Carrier and Vectors

Dr. Debasish Karmakar

Assistant Professor in Zoology

City College, Kolkata - 700009

INTRODUCTION

You have studied that insects are found in abundance compared to any other group of animals. They appeared on the earth prior to human existence. Therefore, they are more adapted. Subsequently, many parasites and viruses have also co-evolved with many insects and used them for their life cycle and dispersal. An insect may be a vector or carrier of certain pathogens that render them as insect of public health importance or as insect of economic importance. Vector-borne diseases are responsible for human illnesses caused by parasites, viruses and bacteria that are transmitted by mosquitoes, sandflies, triatomine bugs, blackflies, ticks, tsetse flies, mites, snails and lice. Every year there are more than 700 000 deaths, globally from diseases like malaria, dengue, schistosomiasis, human African trypanosomiasis, leishmaniasis, Chagas disease, yellow fever, Japanese encephalitis and onchocerciasis

Vector		Disease Caused	Type of pathogen
Mosquito	*Aedes*	Chikungunya	Virus
		Dengue	Virus
		Lymphatic filariasis	Parasite
		Rift Valley fever	Virus
		Yellow Fever	Virus
		Zika	Virus
	Anopheles	Lymphatic filariasis	Parasite
		Malaria	Parasite
	Culex	Japanese encephalitis	Virus
		Lymphatic filariasis	Parasite
		West Nile fever	Virus
Aquatic snails		Schistosomiasis (bilharziasis)	Parasite
Blackflies		Onchocerciasis (river blindness)	Parasite
Fleas		Plague (transmitted from rats to humans)	Bacteria
		Tungiasis	Ectoparasite
Lice		Typhus	Bacteria
		Louse-borne relapsing fever	Bacteria
Sandflies		Leishmaniasis	Parasite
		Sandfly fever (phlebotomus fever)	Virus
Ticks		Crimean-Congo haemorrhagic fever	Virus
		Lyme disease	Bacteria
		Relapsing fever (borreliosis)	Bacteria
		Rickettsial diseases (eg: spotted fever and Q fever)	Bacteria
		Tick-borne encephalitis	Virus
		Tularaemia	Bacteria
Triatome bugs		Chagas disease (American trypanosomiasis)	Parasite
Tsetse flies		Sleeping sickness (African trypanosomiasis)	Parasite

Vector-borne diseases are a major concern of public health at a global scale. These diseases are unpredictable and very difficult to be controlled. However, the implementation of good management practices in different economic, environmental and agricultural sectors could prove effective in slowing down their progress in relation to effects owing to climate change and globalization. In the present unit we shall discuss the difference between carriers and vectors of the pathogens and their relationship with the host. Host-vector relationship and vector adaptations will be also discussed.

Difference Between Vector and Carrier

Sl. No.	Character	Vector	Carrier
1.	Definition	In molecular biology, vector refers to DNA molecules that carry foreign genes inside a host cell for replication and expression, integration and inheritance.	Carriers are organisms which harbour and transmit disease-causing pathogens to the host cell without themselves getting infected or showing any symptoms. The pathogen usually does not carry out any portion of its life cycle in the carrier.

Difference Between Vector and Carrier

Sl. No.	Character	Vector	Carrier
2.	Function	Vectors are indispensable regarding genetic manipulation and gene transfer. It is an integral part of all molecular biology-based research like gene therapy and generation of transgenic organisms. They deliver a gene of interest to the host cell for their integration, expression of the gene product or recombinant protein production, thereby finding its extensive application in genetic engineering and biotechnology.	Carriers act as reservoirs for several pathogens which lead to infectious diseases in individuals. However, they do not serve as vessels for the replication and multiplication of pathogens. They do not show any properties of expressing a foreign DNA and thus, do not take part in genetic manipulation and engineering.

