Microbe-Animal Interactions

Introduction

- All animals live with microbes on and inside their bodies—within humans, microbes can outnumber cells by a factor of ten—and animals engage with these microbes via the mutual exchange of different molecules.
- Micro-organisms found in the alimentary tract may have either good or bad effects on the host animal.
- The disadvantages may be conditions like gastroenteritis or pathogenic disorders like poisoning of food by bacteria such as *Salmonella*.
- Benefits of course are interactions involved in digestion of food within the stomach and intestines.
- An example here being bacteria like *Lactobacillus bifidus* and *Lactobacillus acidophilus* which aids the digestion of lactose.
- Assimilation of vitamins such as Vitamin K, essential for blood clotting is also aided by micro-organisms.
- Animal bodies then, provide the ultimate habitat for micro organisms to survive. With adequate nutrient availability, moisture, pH and temperature levels maintained, environmental conditions are optimal for survival.

Termite Gut Microflora

- One of the most well-characterized symbiotic systems is that of termites and their intestinal microorganisms, which digest cellulose. The termite gut teems with microbes that are essential for the digestion of cellulose. Without these microbial symbionts, termites would be unable to digest wood.
- The intestinal tracts of termites are small **ecosystems** with a wide range of microhabitats that strongly differ in their abiotic and biotic environment.
- Many of the environmental features are intrinsic properties of the gut, whereas others result from physiological activities of the host or the microbial residents in the respective location.
- The termite gut microbiota comprises all three domains of life: Bacteria, Archaea, and Eukarya (flagellate protists occur in lower termites).
- The isolates obtained from termite guts are typically not very abundant (**12**); in particular, the termite-specific lineages remain mostly uncultured.

Termite Gut Flagellates

- Most termite gut flagellates belong to the phylum Parabasalia.
- They are large enough to phagocytize wood particles, and their great motility due to multiple flagella prevents washout—probably adaptations to the termite diet and the microbial habitat in the termite gut.
- Many, but not all, species of lower termites harbor flagellates of the order *Oxymonadida* (phylum *Preaxostyla*). Some lineages developed special holdfasts that attach to the hindgut cuticle, and the cells can be so small that they disappear within the bacterial biofilm.

- **Bacteria**
- *Spirochaetes* are characteristic members of all termite gut communities.
- The highest proportion of spirochetes is found in wood-feeding termites, whereas their numbers among fungus-cultivating and humus-feeding termites are typically rather low.
- *Bacteroidetes* are highly abundant in fungus-cultivating termites.
- Members of the *Elusimicrobia* make up a large proportion of the bacterial community in many lower termites and have been identified as endosymbionts of certain flagellates.
- *Verrucomicrobia* related to "*Candidatus* Nucleococcus," an intranuclear symbiont of termite gut flagellates (**103**), are abundant in several lower termites but found also in hosts that lack flagellates.

Archaea

- There are four major lineages of *Euryarchaeota* in termite guts: *Methanosarcinales*, *Methanomicrobiales*, *Methanobacteriales*, and a deep-branching clade distantly related to the nonmethanogenic *Thermoplasmatales* .
- The latter were identified as a new order of methanogens that was initially referred to as *Methanoplasmatales* but is now called *Methanomassiliicoccales*, after the first isolate of the order.

Nematophagus Fungi

- Nematophagous fungi are microfungi that can capture, kill and digest nematodes.
- They use special mycelial structures, the so-called traps, or spores to trap vermiform nematodes or hyphal tips to attack nematode eggs and cysts before penetration of the nematode cuticle, invasion and digestion.
- Nematophagous fungi, including those that are variously called predaceous, nematode-trapping, and nematode-destroying fungi, possess amazing abilities to capture nematodes and reduce the population size of plant-parasitic nematodes.
- Such abilities have significant applied interests in agriculture.

