

Aerosol (Airborne) Transmission of Animal Diseases

Qiang Zhang, Professor
Department of Biosystems Engineering
University of Manitoba

Outline



- Basics of aerosols
- Aerosol transmission of diseases
- Aerosol control technologies



Basics of aerosols **(Particulate Matter, PM)**

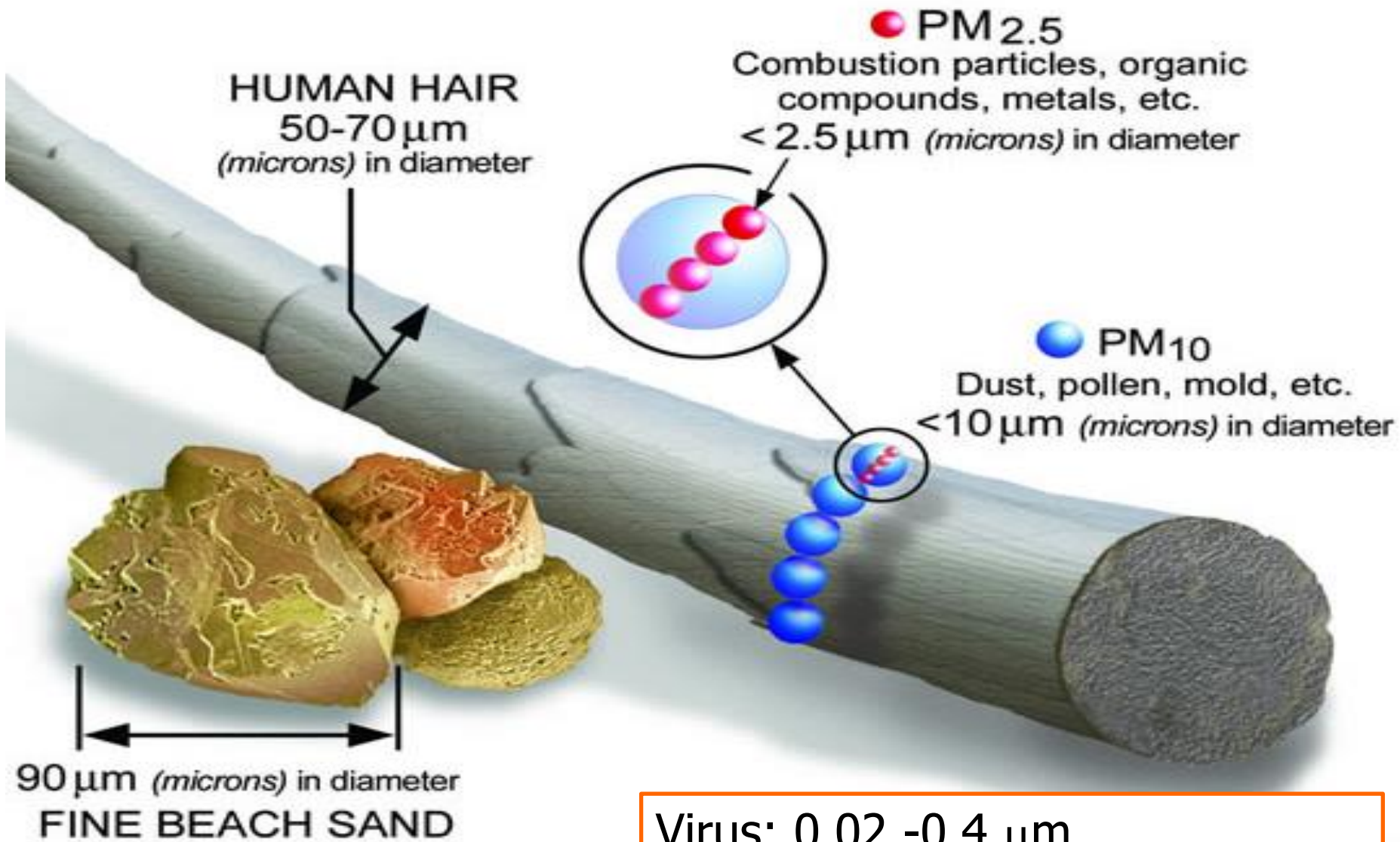
Understanding terms

- **Particulate matter (PM)**: complex mixture of small particles and liquid droplets. PM_{10} and $PM_{2.5}$ represent PM with aerodynamic diameters less than $10\ \mu\text{m}$ and $2.5\ \mu\text{m}$, respectively
- **Aerosols**: stable suspensions of solid or liquid particles in air, *referring to the particulate and air mixture, as opposed to the particulate matter alone.* However, it is common to use the term aerosol to refer to the particulate component alone.
- **Bioaerosols**: aerosols of biological origin or containing biological agents

