Challenge Statement

Zeetings Live Poll

Go to: ccmicrobiology
Flash Review
## Symbiotic Association Interactions between Species

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Species Interacting</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutualism</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Syntrophy</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Commensalism</td>
<td></td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Parasitism</td>
<td></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Antagonism (amensalism)</td>
<td></td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Competition</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Carbon Cycle

**Figure 27.2**

- Anaerobic
  - Carbon fixation
  - Anaerobic respiration and fermentation
  - Methanogenesis
  - Methane oxidation

- Aerobic
  - Carbon fixation
  - Respiration
  - Carbon monoxide oxidation
  - CO

- Organic matter (CH₂O)
The Microbes Side
Digestion is a Symbiotic Relationship

Taking a cue from our Ruminant Friends
Ruminants

- organisms that have a rumen:
  Ex.) cows, goats, sheep, deer, camels, moose, elks, etc

Rumen:
A 4-gut organ found at the beginning of the digestive system where food get regurgitated for rumination

A bioreactor organs that ferment indigestible plant matter
Digestion

Ruminant animals are unable to digest plants on their own.

Plants are made of cellulose, xylan, and fructosan (long polymeric compounds) which are all indigestible by the animal because of the very stable and insoluble covalently linked glucose residues.

Solution: the Rumen

Rumen is an controlled environment: 38°C, anaerobic conditions, pH is buffered by carbonate (keeping it neutral), chemostat growth vessel: constant log growth phase (constant input and output of nutrients and waste).
Microbes found in the Rumen are obligate anaerobes that are able to break down cellulases, xylanases, and fructosanases.

The polymers are hydrolyzed and glucose undergoes fermentation to generate: lactate, succinate, acetate, propionate, butyrate, methane, hydrogen gas, and carbon dioxide.

Methane plays an important role because of the methanogenesis.

Methane is a byproduct of microbial metabolism.
Fermentation

- The end product of one microbe is another microbe’s food
- Digestion is a community effort!
  - There are cellulose, starch, lactate, succinate, pectin decomposers, and methanogens
  - Ex) Fibrobacter succinogenes (cellulose decomposer) produces succinate, acetate, and formate → schwartzia succinivorans (succinate decomposer) produces propionate
## Characteristics of Some Rumen Prokaryotes

<table>
<thead>
<tr>
<th>Organism</th>
<th>Gram stain</th>
<th>Phylogenetic domain</th>
<th>Morphology</th>
<th>Motility</th>
<th>Fermentation products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cellulose decomposers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fibrobacter succinogenes**</td>
<td>Negative</td>
<td>B</td>
<td>Rod</td>
<td>-</td>
<td>Succinate, acetate, formate</td>
</tr>
<tr>
<td>Butyrivibrio fibrisolvens**</td>
<td>Negative</td>
<td>B</td>
<td>Curved rod</td>
<td>+</td>
<td>Acetate, formate, lactate, butyrate, H₂, CO₂</td>
</tr>
<tr>
<td>Ruminococcus albus**</td>
<td>Positive</td>
<td>B</td>
<td>Coccus</td>
<td>-</td>
<td>Acetate, formate, H₂, CO₂</td>
</tr>
<tr>
<td>Clostridium lacticum**</td>
<td>Positive</td>
<td>B</td>
<td>Rod (endospores)</td>
<td>+</td>
<td>Acetate, formate, butyrate, H₂, CO₂</td>
</tr>
<tr>
<td><strong>Starch decomposers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevotella ruminicola</td>
<td>Negative</td>
<td>B</td>
<td>Rod</td>
<td>-</td>
<td>Formate, acetate, succinate</td>
</tr>
<tr>
<td>Ruminobacter amylophilus</td>
<td>Negative</td>
<td>B</td>
<td>Rod</td>
<td>-</td>
<td>Formate, acetate, succinate</td>
</tr>
<tr>
<td>Selenomonas ruminantium</td>
<td>Negative</td>
<td>B</td>
<td>Curved rod</td>
<td>+</td>
<td>Acetate, propionate, lactate</td>
</tr>
<tr>
<td>Succinobacillus amylofytica</td>
<td>Negative</td>
<td>B</td>
<td>Oval</td>
<td>+</td>
<td>Acetate, propionate, succinate</td>
</tr>
<tr>
<td>Streptococcus bovis</td>
<td>Positive</td>
<td>B</td>
<td>Coccus</td>
<td>-</td>
<td>Lactate</td>
</tr>
<tr>
<td><strong>Lactate decomposers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selenomonas lactilytica</td>
<td>Negative</td>
<td>B</td>
<td>Curved rod</td>
<td>+</td>
<td>Acetate, succinate</td>
</tr>
<tr>
<td>Megasphaera elsdenii</td>
<td>Positive</td>
<td>B</td>
<td>Coccus</td>
<td>-</td>
<td>Acetate, propionate, butyrate, valerate, caproate, H₂, CO₂</td>
</tr>
<tr>
<td><strong>Succinate decomposer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schwartzia succinovorans</td>
<td>Negative</td>
<td>B</td>
<td>Rod</td>
<td>+</td>
<td>Propionate, CO₂</td>
</tr>
<tr>
<td><strong>Pectin decomposer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lachnospira multipartita</td>
<td>Positive</td>
<td>B</td>
<td>Curved rod</td>
<td>+</td>
<td>Acetate, formate, lactate, H₂, CO₂</td>
</tr>
<tr>
<td><strong>Methanogens</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methanobrevibacter rumineum</td>
<td>Positive</td>
<td>A</td>
<td>Rod</td>
<td>-</td>
<td>CH₄ (from H₂ + CO₂ or formate)</td>
</tr>
<tr>
<td>Methanomicrobiurn mobile</td>
<td>Negative</td>
<td>A</td>
<td>Rod</td>
<td>+</td>
<td>CH₄ (from H₂ + CO₂ or formate)</td>
</tr>
</tbody>
</table>

