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particulate matter: measurement techniques

brent w. auvermann
associate professor and extension agricultural engineer
amarillo, tx

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outline

- the role of PM measurement in dairy production
  - regulation
  - research
  - self-assessment
- what is PM, and how is it classified?
- what techniques are available to measure PM?
  - direct
  - indirect

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the role of PM measurement in dairy production

- regulation
  - mass concentrations [M L^{-3}]
    - federal (National Ambient Air Quality Standards)
    - state and local ambient standards
  - emission rates [M T^{-1} or M L^{-2} T^{-1}]
    - federal CAA permitting
      - Title V “major sources”
      - New Source Review (NSR)
      - Prevention of Significant Deterioration (PSD)
  - legal proceedings
    - nuisance odor
    - visibility impairment and liability

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the role of PM measurement in dairy production

- research
  - baseline monitoring
    - what are the typical concentrations?
    - how do they vary over time?
      - diurnally
      - seasonally
      - with capacity changes
  - determining “emission factors”
    - rate of emissions per unit throughput or production
    - lbs PM_{10} per day per 1,000 day capacity
    - lbs $PM_{2.5}$ per cwt of milk produced

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the role of PM measurement in dairy production

- research (cont'd)
  - evaluating abatement measures
    - am i achieving my goals?
    - am i creating new problems by solving old ones?
    - am i spending my money wisely?
    - how could i achieve my goals more efficiently?
      - energy
      - currency
      - labor intensiveness
  - projecting downwind concentrations
    - what are my neighbors' likely exposures?
    - is there a need to reduce their exposures?

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the role of PM measurement in dairy production

- self-assessment
  - determining baseline performance
  - evaluating management changes
    - environmental management systems (EMS)
    - documenting improvements
  - planning future steps
  - engaging neighbors and communities
  - going beyond *what is required* to *what is possible*

