

XXII. *Wolbachia* (Some discussion on pp. 3, 38, 463, 470-474; Roberts & Janovy, 2009, 8th ed)

I. Introduction

A. *Rickettsia* bacteria

1. Once grouped with viruses
 - a. Extremely small (1 μ length, 0.3 μ diameter)
 - b. Reproduce only within cells of other organisms
2. Eukaryotic mitochondria thought to have evolved from a *Rickettsia*-like organism that had established a symbiotic association with another prokaryote

B. *Wolbachia*

1. Type of bacteria commonly found in ...
 - a. Arthropods
 - (1) Arachnids
 - (2) Isopods (Crustacea)
 - (3) Insects (15-20% of all species)
 - b. Nematodes
2. Transmitted in host cytoplasm
 - a. Aspects of eukaryotic fertilization
 - (1) Male sperm contributes nuclear DNA
 - (2) Female ovum contributes
 - (a) Nuclear DNA
 - (b) Cytoplasm (organelles such as mitochondria)
 - b. Vertical transmission (mother to offspring)

II. Cytoplasmic incompatibility (=CI) causes reproductive isolation

A. Types

1. Infected hosts cannot form viable zygotes with gametes from unparasitized hosts
2. Parasitized females reproduce only by parthenogenesis (Restricted to Hymenoptera hosts)

Slide of Parasitoid wasp *Trichogramma kayaki* Werren, J.H. 2003, Natural History Feb p. 63.

3. Feminization
 - a. Male hosts converted into reproductive (& reproductively isolated) females
 - b. Found in crustacean isopods

Word Slides of a 2008 discussion on Crust-L concerning hermaphrodites in isopods

B. All above effects are reversible with antibiotics

III Phylogenetic studies

- A. Closest relatives of *Wolbachia* are arthropod-borne *Rickettsia* bacteria that cause blood diseases in mammals

Slides of *Rickettsia rickettsii*. <http://www.textbookofbacteriology.net/Rickettsia.html> & http://en.wikipedia.org/wiki/Image:Rocky_mountain_spotted_fever.jpg

B. Six major subdivisions (A thru F) in *Wolbachia*
 Slide Fenn & Blaxter (2006) *Trends in Parasitology*: vol 22 (2) pp 60-63, showing phylogenetic relationship among *Wolbachia* strains.

- IV. Has *Wolbachia* been responsible for speciation?
- A. Definition of a species: Individuals must be able to produce offspring capable of reproducing
 - B. Arthropods as hosts
 1. About 80% of terrestrial animals are arthropods (high speciation rate)
 2. Could be explained by *Wolbachia*
- V. *Wolbachia* in nematodes
- A. Only in vector-transmitted Onchocercidae:
 1. Species
 - a. *Onchocerca volvulus* = river blindness
 - b. *Brugia malayi* & *Wuchereria bancrofti* = elephantiasis
 - c. *Dirofilaria immitis* = dog heartworm
 1. Mutualistic association with nematodes (See p. 461)
 2. Treat mammalian host with antibiotics...
 - a. *Wolbachia* killed
 - b. Nematode in human adversely affected
 - (1) Delayed molting (= reduced growth)
 - (2) Sterilization & death
 3. *Wolbachia*-derived products affect immune systems of nematode hosts
 - B. Life inside a eukaryotic cell
 1. Intracellular symbionts usually have a reduced genome as they rely upon the host cell for metabolic needs
 2. *Wolbachia* genomes contain a large proportion of repeated sequences which is unusual for bacteria
 - C. What do *Wolbachia* do for, or to, their hosts?
 1. Bacterial Type IV secretion systems
 - a. They export "virulence factors," or proteins implicated in the pathogenesis caused by many bacteria
 - b. In *Wolbachia*
 - (1) Sequence of a Type IV secretion system has been recently found
 - (2) Closely associated with a *Wolbachia* surface protein (= WSP) that could export proteins out of the bacteria
 2. Ankyrin = ANK
 - a. Mediates protein-protein interactions
 - b. Implicated in host-pathogen interactions
 - c. Might be involved in regulating host nematode cell-cycle
 - d. Bacteriophages = viruses that infect bacteria
 - (1) In the fly *Drosophila* 8 ANK genes are within prophage

- gene segments
- (2) Phages may be able to move between *Wolbachia* strains in hosts infected with multiple stains
- (3) Phages can move genes between species and might have a role in generating diversity in *Wolbachia*

Slides diagramming reproduction of bacterial phages and the concept of lateral transfer of genes between species

D. Metabolic mutualism?

1. *Wolbachia* in *Brugia malayi* (= wBm) has genes for synthesizing riboflavin and heme groups
2. Heme groups are essential in modifying ecdysteroid molting and reproduction hormones
 - a. Believed that *B. malayi* cannot synthesize these molecules
 - b. Situation unclear as other filarial nematodes not infected by *Wolbachia* also cannot synthesize heme groups
 - (1) Get hemes from mammalian host
 - (2) *Wolbachia* might provide filarial nematode vital nutrients when there is a great need

E. Immunological enigmas

1. Characteristics of filarial diseases
 - a. Specific immunosuppression of hosts
 - b. Extreme longevity in immunocompetent hosts
2. The human immune system responds to *Wolbachia* surface proteins (= WSP)
 - a. Especially responsive to infective J₃ larvae
 - b. WSP induces T helper (TH)1-type response
3. *Wolbachia* may induce an immune response that has a role in nematode survival