**Notes:**
- B. Bacteria; A. Archaea
- *These species also degrade xylan, a major plant cell wall polysaccharide (see Section 21.17).*
- *Also degrades starch*
Methanogens & Methanogenesis

Methanogenesis is the formation of methane produced by methanogens.

Creation of methane is important to the microbe’s digestion as it helps remove excess Hydrogen gas that is produced by other microbes in the rumen.

Too much Hydrogen gas in the rumen will upset the balance in the microbiome.
How Methanogenesis Operate
Methane! Methane!

What’s the big deal about methane?
Methane (CH$_4$)

- Methane is a greenhouse gas (ghg)
  - Other ghgs: carbon dioxide, nitrous oxide, fluorinated gases (hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride – synthetic ghgs)
- Why is it so bad?
  - According to the EPA (Environmental Protection Agency), CH$_4$ is more efficient at trapping radiation than CO$_2$, and has a 25x greater impact than CO$_2$ over a 100-year period.
  - Globally, over 60% of total CH$_4$ emissions come from human activity
  - The atmospheric lifetime for CH$_4$ is 12 years
Methane contributors

According to the EPA:

#1: Energy and Industry
- Primary component of natural gas
- Emitted during all stages of production and sale

#2: Agriculture
- Generated through enteric fermentation & manure

#3: Waste from Homes & Businesses
- Combustion of natural gas and petroleum products for heating and cooking
- Organic waste sent to landfills
- Waterwaste treatment
- Released when fluorinated gases (HFC) are used, such as air conditioning and refrigeration systems undergo service or are leaking
● Intergovernmental Panel on Climate Change (IPCC):
  ○ Ruminant livestock account for ~27% of methane emission
● The average cow emits ~250Liters of methane per day
  ○ Ruminants contribute about 25% of anthropogenic methane emissions
● Let’s break it down to the U.S.
  ○ The average methane
How is this related to Climate Change??

Why should I care? It’s not MY issue!
Doom & Gloom

Climate Change impacts us as a whole:
Climate Change Impacts Health?

CDC (Center for Disease Control) and WHO (World Health Organization) have both stated Climate Change affects Public Health

- Extreme Heat
- Natural disasters
- Air Pollution
- Vector-Borne Disease
- Water-Related Illness
- Food Security
- Mental Health and Stress-Related Disorder
Everything seems bleak! What to do?!

1. Compost!

2. Decrease the amount of meat consumed (ruminant and/or red meats)

We’re not perfect and it’s hard to adapt to change, but adapting to these habits is a lot easier than adapting to a changed living environment.
How do microbes play a part in Climate Change?

- Improper waste disposal generates methane in landfills
- Methane from Ruminant Animals production
- Influences on the Nitrogen and Carbon Cycle
- Alternative Energy - Alternative Biofuel
- Disease
Over to Victoria

How are my actions related to climate change?

Let's Play…

Jeopardy!