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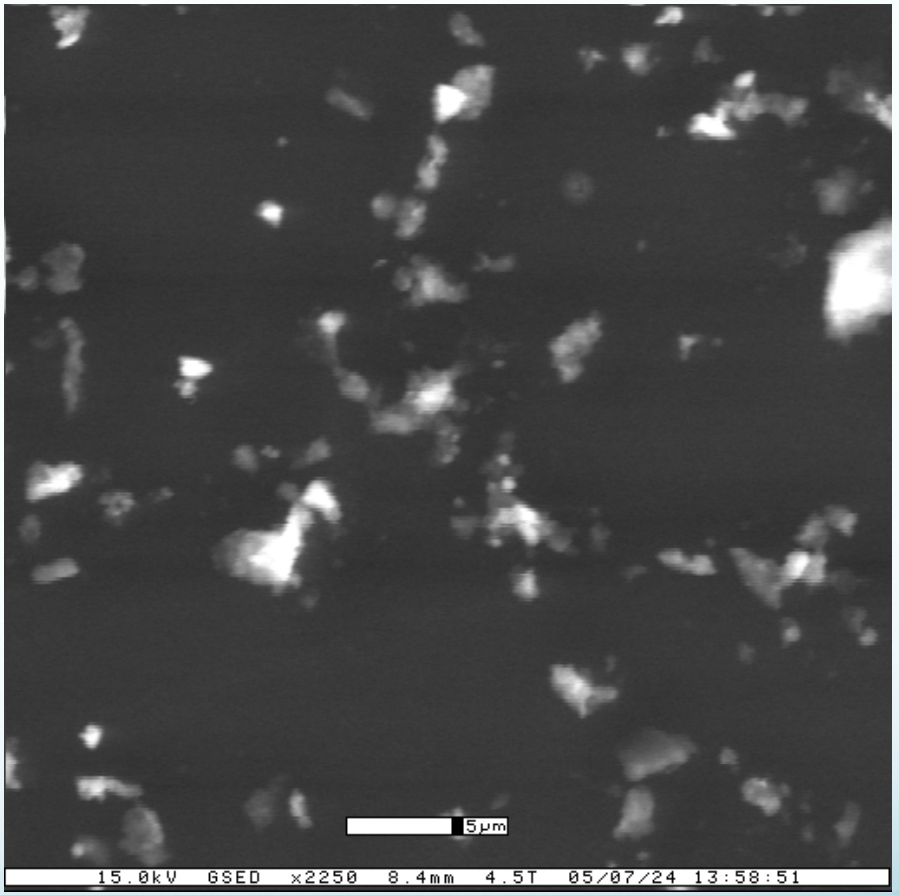
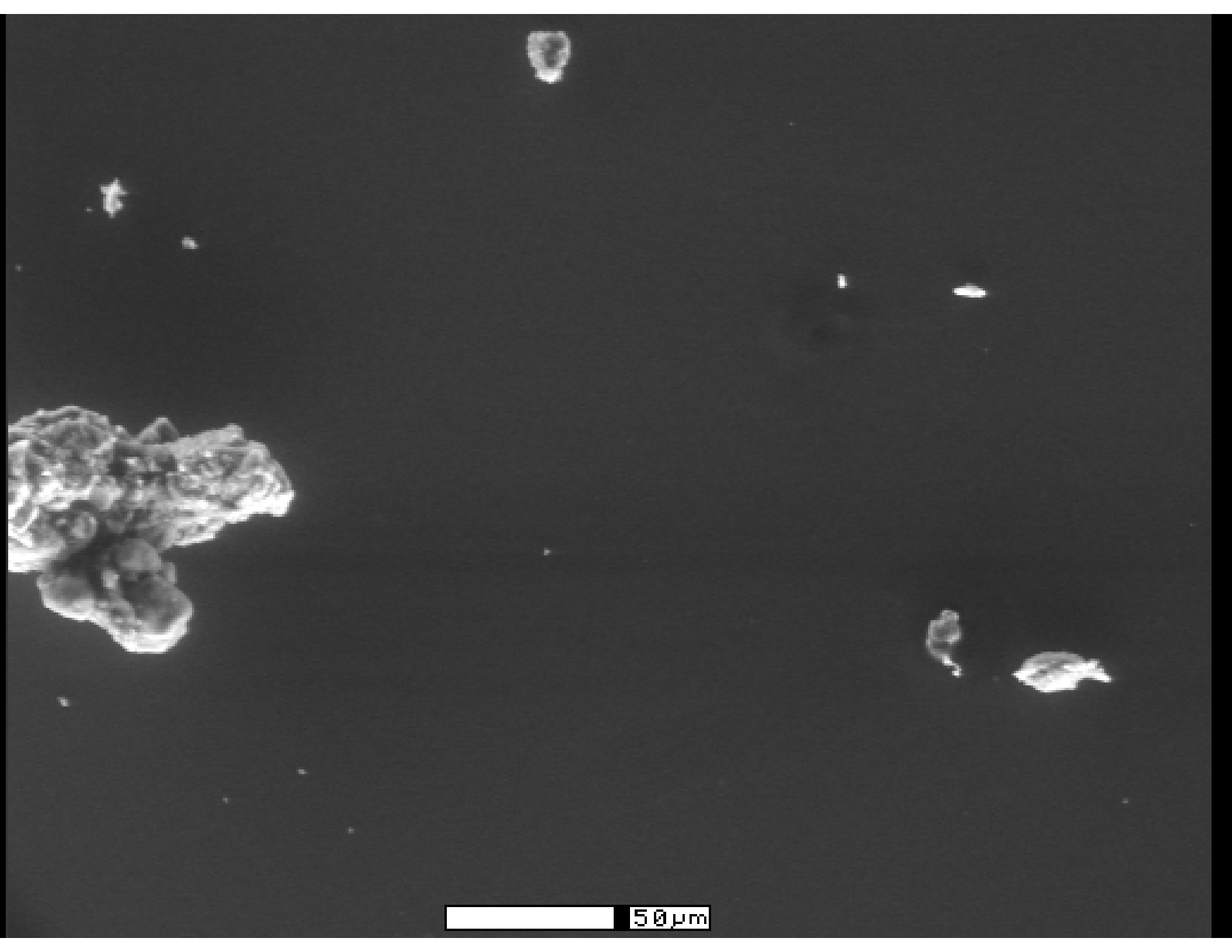
what is PM, and how is it classified?