Difference Between Vector and Carrier

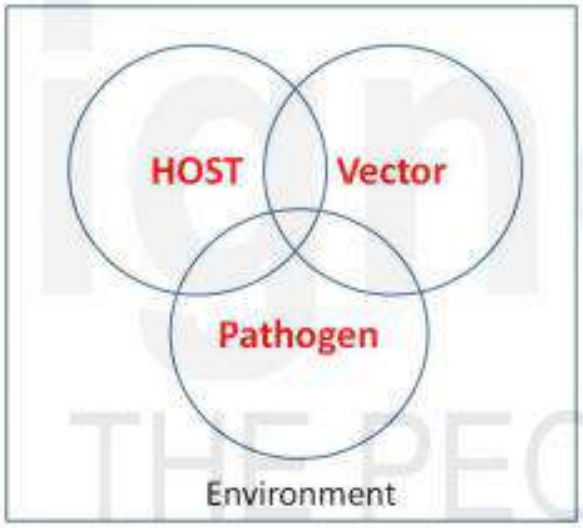
Sl. No.	Character	Vector	Carrier
3.	Genetic Material	Vectors are DNA molecules or viruses that carry a foreign gene.	Carriers are living organisms that carry pathogenic microbes, parasites and viruses capable of causing infection.
4.	Impact on Health	Vectors find their application in gene editing and genetic engineering. Thus, they often have a neutral or positive impact on human health as recent studies suggest the use of vector-based therapy in treating genetic disorders, previously known to be incurable.	Carriers are often deleterious to human health as they transmit several pathogenic bacteria, parasites and viruses capable of causing infectious diseases. Often these diseases are debilitating and can cause death.

Difference Between Vector and Carrier

Sl. No.	Character	Vector	Carrier
5.	Replication and Transmission	Vectors replicate within the host cell, amplify and propagate the foreign gene for their expression. They take part in both horizontal gene transmission where the genetic material is transferred between different organisms, and also in vertical gene transmission where the genetic material is passed down between generations.	Carriers are incapable of replicating and propagating the pathogen they carry. They simply transmit it to other organisms through mediums like body fluids (blood and saliva).

What is Carrier?

Carrier If an insect is having any pathogen associated with its life cycle or carries any pathogen symbiont/parasite (ecto or endo) and harbours these pathogens of a disease without manifestation of symptoms and is capable of transmitting the infection; the condition of such an individual is referred to as the carrier. A carrier can transmit the pathogen to its offspring. The carriers can or cannot become a vector as it depends upon several factors.



Elements of vector borne disease transmission.

Transient Carrier: The host can be infectious for a short period in transient carriers, or over a prolonged period in a chronic carrier.

Asymptomatic carriers: The person or animal infected with pathogen can potentially spread its pathogen, but does not show clear symptoms. The symptoms may be mild, or may be completely absent. These hosts are called carriers, or asymptomatic carriers.

Incubating Carriers: The person or animal has been infected and can spread the pathogen, but do not yet show the symptoms of the illness.

Convalescent carriers: These types of carriers continue to spread the pathogen even though they have recovered from illness.

