Lecture: Medical Significance of Phylum Arthropoda

1. Characteristics of Phylum *Arthropoda*
2. Classification of Arthropods. Subphylum *Crustacea* and its medical significance
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4. Subphylum *Uniramia*. Class *Hexapoda, or Insecta*. Medical significance of insects

1. Characteristics of Phylum *Arthropoda*

This is the largest and most successful of the animal phyla, with over 1 000 000 identified species.

Arthropods can be found on every continent and in every ocean, from the harsh climate of Antarctica to the dryness of the desert to the dampness of the rainforests, and even to the darkness of the ocean's depths. They can be found in ponds, on plants, in and on other animals, and even in our own houses.

Characteristics

Arthropods are invertebrate animals having an exoskeleton (external skeleton), a segmented body, and jointed appendages.

Exoskeleton*.** Arthropods are protected by a hard exoskeleton (outer skeleton) composed of ***chitin. However, because the exoskeleton cannot grow, it must periodically be shed to allow for the organism to grow.

Metamerism. Body composed of numerous segments (somites), segmented condition may be concealed. In the primitive Arthropod, the body was thought to be a series of metameres, each, except for the first and last, with a pair of appendages. Metamerism is an example of an important biological trait, that of replication and modification to develop new traits and capabilities.

All arthropods have segmented bodies divided into a **head, thorax,** and **abdomen.** In some cases, such as with the lobster, the head and thorax are fused together (cephalothorax).

Arthropods also have ***jointed appendages***. Arthropods can locomote in a wide variety of ways. They can walk, crawl, climb, hop, fly, glide, swim, skate, dive — almost every type of locomotion.

Arthropods have a complex internal design.

Double ventral nerve cord is with ganglia at each segment. Only the brain (most anterior) ganglia is above the digestive system. They also have **well-developed sensory organs**, that include antennae, eyes, and in some cases internal ears.

Open circulatory system. A dorsal (upper) vessel directs blood forward toward the brain, an open system allows the blood to circulate back through the body.

Respiration occurs through the body surface, gills, trachea, and/or book lungs. The oxygen is carried in an open circulatory system.

Arthropods have a **complete digestive** and **excretory systems**. Excretory structures called *Malpighian tubules.*

Reproductive system. The sexes are separate with few exceptions. Arthropods reproduce sexually, however, some insects are parthenogenic, females produce offspring without mating. However, some insects are *parthenogenic*, females produce female offspring without mating, e.g., in the Order *Hymenoptera* (bees and wasps) haplodiploidy is common. An example is the honey bee where the queen bee stores sperm and selectively fertilizes her eggs, unfertilized eggs develop into males and fertilized eggs develop into females.

2. Classification of Arthropods. Subphylum *Crustacea* and its medical significance

Because this phylum is so large, there are numerous ways of classifying it. Below is the most widely-accepted 4-subphylum principle of dividing this large phylum.

1. Subphylum Trilobita consists of the trilobites, which are only known by the fossil record. This subphylum therefore is extinct.

2. Subphylum Crustacea contains 30 000 species of arthropods that lead mostly aquatic lives. They have two pairs of antennae and mandibles. Marine members include shrimp, lobster, & crabs. Terrestrial crustaceans called **isopods** (pillbugs or rollypollys). Freshwater members include crayfish and daphnia. All have **mandibles** for chewing or tearing. They have cephalothorax & abdomen. Lobsters and large custraceans are called **Decapods.** They have 10 pairs of jointed appendages and breathe through gills.

Medical significance of Crustaceans:

- ***Cyclops*** (Order *Copepoda*) are intermediate hosts for larval stages of broad fish tapeworm (*Diphyllobotrium latum*) and dragon worm (*Dracunculus medinensis*)

- **Crabs and crayfish** (Order *Decapoda*) have sanitary significance because they clean natural water reservoirs by feeding on the carrion lees. They are also the intermediate hosts for larval stages of lung fluke (*Paragonimus westermani*) and Chinese liver fluke (*Clonorchis sinensis*).

