MMG 301 Introductory Microbiology, Dr. Frank Dazzo
Animal-Microbe Interactions

Previous pertinent topics already covered:

1. Microbial pathogenesis:

A. Animal diseases caused by eukaryotic microorganisms:

- **malaria (*Plasmodium falciparum*)**
- **amoebic dysentery (*Entamoeba histolytica)*,**
- **trypanosomiasis (*Trypanosoma*),**
- **amoebic meningocephelitis (*Naegleria* fowleri)**
- ***Pfiesteria* "cell from hell" fish infections**

B. Fatal human diseases caused by bacteria:

- **pyogenic skin wounds (*Staphylococcus aureus*)**
- **lyme disease (*Borellia burgdorferi*)**
- **gonorrhea (*Neisseria gonorrhoeae*)**
- **various exotoxicities:**
  diphtheria – *Corynebacterium diphtheriae*,
  botulism – *Clostridium botulinum*,
  teatnus – *C. tetani*,
  cholera – *Vibrio cholera*
- **bacterial respiratory tract infections (*Streptococcus pyogenes, Klebsiella pneumoniae*)**
- **bacterial meningitis (*Neisseria meningitidis*)**
- **tuberculosis (*Mycobacterium tuberculosis*)**
- **syphilis (*Treponemia pallidum*)**
- **gastrointestinal infections/diarrhea: *Escherichia coli, Salmonella, Shigella)***
- **Legionaires disease: *Legionella pneumophila***
- **Anthrax (bioterrorist agent): *Bacillus anthracis***

C. Significant human diseases caused by viruses
(grouped according to their route of dissemination):

- **Respiratory infectious droplets: influenza, common cold, measles, mumps, chickenpox, smallpox, "severe acute respiratory syndrome" = SARS**
- **Direct contact with bodily fluids: AIDS, hepatitis B, herpes**
- **Fecal contamination: gastroenteritis, hepatitis A, polio**
- **Insect vectors: West Nile, equine encephalitis**

2. Normal human - microflora interactions:

- **commensalistic, mutualistic, or opportunistic in scope;**
- **includes microflora on skin, oral cavity, gastrointestinal tract, genitourinary tract, respiratory tract.**

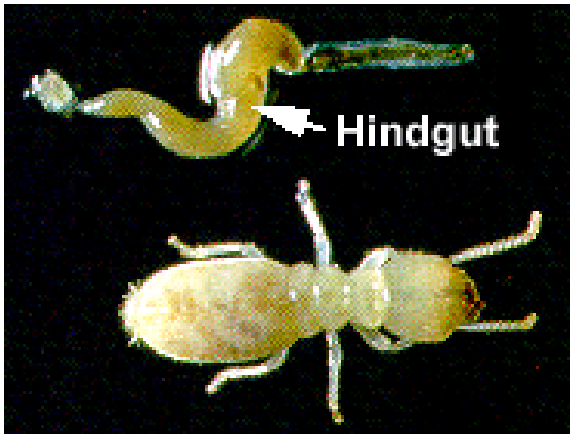
3. Mutualistic animal – microbial symbioses:

- **Bioluminescent *Vibrio* in cavity below eyes of marine fish**
- **Bacterial endosymbionts in tube worm near deep sea hydrothermal vents**

Estimates of CH_4 released into the atmosphere

Source	CH_4 emission (10^{12} g/year)
Biogenic	
Termite gut	25-150
Bovine rumen	80-100
Submerged paddy fields	70-150
Natural wetlands	120-200
Landfills	5-70
Oceans and lakes	1-20
Tundra	1-5
Total Biogenic	302-665 (81-86% of total)
Total Abiogenic (industrial, automobile, volcanos, etc)	48-155 (13-19% of total)
Sum Total	48-821

2 other major microbe-animal interactions: termite hindgut and rumen have anaerobic fermentations that provide major sources of methane.

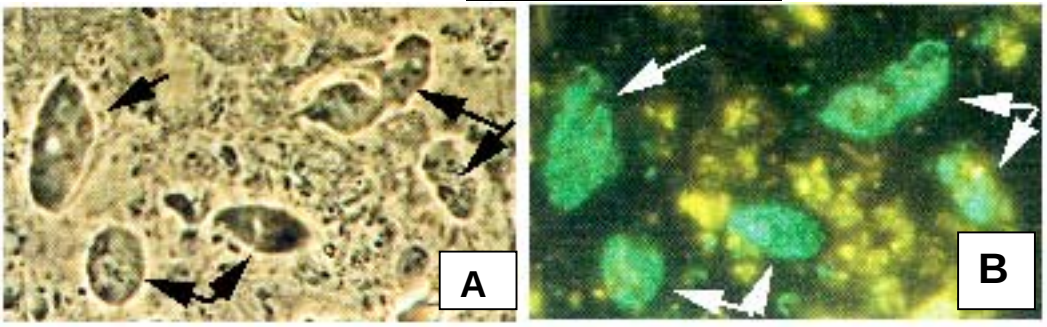


Microbiology of the Termite hindgut:
Major food consumption: wood (high in cellulose, low in fixed N).
Obligatory mutual symbiosis: termite completely dependent on its hindgut microflora to provide its C + N nutrition derived from anaerobic degradation of the wood particles.

