Today, we will:

- Discuss the HERP index, and do some example problems
- Review some fundamentals

\[ \text{HERP INDEX} = \frac{\text{Human Exposure (dose)}}{\text{Rodent Potency (dose)}} \]

An index for comparing the carcinogenicity of substances

Rat i. mouse test

Define

\[ TD_{50} = \text{daily dose rate} \left( \frac{\text{mg of chemical}}{\text{kg of body weight}} \right) \text{ for which} \]

50% of the rodents develop cancer

Define HERP index (5%)

\[ \text{HERP} = \left( \frac{\text{daily human dose} (\text{mg/kg})}{\text{rodent TD}_{50} (\text{mg/kg})} \right) \times 100\% \]

See HERP table on website

- HERP value of 0.6% means that a person has a \( \frac{0.6}{2} = 0.3\% \)
  chance of getting cancer
- Assume that rat i. mouse scale up one-to-one with people
- \text{LARGER HERP mean greater risk}
Example: HERP Index

Given:
- Bacon has some carcinogens
- Diet soda with saccharin has some carcinogens

To do: Using HERP data, calculate how many 30 gram servings of bacon per day (every day of your life) you would need to eat to have the same cancer risk as drinking the average amount of diet cola with saccharin (every day of your life). [Average is about one can per day.]

Solution:
Here are some selected screen shots from the HERP table on the website:

<table>
<thead>
<tr>
<th>Possible hazard:</th>
<th>Average daily U.S. exposure</th>
<th>Human dose of rodent carcinogen</th>
<th>Potency TD&lt;sub&gt;50&lt;/sub&gt; (mg/kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HERP (%)</td>
<td></td>
<td></td>
<td>Rats</td>
</tr>
<tr>
<td>140</td>
<td>EDB: production workers (high exposure) (before 1977)</td>
<td>Ethylene dibromide, 150 mg</td>
<td>1.52</td>
</tr>
<tr>
<td>17</td>
<td>Clofibrate</td>
<td>169</td>
<td>(+)</td>
</tr>
<tr>
<td>12</td>
<td>Phenobarbital, 1 sleeping pill</td>
<td>Phenobarbital, 60 mg</td>
<td>(+)</td>
</tr>
<tr>
<td>0.008</td>
<td>Aflatoxin: daily U.S. avg (1984-89)</td>
<td>Aflatoxin, 18 ng</td>
<td>0.0032</td>
</tr>
<tr>
<td>0.007</td>
<td>Celery, 14 g</td>
<td>Caffeic acid, 1.51 mg</td>
<td>297</td>
</tr>
<tr>
<td>0.007</td>
<td>d-Limonene</td>
<td>Food additive, 1.01 mg</td>
<td>204</td>
</tr>
<tr>
<td>0.007</td>
<td>Cinnamon, 21.9 mg</td>
<td>Coumarin, 65.0 µg</td>
<td>13.9</td>
</tr>
<tr>
<td>0.006</td>
<td>Coffee, 11.6 g</td>
<td>Furfural, 783 µg</td>
<td>(683)</td>
</tr>
<tr>
<td>0.005</td>
<td>Coffee, 11.6 g</td>
<td>Hydroquinone, 290 µg</td>
<td>82.8</td>
</tr>
<tr>
<td>0.005</td>
<td>Saccharin: daily U.S. avg (1977)</td>
<td>Saccharin, 7 mg</td>
<td>2140</td>
</tr>
<tr>
<td>0.005</td>
<td>Carrot, 12.1 g</td>
<td>Aniline, 624 µg</td>
<td>194&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.004</td>
<td>Bread, 79 g</td>
<td>Furfural, 584 µg</td>
<td>(683)</td>
</tr>
<tr>
<td>0.001</td>
<td>Bacon, 19 g</td>
<td>Diethylamine, 19 ng</td>
<td>0.0266</td>
</tr>
<tr>
<td>0.0008</td>
<td>Bacon, 19 g</td>
<td>Dimethylamine, 57.0 mg</td>
<td>0.0959</td>
</tr>
<tr>
<td>0.0008</td>
<td>DDE: daily U.S. avg (before 1972 ban)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>DDE, 6.91 µg</td>
<td>(--)</td>
</tr>
<tr>
<td>0.0007</td>
<td>TCDD: daily U.S. avg (1994)</td>
<td>TCDD, 12.0 pg</td>
<td>0.0000235</td>
</tr>
<tr>
<td>0.0007</td>
<td>Bacon, 19 g</td>
<td>N-Nitrosopyrrolidine, 324 ng</td>
<td>(0.799)</td>
</tr>
<tr>
<td>0.0006</td>
<td>Methyl eugenol</td>
<td>Food additive, 7.7 µg</td>
<td>(19.7)</td>
</tr>
<tr>
<td>0.0004</td>
<td>EDB: Daily U.S. avg (before 1984 ban)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>EDB, 420 ng</td>
<td>1.52</td>
</tr>
<tr>
<td>0.0004</td>
<td>Tap water, 1 liter (1987-92)</td>
<td>Bromodichloromethane, 13 µg</td>
<td>(72.5)</td>
</tr>
<tr>
<td>0.0004</td>
<td>Celery, 14 g</td>
<td>8-Methoxypsoralen, 8.56 µg</td>
<td>32.4</td>
</tr>
<tr>
<td>0.0003</td>
<td>Mango, 1.0 g</td>
<td>d-Limonene, 40.0 µg</td>
<td>204</td>
</tr>
</tbody>
</table>
Solution:

Let \( N_b \) = # of 30 g serving of bacon per day

Let \( N_s \) = # of can of soda per day

Equate the risk:

\[
\frac{\text{Bacon risk}}{\text{Soda risk}} = N_b \left( \frac{\text{HERP}}{\text{serv}} \right)_b \left( \frac{\text{mg}}{\text{serv}} \right)_b = N_s \left( \frac{\text{HERP}}{\text{serv}} \right)_s
\]

Solve for \( N_b = \frac{N_s \left( \frac{\text{HERP}}{\text{serv}} \right)_s}{\left( \frac{\text{mg}}{\text{serv}} \right)_b \left( \frac{\text{HERP}}{\text{mg}} \right)_b} \)

\[
N_b = \frac{(\text{1 serving}) (0.005 \%) \text{/serv}}{(30 \text{ g}) \left[ 0.001 + 0.0001 + 0.0007 \right] \text{x} 19 \text{ g}}
\]

\[
N_b = 1.27 \text{ servings of bacon}
\]

\[
\frac{N_b}{\text{serv}} = \text{1.3 servings of bacon}
\]

Always give HERP problem answer to 2 sig. digits,

Actual risk for both cases = \( \text{HERP(1\%)} / 2 = 0.005\% / 2\)

Answer: you have a 0.0025% chance of getting cancer

1 chance in 40,000
**Fundamentals Review**

- Mass per mol of a substance
  
  \[ \text{mass per mol} = \frac{\text{mass}}{\text{mol}} \]
  
  or
  
  \[ \text{mass per mol} = \frac{g}{\text{mol}} \]

- Example: Carbon (C), \( M_C = 12.0107 \frac{g}{\text{mol}} \)

- One mol = \( 6.0225 \times 10^{23} \) molecules

\[ \text{Avogadro's #} \]

\[ \text{kmol} = 1000 \text{ mol} \]

- Molality
  
  \[ m = \frac{n}{M} \]
  
  \( n \) is the number of moles

- \( M_{\text{air}} = 28.97 \frac{g}{\text{mol}} \)
  
- \( M_{\text{H}_2O} = 18.02 \frac{g}{\text{mol}} \)

- **Ideal Gas Law** (gas behaves like an ideal gas)

  \[ P T = n R_u T \]
  
  or
  
  \[ P V = n R_u T \]

  \( R_u \) = Universal gas constant (for any gas)
  
  \( R \) = Specific gas constant (for a particular gas)

  \[ R = \frac{R_u}{M} \]

  \( R_u = 8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}} = 8.314 \frac{\text{kJ}}{\text{kmol} \cdot \text{K}} = 8.314 \frac{\text{J}}{\text{kmol} \cdot \text{K}} \)
\[ M = 28.97 \ \text{kg/mol} \]
\[ R_{\text{air}} = \frac{R_v}{M} = \frac{8.314 \ \text{kJ/mol} \cdot \text{K}}{28.97 \ \text{kg/mol}} = 0.287 \ \text{kJ/kg} \cdot \text{K} \]

or \[ 287 \ \frac{\text{J}}{\text{kg} \cdot \text{K}} \]

\[ \text{Stoichiometric mass balance} \]

\[ aN_2 + bO_2 = cNO \]

\[ a, b, c = \text{mole coefficients} \]

\[ \text{individual molecules or } \# \text{ of mol} \text{ of these molecules must be conserved} \]

\[ \text{N: } 2a = c \rightarrow \boxed{c = 2a} \]
\[ \text{O: } 2b = c \rightarrow b = \frac{c}{2} = a \]

\[ \text{arbitrary: Pick } a = 1 \rightarrow b = 1, c = 2 \rightarrow \boxed{N_2 + O_2 = 2NO} \]

or \[ \text{Pick } a = \frac{1}{2} \rightarrow b = \frac{1}{2}, c = 1 \rightarrow \boxed{\frac{1}{2} N_2 + \frac{1}{2} O_2 = NO} \]
Doctor, please help! I woke up with this strange looking mole on my hand!

- **Volume Flow Rate**
  - \( Q \) or \( V \)
  - More popular in air pollution \([m^3 \cdot \text{sec}]\)
  - Less popular in fluid mechanics \([L^3 \cdot \text{sec}]\)

\[
\{Q\} = \left\{ \frac{\text{Vol}}{\text{time}} \right\} = \left\{ \frac{L^3}{t} \right\}
\]

\[
[Q] = \left\{ \frac{m^3}{s} \right\}, \left\{ \frac{m^3}{\text{min}} \right\}, \left\{ \frac{ft^3}{\text{min}} \right\}, \left\{ \frac{L}{\text{min}} \right\}
\]

\[Q = U \cdot A\]

\( U \) - avg velocity in a duct, \( A \) - cross-sectional area

\[\text{CFM}\]