BIOLOGICAL POLLUTANTS OF INDOOR AIR
People work in offices, study at school, stay at home to relax or do housekeeping. In total, they spend about 90% of their lifetime in indoor environments. As a consequence, they expect indoor environments to be cozy and healthy.

Among the four environmental parameters that were shown to affect the occupant well-being (thermal, visual, acoustic and air quality), the quality of air proved to be of importance to people.

Perceived air quality is impacted by both environmental physico-chemical factors (temperature, humidity) & biological factors.

Nature, impact, sources of the latter & ways to control them are depicted in the following pages.
DIVERSITY OF BIOLOGICAL AIR POLLUTANTS

Biological pollutants of indoor air harbor different sizes, shapes and structures. They include:

**Microorganisms:**
- fungi such as molds and yeasts
- bacteria

**Molecules:**
- endotoxins
- allergens

**Biological Particles:**
- viruses
- pollens

A WIDE RANGE OF BIOLOGICAL COMPOUNDS CONTRIBUTE TO ALTER INDOOR AIR QUALITY.
Indoor biological pollutants affect occupant’s well-being, even occupant’s health in some cases. Depending on the nature and types of biological pollutants, but also on occupant sensitivity, exposure may lead to:

- infections
- irritations
- intoxications
- allergies

It was shown that:
- increase by 30% to 50% of people with asthma was observed in dwellings with signs of humidity or presence of molds\(^6\)
- early exposure to molds has been associated with asthma in 7-year old children\(^7\)
Biological pollutants can be found in air and on any surfaces, including on inert materials and on living organisms.

They may be of different origins, coming from:
- outdoor sources
- furniture
- building walls
- plants
- insects and mites
- pets
- occupants

Only a small proportion of them is really harmful to people.

However, it is important to reduce the total load of indoor biological pollutants as much as possible, to limit risk. This should be done by a constant control of their sources, their development & their spreading in buildings.
Impact of indoor biological pollutants can be mitigated either by reducing sources and/or avoiding microbial growth. This can be made through:

- **filtration** of incoming air
- keeping **ventilation & air conditioning systems clean** (filters should be regularly changed, etc.)
- **cleaning carpets, mattresses, furniture, regularly**
- maintaining **humidity at low level** (30% to 50% are recommended in dwellings9).

To that purpose:

- avoid stagnant water, wet surfaces and wet materials
- provide appropriate ventilation
- use dehumidifier
CONCLUSION

Indoor air quality is altered by pollutants which can be of physical, chemical or biological nature. Indoor biological pollutants originate from living organisms, and are highly diverse in size, shape and structure.

Their impact on health and comfort varies a lot, depending on their properties but also on occupant’s susceptibility. Consequently, attempts to define acceptable concentration levels of biological pollutants in air have failed so far.

The best way to control their load remains keeping indoor environment dry and cleaned.

Saint-Gobain’s main concern is to offer solutions which contribute to make places more comfortable for people’s life and work. In this sense, lowering the amount of indoor air pollutants, including biological ones, is a priority. To that purpose, Saint-Gobain develops and proposes different building materials or systems which can reduce the amount of target chemicals indoor, which can control the level of humidity in air and walls, which can impair microorganism development. All of these materials or systems participate to decrease the risk of microbial dissemination and their consequences in buildings.
WHAT?  WHEN?  WHY?  WHERE?
Molds

Molds are microorganisms that develop on surfaces, forming stained and fluffy structures. Mold growth is favored in wet environments (humidity between 70% and 95%), under mild temperature (20°C to 30°C) and requires organic nutrients, which can be found in dust.

They are found:
- in bathrooms with poor ventilation
- in poorly maintained ventilation systems
- on any material which can be wet because of plumbing leakage, condensation, etc

Molds release particles called spores in the air. Such spores contribute to mold spreading, and may affect health or well-being of occupants. In France, 37% of dwellings show signs of mold contamination. In North America, 30% to 50% of office and residential buildings have humidity high enough to encourage mold growth.
Molds are made of **two parts:**

- **filaments or mycelium** that are a **few millimeters** long and are involved in surface colonization
- and **spores** that are **2-µm to 20-µm even 200-µm** wide and contribute to dissemination by air

Molds may affect occupants through a wide range of mechanisms which include invasion by or contact with spores, or production of **chemical pollutants** such as microbial volatile organic compounds (**mVOC**).

The most common molds found in indoor environments are **Aspergillus, Cladosporium, Penicillium, Alternaria.**
BACTERIA

Bacteria are single-cell living organisms (1-µm to 10-µm wide). They are found all around us: on surfaces, in air, in dust, in water, etc.

Most bacteria are generally safe. However, some species can become problematic and can affect occupant health, especially in places with the most sensitive people such as schools, residences for elderly, hospitals, etc.

