**Medical Entomology**

**Objectives**
1. Describe the different types of medically related effects caused by arthropods (direct and indirect)
2. Define the terms associated with disease transmission
3. Describe the general characteristics of the 7 diseases covered including:
   - Vector
   - Where it is a problem
   - Disease symptoms
   - How it is treated and controlled
   - Type of disease

**Introduction**
Arthropods and insects in particular cause many medically related effects. Directly they can cause dermatitis and allergic reactions. But indirectly, they can pass on diseases that can be debilitating and sometimes fatal.

**Direct Effects - Host Reactions**
Some quantifiable, economic effects include:
- **Mechanical Reactions** (dermatosis, dermatitis, itching)
- **Exsanguination** (loss of blood, annoyance)
- **Myiasis** (dipterous larvae invading living tissues)
- **Toxins & Paralysis** (envenomization)
- **Allergic Reactions** (anaphylaxis)
- **Entomophobia** (psychological fear of insects)

Let's take a look at each of these direct effects in more detail.

**Mechanical Reactions** (Dermatosis, Dermatitis, and Itching)
- The scabies mite is an obligate parasite, meaning it must feed on a host in order to complete its lifecycle. After mating, the female mite will burrow under the skin and lay her eggs.
- Sarcoptic mange found in animals is basically the same as that in humans. Most animals, including cattle, pigs, horses, and dogs, experience the same dermatitis leading to weight and hair loss.

**Mechanical Reactions Continued**
- Larval mites have six legs.
- Larvae feed on vertebrate hosts.
- Chiggers (red bugs) do not burrow under skin.
- Mites fall off skin after feeding.
Another direct effect of insect feeding can be exsanguination, or blood loss. One mouth type is rasping. The bites are very painful and the blood loss can be significant. Some results of feeding of this type can be a loss of weight or a reduction in milk production in cattle.

### Exsanguination (Loss of Blood, Annoyance)

Horn flies on cattle causes annoyance and blood loss

Fly (dipterous) larvae may invade and feed on living tissues of livestock and other animals including rabbits, squirrels, dogs, and humans. This is known as myiasis. The fly larvae must have access to the outside in order to breathe, so they create holes in the flesh of the host. The holes and tissue damage caused by the myiasis causes economic damage because it reduces the quality of the hide.

### Myiasis continued

Myiasis is generally one of 2 forms:

1) Obligatory - the parasite depends on the host for completion of a certain part(s) of its life cycle. One example is the bot fly we have previously discussed.

2) Facultative - the parasite is generally free-living but can utilize a host in certain circumstances. One example is urinary myiasis. This is caused when rat-tailed maggots from contaminated water enter the urethra of a human host. Facultative myiasis in humans is not as common as found in other vertebrate animals.

### Source of Myiasis

First, some flies lay their eggs around the mouth, legs and other body parts of the host. After laying the eggs, the adult fly will annoy the host causing the host to lick the area of deposited eggs thereby ingesting them. The eggs hatch in the intestinal tract and develop to pupa stage that is excreted with the host waste.

Second, other flies lay their eggs on the hair shafts of its host. The larvae hatch and travel to the skin and burrow into the host. The larvae travels under the skin making its way to the back of the host. The developing larva is known as a warbler because it cuts a whole through the hide of the host for respiratory purposes and for exit when it reaches the pupa stage.

### Sources of Myiasis Continued

Third, they may hitch a ride. Dermatobia hominis is known as the human bot fly. This bot will parasitize other vertebrates including cattle, swine, cats, dogs, and horses. The adult bot fly captures another Dipteran fly usually a bloodsucker such as a mosquito and glues its eggs along the abdomen of the carrier fly. When the mosquito is taking a blood meal from its host the newly hatched larva penetrates the skin of the host and sets up residence. The entire life cycle takes 3 to 4 months.

### Envenomization and Allergic Reactions

The venom of most arthropods and insects do not cause death in most humans or animals. Some, however, are extremely sensitive to the proteins in the venom and may have a severe allergic reaction that results in death. This hypersensitive response is known as anaphylaxis.

Some examples of venomous arthropods and the source of the venom include:

- Spider bites
- Scorpion stings
- Hymenoptera (ants, bees, and wasps) stings
- Lepidoptera larvae with “urticating hairs”
- Coleoptera - blister beetles (causes painful blisters and can kill horses if ingested)
- Coleoptera – Stored product beetles (itching or respiratory problems from contact with the frass)
Examples of Venomous Arthropods - Urticating

Some Lepidoptera larvae have “urticating hairs” that produce burning and itching direct effects when passively touched.