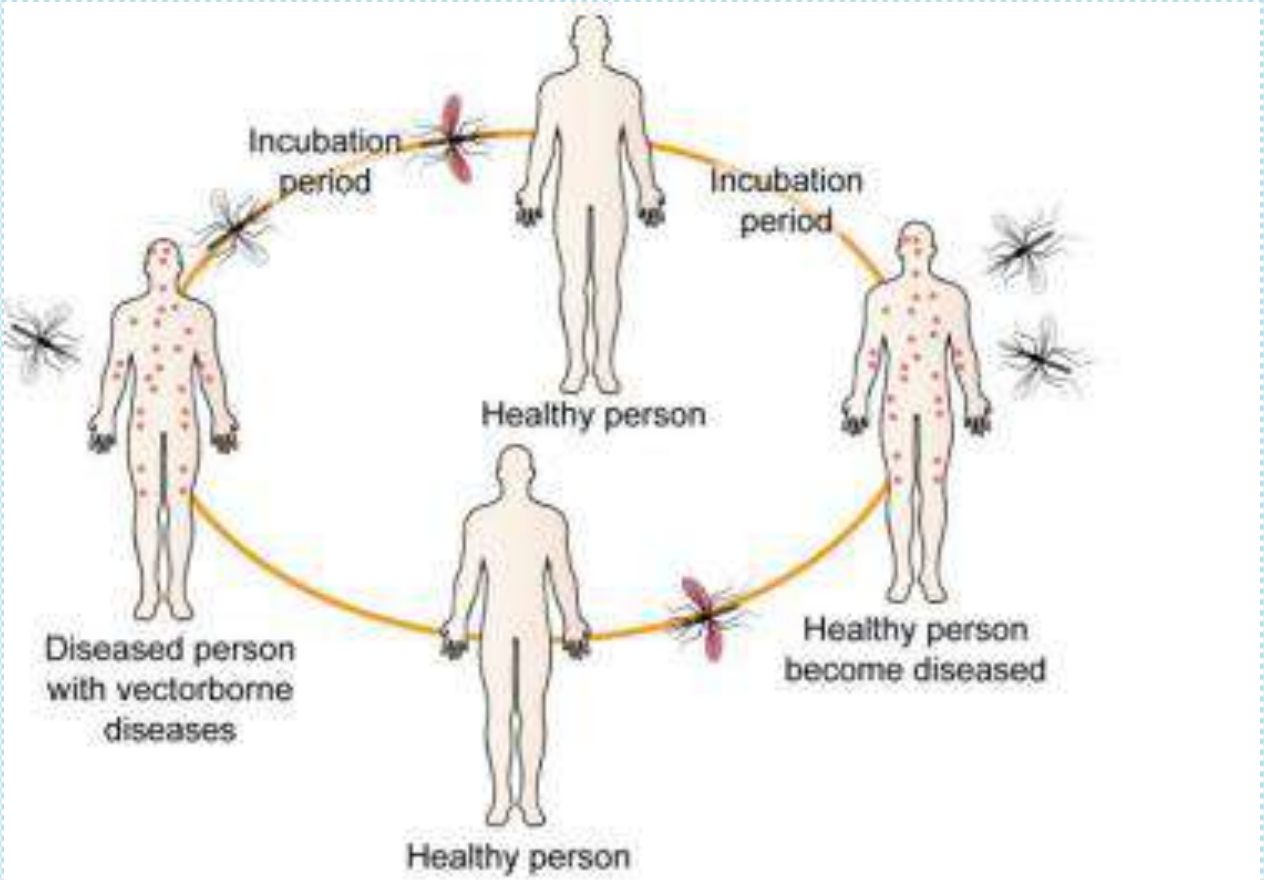
What is Vector?

Vector: A disease vector (Vector is a Latin word which means 'bearer') is any agent (a human, animal or microorganism) that carries and transmits an infectious pathogen into another living organism, either directly via the blood flow or indirectly via the food, water or any other element of a susceptible organism which may be in contact with it.

- Better way to understand is the organism which is able to hold pathogen in live form and may or may not increase its population and/or helps to change non infective stage of pathogen to infective stage and is able to transmit the pathogen to other organism.

- How good is a vector that depends upon how efficiently it transmits the disease pathogen to the healthy person / animal and how many of such healthy person/animals it infects. You can also say number of secondary cases produced from one single case by a vector is also called as vectoral capacity.

- Arthropods form a major group of pathogen vectors with mosquitoes, flies, sand flies, lice, fleas, ticks, and mites transmitting a huge number of pathogens. Many such vectors are haematophagous (blood feeding), which feed on blood at some or most stages of their life. During the feeding process, the pathogen enters the blood stream of the host.



: Transmission of disease from infected person to healthy.

Carrier is an individual who has the disease but no symptoms. It is capable of transmitting the disease to a new individual.

Vector is an organism which is capable of transmitting the diseases without having the disease itself.