3. Subphylum Chelicerata consists of arthropods that have 6 pairs of appendages, four of which are legs (or five in the case of the horseshoe crab):

- **chelicerae** - claws or fangs (1 pair). Chelicerae of spiders have venomous glands.
- **pedipalps** used for feeding, sensing, transferring sperm (1 pair). These species lack antennae and mandibles/
- **walking legs** for movement (4 pairs)

The Subphylum Chelicerata includes Class **Arachnida**: spiders, ticks, scorpions, mites. The representatives have a **cephalothorax** (fused head & thorax) and **abdomen,** no antennae. Spinnerets in spiders make web.s

Medical significance of Subphylum Chelicerata (see below)

4. Subphylum Uniramia is the largest of the subphyla, including insects and their relatives. These arthropods have one pair of antennae and one or two maxillae. They also have mandibles. Respiration occurs through the trachea, body surface and/or gills. **Uniramia** includes 3 Classes.

1. Class Chilopoda
2. Class Diplopoda
3. Class Hexapoda, or Insecta

The ***Class Hexapoda (Insecta)*** is composed entirely of insects and is the largest group in the animal kingdom, with 29 orders and 800 000 known species. It is estimated that there may be up to 50 000 000 species of insects on Earth, most of which have not yet been discovered. Insects have 3 pairs of legs, 3 body parts - head, thorax, and abdomen. Most of insects have wings. All appendages attach to the thorax. Mandibles are for chewing.

Insect Life Cycle is with *metamorphosis* (means *change form*) - biological process by which an animal physically develops after birth or hatching, involving a conspicuous and relatively abrupt change in the animal's body structure through cell growth and differentiation. There are 2 types:

1. *Incomplete metamorphosis* has three stages: egg → nymph → adult (example: crickets, grasshoppers, dragonflies and cockroaches)
2. *Complete metamorphosis* has four stages: egg → larva → pupa → adult (example: butterflies, bees, flies, beetles and many other insects develop)

Parasitic arthropods may be ecto- ,endo- and mesoparasites; they may serve as definitive or intermediate hosts, or as vectors.

Vector - host that plays an active role in transmission, can be a definitive or an intermediate host. Depending on the route of transfer of pathogen the insects are:

- **mechanical vectors** (flies, cockroaches)
- **specific vectors** (mosquitoes, sand flies)

For parasitic arthropods such *routes of transmission* are possible: peroral (alimentary), sexual intercourse, transmissive (transmissive inoculative and transmissive contaminative)

Depending on *life mode* the parasitic arthropods are subdivided into:

- true parasites
- commensals
- poisonous or venomous species.

3. Subphylum *Chelicerata*. Class *Arachnida*. Parasitic ticks and mites

Subphylum Chelicerata constitutes one of the major subdivisions of the Phylum Arthropoda and includes marine horseshoe crabs and arachnids (scorpions, spiders, mites, ticks, harvestmen, and solifugae [sunspiders]).

Class Arachnida is a class of **8-legged** arthropods, including spiders, ticks, scorpions, mites. Arachnids are found throughout the world, from ponds to rainforests to desert to attics. They prefer warmer climates. Their body is separated into only 2 parts: the **cephalothorax** contains the mouthparts as well as the **chelicerae** (pincers or claws used for feeding), **pedipalps** (feet used to touch or capture) and 4 pairs of legs. Arachnids lack antennae. The second segment - **abdomen** - contains the rest of the body. Most arachnids breathe in through **tracheae or book lungs**.

Most arachnid species are considered to be pests or are thought to be dangerous to humans.

Order Araneae: Spiders includes ~ 35 000 spp

Some spiders can kill humans, but these occurrences are very rare. The most dangerous spiders in the world are

- Redback Spiders (*Latrodectus* species and their relations)
- Funnel-web spiders (*Atrax* and *Hadronyche* species),
- Banana Spiders (*Phoneutria* species)
- Recluse Spiders (*Loxosceles* species).