Examples of Venomous Arthropods - Stinging

Many arthropods including spiders, scorpions and hymenopterans have a defensive sting organ. In insects, the sting is a modified ovipositor.

Examples of Venomous Arthropods - Blistering

Blister beetles in the order Coleoptera causes irritation with possible skin blistering by the toxic chemical Cantharidin.

Entomophobia

Entomophobia is the psychological fear of insects. Many people fear insects, but some have an irrational fear. This fear may lead to psychological problems such as:

Delusory parasitosis: This is when a person is mentally sure that insect infestation is real when in fact it does not exist. This condition can even bring on physical symptoms including welts and skin irritations.

Entomophobia: The general fear of insects, or of becoming infested with something may bring about stress and high anxiety. This may result in careless use of insecticides in and outside of the home, on pets, on children, and on yourself.

Indirect Effects - Disease Transmission Terms

Epidemiology is the study and applied ecology of disease transmission where all factors of the natural history of the disease and vector are of interest.

Vectors are all classes of arthropoda that have the capability of transmitting pathogenic organisms to its host causing minor and major debilitating diseases. The host generally houses the pathogen through one or more of its life cycles, specifically the infective stage during active transmission by the vector.

The pathogen is the organism that is passed by the vector and causes the disease. Vertebrates that can house and maintain the pathogen during benign and infective stages of the pathogen’s life cycle even when active transmission is not taking place, are termed reservoirs.

Disease Transmission - Vectors

Three things are needed for most disease transmission:
1) competent vector
2) host
3) pathogen (causal organism).

Depending on the pathogen’s life cycle, a fourth entity necessary for the disease transmission would be a “reservoir.”
**Types of Disease Transmission**

**Mechanical transmission** is where the arthropod acquires the pathogen by passive means. An example of this would be the house fly landing on an area contaminated with pathogenic organisms and the organisms adhere to the skin or other body parts of the fly and when the fly lands on another substrate such as eating utensils and food the organism(s) falls from the fly and is left behind to be ingested by the host. **Cyclo-Propagative** transmission is when a pathogen is delivered by deliberate means and the organism goes through cyclical changes in the body of the arthropod and/or host. Malaria transmitted by mosquitoes and chiggers transmitted by Hemipterans are excellent examples of this type of transmission because it multiplies in the vector and host. **Cyclo-developmental** transmission is similar to cyclo-propagative with the exception of the pathogen does not multiply in the arthropod (vector). Elephantiasis is caused by an obligate filariases (worm) that is in the mosquito starting with the microfilaria to the infective stage then delivers it to the host where it multiplies. **Propagative** transmission has no cyclical changes but multiplies propagative only. The flea produces the bacterial organism "yersinia pestis" which is the causal organism for the plague. Lice produces a bacterial organism "Borrelia recurrentis" that is a causal organism for relapsing fever. Yellow fever a virus produced by mosquitoes.

**Viral and Protozoan Review**

Viruses are microscopic infectious agents that replicate themselves only within cells of living hosts. Many viruses are pathogenic. The term arbovirus refers to a virus that is transmitted by an arthropod (arthropod borne). There are approximately 100 known arthropod viruses; they are mainly isolated from mosquitoes. Examples of viruses are Yellow Fever, West Nile Virus, Eastern Equine Encephalitis Virus, Western Equine Encephalitis Virus, and Dengue Virus.

Protozoa consist of a single cell including a nucleus. The cell contains its own structures needed for life functions. Protozoa are a large and diverse complex group with many shapes and sizes. Protozoa can be parasitic with a requirement of living within another organism or they can be free-living in moist habitats. Protozoan infections include malaria from mosquitoes, and African sleeping sickness acquired by the bite of the Tsetse fly in Africa.

**Bacterial Review**

Bacteria are unicellular organisms that lack nuclei. Their DNA is not contained and is just free floating in their cytoplasm. Bacteria invading the host often resist immune defenses to begin growing, harming the host in some way. Some bacteria, like Rickettsia, invade tissues and causes typhus. Others produce toxins that damage tissues. The figures on the right depict Salmonella on a cockroach.