TYPES OF VECTORS (MECHANICAL AND BIOLOGICAL VECTORS)

Insects as vectors can assume different roles according to the relationship they establish with the infectious agent they carry.

Mechanical Vector:

The only function of these vectors is to transport the infectious agents, which don't really need vectors to complete their life cycle (that is, the insect isn't a host of the pathogen). For example some flies transport infectious agents/ pathogens of some intestinal infections, but these agents/pathogens do not need flies to complete their life cycle. That means the transmission is not dependent on the vector specification; it could have been transmitted with bare hands or any other means.

Therefore, the mechanical transmission is the transmission which occurs by contamination of pathogen through mechanical means like a fly sitting on infected wound/garbage/faeces etc. and contaminating the food article by just sitting on them.

TYPES OF VECTORS (MECHANICAL AND BIOLOGICAL VECTORS)

Flies can carry human pathogens on the sponging mouthparts, on body and leg hair (i.e., setae), or on the sticky pads of the feet (i.e., tarsi).

- **Fine hair on the pads of a fly's feet are coated with a sticky substance which improves the fly's ability to adhere while resting or climbing on non-horizontal surfaces.**
- **This substance also enhances the adhesion of particles, i.e., viruses, bacteria, and protozoan cysts, to fly's legs, which then can be directly transported to the next visited person where it can be dislodged.**
- **Small particles readily adhere to a fly's exterior surfaces due to the electrostatic charge of fly exoskeleton and any particle with a different charge or a neutral charge will adhere to the fly surface.**
- **Protozoan parasites can pass through the fly gastrointestinal tract without alteration of their infectivity and can be subsequently deposited on visited surfaces in "faecal spots".**
- **Sometimes, the parasites present in fly alimentary tracts can be regurgitated, i.e., vomit drops, on a surface perceived by a fly as a meal (regurgitation always precedes feeding).**
- **Frequent meals on contaminated substrates together with alternating regurgitation and ingestion cause progressive accumulation of human pathogens in the fly alimentary system.**