- no such thing as a “10-micron particle” *per se*
- livestock PM tends to be a mixture of many particle types of variable shape and composition
  - fibers (livestock hair, fibrous feedstuffs)
  - slivers and flakes (dander, clay particles)
  - conglomerates
  - sand and silt




50µm

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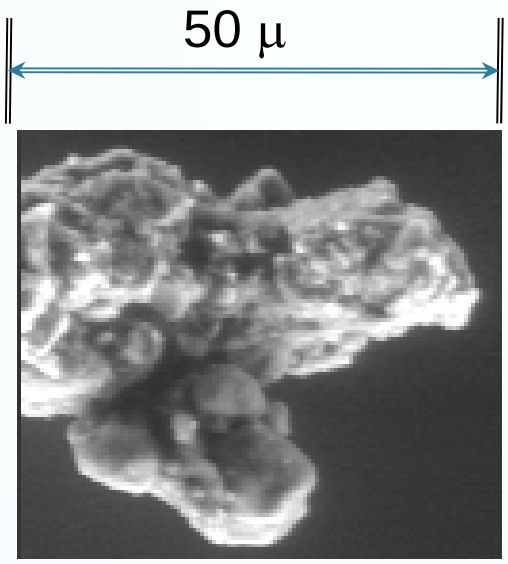
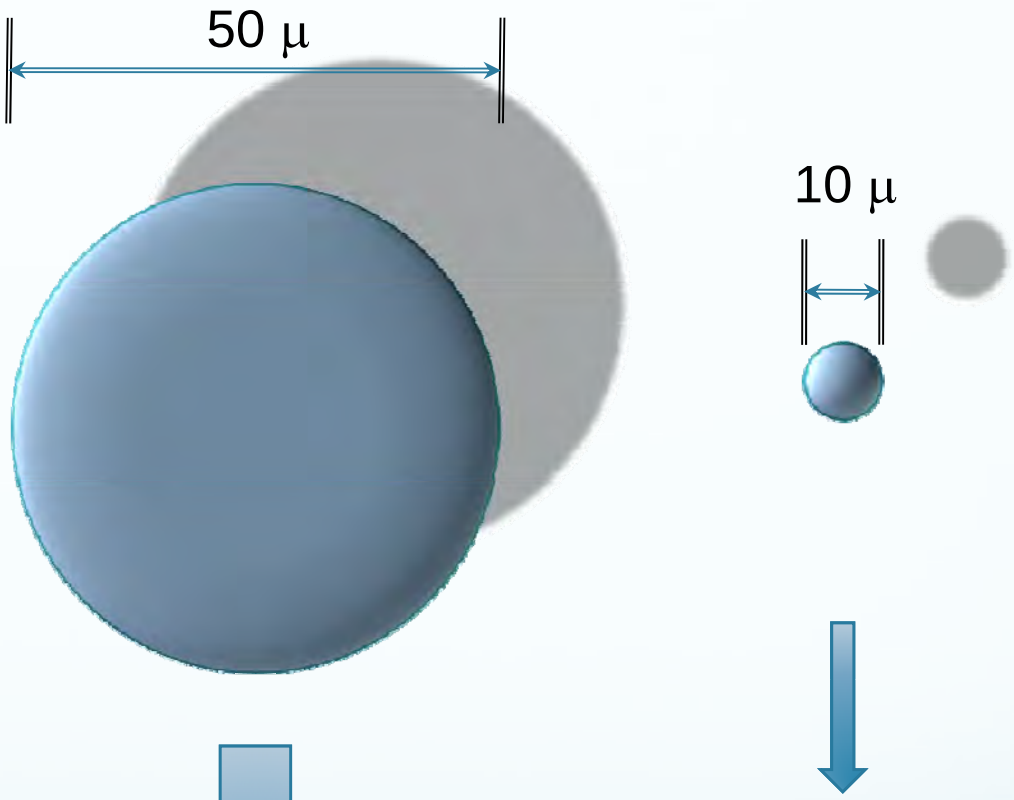
"aerodynamic diameter"





