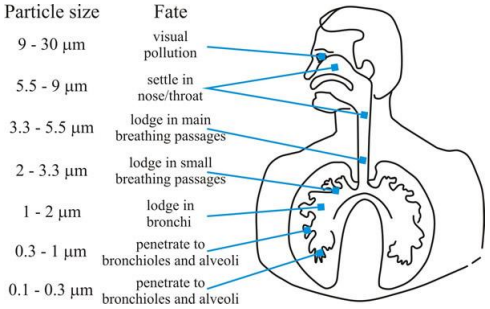
Identify exposures

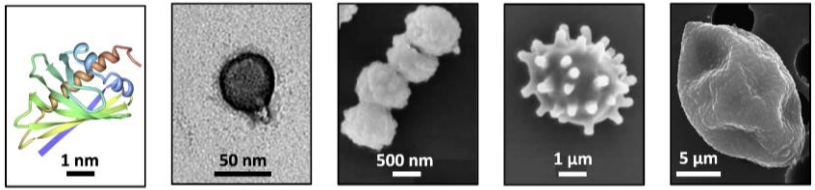
Roads of exposure = road of transmission?

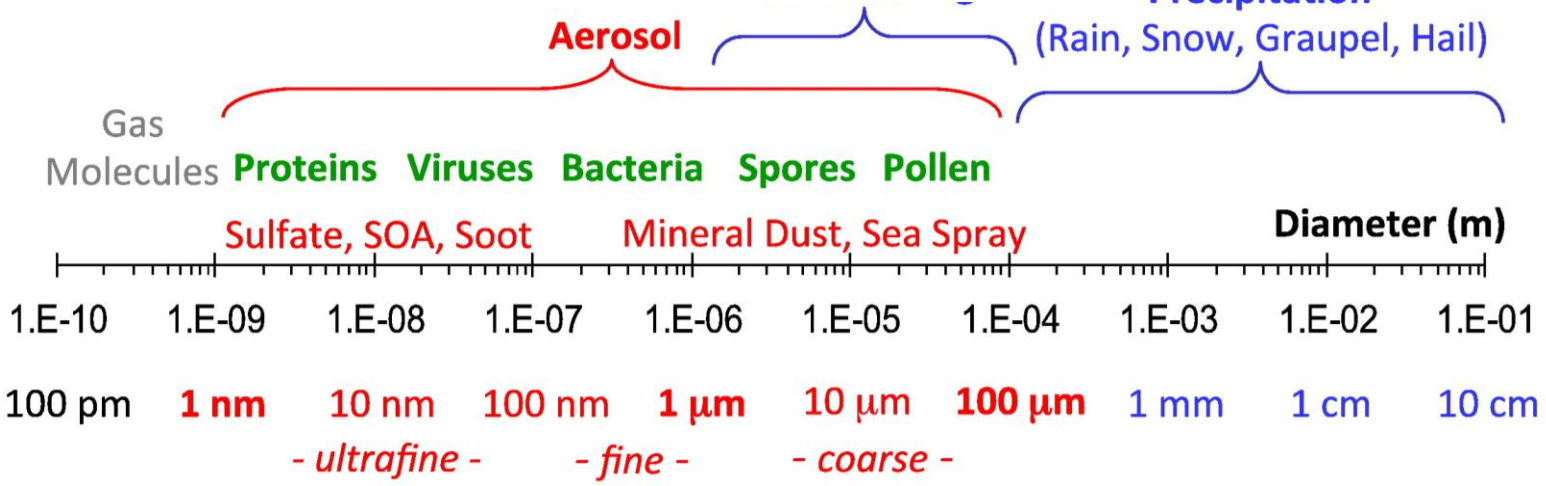


Bioaerosols

airborne particles, either living or derived from living organisms







Fröhlich-Nowoisky et al. 2016.
doi.org/10.1016/j.atmosres.2016.07.018

Identify exposures

List occupational activities that involve contact with human blood, body fluids, or sharp objects, and explain how to protect workers by breaking the chain of transmission.

- Hepatitis B Virus (HBV)
- Hepatitis C Virus (HCV)
- Human Immunodeficiency Virus (HIV)

Recommendations

https://oshwiki.osha.europa.eu/en/themes/prevention-sharp-injuries

https://www.osha.gov/bloodborne-pathogens/worker-protections

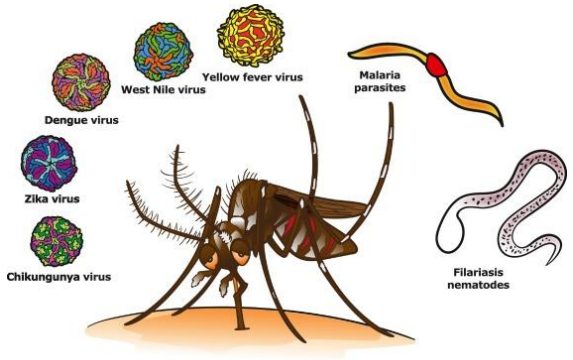
https://www.cdc.gov/dental-infection-control/hcp/dental-ipc-faqs/occupational-exposure.html

Identify exposures

List occupational activities that involve a risk of stings and bites, and explain how to protect workers by breaking the chain of transmission

Tetanus, rabies
Oral microbiome

Lyme disease
Tick-borne encephalitis



Risk Prevention Approach

Control of bioaerosol-related risks

Implement the **STOP** measures:

Substitution - substitute materials / change processes.