Understanding terms

- **Dust:** solid particles generated by the handling, grinding, abrasion, or cutting of bulk materials
- **Aerodynamic diameter:** diameter of a sphere with unit density (1.0 g/cm^3) that has the same settling velocity as the particle of interest; dictates the **suspension** time of the particle in the air

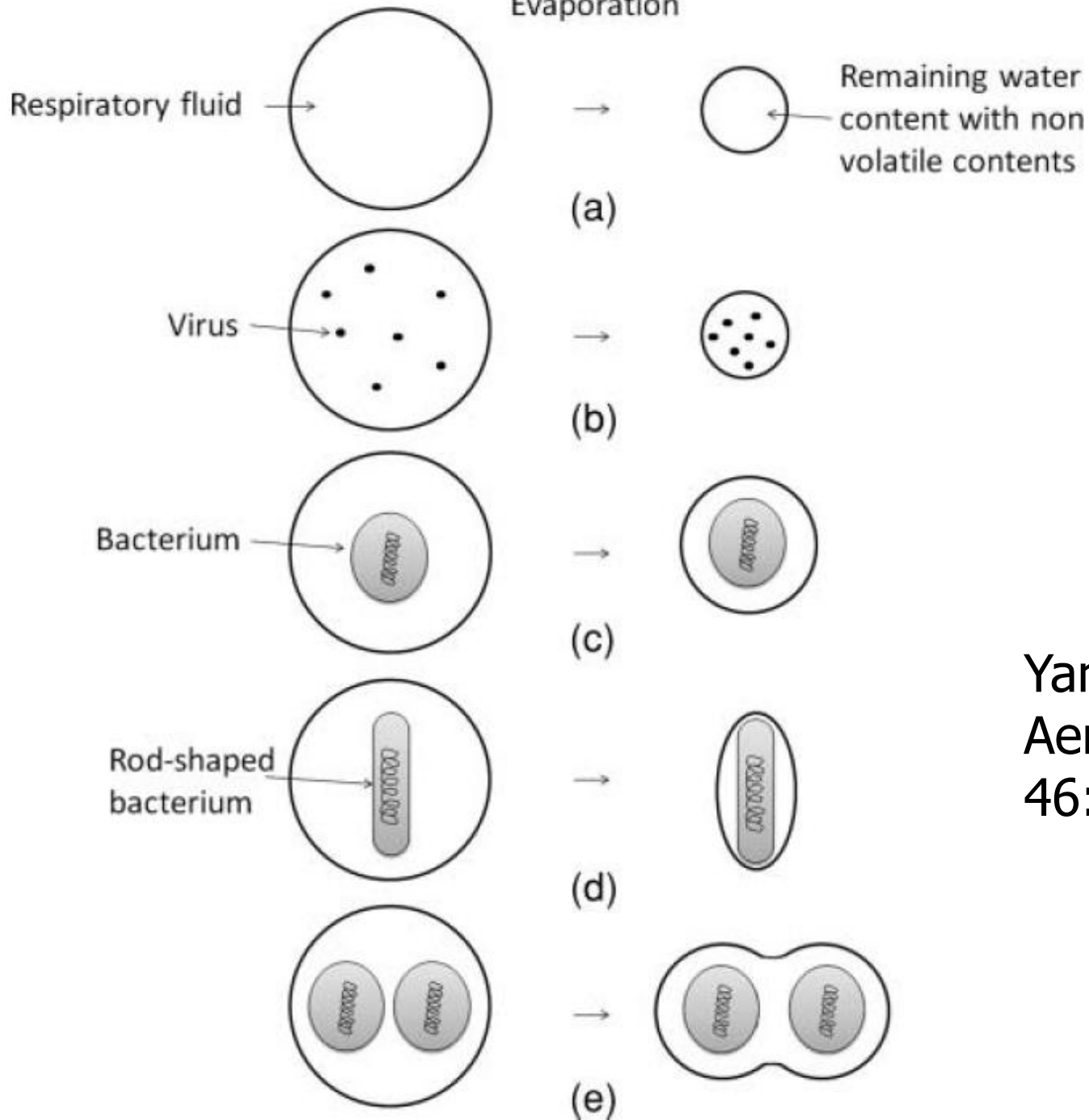
Size of aerosols responsible for airborne disease transmission: not definite, but commonly accepted as **<5 μm** (some suggest **<10 μm**)