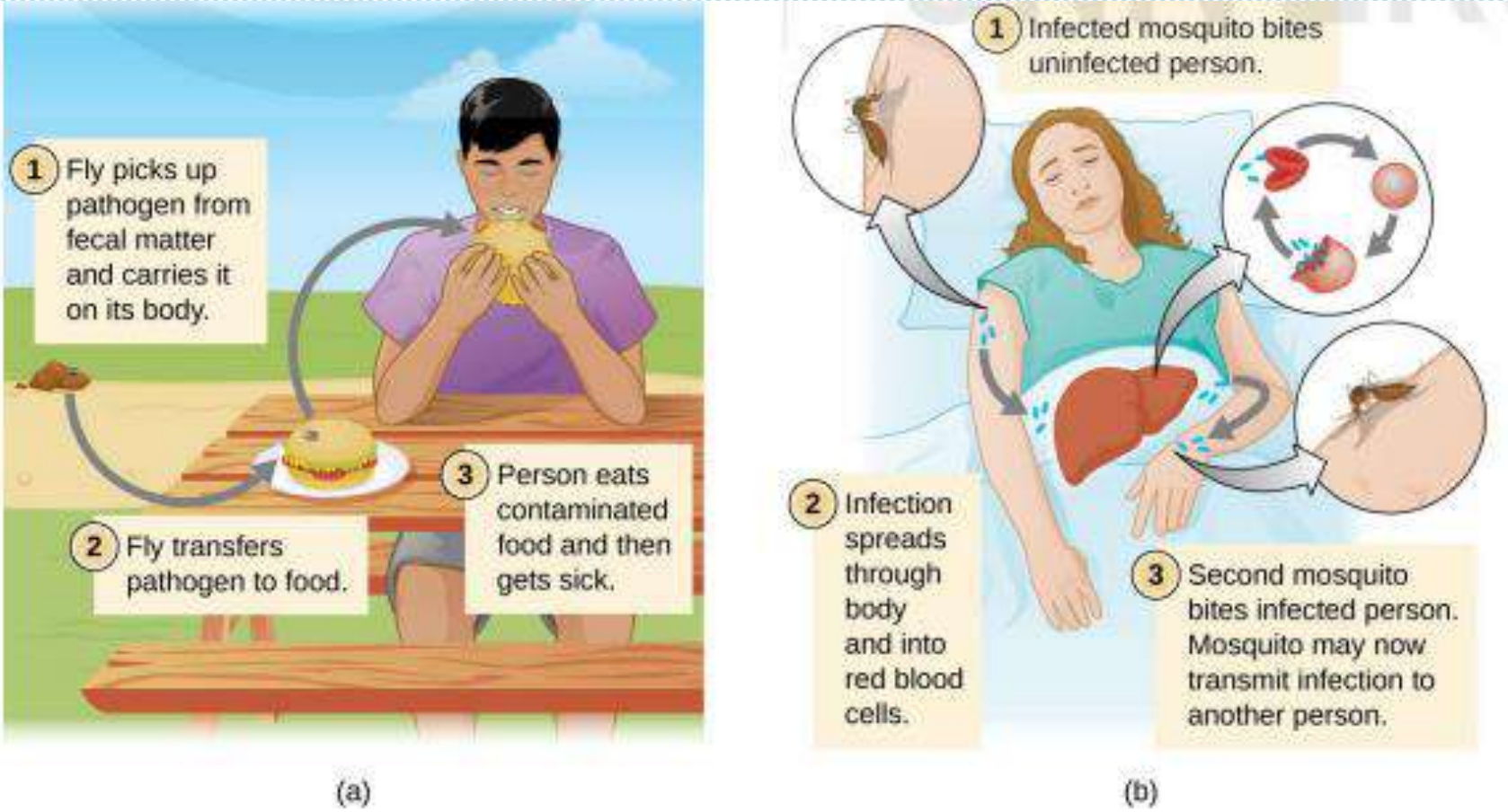
Biological Vector

An essential element in the pathogen's life cycle, which needs the insect (that is, the vector) to complete its development before being transmitted to another organism.

All intermediate hosts are biological vectors but all biological vectors are not necessarily intermediate hosts. Most of infectious agents travel inside insect's hemolymph (the liquid equivalent to blood in insects). This is the case of the pathogen (an apicomplexan from the genus *Plamsodium*), responsible for malaria which travels from an organism to another inside the hemolymph of different mosquito species from the genus *Anopheles*. In biological transmission the biology and the behaviour of vector play a vital role in transmission of disease.

Most arthropod vectors transmit the pathogen by biting the host, creating a wound that serves as a portal of entry. The pathogen may go through part of its reproductive cycle in the gut or salivary glands of the arthropod to facilitate its transmission through the bite.

For example kissing bug transmits Chagas disease to humans by defecating when they bite, after which the human scratches the infected faeces into mucous membrane or break in the skin. Biological transmission, because it involves survival and reproduction within a parasitized vector, complicates the biology of the pathogen and its transmission.



a) A mechanical vector carries a pathogen an its body from one host to another (not as an infection) b) A biological vector carries a pathogen from one host to another after becoming infected itself.

Table 5.2: Insect vectors and diseases caused by them.

Vectors	Species/ Genera	Disease	Mode of Transmission
Fly	House fly (*Musca*) 	Typhoid Cholera Dysentery Anthrax Tuberculosis	Mechanical Transmission
Mosquito	*Aedes* 	Chikungunya Dengue fever Rift Valley fever Yellow fever Zika	Infective bite Biological
	Anopheles 	Malaria Lymphatic filariasis	Infective bite Biological
	Culex 	Japanese Encephalitis Lymphatic filariasis West Nile fever	Infective bite Biological