- **Sources of cellulases: 1) termites themselves, 2) anaerobic cellulolytic protozoans in hindgut of "lower" termites. Hindgut of "higher" termites contain no protozoans nor bacterial cellulases.**
- **The termite and protozoan cellulases depolymerize cellulose to glucose, which then is fermented by various gut microbes into acetate (absorbed & used by the termite), CO_2 and H_2.**
- **The CO_2 + H_2 products have 2 major fates in the termite gut:**

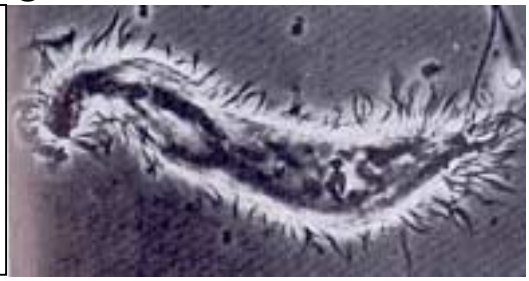
(1) favored fate is microbial acetogenesis $CO_2 + H_2 \rightarrow CH_3COOH$ (acetate) assimilated by the termite, and (2) the competing reaction is microbial methanogenesis $CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$

- **Methanogenesis is mediated by free-living methanoarchaea and other methanoarchaea endosymbionts of protozoa**

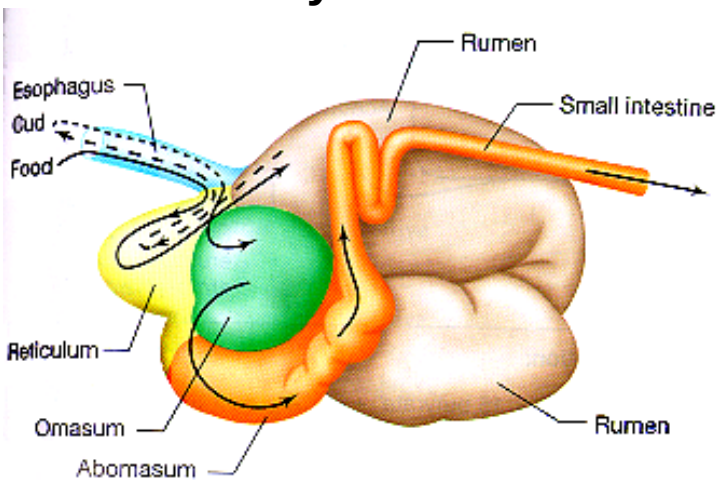


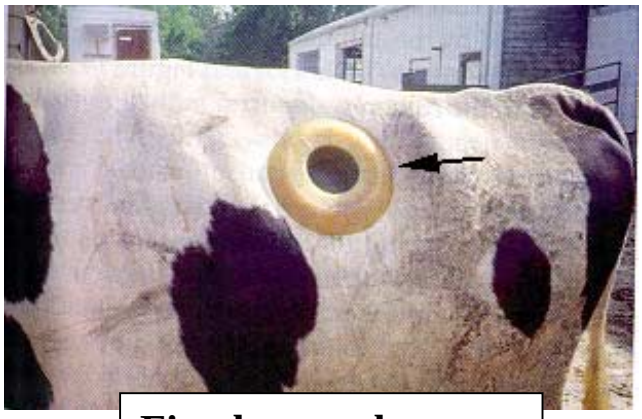
Phase contrast (A) and epifluorescence microscopy (B) of the termite gut contents showing ingested wood particles (yellow) and protozoa (arrows) containing many endosymbiotic methanoarchaea that produce a green autofluorescent enzyme cofactor (F_{420}) required for methanogenesis.

Two types of spirochetes: some are free-living N_2-fixers and others are ectosymbionts attached to the surface of flagellated protozoa where they provide some motility.



Rumen ecosystem: warm-blooded herbivores, cow sheep goats





Fistula sample port

Ingested plant feed travels from the esophagus to the reticulum and quickly to the large rumen vat where it is digested microbiologically, then passes to the acidic stomach (omasum, abomasum), then small and large intestines.

- **A vast diversity of rumen microbes decompose the ingested plant material into volatile fatty acids that are absorbed and utilized by the animal, plus gas fermentation products that the animal expels.**
- **Cellulolytic bacteria and protozoa extracellularly hydrolyze cellulose to cellobiose (disaccharide of glucose) + glucan oligosaccharides.**
- **Many anaerobic bacteria ferment these glucose oligomers into various volatile fatty acids (acetate, propionate, butyrate) that are absorbed and assimilated by the animal, plus $CO_2\uparrow$ + $CH_4\uparrow$.**