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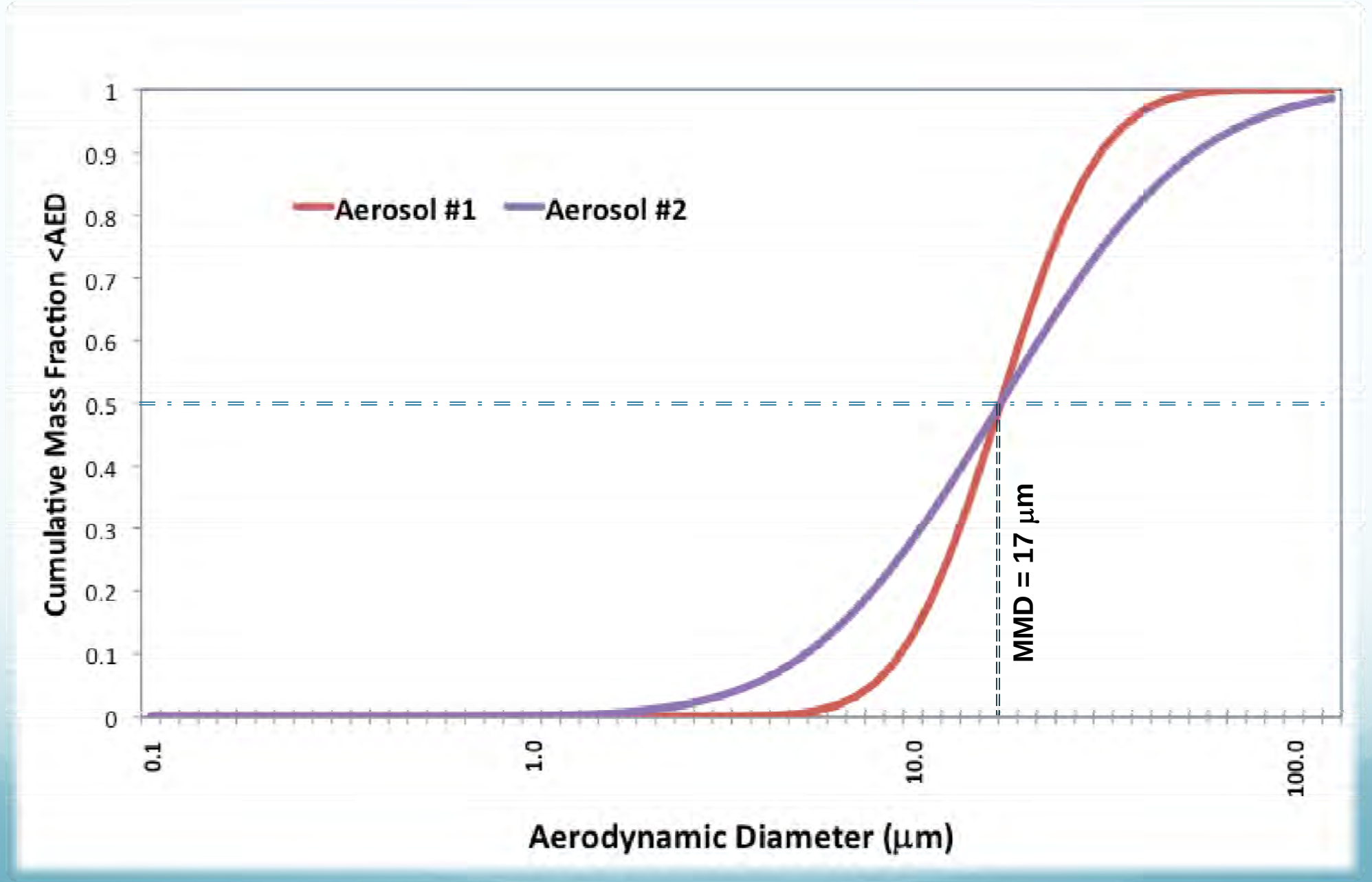