**Insect Transmitted Diseases**

With this background knowledge, you will now learn about 7 insect transmitted diseases. They are:

1. **Yellow Fever**
2. **Plague**
3. **Typhus**
4. **Dengue Fever**
5. **Trypanosomiasis** (i.e. African sleeping sickness and Chagas' disease)
6. **Encephalitis**
7. **Malaria**

To learn about these diseases you will need to do a little exploring. Be sure read the textbook readings and fill out tables 1 & 2 on your study guide. The information contained in this table will be what you are tested on.

*If you are having trouble, you may find additional information at www.infoplease.com.*

**Yellow Fever**

Yellow fever is a virus vectored by mosquitoes. Yellow fever is a tropical disease mostly found in Africa and South America. There are two types of yellow fever each with different infection cycles. Jungle yellow fever is primarily found in monkeys in tropical rain forest. When humans enter the rain forest to work, they can be bitten by mosquitoes that have fed on infected monkeys. The second type of yellow fever is Urban yellow fever which is found in humans. The Aedes aegypti mosquito has adapted to living around humans in urban settings and breeds in most artificial containers such as pots, discarded tires, and other vessels that hold water. In 1905, New Orleans recorded the last epidemic of yellow fever in the U.S. This mosquito has changed history, because until an eradication program was instituted in the early 1900's, the construction of the Panama Canal could not be completed. Not long after that, a vaccine was developed that is still used today. Also, quarantine methods for ships, planes, and persons traveling from suspected areas with yellow fever are enforced. Mild forms of the virus cause fever and headache, but the severe form causes rapid heartbeat, back pains, bleeding into the skin, nausea, and vomiting with internal hemorrhaging leading to coma and possible death.

**Plague**

Plague can occur where humans and large populations of rats and fleas coexist. Plague is not spread from person to person, but by the bite of an infected flea. Both male and female fleas can transmit the plague bacterium, Yersinia pestis, through bites. The flea has a temporary obstruction at the entrance of the stomach and when the flea tries to feed repeatedly, back pressure causes the regurgitation of blood meal to re-enter the bite wound. (Ok, that is pretty gross.) There are two common forms of plague, bubonic and black. Bubonic plague comes with high fever and chills, delirium, bleeding under the skin, enlarged lymph glands (buboes), and prostration. If the plague invades the lungs, pneumonic plague, the infection can be spread to others through coughs or sneezes. In black plague the hemorrhages are black and result in "black death". The mortality rate is 50-60% and if it is pneumonic is fatal in 24 hours if not treated. Plague is treated with antibiotics such as streptomycin and tetracycline. Since plague is mainly spread through infected fleas, rodent control is of vital importance in infected areas.
Trypanosomiasis
Protozoan African Sleeping Sickness
The reservoir for the Rhodesian strain is humans and antelopes. The reservoirs for the Gambian strain are humans and antelopes. The Trypanosome is transmitted by the Glossina flies (also known as the tsetse flies) of the order diptera. There are two types of Trypanosomes:
1) Trypanosoma brucei gambiense
2) Trypanosoma brucei rhodesiense
Trypanosoma brucei rhodesiense is associated with the bite of Tsetse flies and is a much milder disease. The flight is mostly found in Europe, Africa, Asia, Mexico, and South America. The Tsetse fly vectoring this virus can infect approximately 200 animal species, including horses, alligators, and many common birds. Approximately one fifth of the infections take place in humans developing into West Nile Fever. Generally less than 1% of people that develop a severe case of West Nile Fever develop into West Nile Fever. Typically less than 1% of persons infected with Dengue Hemorrhagic Fever require replacement of lost blood.

Dengue Fever
Dengue is caused by the DEN virus and primarily found in warm tropical areas. Dengue is vectored by six species of mosquitoes in the genus Aedes, especially Aedes aegypti. These mosquitoes are distributed worldwide, and the first reported epidemics in 1779-1780 appeared in Asia, Africa, and North America. Currently DEN viruses are found in Southeast Asia, Caribbean basin, Mexico, south Pacific, Central, and South America. Dengue was considered to be a non-fatal disease until four distinct virus serotypes (DEN-1 through 4) were discovered. The mild form of Dengue is known as "breakbone fever" because besides a rash, fever, and severe headaches, there are intense muscle and joint pains. Most people infected with this form make a complete recovery. However, severe cases known as Dengue Hemorrhagic Fever and Dengue Shock Syndrome can occur if the infected person is exposed to one serotype followed by exposure to another serotype within approximately 5 years. Most fatal cases are among children and young adults with most countries reporting about a 5% mortality rate. People infected with Dengue need to rest and drink plenty of water because there is no specific treatment. Dengue Hemorrhagic Fever requires replacement of lost fluids, and most people require transfusions to control blood loss.