Source: US EPA

Virus: 0.02 -0.4 μm
 TB (mTb): 2-4 μm in length
 0.2-0.5 μm in width

Evaporation



Yang et al. 2012.
Aerosol Sci. Tech.
46:1–12



Aerosol transmission of diseases

Disease transmission



- Modes of disease transmission
 - direct contact
 - indirect contact through contaminated objects
 - **airborne transmission**

The concept of airborne disease transmission is ancient, but serious studies only began in 1930's (Knight 1980. Annals NY Academy Sci. 353:147–56).

Many still consider airborne transmission of disease pathogens elusive.

Examples of diseases transmissible by aerosols



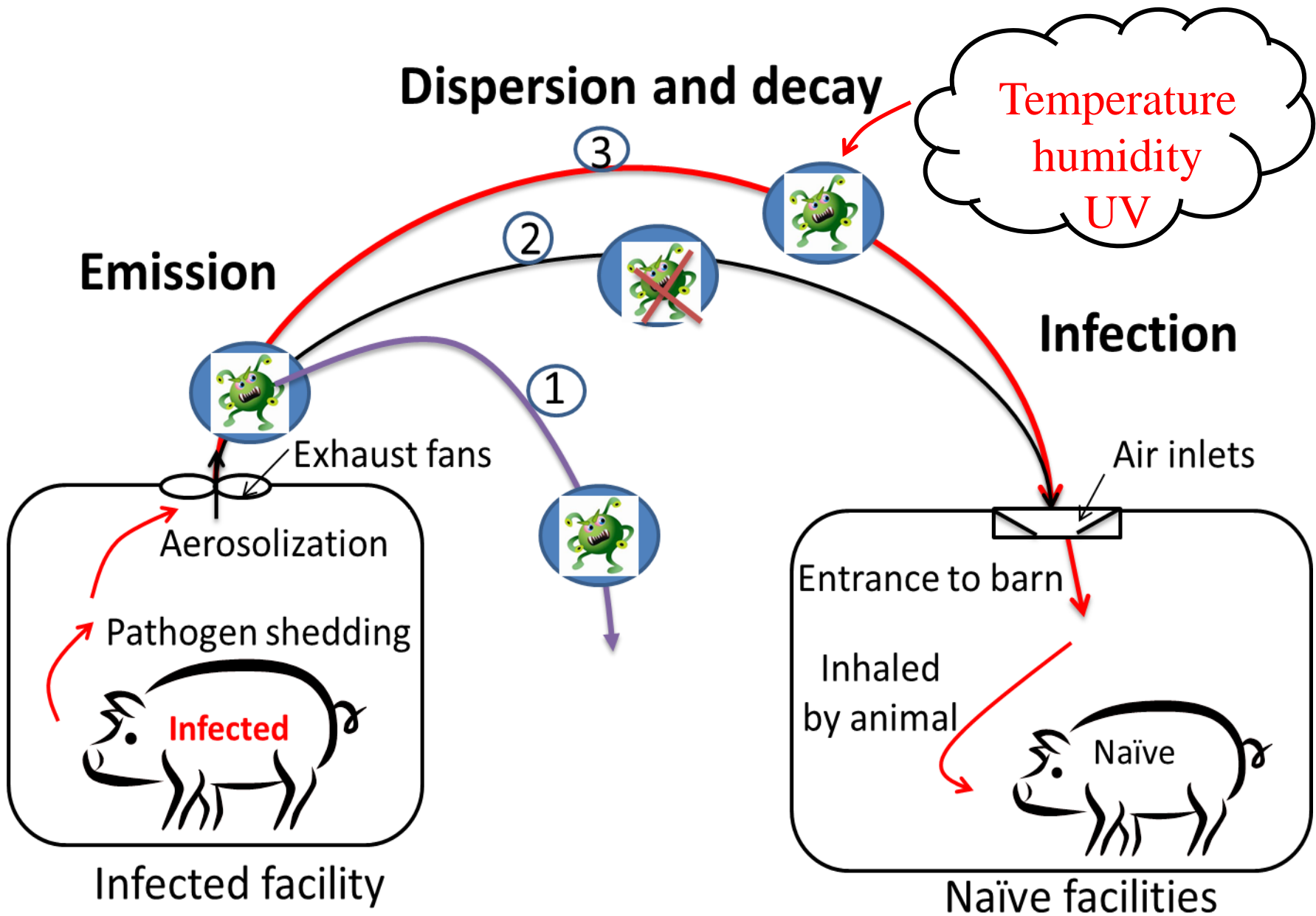
- FMD (foot and mouth disease) (up to 250 km by winds)
- PRRS (porcine reproductive and respiratory syndrome) (about 9 km)
- PED (porcine epidemic diarrhea) ? (PEDv detected in air 10 miles downwind)
- Aujeszky's disease
- Avian Influenza
- Newcastle disease