Sandflies	*Phelebotomus* 	Leishmaniasis Sandfly fever (*Phelebotomus* fever)	Infective bite Biological
Blackflies "buffalo gnats" & "turkey gnats,		Onchocerciasis or river blindness Africa, America, Latin and Yemen	Infective bites Biological
Tse tse fly		Sleeping Sickness Africa	Infective bite Biological

Triatomine bugs		Chagas disease (American trypanosomiasis)	Infective bite Biological
Fleas		Plague rickettsiosis	Transmitted by fleas from rats to humans Biological
Lice		Typhus and louse-borne relapsing fever	Infective bite Biological
Ticks (These are arachnids).		Crimean-Congo haemorrhagic fever Tick-borne encephalitis	Infective bite of larval stage Biological

MODE OF TRANSMISSION OF DISEASE

There are various modes of transmission of pathogens by the biological vectors stated as under:

Propagative Transmission

Propagative transmission occurs when the organism/pathogen ingested with the blood meal undergoes multiplication in the body of the arthropod. Arboviruses (eg. Dengue, JE virus , Chikungunya, Zika), for example, replicate extensively in various tissues of mosquitoes and are transmitted to a new host in the salivary fluid of the mosquito when it takes a blood meal. The agent undergoes no cyclical changes but simply grows and multiplies in body of vector (Plague bacilli in rat flea).

Cyclopropagative Transmission

In this type of transmission, the pathogen undergoes a developmental cycle (changes from one stage to another)as well as multiplication in the body of the arthropod. The best example of a disease transmitted in this way is malaria, in which a single zygote may give rise to as many as >200,000 sporozoites. The agent undergoes cyclical changes and also multiplies in the body of arthropods.

Cyclodevelopmental Transmission

In cyclodevelopmental transmission the pathogen undergoes developmental changes from one stage to another, but does not multiply. For example in filaria, a single microfilaria ingested by a mosquito (Culex) may result in only one third-stage of infective larva. Essentially however, the number of infective larvae is significantly lower than the number of microfilariae ingested with the blood. The agent undergoes cyclical changes but does not multiply in the body of arthropods.

MODE OF TRANSMISSION OF DISEASES

Vertical and Direct Transmission

- Some viruses and rickettsiae are transmitted from the female parent arthropod through the eggs to the offspring. If the pathogen actually infects the developing egg, this is termed 'transovarial transmission' (TOT).
- TOT or Vertical transmission is the spread of pathogen form parent to offspring. The developing ovum is infected and agent is present in interior of egg.
- In either case, the newly hatched arthropod larval stages are infected with the pathogen, which is then transmitted to subsequent developmental stages of the arthropod ('trans-stadial transmission').
- Veneral transmission of certain viruses has also been documented. Thus, male mosquitoes that become infected trans-ovarially or vertically can transfer the virus to uninfected female mosquitoes in the seminal fluid during copulation. Finally, certain arbo-viruses have been shown to infect their tick or mosquito vectors when infected and uninfected arthropods co-feed in close proximity to each other on the same vertebrate host in the absence of viraemia (Viruses present in the blood stream) in that host.
- The virus is apparently attracted to the uninfected female arthropod through a chemo-tactic response to the salivary fluid injected into the bite wound. These latter types of transmission have obvious epidemiological importance in the ultimate infection of humans or other animals and in the maintenance of the pathogen in nature.