Indoor sources of bacteria are diverse:
- outdoor
- occupants
- pets
- poorly maintained ventilation systems, especially when water reservoirs (fountain, retention points, etc.) are present with mild temperatures
Two main families of bacteria are traditionally described: they were depicted according to their ability to retain the coloration dye during GRAM staining, a property linked to the structure of their envelope:

- the so-called GRAM-positive bacteria harbor a single membrane
- the so-called GRAM-negative bacteria harbor two membranes

Both of these families include pathogenic and non-pathogenic species. In indoor environments, *Bacillus*, *Micrococcus* and *Staphylococcus* (*Pseudomonas* eventually) are commonly encountered.

*Legionella pneumophila* is a well-known GRAM-negative bacterium which causes the pneumonia-like legionnaires’ disease. It grows in warm water (20°C to 40°C) and is carried by water droplets in air. One of the sources of *L. pneumophila* are heating, ventilation and air conditioning (HVAC) systems.
Endotoxins are molecular complexes carried by certain bacteria. Endotoxins are linked to cellular fragments after death, and retrieved in the particulate pollutants of air.

Once inhaled, endotoxins may generate multiple symptoms in people, including cough, fever, irritations of the respiratory tract, chest congestion.

However, because of their interaction with the immune system, endotoxins are also suspected to positively influence its development and maturation in young children. 

Endotoxins in air can affect occupant’s well-being, but exposure at earlier ages may improve children immunity.
Endotoxins are molecular components of the cellular envelop of **GRAM-negative** bacteria. **They are made of a core of fatty acid and a chain of sugars.** They are released in the environment following bacteria cell lysis. Endotoxins are **heat-resistant.** They may become **problematic at high concentrations**, especially in environments with high levels of bacteria (sewage, wastewater treatment units, farms).
ALLERGENS

The majority of allergens found indoor are proteins and come from:
- mold spores
- mites
- pets (cats, dogs, etc.)
- insects (cockroaches, roaches)
- rodents

Allergens can trigger specific, abnormal and excessive immune responses.

The relationship between allergen exposure and sensitization, asthma or allergic diseases is very complex and remains poorly understood.
Mites are microscopic organisms (150 µm to 500 µm) of the spider family. They are found in dust, especially in bedding. Fragments and faeces carry allergens and may be present in air. *Dermatophagoides pteronyssinus* and *D. farinae* are the most common species indoor. They feed on human dander and grow in warm (25 °C to 32 °C), humid (60% to 80%) environments. The associated allergens, Der p and Der f, respectively, cause respiratory allergies.

Pets, especially cats and dogs, produce Fel d 1 and Can f 1, respectively. These allergens are secreted in sweat and saliva, and are mainly carried by particles below 5 µm. They are retrieved in the air of buildings, with or without animal presence.

Cockroaches thrive in damp, dark environments, and are very resistant. They produce droppings that carry allergens. Bla g 1 and Bla g 2 are the most common ones.

In deprived urban areas, the presence of mice and rats is also a source of allergens. Mus m 1 is the most common one. It is produced mainly in urine and is found in the air, carried by particles of any size.
Viruses are sub-micrometric biological particles which cannot reproduce nor develop outside their host, and can survive in the environment for a limited period of time. Airborne viruses are transferred through droplets coming out from infected hosts by coughing, sneezing, etc. Cold and low humidity conditions favor survival and transmission for some influenza viruses. But this does not apply to all types of virus\textsuperscript{13}. 

\textbf{VIRUSES}

Viruses are host-dependent, but some survive in air.
Viruses are **0.02 µm to 0.5 µm** wide infectious agents. Each type can enter and develop in a *limited range of hosts* only, and many are species-specific.

They are made of a proteinaceous capsule which surrounds the genetic material.

Viruses may be released in the air by their host, and stay there or settle onto surfaces. In both cases, their survival is limited to a few hours. *Influenza, measles, chicken pox,* are examples of common airborne viral diseases.
POLLENS

Pollens are **biological particles produced by flowers** for plant reproduction. Pollens can originate from indoor plants, but they generally come from outdoor: they are carried by air, dust, clothes, etc. The surface of pollens harbours molecules that can be more or less allergenic, depending on plant species, and that may cause **hay fever, rhinitis, or other symptoms**.
67% of the indoor pollen concentrations can be explained by the outdoor concentrations. Indoor pollen concentrations are generally lower than outdoor, and depend on ventilation schemes. Indoor pollens mainly originate from wind-pollinated plants, which produce a higher amount of pollens than insect-pollinated plants. Indoor pollens preferentially accumulate in dust: the quantity of floating pollens has been estimated as being about ten times lower than the pollen quantity found on floor. Pollens persist indoor, even after the pollination period. A direct relationship between pollen concentrations and symptom load cannot be made.