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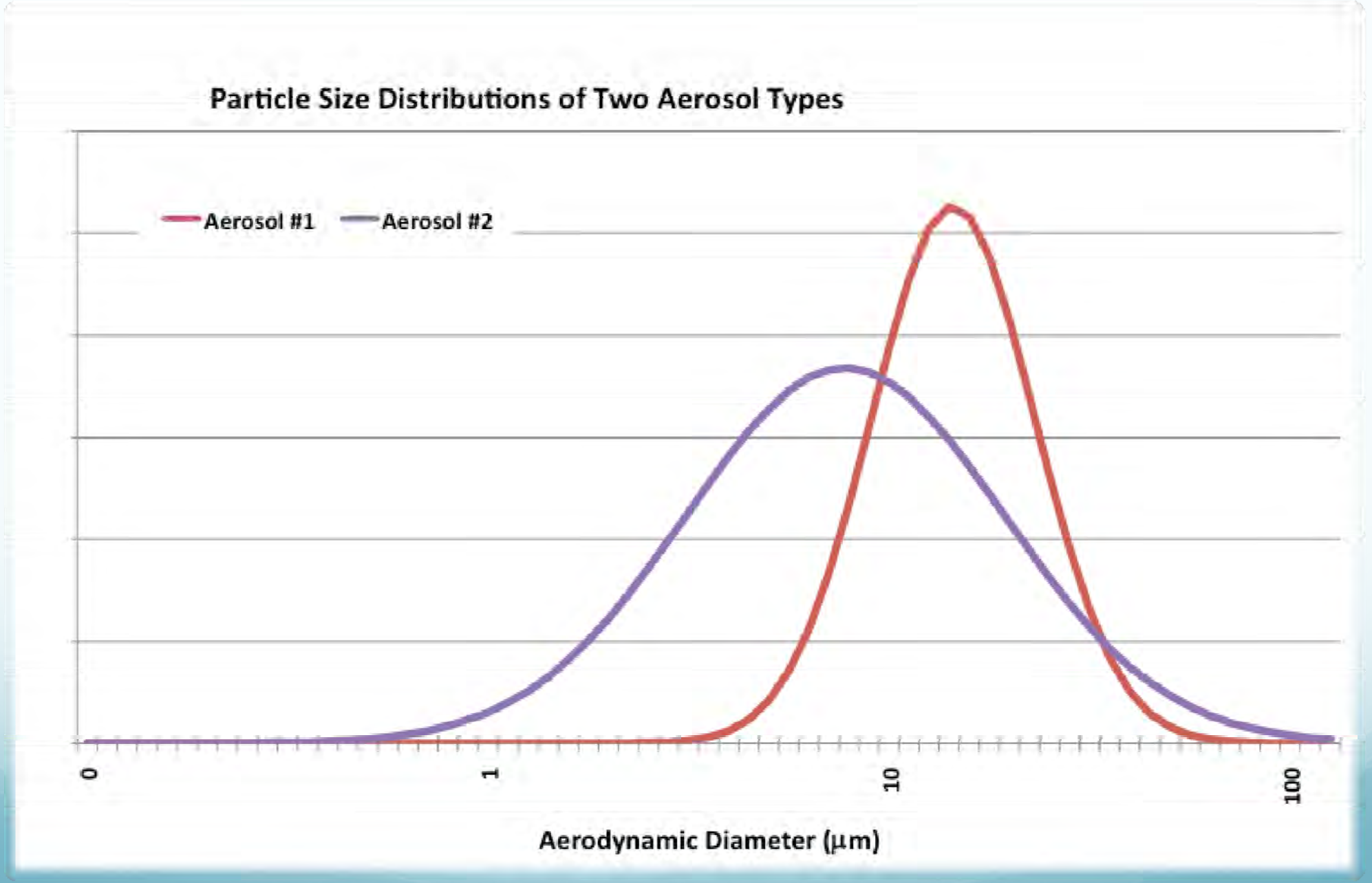
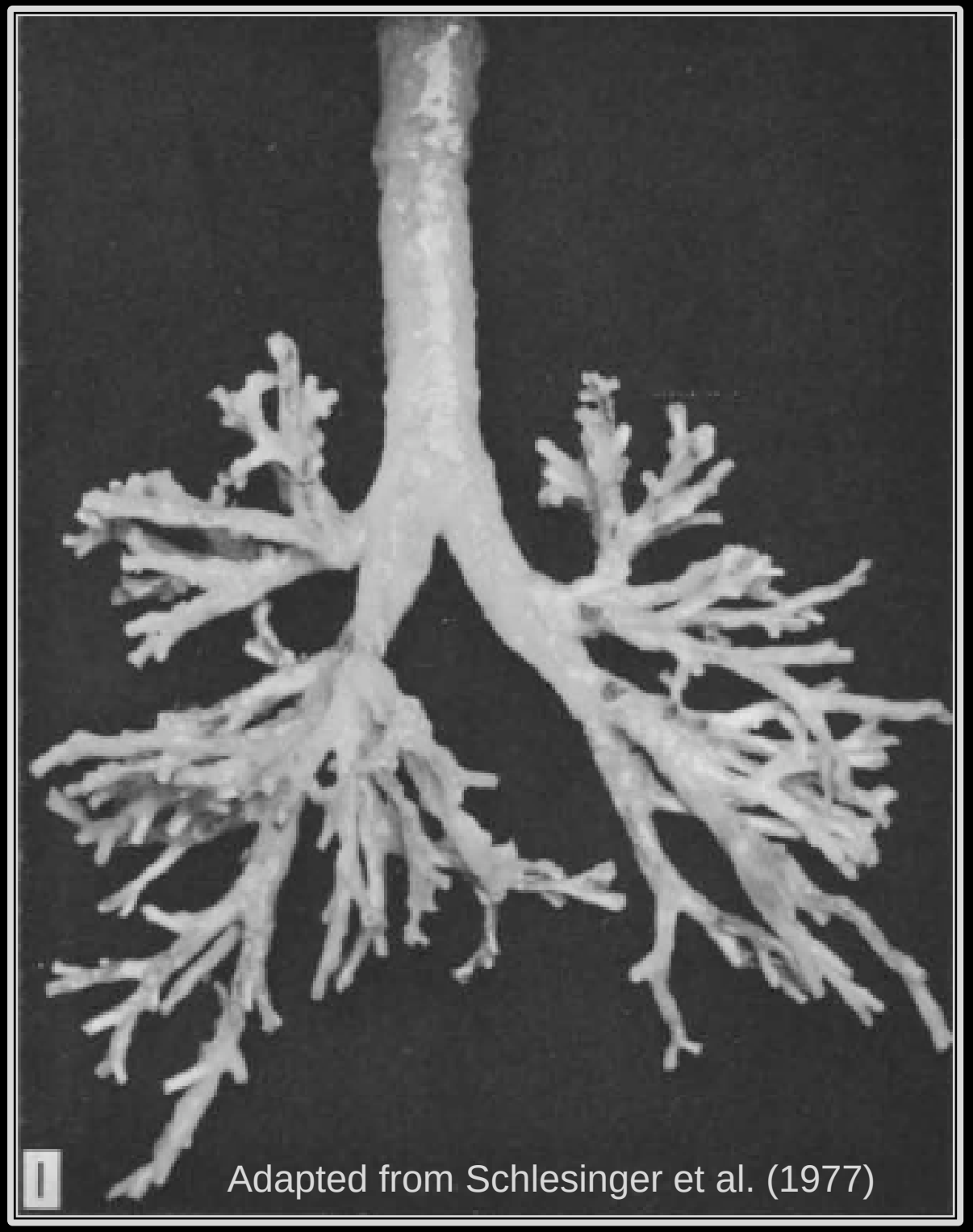


