

## PHENOMENON OF INFECTION/ INFECTION PROCESS

It is the **third link** in the infection chain after survival and dispersal of inoculum. Infection process means Entry and colonization of pathogen in the host tissues.

**1. PRE-PENETRATION:** Depending upon the plant pathogen activity, the plant pathogens are classified in to 2 categories

1. Active invaders and 2. Passive invaders

Active invaders	Passive invaders
1. Pathogens which make an aggressive effort to gain entry into intact host cells.	1. No aggressive effort
2. They do not require help of any external agency to gain entry into host cells.	2. Require help of external agencies like insect vectors or wounds caused by agricultural implements.
3. Eg. Phyto-pathogenic fungi Phanerogamic parasites	3. Eg. Plant viruses Phyto-pathogenic bacteria

Plant viruses are particulate in nature and they do not have any capacity to enter the host cell so they do not make any aggressive effort for entry, but depend on different insect vectors for their entry into host cell. Bacteria have no dormant structures; hence no pre penetration activity except for multiplication in infection drops on the natural openings. In fungal pathogens, pre-penetration includes spore germination and growth of the resulting germ tube on the surface of the host plant. Fungal invasion is chiefly by germ tubes or structures derived from them.

**2. PENETRATION:** Pathogens penetrate plant surfaces by direct penetration or indirectly through wounds or natural openings. Bacteria enter plants mostly through wounds and less frequently through natural openings. Viruses, viroids, mollicutes, fastidious bacteria enter through wounds made by vectors. Fungi, nematodes and parasitic higher plants enter through direct penetration and less frequently through natural openings and wounds.

### A. Indirect Penetration

#### 1. Wounds

Wounds caused by farm operations, hail storms, or insect punctures, etc., will help in the entry of different plant pathogens into the host cells.

Ex. *Rhizopus*, *Gloeosporium*, *Aspergillus*, *Penicilium*, *Colletotrichum*, *Diplodia*, etc.

*Macrophomina phaseolina* Pathogen causing brown rot of fruits (*Sclerotinia fructicola*) enters through the wounds caused by insect punctures.

#### 2. Natural openings

##### a) Stomata:

In *Puccinia graminis tritici*, the uredospore germinates and forms a germ tube which on approaching stoma swells at the tip to form an appressorium. The haustoria produce and penetrate the cell.

*Xanthomonascampestrispv. malvacearum*(Black arm of cotton), *Xanthomonasphaseoli*(Bacterial leaf spot of green gram), *Phytophthora infestans*(Late blight of potato), *Albugo candida* (White rust of crucifers) enters through stomata.

**b) Lenticels:** *Sclerotiniafructicola*(Brown rot of fruits), *Streptomyces scabies* (Scab of potato), *Phytophthora arecae*(Mahali disease of arecanut)

**c) Hydathodes:** *Xanthomonascampestrispv. campestris*(Black rot of crucifers)

**B) Direct penetration:** Most fungi, nematodes and parasitic higher plants are capable of penetrating the host surface directly. However, the plants are provided with different mechanisms of defense which include structural features of the host, presence of chemical coverings on the cell walls, and anti-infection biochemical nature of the protoplasm. Hence, the pathogen should have mechanisms to overcome these barriers for direct penetration.

a) *Breakdown of physical barriers.* Viruses have no physical force or enzyme system of their own to overcome structural or chemical barriers of the host and therefore come in contact with the host protoplasm only through wounds. Bacteria are mostly weak parasites and cannot employ force to effect penetration. Fungi and nematodes are the only group of plant pathogens that employ force for direct penetration of the host. Fungi penetrate host plants directly through a fine hypha produced directly by the spore or mycelium or through a penetration peg produced by an appressorium.

b) *Breakdown of chemical barriers:* the host is provided with defense mechanisms against invasion which include i) presence of cuticular layer on the epidermis, ii) lack of suitable nutrients for the pathogen in the host cells, iii) presence of inhibitory or toxic substances in the host cells, iv) exudation of substances toxic to pathogen or stimulatory to antagonists of the pathogen. Ex: The glands in leaf hairs of begalgram contain maleic acid which is antifungal and provide resistance to infection by the rust fungus (*Uromyces cicerisarietini*). Similarly, protocatecheuic acid and catechol in the red scales of onion provide resistance to onion smudge pathogen, *Colletotrichum circinans*. To overcome these physical and chemical barriers, the fungi produce various enzymes, toxins organic acids and growth regulators.

### 3. POST PENETRATION

**Invasion and colonization:** Infection is the process by which pathogens establish contact with the susceptible cells or tissues of the host and derive nutrients from them. A parasitic relationship is formed between host cytoplasm and parasite cytoplasm. During infection, pathogens grow and multiply within the plant tissues. **Invasion** of plant tissues by the pathogen, and growth and reproduction of the pathogen (**colonization**) are two concurrent stages of disease development.

Fungi spread into all parts of host organs, either by growing directly through the cells as an intracellular mycelium or by growing between the cells as an intercellular mycelium. During establishment, pathogen produces different substances which include enzymes, toxins, growth hormones and polysaccharides which will help in colonization of the host. In **ectoparasites** the main body of the pathogen lies on the surface of the host with only feeding organs (haustoria) penetrating the tissues Ex: Most of the powdery mildew fungi. Some fungal parasites develop both external and internal mycelium Ex: *Rhizoctonia solani*. The endophytic parasites or **endoparasites** grow subcuticularly (*Diplocarpon rosae*, black spot of rose), in parenchyma tissues (most fungal and bacterial pathogens as well as many nematodes) or in vascular tissues (vascular wilt parasites). Some pathogens

are **endobiotic**, *i.e.*, mycelium is not produced and the thallus is entirely present within a host cell Ex: *Synchytrium endobioticum*.

Bacteria invade tissues intercellularly, but also grow intracellularly when parts of the cell walls dissolve. Viruses, viroids, mollicutes and fastidious bacteria invade tissues by moving from cell to cell intracellularly. Infection caused by microbes may be local (involve single cells or few cells or small

area) or **systemic** (pathogen spreads and invades most or all susceptible cells and tissues throughout the plant Ex: *Sclerosporagraminicola*). The time interval between inoculation and appearance of disease symptoms is called the **incubation period**.

#### **Exit of the pathogen**

After invasion and colonization of the host, the pathogens come out of the host to maintain the continuity of the infection chain or disease cycle and escape death due to overcrowding. Once the pathogens exit from the host, they survive and are disseminated to other hosts and continue the infection cycle.

**Viruses** can exist only with the living protoplasm and hence disseminated through their animate vectors like insects, fungi, nematodes, etc. The **bacteria** ooze out in the form of slime on the host surface from where they can be disseminated through water and insects. However, the **fungi** have the most elaborate system of exit. Most plant pathogenic fungi grow out on the host surface and produce repeating spores (secondary inoculum), usually asexually, under favourable conditions. The spores thus formed are disseminated through wind, water, soil, seed, vegetative propagating material, agricultural implements, etc.