- Nematophagous fungi have been traditionally divided into four main groups based on the mechanisms that they use to attack nematodes:
- (i) nematode-trapping fungi, producing extensive hyphal networks, knobs, and constricting rings as trapping devices to catch and hold live nematodes;
- (ii) endoparasitic fungi, as obligate parasites that exist as conidia in the environment and infect nematodes by either adhering to the surface of the prey or by directly being ingested by the nematodes followed by germination, growth, and nematode killing;
- (iii) egg- and cyst-parasitic fungi, as facultative parasites that grow on and parasitize the sedentary stages of nematodes such as eggs; and
- (iv) toxin-producing fungi, producing toxic compounds that are active against nematodes.

- Many fungi have evolved to parasitize mobile stages of nematodes by employing complex and sophisticated predation structures, including:
- (1) trapping structures to immobilize nematodes;
- (2) adhesive conidia to attach and colonize the nematodes' pseudocoeloms;
- (3) acanthocytes, spiny balls, and stephanocysts to damage the cuticle of nematodes and then consume them; and
- (4) gun cells to launch finger-like tubes directly at the target nematodes

Common Genera of nematode-trapping fungi are:-

1. **Arthrobotrys**
2. **Dactylaria**
3. **Dactylella**
4. **Trichothecium**

MECHANISMS

- When a nematode prey attempts to move past an adhesive hyphal structure, it is sticks to it and is trapped.
- When it tries to pass through a constricting ring, a fungal ring contracts by a sudden osmotic swelling and traps the nematode.
- Voilent movements and attempts by nematodes to escape generally fails.
- The fungal hyphae penetrates into nematode which is then enzymatically degraded.
- When growing in the absence of nematode appears to induce the formation of morphological structure that traps the nematodes.
- This is a unique relationship in which presence of prey induces the formation of fungal structures that result in its capture and consumption.

EXAMPLE

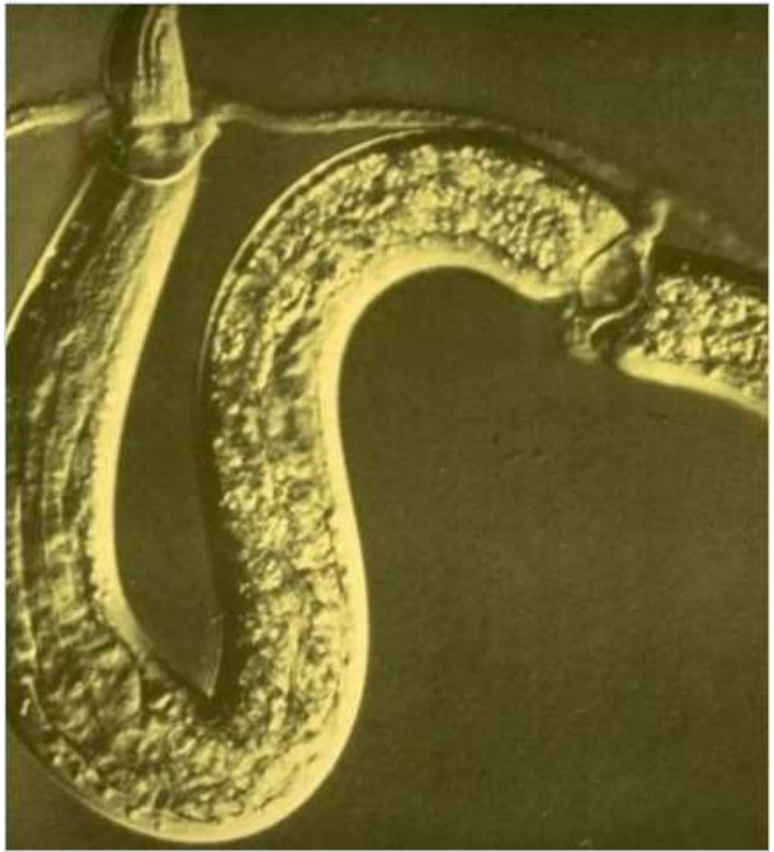
Hohenbuehelia and Resupinatus- capture nematode y means of adhesive knobs.

Pleurotus ostreatus (edible oyster mushroom) & Pleurotus sp. Form no trap structure.