Order Scorpiones includes ~ 1200 spp. Scorpions are venomous. The venom of scorpion species is not lethal. There are two truly very dangerous scorpions to human:

- **Fat tailed scorpion *Androctomus australis.*** Numerous deaths in Middle East countries and North Africa are attributed to it though again children and elderly are more at risk. It is not native to Asia (except perhaps India) and America. It is also known to be quite aggressive.
- **Death stalker *Leiurus quinquestriatus***

Order Acarina: Mites, Ticks (25 000 spp).

It is combined order including 3 groups: **Parasitiformes**, **Sarcoptiformes, *Trombidiformes.***

Members of the *Acarina* lack a visible body division. Thus, the abdominal segmentation has disappeared and the abdomen has fused with the presoma. Chelicerae and pedipalps are fused to form a *hypostome* – a harpoon-like structure that allows ticks to anchor themselves firmly in place on a host mammal while sucking blood. Development is with incomplete metamorphosis. They have diversity of hosts. They also have the most medical significance among arthropods.

Sarcoptes scabiei – human itch mite, or scabies mite – is a cause of **scabies** and is distributed worldwide. Epidemics of the disease may occur for long periods but mites may be common at all times in very poor communities with inadequate washing facilities.

The disease is transmitted by person-to-person contacts. The female mite burrows into the skin on the webbing side of fingers, later spreading to the wrists, elbows and the rest of the body. The buttocks, women's breasts and external genitalia may be involved. The mite tunnels itself through the upper layer of the skin depositing eggs. The mite larvae escape the tunnel and wander on the skin and start new burrows and mature there to continue the cycle.

Pathogenecity. Scabies **itch** is due to the sensitization of the patient to the mite and eggs and is characteristically **nocturnal**. **Septic pustules** may develop after scratching, if the hygiene is poor.

Diagnosis is made by the **characteristic rash** and by smearing black ink on the skin and observing burrows when the ink is wiped away. Microscopic examination of a skin scraping shows mites.

Prevention. If possible, the whole family should be treated. Contact with an infested person should be avoided. Clothes should be washed in hot water.

Demodex folliculorum is a microscopic worm-like mite with clearly defined cephalic, thoracic, and abdominal portions; with eight legs. It is sometimes found on the surface of the skin, particularly on those parts where the sebaceous glands are large, and on individuals affected with acne or seborrhea oleosa.

Pathogenecity. *Demodex* feeds on the skin sebum and oils. Around 80% of the adult population has *D.folliculorum* infection. The frequency of disease is less in children: it is rarely found in children under 5 years old.

Pyemotes ventricosus**,** or **Grain itch mite**

It is predatory mite that has been the first mite recognized as cause of allergy in 1923. It causes **"straw-itch", "grain-itch",** and **itching from contact with cereals.**

Pathogenecity. The young females attach to the man skin and cause a **papular dermatitis** accompanied by many symptoms: **pruritus, headache, fever and perspiration. The site of the bite is marked by a vesicle surrounded by a wheal.** It has been frequently recorded in cases of human dermatitis in Europe, North Africa, India, Australia and the USA. The mite is parasitic on the larvae of many insects. Such insects, accompanied by their mite, can infest straw, hay and grain.

Cheyletus eruditus. The first paper to point out the specific value of *Cheyletus eruditus* as a predator of acaroid mites appeared in 1912. The first described **human dermatitis** caused by *Cheyletidae* mites has been done in 1917. The mite may be found in grain stores, a chaff pile, it is capable of causing dermatitis in indoor companion animals.