Importance of aerosol transmission of animal diseases

- Most biosecurity measures for preventing animal disease spread have been focused on direct and indirect contact, with little consideration of airborne transmission.
- Relative to contact transmission, airborne transmission is less understood and much more difficult to control
- Airborne transmission may spread diseases in a considerable distance

Processes of airborne transmission

- Pathogens shed by an infected host are **aerosolized**
 - Pathogens may stay in the air as a single particle, **but most likely they attach to aerosols**
- Pathogen-laden aerosols are dispersed in the air, move with air currents
 - If **inhaled** by other animals, they will cause infection. *Small aerosols reach the lower respiratory tract upon inhalation, and infectious dose by aerosol inhalation is much less (100-fold for influenza viruses) than by inoculation with intranasal drops*
 - If **settled on surfaces**, other animals may get infected by touching/licking the contaminated surfaces



Long distance transmission

Some research questions



- How are pathogens aerosolized?
- What type (solid or liquid, large or small) aerosols are carriers of pathogens?
- How do aerosols behave in the atmosphere (suspension time, size change, etc.)?
- How long do pathogens survive in the air?
How is their survival affected by the environmental conditions and aerosol properties?

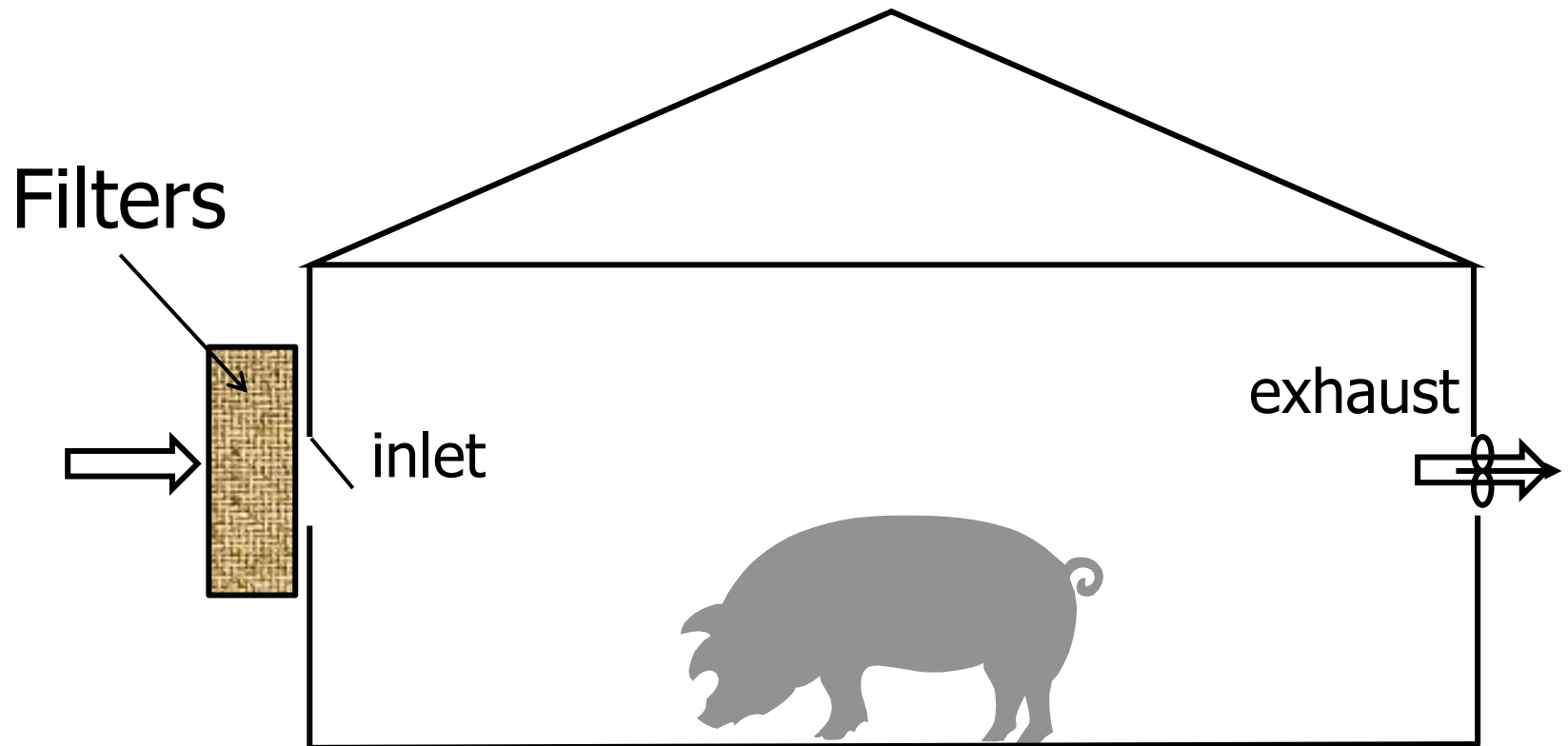


Control technologies

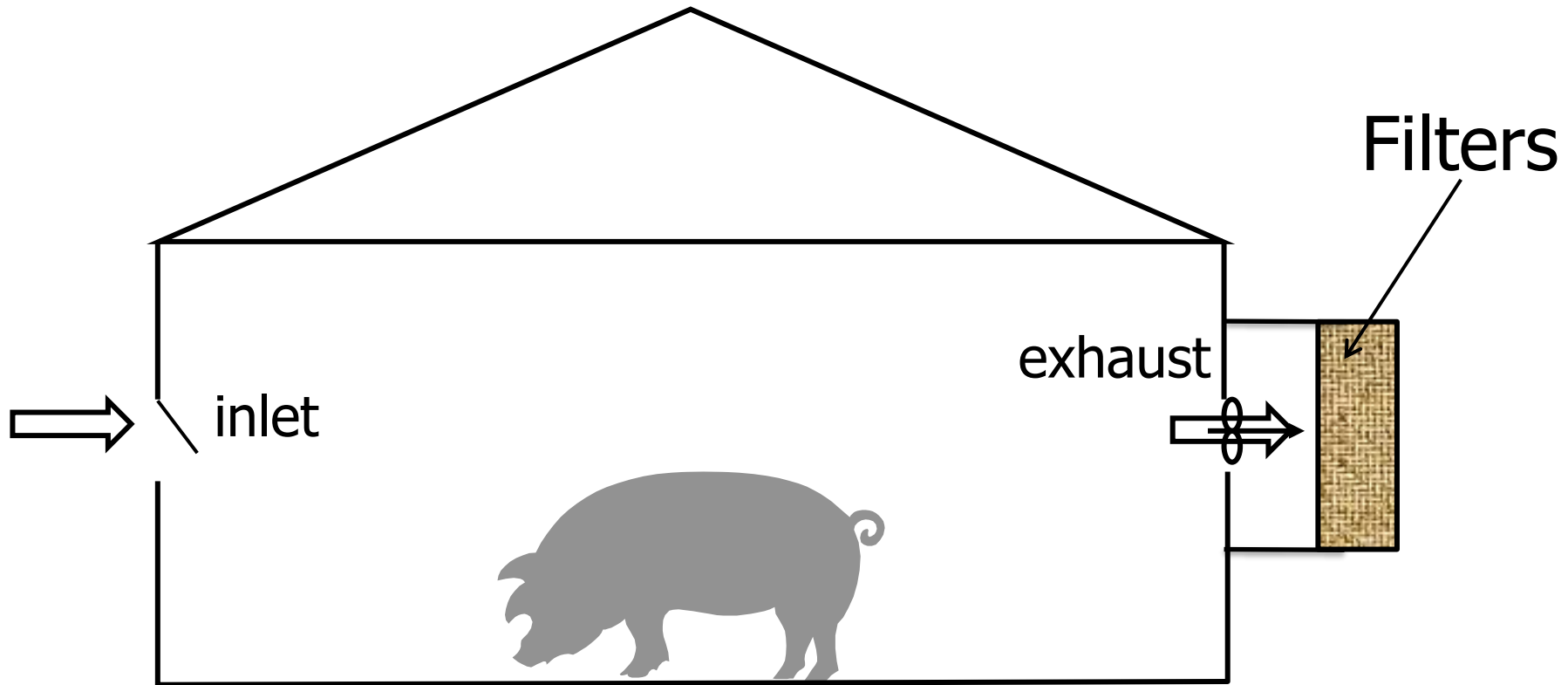
Technologies for reducing aerosol transmission of diseases

