Today, we will:

- Wrap up our discussion about carbon monoxide poisoning
- Discuss the conditioning of inhaled air in Section 2.3.2
- Do some example problems
- Discuss toxicology in Section 2.4
- Discuss sick buildings and bioaerosols in Sections 2.5-2.6
- Discuss dose-response characteristics in Section 2.7

The importance of humidity & temperature in breathing:

- The alveoli require 100% humid air @ the body's core Temp. 
  \( 37.0 ^\circ C = 98.6 ^\circ F \)
- By about \( \frac{2}{3} \) of the way down the bronchial tree,
  \( T = 37.0 ^\circ C, \ \phi = 100\% \) (saturated with water vapor)

When you INHALE:
- Cold, dry air in
- Mucous lining (very moist mucus)
- Heat transfer from mucus to air
- \( \text{H}_2\text{O} \) evaporates from mucus to the air
  (leads to additional heat \( \Delta T \) for the mucus cool down a little)

When you EXHALE:
- Mucous dryer & cooler
- Condensation onto mucus occurs
  (recover some of the moisture lost during inhalation)
Overall, we recover about 25% of the water that was evaporated during inhalation.

Overall, the body loses both heat and water by breathing. Up to 15% of your body's total heat loss is due to breathing.
Example

Given: A man is walking on a hot day in Arizona.
- The outside air conditions are $T = 35^\circ C$, $P = 99.8$ kPa, and $\Phi = 10\%$.
- After breathing, the exhaled air conditions are $T = 30^\circ C$, $P = 99.8$ kPa, and $\Phi = 85\%$.

To do: Estimate the man’s volume of \underline{liquid} water loss per hour due to breathing.

Solution:

\[
\begin{align*}
\text{Table A-17} & \rightarrow P_v \text{ or } P_{sat} \text{ of } H_2O @ T = 30^\circ C \rightarrow 4.246 \text{ kPa} \\
\text{(exhale)} & \\
\text{Ex. 1-29} & \rightarrow C_j = \frac{P}{T} \frac{M_j}{R_u} \\
\text{(inhale)} & \\
\text{Def of } \Phi & \Rightarrow y_j = \frac{P_j}{P}, \quad \Phi = \frac{P_j}{P_{vj}} \\
\text{Let } y_j = \Phi \frac{P_{vj}}{P} \\
C_j = \Phi \frac{P_{vj} M_j}{R_u T} \\
\end{align*}
\]

Recall, $\dot{m}_j = C_j Q = C_j V$

\text{What Q to use? } Q_t \text{ or } Q_a ?$

Since the air is conditioned in the bronchial tubes, $Q_t$ is the better choice.

\[
\begin{align*}
\text{Table 2.4} & \rightarrow \text{Light exercise (LE) } Q_t = 32.2 \text{ L/min (of air)} \\
\text{So, inhalation} & \rightarrow \dot{m}_{j, \text{in}} = C_j Q_t = \Phi \frac{P_{vj, \text{in}} M_{H_2O}}{R_u T_{\text{in}}} Q_t \\
\text{Similarly, exhalation} & \rightarrow \dot{m}_{j, \text{ex}} = C_j Q_t = \Phi \frac{P_{vj, \text{ex}} M_{H_2O}}{R_u T_{\text{ex}}} Q_t
\end{align*}
\]
Combine \( \dot{m} \), net loss = \( \dot{m}_{\text{ex}} - \dot{m}_{\text{in}} \)

\[ Q_j = \frac{\dot{m}_j}{P_j} \]

where \( P_j \) here \( u \) in terms of liquid water
\( P_j = 1000 \text{ baryes} \)

Final eq.

\[ Q_j \left[ \text{or } T_j \right] = \frac{Q_t}{P_j} \frac{M_j}{Ru} \left[ \left( \frac{\Phi P_j}{T} \right)_{\text{ex}} - \left( \frac{\Phi P_j}{T} \right)_{\text{in}} \right] \]

Ans. in variables

Plug in the \& do some unit conversion:

\[ Q_j = 0.042 \frac{L}{hr} \text{ of liquid water} \]

For HE (heavy exercise) \( \rightarrow \text{get } 0.116 \frac{L}{hr} \)

Toxicology Sec 2.9 (Read)

Ex. 2.3 \( \rightarrow \text{make sure you understand this problem} \)

- Particle \( D_p \) = particle diameter (in microns typically)
  \[ 1 \mu m = 10^{-6} m \]

- General "rule of thumb" \( \cdot \text{If } D_p \leq 10 \mu m, \text{ it is } \text{inhaleable} \)
  \[ \text{[gets into the bronchial tubes, but mucous catches it,} \\
  \text{\& cilia remove these particles]} \]
If $d_p \leq 2.5 \text{ mm}$, the particle is \textbf{respirable}.

[get all the way down to the alveolar region]

"Fine particles" \textbf{→} These are of greater concern

\textbf{Ch. 8 \rightarrow Particle}

\textbf{Sec. 2.5-2.6 Sick Buildings \& Bioaerosols}

\textbf{SBS Sick Building Syndrome} \textbf{→} People get sick due to poor air quality in a building caused by molds, yeasts, bacteria, spores, etc.

\textbf{Bioaerosols} \textbf{[also called biogenic aerosols]}

\textbf{aerosol} = particle suspended in air

\textbf{biological (life)} \textbf{→} pollens, bacteria, viruses, molds, \textit{etc.}
When setting PELs, 3 things to consider:

- 1. **Body exposure** → How much the body is exposed to
- 2. **Body absorption** → How much the body actually absorbs
- 3. **Body response** → How does the body react to the chemical