Technical/engineering - ventilation, containment, water/humidity control

Organizational - good hygiene, training and awareness, work practices

Personal Protective Equipment (PPE) – respiratory protection, barrier protection

Act on the Reservoir

- Remove conditions that favor the development of biological agents (regular cleaning, functional ventilation, maintenance, etc.)
- Eliminate pathogenic biological agents (vaccination, early diagnosis, screening)
- Substitute pathogenic biological agents (biological research laboratory, biotechnology)
- Contain the reservoir of pathogenic biological agents
- Control the introduction of contaminated animals

Propose

- Worker Vaccination
- Prophylactic treatment before traveling to an endemic area
- Treatment or vaccination after accidental exposure
- Specific precautions address to employers and workers that have to:

  Collect and review information about workplace hazards.

  Inspect the workplace for and identify new or recurring hazards.

  Characterize the nature of identified hazards and determine strategies for prevention, mitigation, and control

Case Study

Hazardous Drugs in Healthcare Settings: Exposure to Antineoplastic Agents at Work

In 2017, a 41-year-old patient care assistant working on an oncology floor developed an itchy rash approximately 30 minutes after emptying a commode of urine into a toilet (Kusnetz & Condon, 2003). She denied any direct contact with the urine, wore a protective gown and nitrile gloves, and followed hospital policy for the disposal of materials contaminated with antineoplastic drugs. The rash subsided after 1 to 2 days. Three weeks later, she had a similar reaction approximately 1 hour after performing the same procedure for another patient. Upon investigation, it was found that both hospital patients had recently been treated with vincristine and doxorubicin. The patient care assistant had no other signs or symptoms and reported no changes in lifestyle and no history of allergies or recent infections. After treatment with diphenhydramine (intramuscular) and oral corticosteroids, her symptoms disappeared. Although the cause could not be confirmed, both vincristine and doxorubicin have been associated with allergic reactions when given to patients. The aerosolization of the drug present in the urine may have provided enough exposure for symptoms to develop in the patient care assistant (Department of Health and Human Services, National Institute for Occupational Safety and Health, 2004).

Formulate the Recommandations

Case Study

Recommendations

Wear:

- safety glasses with side shields and a face shield if splashing is possible when handling any possibly contaminated substance such as urine or feces
- two pairs of protective chemotherapy gloves and a disposable gown if handling linens, feces, or urine from patients who have received hazardous drugs within the last 48 hours.

Inspect gloves for defects and change gloves on a regular basis

Gloves should not be used for more than 30 minutes !

Remove the outer gloves and the gown by turning them inside out and placing them into the chemotherapy waste container.

Repeat the procedure for the inner gloves.

Always wash hands with soap and water before donning protective gloves and immediately after removal (American Society of Health-System Pharmacists, 2018; Polovich & Olsen, 2018).

Case study

Recommendations

Place wastes such as needles, empty vials and syringes, gloves, and gowns in chemotherapy waste containers

While disposing of contaminated materials in toilets, close the toilet lid or use a plastic backed absorbent pad placed over the toilet without a lid during flushing.
Assuring that drug-contaminated waste is properly contained will protect workers from respiratory exposure to volatile or micro-aerosolized drugs.
Fold soft materials (sheets, hygiene care products) inward to prevent leakage. Place in sealed bags.

Conduct regular training reviews with all potentially exposed workers in workplaces that use hazardous drugs.
Make sure that training conforms to the requirements
Establish procedures for cleaning and decontaminating work areas and for proper waste handling and disposal of all contaminated materials, including patient waste.

Key Messages to Remember

- Biological risks evolve with work practices, emerging pathogens, and environmental changes.

- Continuous risk assessment and regular adaptation of protective measures are necessary.

- Communication and ongoing training are major levers in a context of constant change.

? And now?

How can we sustainably adapt our protection strategies in the face of constantly evolving biological risks?

Legislation

832.321

Ordonnance sur la protection des travailleurs contre les risques liés aux microorganismes

(OPTM)

du 25 août 1999 (Etat le 1er janvier 2020)

Directive 2000/54/EC on biological agents

Biological agents' shall be classified into four risk groups, according to their **level of risk of infection:**

Group 1 biological agent means one that is unlikely to cause human disease

Group 2 biological agent means one that can cause human disease and might be **a hazard to workers**; it is **unlikely to spread** to the community; there is usually effective prophylaxis or treatment available;