Why Classify Particles by Aerodynamic Diameter?

- Main focus is *human respiratory health*
- The smaller the particle, the easier it is to carry along sharp turns without colliding with the passage walls
- In respiratory systems, the smaller particles penetrate deeper into the lungs where O_2/CO_2 exchange occurs
- $PM_{2.5}$ is more of a health threat than PM_{10} or PM_{50}



fine particles are important for other reasons, too

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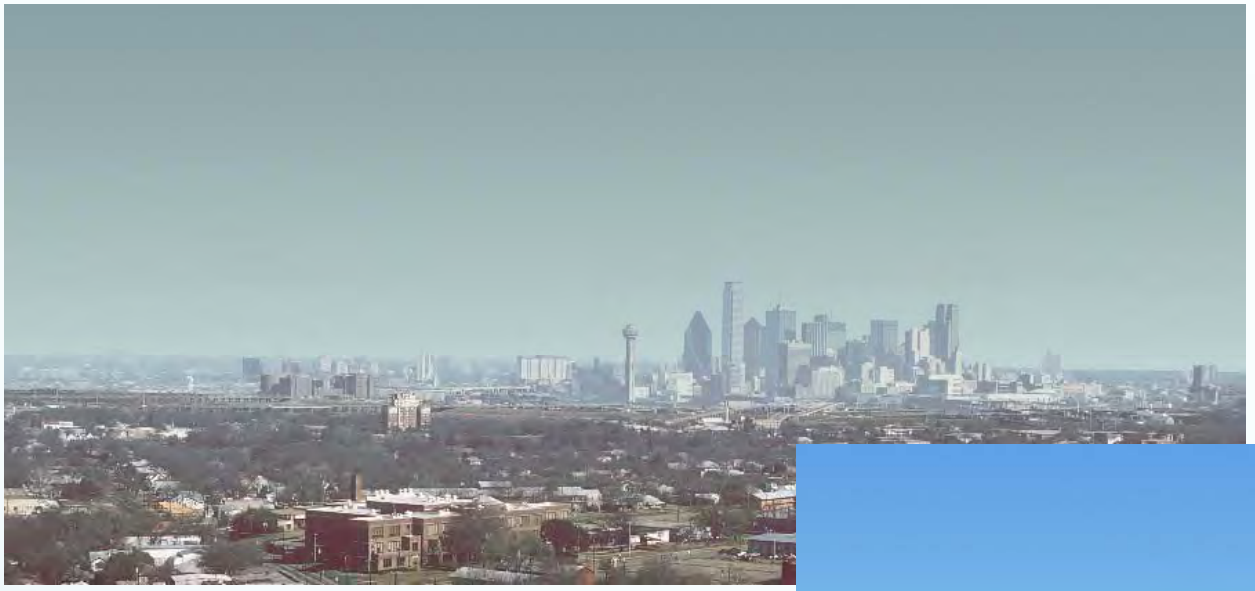