Pathogenecity. Adults and larvae fall on the open parts of body in lawn-and-garden works. In the site of bite the **erythema, wheal**, the **fever** are possible. **The cutaneous lesions** are generally in the **form**

of erythematous papules and **urticariform plaques, which on a smaller scale are able to occur as blisters or eczematous lesions**

Family Pyroglyphidae: House Dust Mites (HDM)

The HDM are a cosmopolitan guests in human habitation (in sofas, carpets, bed sheets and cover, floors and cabinets). HDM feed on organic detritus such as flakes of shed human skin and flourish in the stable environment of dwellings.

Pathogenecity. Certain individuals are allergic to these organisms. Symptoms may vary from one person to another, but there are **3 common symptoms: asthma, perennial rhinitis and childhood eczema**

Family Trombiculidae includes the *mites whose larvae (redbugs, harvest mites, scrub mites, or chiggers) are parasitic on vertebrates* and whose nymphs and adults are bright red and free-living, living on insects eggs or minute organisms in the soil.

Pathogenecity. They attach to the skin in the ankles, waistline, armpits and perianal area after walking through a grassy environment. These mites do not feed on blood but on partially digested skin cells using enzymes in the chigger's saliva. The host reacts to the mouth parts and saliva of the mite. The bite causes severe irritation and sometimes fever.

Suborder Acaridei includes the *ticks of granary complex*. Their chelicerae are adapted for piercing and tearing. They spoil dried fruits, grain, flour, cheese. Their impact on human as arthropods of medical importance is due to

- the allergic (catarrhal and asthmatic) reactions of respiratory tract and skin
- inflammation in the gastrointestinal tract
- ability to transmit many pathogens

Chigger-mite and results of its bites

Chigger, harvest mite larval ectoparasite (*Trombicula* spp.) lives on human epidermis (skin). The larval stage is parasitic on humans and causes the disease chigger dermatitis.

Ticks are divided into two families:

1. Family *Argasidae* (contains 4 genera: *Argas, Ornithodoros, Otobius,* and *Antricola*) - the soft ticks. These ticks have a wrinkled appearance, which is akin to soft leather. They harbor and transmit bacteria *Borrelia* spirochetes that cause relapsing fever.
2. Family *Ixodidae* - the hard ticks - are distinguished by a hard dorsal plate in the shape of a fingernail and elongated mouthparts that have rows of backward pointing teeth. Some species of tick use these teeth in conjunction with a cement to remain attached to the host while blood feeding.

Family Ixodidae

Ixodes ricinus, dog tick, is a hard tick that infests livestock, deer, dogs, and a wide variety of other species including humans. It has long mouthparts that can make its bites painful and annoying; the bites can also become secondarily infected by bacteria. Feeding by large numbers of ticks may result in anemia. The life cycle requires 1-3 years to complete, and may require one, two or three different host animals.

Ticks as disease vectors can also transmit **numerous diseases** including:

1. **tick-borne encephalitis** – *viral infection* of CNS; disease is incurable once manifest, but infection can be prevented by vaccination
2. **Crimean–Congo hemorrhagic fever** – *viral disease*. CCHF is characterized by a *sudden onset of high fever, chills, severe headache, dizziness, back, and abdominal pains*. Additional symptoms can include *nausea, vomiting, diarrhea, neuropsychiatric, and cardiovascular changes*. The mortality rate from CCHF is approximately 30%, with death occurring in the second week of illness.
3. **Rickettsial tick-borne fever** – *bacterial disease*. Initial signs and symptoms include *sudden onset of fever, headache and muscle pain, followed by development of rash*. The disease can be difficult to diagnose in the early stages, and without prompt and appropriate treatment it can be fatal.
4. **Lyme disease** is caused by at least 3 species of spirochaete *bacteria* of Genus *Borrelia*. Symptoms are varied and may include *rashes, fever, muscle and joint pains, and arthritis*. The disease is not fatal and treatable with antibiotics.
5. **Tularemia** (rabbit fever, deer-fly fever) is a serious infectious disease *caused by bacterium Francisella tularensis* affecting *lymph nodes, skin, sometimes eyes, throat, lungs*

6. **babesiasis** (Babesia divergens, Texas fever) - malaria-like disease *caused by protozoan* parasites of the genus *Babesia*.