MODE OF TRANSMISSION OF DISEASES

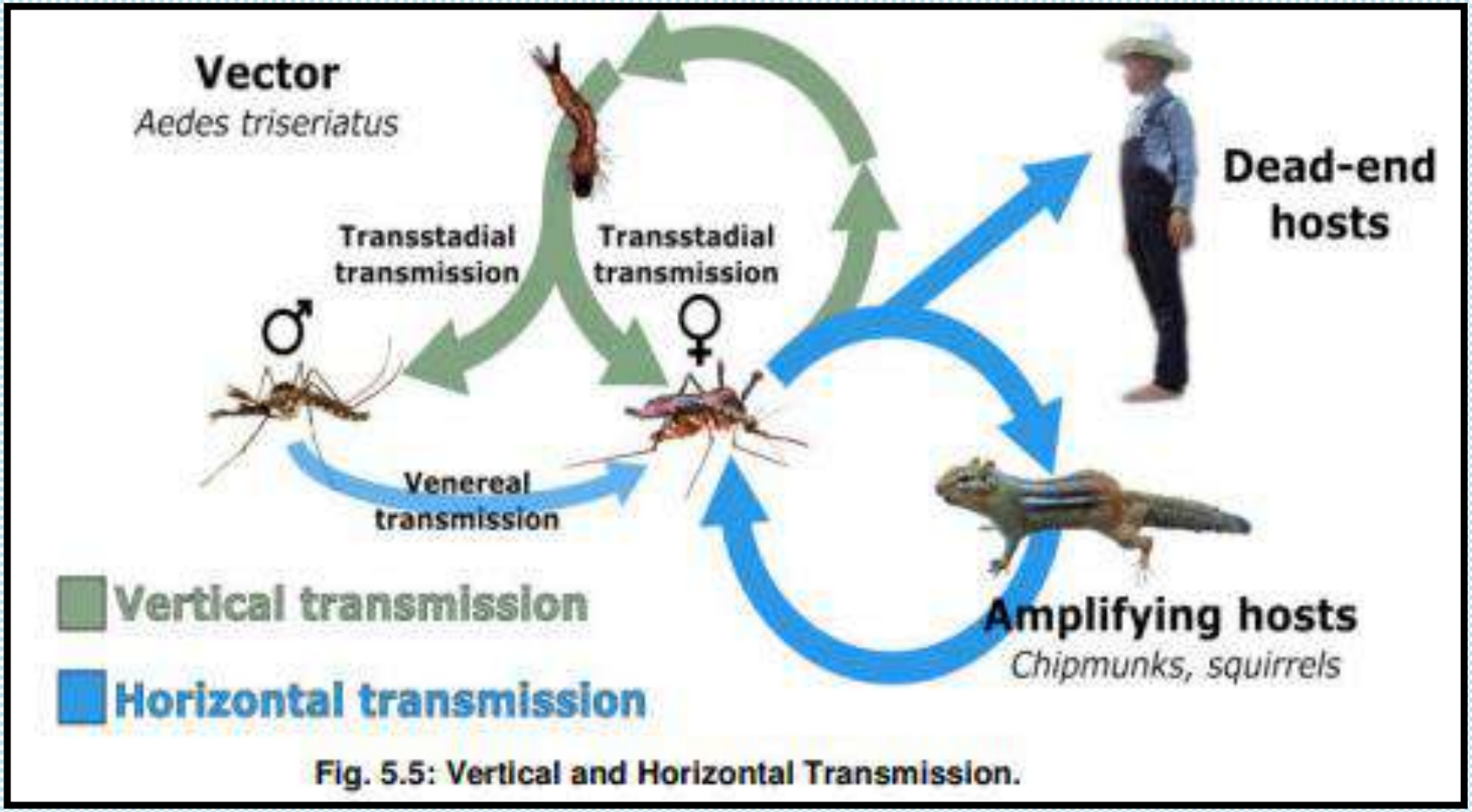


Fig. 5.5: Vertical and Horizontal Transmission.

HOST-VECTOR RELATIONSHIP

Host is a main factor which receives the pathogen from vectors. There is a mutual parasitic relationship of vector with its host. There we can say a host is an organism that harbours a parasitic, a mutual, or a commensal guest or symbiont, typically and providing nourishment and shelter in or on its body.

VECTORIAL CAPACITY

Vectorial capacity is a measurement of the efficiency of vector-borne disease transmission. It is the capability of a vector for disease transmission to a host, as influenced by behavioural, ecological and environmental factors, such as population density, host preference, feeding habits or frequency, duration of latent period, or longevity.

