Chapter 1. Introduction to Insect Pathology: history, definition, and types of associations between insects and microorganisms

1. Why we study insect pathology?
   - basic discipline in biology
   - ecological balancer in nature (biocontrol agents)
   - insects are more easy to handle than other organisms
   - give a basic information to microbiology, genetic engineering
   - to control disease of insect and insect pests

2. Scope of insect pathology
   - insect: over 75% of all animals, many are economically and medically important
   - insect pests: aphids, mites, whiteflies, caterpillars
Aphids and sooty mold

Dust mite and two-spotted spider mite and damaged maple

Greenhouse whitefly and damaged tomato

Diamondback moth (*Plutella xylostella*) and damaged leaves

- medically important insects (vector of arthropod-borne disease):
  * mosquito: malaria, yellow fever, west nile fever, dengue hemorrhagic fever, encephalitis, elephantiasis (*New laser Zaps*)
  * black fly: human onchocerciasis (river blindness)
  * sand fly: leishmaniasis
* tsetse fly: african sleeping sickness
* mite / tick: scrub typhus (tsutsugamushi), Lyme disease
* louse: fever, epidemic typhus
* flea: bubonic plague (black death, 14C in Europe)

< Lymphatic filariasis (=Elephantiasis), caused by *Brugia malayi* (filarial nematode), transmitted by mosquitoes >

< Black fly (Simuliidae) and river blindness, caused by *Onchocerca volvulus*, filarial nematode >

< Sand fly (Psychodidae) and Leishmaniasis, caused by *Leishmania* protozoa >
Black death (bubonic plague = pest)

Plague is an infectious disease of animals and humans caused by a bacterium named *Yersinia pestis*, transmitted by a rodent flea.
Bubonic plague infection causes tiny **blood vessels** in the feet and toes to **clog up and cut off circulation**. Without blood, the flesh dies and turns black (called "gangrene"). This is why in the Middle Ages bubonic plague was called "the Black Death"
3. Application of insect pathology

- general biology, medicine
  - vector transmission
  - immunity
  - infection process
- agriculture
  - control of insect pest by natural enemies (pathogens)
- economic and medical entomology
- ecology
- taxonomy
  - symbionts for certain species used to separate species or subspecies

< Entomopathogenic nematode, Steinernema carpocapsae, with Xenorhabdus nematophila in the vesicle>

< S. feltiae with X. bovienii, symbiotic bacteria in the vesicle >
4. Brief history of insect pathology

- ancient chinese (BC 7)
  - identify fungal species of *Cordyceps* from the silkworm

- Aristotle (384 - 322 BC)
  - observed honey bee disease, "rusts" → today, known as foulbrood (부저병)

- Kirby and Spence (1826): divided the insect disease into two classes
  - accidental external injury or internal derangement
  - vegetable (i.e., fungi) and animal parasitic organisms (i.e., nematodes, mites, and parasitic insects)

- Agostino Bassi (1773 - 1856): father of insect pathology
  - the first demonstration that an insect pathogen, a fungus (later named as *Beauveria bassiana*), caused an infectious disease in insects
• Louis Pasteur (1822 - 1895)
  - first use of microscope for diagnosis of a disease
  - played a dramatic role in rescuing the silkworm from disease called "pebrine",
    caused by microsporidian fungus (Nosema bombycis)

• Metchnikoff (1879) : Nobel prize (1908)
  - studied the diseases of the wheat cockchafer, Anisoplia austriaca, caused by a
    fungus, Metarhizium anisopliae
  - to control of the wheat cockchafer, he suggested applications of 1)
    fungus-killed larvae, 2) free fungal sopres, 3) the soil in which the
diseased larvae had been found
• de Herelle (1912)
  - reported control of locusts using a bacterium (*Coccobacillus* sp.) in Argentina and Columbia effectively

• R.T. White and Dutkey (1920s - 1930s)
  - USDA entomologist, worked with *milky disease*, caused by bacteria (*Bacillus popilliae*) of the Japanese beetle (*Popillia japonica*), which was introduced in 1916
  - *Paenibacillus popilliae* (=*Bacillus popilliae*) is the first insect pathogen to be approved by the US federal government for use against insect pest, and has been **produced commercially**

  < *P. popillae* infected white grub, milky disease >

• Steinhaus: head of the first insect pathology lab at UC Berkeley (1945)
  - He has been considered the founder of modern insect pathology and father of invertebrate pathology

  < Edward Arthur Steinaus, 1914 - 1969 >
5. Glossary of terms used in insect pathology

- **Disease** (질병): lack of ease, departure from the state of health or normality
  - infectious disease (=contagious): caused by the action of a living organism or by-products
  - noninfectious disease: caused by other than living organism, such as mechanical injuries, nutritional disease, genetic disease

- **Infection** (감염): entry of a pathogen into a susceptible host, resulting in the presence of the pathogen within the body of the host, whether or not this causes pathological effects

- **Infectivity** (감염력): the ability of an organism to gain entry into a host

- **Pathogenicity** (병원성): the potential ability to produce disease (applied to group or species of microorganisms)

- **Virulence** (독성): the disease producing power of an organism (degree of pathogenicity within the group or species)

- **Pathogen** (병원체): a specific cause of disease
  - potential pathogen: incapable of invading host without the assistance of other biological factors (e.g., injury)
  - facultative pathogen: able to invade insect tissue without the assistance of other biological factors (can live and reproduce independent of host)
  - obligate pathogen: can only be replicated (survived) inside living host

- **Enzootic disease** (풍토병): a disease, usually in low incidence, which is constantly present in a population

- **Epizootic disease** (유행병): an outbreak of disease in which there is an unusually large number of cases

- **Panzootic disease** (유행병): a disease affecting all or a large portion of the animals of a region

- **Septicemia** (패혈증): multiplication of microorganism in the blood

- **Toxemia** (독혈증): dissemination of toxins in the blood

- **Entomogenous**: organism growing in or on the bodies of insects

- **Entomophagous** (식충성): insectivorous

- **Symbiosis** (공생): living together + the act of (evolutionarily diverse groups of organisms live in close association with one another)
  - parasitism: one organism lives at the expense of the other (cf. parasitoidism)
  - commensalism: an association in which one benefits without apparent effects (harm or benefit) on the other
  - mutualism: both associates benefit
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<th>Host</th>
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- **Ascaris lumbricoides**
- **Phoresy (=hitch hiking)**
- **Aphid and Buchnera aphidicola symbiotic bacteria**

**Types of transmission**
- **horizontal**: transmission of a pathogen from infected individual to conspecific individual within a generation
- **vertical**: transmission of a pathogen from one generation to the next (from parent to offspring)
  - **transovum**: from parent to offspring by way of the egg, can be surface or internal
6. **Virulence and Transmission**

- Pathogens, which typically rely on a host for reproduction and survival, need to be transmitted from host to host to ensure their survival in the host population.
- It is in the interest of a pathogen to optimize its transmission success over the lifetime of the infection.
- During infection the pathogen reproduces within the host thereby reducing host fitness.
  - Fitness: ability to reproduce offspring.
- Host fitness vs. pathogen virulence vs. transmission success.

![Graph showing the relationship between host fitness and transmission success.](image)

- Pathogen with vertical transmission
  - develop less virulent forms with little impact on host fitness since host reproduction is vital for pathogen transmission.
- Pathogen with horizontal transmission
  - evolve more virulent forms with high negative impact on host fitness since transmission within the host population is independent from host reproduction.