Trypanosomiasis - Chagas
Protozoan Chagas Disease
Conenose bugs belonging to the order Hemiptera and genus Triatoma are the chief vectors of Chagas disease. The pathogenic organism transferred is a flagellate protozoan known as Trypanosoma. Reservoirs are man, mammals, armadillos, rodents, carnivores, and monkeys. The Trypanosoma is associated with the bite of the vector. Other avenues of infection include the vector dropping its feces on a sleeping person as it is taking a blood meal. The disease runs its course rapidly, and usually within 4 weeks of the infection, and if the patient recovers, the disease enters the chronic stage where the parasite and the host set up an equilibrium. In chronic cases, death can occur suddenly because the Trypanosome sets up residence in the heart and destroys cardiac as well as other body cells.

Encephalitis
There are five viruses vectored by mosquitoes that infect horses and humans. Eastern Equine Encephalitis, Western Equine Encephalitis, Venezuelan Equine Encephalitis, St. Louis Encephalitis, and West Nile Virus. Mosquitoes feed on wild birds infected with the virus then transfer the virus to horses and humans. The symptoms for different Encephalitis include fever, drowsiness, and depending on type, paralysis leading to death. The Eastern type is the most virulent with 90% mortality happening in 2 to 3 days. The Western type has about a 50% mortality. Annual vaccination of horses is needed to prevent the disease from spreading.

Malaria
There are four species of Plasmodium that causes human malaria. Plasmodium falciparum, P. malariae, P. vivax and P. ovale. Plasmodium falciparum is the most severe and often fatal. During WWII, in some parts of Asia, this strain of malaria claimed the lives of more military personnel than enemy fire. The Anopheles mosquito is responsible for the transmission of human malaria. The adult mosquito takes a blood meal containing the sexual stages (microgametocyte male and macrogametocyte female) from an infected host. These stages fertilize in the gut of the mosquito and bore through the gut wall making an oocyte. The oocyte develops into an infective stage called a sporozoite. The oocyte ruptures, and the infective sporozoites travel up to the salivary glands of mosquito and are injected into the next host during the blood meal. When malaria begins, there is a cycle of fever and chills that last several hours and recur every three to four days. If untreated, the spleen and the liver become enlarged, anemia develops, and jaundice appears. Death may occur, especially in infants, elderly, and pregnant women.
Case Study 2

Your coach buddy, Will Muschamp, has just returned from a three-week tour of Africa where he taught the team how to be tough. He stopped in last Thursday to play a round of golf with you and soon began to complain of flu-like symptoms including a headache, fever, chills and body aches, as well as mild acne (red spots). By late Friday, his temperature had dropped, but yesterday, just before he was planning to leave, it rose back up sharply. Before you came to class this morning, his eyes were looking strange and he began to vomit blood. Your med-student roommate can’t figure out what’s wrong with him. Doc, was beginning to look at you funny as you left. Before you go home today you had better have a good explanation of his symptoms or else!

Which insect transmitted disease do you think coach has?

Points: fever, headache, pain, skin rash, bruises, and bleeding gums (internal bleeding), Tampa waterfront area (mosquitoes), red swollen spots (bites?)

Case Study 3

Your uncle, Geraldo Rivera, has just returned from an extensive trip to Kosovo/Yugoslavia to interview rebels hiding out in the foothills. He then went on to Africa to interview the Gators on their toughening up tour. On his way home, he stops to visit you for the weekend and begins to complain of flu-like symptoms, high fever aching joints, and mild acne. He tells you he had a strange rash on his leg in Africa but that it had gone away when a local medicine man applied elephant dung to it. You tell him to go lay down for a while and ask if he would like to take some of the tetracycline you never finished from that ingrown toenail infection you had. For the next couple of days he is extremely tired and spends most of the time sleeping in your bed. The secret service men take him to the hospital and says that he can’t figure out what he had.

Which insect transmitted disease do you think he has?

Points: high fever, rash, aching joints area of poor sanitation (rebel camp), cured with antibiotics

Case Study Answers: 1) Dengue, 2) Malaria, 3) Rickettsia