4. Subphylum Uniramia. Class Hexapoda, or Insecta. Medical significance of insects

Insect-borne diseases are among the most devastating of all human diseases. Insects (mostly flies, fleas, and lice) serve as effective vectors of disease by transmitting pathogens via their blood meals. Malaria is the most serious and costly of all insect-borne diseases and continues to killl between 1 and 3 million people per year.

Order Hemiptera: True Bugs

Most hemipterans are phytophagous, feeding on plant sap. A few, however, are parasites, feeding on the blood of larger animals. These include, for instance, *bedbugs* and *kissing bugs*.

Cimex lectularius, bed bug, is small (1-7 mm long), wingless, brownish, flattened insect that feeds on the blood of people and animals while they sleep. Bed bugs are not known to spread disease. Bed bugs can be an *annoyance* because their presence may cause *itching and loss of sleep*. Sometimes the itching can lead to *excessive scratching* that can sometimes increase the chance of a *secondary skin infection*.

Genus ***Triatoma*** of the family Reduviidae is also known as ***kissing bug*** which can transmit a protozoan potentially deadly *Trypanosoma cruzi* that causes **Chagas disease** in South and Central America.

Order Phthiraptera: Lice

Family Pediculidae. Three species of sucking lice are most important for human health:

- ***Pediculus humanus capitis*** (head louse) infesting human heads
- ***P. humanus humanus,*** also ***P. vestimenti*** (body louse) infesting undergarments or clothing in contact with a human body
- ***Phthirus pubis*** (crab, or pubic, louse) infesting mainly the pubic hair

The head louse and the body louse are different in ecological character but morphologically almost indistinguishable.

P. humanis capitis. Human lice infestation is called **pediculosis.** Lice eggs are *nits* usually located within 6-10 mm of the scalp. They are hard to see and are often confused for dandruff or hair spray droplets. Nits are laid by the adult female and are cemented at the base of the hair shaft nearest the scalp. They are 0.8 × 0.3 mm, oval and usually yellow to white. Nits take about 1 week to hatch (range 6 to 9 days) to release a nymph. The life cycle of the head louse has three stages: egg, nymph, and adult. Lice spend all of their life on one very specific host and both male and female feed on blood and leave one host only to transfer to another.

Pathogenecity. The primary symptom of pediculosis is *itching*. It is the *result of an allergic reaction to louse saliva* and takes two or more weeks to develop. By this time, the infestation is well established. Heavy infestations *may result in fever, secondary infections, excoriation and pyoderma* (skin disease with suppuration).

The routes of transmission include direct contact of the heads as the main route and common use of bedding, towels, caps, and lockers among community and family members as well. Therefore, prevention and control of head lice infestation must depend on avoidance of common use of towels and combs.

P. humanus humanus (P. vestimenti): **Body louse** is similar to the head louse except that it is found on the body and clothes. Body lice infestations can spread rapidly under crowded conditions where hygiene is poor and there is frequent contact among people.

Pathogenecity. *Itching and rash* are common; both are body's allergic reaction to the lice bite. Long-term body lice infestations may lead to *thickening and discoloration of the skin*, particularly around the waist, groin, and upper thighs. *Scratching may cause sores on the body*. These sores can sometimes become infected with bacteria or fungi.

Diagnosis is based on finding eggs or nits in seams of clothing.

Human lice (*Pediculus humanus* and *P. capitus*) may also transmit infectious diseases, including:

- **epidemic relapsing fever**, caused by bacterium *Borellia recurrentis*, a spirochaete pathogen
- **epidemic typhus** (*Rickettsia prowazeki*)
- **trench fever** (*R. quintana*)

Phthirus pubis: **Pubic louse**, or **crab louse**.

P. pubis infestation is called **phthiriasis.** The lice infest widely-spaced coarse hair in the pubic area in adults or eye lashes in children. Transmission in adults is usually by sexual intercourse.