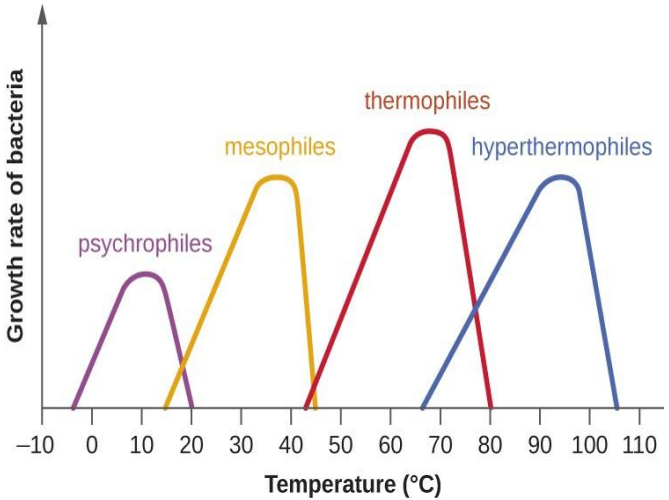
Group 3 biological agent means one that can **cause severe human disease** and present a **serious hazard to workers**; it may present a **risk of spreading** to the community, but there is usually **effective prophylaxis or treatment available**;

Group 4 biological agent means one that **causes severe human disease** and is a **serious hazard to workers**; it may present **a high risk of spreading** to the community; there is usually **no effective prophylaxis or treatment available**.

Guideline values for non-pathogenic airborne micro-organisms

SUVA recommendations:

- Total cultivable mesophilic germs: 10,000 colony-forming units (CFU)/m^3 air.
- Gram-negative bacteria: 1'000 CFU/m^3 air.
- Cultivable fungi: 1'000 CFU/ m^3 air.
- Endotoxins: 1'000 endotoxin units/m^3 = 100 ng/m^3 air (Holland, 90 EU)



European norm

EN 14126:2003 (SN_EN_14126_F) is the standard to determine whether protective clothing offers necessary protection against infective agents, which prescribes the requirements for materials, seams and garments. For protective clothing which passes EN 14126:2003, wording “-B” will be added behind “TYPE” classification, namely “TYPE 3-B”, “TYPE 4-B” and “TYPE 5-B”. A standard is reviewed every 5 years.

EN 14126:2003 includes 5 test methods to determine the protection class against several specific biological hazards. The higher the protection class, the higher the protection level.

ISO 16603:2004 – Resistance to penetration by blood and body fluids using synthetic blood

Occupational Exposure Limits (OELs)

OEL set at 60 ng/m^3 for all enzymes from 2018 in EU
This limit is adopted by the European Chemicals Agency (ECHA)

(including fungal alpha-amylase in the sector of bakery ingredients suppliers and enzyme manufacturers)

Legislation for mycotoxins

Commission Regulation (EC) No 1881/2006
setting maximum levels for 8 mycotoxins in foodstuffs :

- Aflatoxins, in particular in food for young children
- Ochratoxin A
- Patulin
- Deoxynivalenol
- Zearalenone
- Fumonisins
- T-2 & HT-2 toxin
- Citrinin

Commission Recommendation 2012/154/EU

- Ergot alkaloids

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Thank you for your attention

For any questions on the subject:

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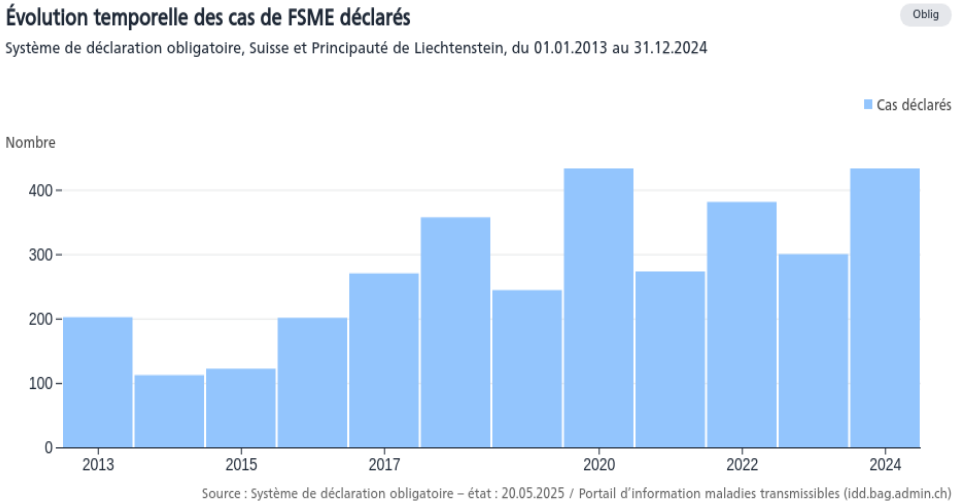
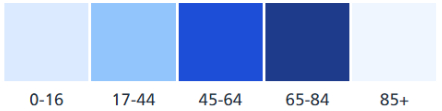
Méningo-encéphalite à tiques (FSME)

- maladie infectieuse virale transmise par les piqûres de tiques
- 0,5% des tiques sont vectrices des virus de la FSME
- symptômes pseudo-grippaux pouvant dégénéré en méningite



Cas par classe d'âge:



Cas par sexe:

Répartition géographique en 2024