VECTOR COMPETENCE

There is one more term "vector competence" which refers to an evaluation of the vector's capability (mechanical or biological) to transmit a pathogen. It is the physiological ability of a vector organism to acquire, maintain and transmit an infectious agent, as described by susceptibility to a pathogen, immune response, and sustaining infection long enough for disease transmission to occur. Therefore, vector competence is actually an additional component of vectorial capacity. Vectorial capacity is a measurement of the efficiency of vector-borne disease transmission.

FACTORS AFFECTING VECTORIAL CAPACITY

- **Anthropophilic / Zoophilic biting:** Efficient vector should bite human preferably (anthropophilic nature like mosquito species Anopheles stephensi and Aedes aegypti) whereas some species like to bite animals as first choice they are called as zoophilic in nature like species of mosquito Anopheles culicifacies. The efficiency of vector is high as we are considering vectors for human health therefore more efficient will be that vector whose preference is human for feeding.
- **Longevity:** It is referred to the life expectancy of a insect vector in days. But why it is important for vectorial capacity, there are two important factors for vectorial capacity: 1) the life span of the insect vector must be higher than the incubation period of pathogen so that pathogen can come as expressive in the salivary glands of the insect to get inside the host. For example, the incubation period of malarial parasite is 10-16 days and similarly for dengue virus it is 8-12 days and life span of the vector is higher than that of about 30-40 days. 2) if vector lives longer as infected with parasite/virus it will feed more on host and spread the diseases more.
- **High productivity:** The vectors should be produced in high number for their survival and transmission.
- **Daily survival of vectors:** The vectors should be able to survive on daily basis from their natural enemy and climatic conditions.

- **Facilitate pathogen:** Physiology of vector should support the lifecycle and should be able to increase the pathogen numbers to a threshold of transmittable level and should be able to keep pathogen in it body throughout its life span for transmission.
- **Density of Vector:** Density of vectors is very important for transmission of diseases, high density is directly related to high infection rates in community in a particular location.
- **Bio-rhythm with host:** The vector is efficient if it has smooth and efficient biorhythm with the host on which it is dependent for blood. Some of the mosquitoes for example Anopheles bite in late night to give least disturbance to the host and keep them selves safe also. Similarly some species like Aedes have habit of biting in the day time but they have developed painless biting and also release a local anaesthesia (numbness) chemical so that the host does not know the mosquito has bitten till the signals of bite reach to host brain. By that time the mosquito has already taken its blood meal.
- **Transovarial Transmission:** In some of the viral transmission the vectors become efficient not only by getting infected from the infected host but the virus/pathogen transmit themselves from one generation to the next through their eggs, such type of transmission is called as vertical transmission also. This type of transmission can make vector infected from the time of emergence into adult and may also not require incubation period as required in the case of transmission through the patient for example in Aedes species.
- **Environmental factors:** Temperature plays vital role in the life cycle of insects in their aquatic forms. With optimum temperature the development of pathogen inside the vector is increased.
- **Intrinsic factors:** The susceptibility status of vector to provide better opportunity for pathogen to grow depends on immune response and is sub-specific.

Mechanical vector	Biological vector
It is the vector which merely transfers the infective stages of parasites without parasitic development. Ex : Housefly and cockroach for *Entameoba.*	It is the vector in which the parasite undergoes a part of the development before it gets transfer. Ex : Female anapheles mosquito in the case of *plasmodium.*

SUMMARY

- **Vector-borne diseases (VBDs) are a major concern of public health at a global scale. They are caused by parasites, viruses and bacteria that are transmitted by vector, which are mostly insects.**
- **A carrier can transmit the pathogen to its offspring. It can be transient, asymptomatic, incubating or convalescent.**
- **A vector is any agent that transmits the infection pathogen into other living organisms directly or indirectly.**
- **Vector can be mechanical or biological. Biological transmission can be propagative, cyclopropagative, cyclodevelopmental or vertical.**
- **Vectorial capacity is a measurement of the efficiency of VBDs. This is affected by many factors like vector density, high productivity, environmental and intrinsic factors.**

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