Pathogenecity. It causes the erythematous lesions seen in the pubic region of patients

Diagnosis is based on finding lice or nits in the infested area; crab lice may be difficult to see at the base of the hair.

Order Siphonaptera: Fleas

Family Pulicidae includes over 1,600 species and subspecies of fleas, which are parasites, populate the Earth's many diverse environments. Fleas are laterally compressed and wingless body covered with many hairs and short spines, with long powerful legs adapted for jumping. The mouthparts are for sucking.

Human flea, *Pulex irritans*, can transmit **plague** (It is responsible for spreading the bubonic plague throughout Europe during the Middle Ages). The species may also transmit **murine typhus**, **tularemia**, and tapeworm, but such occurrences are relatively rare.

Rat fleas, especially ***Xenopsylla cheopis* (the Oriental rat flea)**, are the principle vectors of *Pasturella pestis*, the bacterial pathogen of **bubonic plague**. Fleas can also transmit **murine typhus** caused by *Rickettsia mooseri*.

Tunga penetrans* – chigoe flea** (chigger, jigger, or sand flea) - is the smallest (1 mm long) known flea which causes ***tungiasis. It inhabits in tropical climates, especially Central America, South America, India, and tropical Africa. Researches revealed that ~ 42% of Nigerian school children are infected. The average incidence in Trinidad is 21%. In a traditional fishing village in northeastern Brazil, the overall prevalence was 51% (*Muehlen, 2003*).

Pathogenecity. The pregnant *Tunga penetrans* flea burrows into the host's skin near the plantar surfaces of the foot, in the webbing between the toes, and around the periungual region. *Skin lesion looks like a 5 -10 mm white spot with a central black dot*, which is the flea's exposed hind legs, respiratory spiracles and reproductive organs. *Inflammation* is marked by *painful swelling* that occurs at the site of infestation, leading to the development of a fibrous cyst at the site. Very heavy infestation *may cause ulceration and fibrosis that may cause secondary infections* (bacteremias, tetanus, or gas gangrene).

Order Diptera – Flies (Diptera means "two wings") is a large order, containing an estimated 240,000 species of mosquitoes, gnats, midges and others. This order of insects is characterized by having 1 pair of membranous wings (when present). The mouth parts function as suctorial organs but there is a great deal of variation between different members of this order. The life cycle usually involves a complete metamorphosis.

Families *Muscidae, Calliphoridae, Sarcophagidae*

House flies (family Muscidae), blow flies (family Calliphoridae), and flesh flies (family Sarcophagidae) often live among filth and garbage. They *can transmit cysts of protozoa and eggs of helminthes, bacterial diseases* (dysentery, typhoid fever, cholera**),** enteroviruses (poliomyelitis, infective hepatitis)

Myiasis – disease caused flies' larvae

The species of some genera of parasitic flies (*Cochliomyia*, *Calliphora*, *Oestrus*, *Sarcophaga*, *Gastrophilus*, etc) cause *myiasis*. ***Myiasis** is an animal or human disease caused by parasitic fly larvae feeding on the host's necrotic or living tissue*. The classical classification describes the myiasis by the infected area of the host: dermal, sub-dermal, cutaneous, nasopharyngeal, ocular, intestinal/enteric, or urogenital.

Larvae can burrow through tissue using their mandibular hooks aided by proteolytic enzymes. They can cause mechanical damage and the affected area may be the site of a secondary infection. Cutaneous myiasis may require surgical removal of burrowed larvae. Eggs and maggots may be washed from hair, skin and wounds with soap and water. Urinary myiasis usually clears itself. Purgation with anti-helminthes may be necessary for gastrointestinal myiasis.

Maggot therapy

Maggots are also used occasionally in the field of **medicine**. Maggots are used to ***eat dead tissue***, helping to clean open wounds.