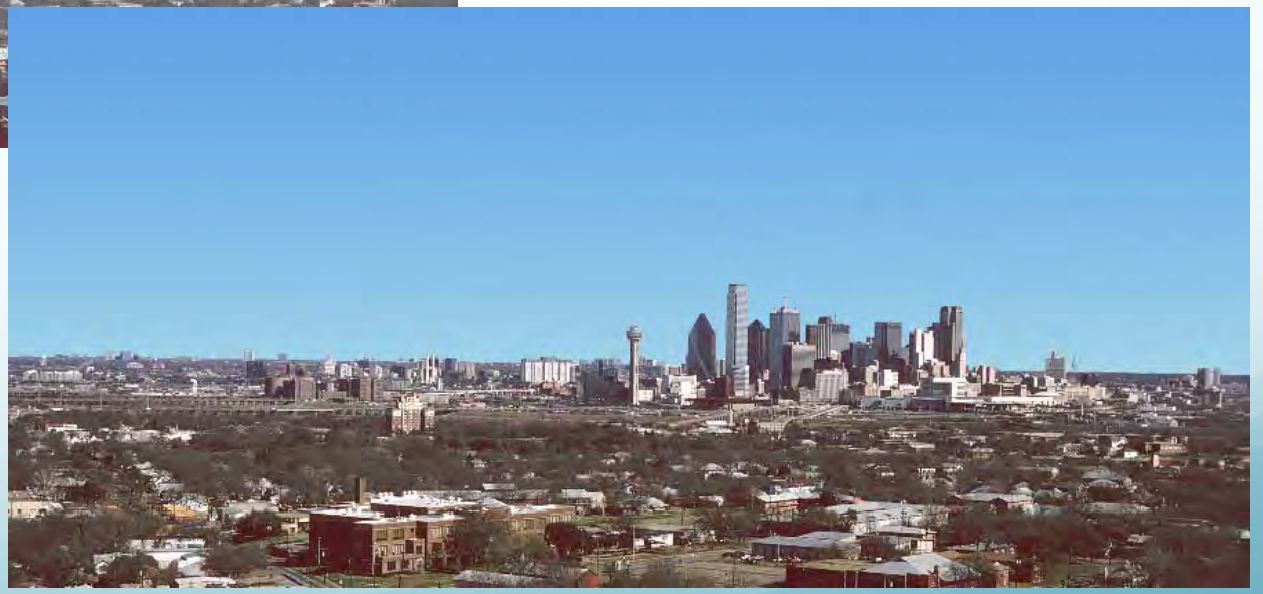

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what techniques are available to measure PM?

- physical basis
  - direct
    - mass concentration ($\mu g/m^3$)
    - number concentration (particles/m^3)
    - total vs. size-selective aerosols (TSP vs. PM_x)
  - indirect
    - active (transmissometry, nephelometry, aethalometry)
    - passive (target imaging)

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what techniques are available to measure PM?

- time basis
  - time-averaged
    - ambient standards (24-hr, annual)
    - occupational standards (8-hr, 30-min)
    - federal or state “reference methods”
    - obscures short-term phenomena
    - *relatively* inexpensive to buy, but may be expensive to run
  - continuous/instantaneous
    - more information; can be used to compute time averages
    - “equivalent methods”
    - relatively high capital expense, but lower labor requirements

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a virtual tour of some methods

Federal Reference Method (TSP)

- No longer used for federal compliance monitoring
- Measures total suspended particulate (~PM_{50})
- Operates at 40 cfm
- Captures TSP on an 8”x10” fiberglass filter
- Filter processing required
  - Pre-exposure conditioning to RH, temp specs
  - Pre-exposure weighing
  - Post-exposure conditioning
  - Post-exposure weighing

Federal Reference Method (PM_{10})

- Currently used for compliance monitoring
- Size-selective inlet collects larger particles on oily impactor surface
- Operates at 40 cfm
- Captures PM_{10} on an 8”x10” fiberglass filter
- Filter processing required
- FRMs also exist for $PM_{2.5}$ compliance monitoring

Tapered-Element Oscillating Microbalance (TEOM)

- Continuous monitor
- May be equipped with size-selective inlets for PM_x