- **Air filtration**
 - incoming air
 - exhaust air (biocontainment)
- **Air ionization**
 - aerosol removal
 - bactericidal and virucidal effect
- **Ventilation**
 - prevent/minimize indoor transmission
- **Aerosol (dust) removal**
 - prevent/minimize indoor transmission
 - reduce pathogen emission

Filter incoming air

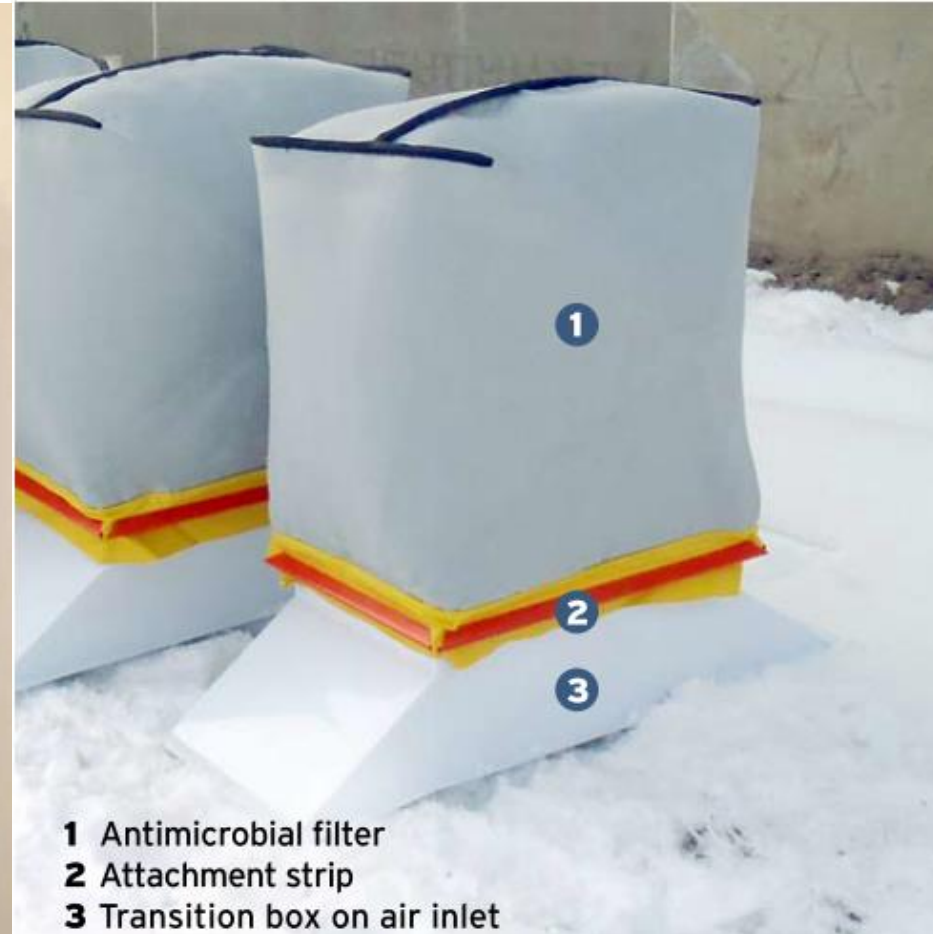


Filter exhaust air (biocontainment)



Mobile biocontainment systems for managing outbreaks?

Filters used for PRRS control



Mechanical filters (Camfil Farr) Antimicrobial filters (Noveko)

(Pouliot et al. 2011)



Big Dutchman <http://www.bigdutchmanusa.com>

Cautions



- Air filtration may interfere with ventilation. Making sure your ventilation fans are capable of overcoming the pressure drops through the filters. If not, adding booster fans is an option
- Filters need regular maintenance (or replacement)

Take home messages



- Many diseases are transmissible by aerosols. Although aerosol transmission is not the main route of transmission of most animal diseases, it is a critical piece in managing disease spread.
- Airborne disease transmission is difficult to manage and few current biosecurity measures are specific for preventing airborne transmission.
- Technologies are available, but expensive.

Thank you for your attention

Questions ?