During the Civil War in the USA, and World War I, battlefield physicians saw that soldiers' wounds that were infested with maggots tended to ***heal better than non-infested wounds***. Soon **'maggot**

therapy' was being used to clean festering and foul-smelling wounds. Maggots not only eat the rotten flesh, they also get rid of harmful bacteria in the wound.

More than 200 hospitals in the U.S. and Europe prescribe maggots of the Blowfly to treat patients with infections from injuries like pressure ulcers ("bed sores"), leg and foot ulcers, stab wounds, and post-surgical wounds that won't heal properly. About 5,000 laboratories grown and microorganism-free maggots are delivered to hospitals across the U.S. every week.

Using maggots is sometimes faster than other non-surgical methods for wound-healing, and is not as likely to injure healthy tissue. The larvae are placed in special bandages which hold the maggots in after they are applied to a human wound.

Open, untreated wounds can often become infected and gangrenous if left untreated. Maggots are implanted directly onto a wound, where they eat dead flesh, clean out dead skin, and kill harmful bacteria. Once maggots reach their fill of dead and dying flesh, they're removed from the wound, and new maggots are applied. Blood can then flow throughout the tissue, promoting the growth of new flesh.

Family Simuliidae

Black flies, buffalo gnat - *Simulium sp* spread *Onchocerca volvulus*, a parasitic roundworm. **Onchoceriasis**, the disease caused by infection of these worms, may cause blindness in peoples of Africa, Mexico, and Central and South America.

Family Ceratopogonidae, punkies, are the vectors of parasitic roundworms of several genera, including *Onchocerca*, *Acanthocheilonema, Dipetalonema, Mansonella*

Family Psychodidae

Sand flies in the genus *Phlebotomus* are vectors of

- protozoan pathogens (*Leishmania* spp.) that cause **leishmaniasis**
- a bacterium (*Bartonella bacilliformis*) that causes **Carrion's disease** (oroyo fever) in South America
- viral agent that causes **sand fly fever (papataci fever)** in parts of Asia and North Africa

Family Tabanidae - horse flies and deer flies may transmit

- the parasitic roundworm (*Loa loa* – eye worm) that causes **loiasis** in tropical Africa
- bacterial pathogens of **tularemia** (*Pasteurella tularensis*)
- **anthrax** (*Bacillus anthracis*)

Family Glossidae, or tsetse flies in the genus *Glossina* (*G. palpalis* and *G. morsitans)* transmit the protozoan pathogens that cause **African sleeping sickness** (sub-species of parasites *Trypanosoma b. gambiense* and *T. b. rhodesiense*).

Family Culicidae - Mosquitoes

Genus *Anopheles* is the principle vector of **malaria** caused by protozoa *Plasmodium. Anopheles* mosquito also transmit the parasitic roundworms *Wuchereria bancrofti* and sometimes *Brugia malayi.* Both worm species are responsible for ***lymphatic filariasis:*** Bancroftian lymphatic filariasis (wuchereriosis) and Brugian lymphatic filariasis (brugiosis) respectively.

Genus *Aedes, e.g., A. aegypti,* includes the vectors of the pathogens that cause **yellow fever, dengue haemorrhagic fever, Rift Valley fever, West-Nile encephalitis,** and roundworms ***Wuchereria bancrofti*** and ***Brugia malayi***

Genus *Culex* includes the vectors of ***wuchereriosis, Japanese encephalitis, St. Louis encephalitis, West-Nile encephalitis, Rift Valley fever, lymphocytic choriomeningitis***

Genus *Mansonia* includes the vectors of *Brugian lymphatic filariasis*.

Order Blattaria – cockroaches are mechanical vectors of many pathogens. Because cockroaches eat a wide range of food, including rotting garbage, it is believed that they spread a number of *bacteria including Salmonella, Staphylococcus* and *Streptococcus* responsible for human diseases (gastroenteritis). The cockroaches can also harbour viruses such as the *polio virus*. Recent reserches have indicated cockroaches can also *cause allergies*.