By mean of toxin they paralyze nematodes

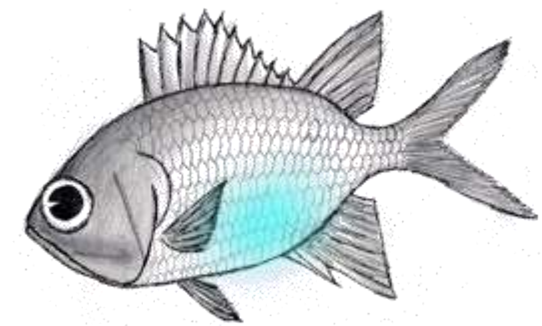
The described Basidiomycota often grow on decaying wood, a nitrogen poor substrate.

It is suggest by Thorn and Barron in 1984 that captured nematodes are source of supplemental nitrogen for fungi.

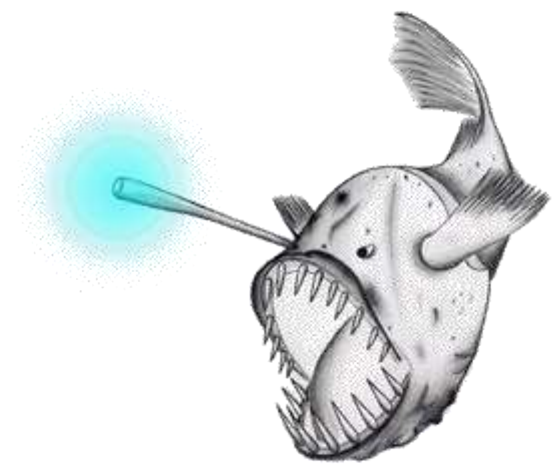


Bioluminescence

- **Bioluminescence** is an emission of cold light by enzyme driven reaction within certain living organisms.
- The most abundant and widely distributed light emitting organisms are luminescent bacteria.
- Such organisms are either found as free-living in the ocean or in symbiotic relationship with the marine host.
- In symbiosis, the bacteria are nourished with readily available food sources for growth, and at the same time the host utilizes the adopted illumination to communicate, to attract prey, and to masquerade itself from predators.



Pinecone fish utilize luminous bacteria, colonized in the ventral cavity



The deep sea Angler fish carries luminous bacteria in a light emitting rod, which attracts prey to the front of its mouth.

... Bioluminescence

- There are three major genera, into which most luminous bacteria are classified; *Photobacterium, Vibrio*, and *Photorhabdus*.
- Species existing in the marine environment are mainly categorized into the *Photobacterium* and *Vibrio* genera, and the terrestrial species are classified into the *Photorhabdus* (previously designated as *Xenorhabdus*) genus.
- Species within the *Photobacterium* genus are generally light organ symbionts of marine animals, whereas the *Vibrio* species exist as free-living forms as well as symbionts in the sea.
- Many luminous bacteria are parasitic, with *Photobacterium* and *Vibrio* families infecting marine crustacea, and *Photorhabdus luminescens* infecting terrestrial insects, such as caterpillars, with nematodes as the intermediate host for the bacteria.
- In addition, free-living luminous bacteria that are dispersed in the seawater can often be found in both the gut tract and on the skin surface of almost all marine animals as non-specific parasites.

Biochemistry of the Bacterial Bioluminescence Reaction

- Bacterial luciferase is the enzyme that catalyzes light emission.
- However, the catalytic machinery also involved the enzymes that supply and regenerate the substrates of bacterial luciferase.
- The DNA sequences coding the proteins in the luminescent system are termed the lux genes.
- Bacterial luciferase is a heterodimer, composed of two different polypeptides, designated alpha and beta encoded by the *lux*A and *lux*B genes, respectively.
- The active site is located within the α subunit.
- The substrates of bacterial luciferase are reduced flavin mononucleotide (FMNH), molecular oxygen, and long chain fatty aldehyde.
- The excess energy, which is liberated from the oxidation of $FMNH_2$ and aldehyde concomitant with the reduction of molecular oxygen, is released as blue/green light emission (MAX ~ 490 nm).

The net chemical equation of the bacterial luciferase catalyzed reaction

- The characteristic color indicates the energy level of the photon that was produced when the excited electron on the flavin chromophore returns to the ground state.
- Flavin analogs with substituted atoms in the chromophore moiety resulted in different luciferase emission colors.