

(a) **Incitant**—It means any agent which incites the disease under the influence of other factors. The term *causal organism* is also equally applicable to the agent or organism which incites i.e. induces disease.

(b) **Pathogen**—An entity (i.e. an agent) that by its persistent association causes the disease is termed as a pathogen. Pathogen may be living (i.e. animate) including viruses (infectious) or non-living i.e. inanimate (non-infectious).

(c) **Pathogenesis**—The chain of metabolic events which bring about the disease is pathogenesis. Pathogenesis “involves the action of the pathogen, susceptibility of the plant and impact of the environment.”

(d) **Pathogenicity**—The relative capability of a pathogen to cause disease is termed pathogenicity. It differs from **virulence**. Successful expression of pathogenicity i.e. the degree of pathogenicity of a given pathogen is termed virulence. A pathogen becomes virulent when it is capable of causing a severe disease, i.e. otherwise, virulent is strongly pathogenic.

(e) **Host**—A plant which is invaded by a parasitic organism and from which the parasite gets its nourishment is commonly referred to as the host.

(f) **Suscept and Susceptibility**—Any plant that can be attacked by a given pathogen is termed *suscept*. Again the condition of a plant which makes it suitable for the attack by a pathogen is referred to as *susceptibility*; otherwise, susceptibility may be defined as the inability of a plant to resist the effect of a pathogen or other damaging factor. The susceptibility of a plant may be increased or decreased by environmental factors.

(g) **Resistance**—This may be regarded as the counterpart of susceptibility; under this circumstances, a plant is able to overcome, completely or in some degree, the effect of a pathogen or other damaging factor.

(h) **Disease cycle**—The chain of events involved in the development of a disease including the stages of development of the pathogen and the effect of the disease on the host is called the disease cycle. Disease cycle therefore includes “inoculation, penetration, infection, incubation period, invasion of the host, reproduction of the pathogen, dissemination of pathogen and overwintering of the pathogen.”

(i) **Disease development**—The chain of events that occur between the time of infection and the complete expression of disease is termed as disease development.

(j) **Inoculation**—It is the process by which pathogens or their reproductive units are brought into contact with plants. The portion of individual pathogens (causing disease) which are brought into contact with the host plant is called *inoculum*. Viruses and plant pathogenic bacteria are carried as such to plants and therefore do not produce any other type of inoculum. Some other pathogens come directly in contact with plants, but they also produce reproductive bodies that can serve as inoculum. Spores of fungi, seeds of parasitic flowering plants, eggs of nematodes etc. serve as inocula. The inoculum produced from the perennating infective organs is the *primary inoculum*. When the host becomes diseased it commonly produces another type of infective bodies or spores which are collectively known as *secondary inoculum*.

(k) **Penetration**—The initial invasion of a host by a pathogen is termed as penetration. Pathogens may enter plants through wounds, through natural openings like stomata, lenticels and hydathodes or by penetrating directly through plant surfaces (cuticle, epidermal cells etc.). Direct penetration of the host surface by some pathogens may take place either through mechanical pressure on the host surface by the pathogen, or through secretion of enzymes

by the pathogen—sometimes, a combination of pressure and enzyme secretion help in the penetration of pathogens on the host surface.

(l) **Infection**—The establishment of a pathogen (parasitic) within a host following penetration is known as infection. To make infection successful the infecting organism must be in a pathogenic stage, the host also must be in a susceptible condition and the environmental condition must be favourable. During and subsequent to infection, some parasites kill and disorganise host-tissue in early stage while others simply obtain their nutrients from living host cells without killing them. The infection when visible externally on the host surface is called **visible infection**—this is commonly known as the appearance of disease. If the infection is established within the host but is not visible externally on the host, it is called **invisible infection**. There may be a long interval between the infection and appearance of disease, but normally one follows the other rather closely.

Again, the infection may be localised and systemic. In case of localised infection, the effect of infection inducing disease development (symptoms) remains restricted in or around the area surrounding the infection locus (the region of infection). In systemic infection, symptoms appear in an area other than the infection locus after a period of interval—during this period of interval the pathogen develops within the host but remains invisible externally without causing any apparent injury.

The infection caused by the primary inoculum within the host is the *primary infection* which induces the disease of the host. Secondary inocula serve to cause the *secondary infection*. The region where the inoculum establishes itself inducing infection is termed as *infection locus* or *infection court*.

(m) **Incubation period**—The time-interval between infection of a plant and the first appearance of disease symptoms is known as incubation period. The duration of the incubation period is generally determined by the specific pathogen host combination and the environment. Duration of incubation period varies according to the nature and infection of plants; in annual plants it varies from a few days to a few weeks while in case of virus diseases of trees, the incubation period varies from a few months to several years.

(n) **Invasion**—It refers to later stages of infection—during this period the pathogen spreads extensively into the tissues of the host. Growth and reproduction of the pathogen take place during this phase. The mycelium of most fungal pathogens invade tissues intercellularly (between cells) or intracellularly (within cells). Bacteria usually invade tissues intercellularly. Viruses invade tissues by either intercellularly (in most cases) or intracellularly.

(o) **Over-wintering of the pathogen**—When a pathogen is a part of the causal complex, the starting point of the incidence of a disease is difficult to determine. In this case, the pathogen is expected to be present in the environment either in or on seed of host, in debris of infected plants of previous season, as dormant spores, sclerotia or other organs in the soil, in the form of an inhabitant soil flora etc. In this way pathogens perennate and withstand unfavourable conditions in the environment are commonly known as over-wintering or over-summering forms, because it is through those forms pathogens tideover unfavourable conditions during winter or summer season. Again with the advent of favourable season, those perennating organs become the source of production of infective organ(s) of the pathogen.

(p) **Symptoms and sign**—The external and internal reactions or alterations of a plant as a result of a disease are designated as *symptoms*. A visible expression of disease in the host plant may also be regarded as symptom. The pathogen or its parts or products seen on a host plant is the *sign*. The sum total of all disease symptoms and sign is termed **disease syndrome**.

INTRODUCTION

711

(q) Various degrees of parasitism (obligate and facultative), saprophytism and facultative), epiphytism, symbiosis etc. among microorganisms have been recognised. These are discussed under the "Fungi" chapter 1 (refer pages 522-524).

stages in the development of disease :

When fungi live on other living organisms (plants and animals) and obtain their food i.e. nutrient from the living tissues of the organisms upon which they live, they are called *parasites*. The vegetative body i.e. hyphae of the parasitic fungi grow either *intercellularly* or *intracellularly* in the host tissue. When fungi grow intracellularly, they send hyphae within the cells of host tissue. Fungi when grow intercellularly send out specialised and modified absorbing organs called *haustoria* (singular : *haustorium*). The victims i.e. living organisms from which the parasitic fungi draw food are called the *hosts*. These fungi obtain nutrients i.e. food matters from the cells of the host tissue with the help of those haustoria. In shape, the haustoria may be knob-like,

short or long, unbranched or branched forming a miniature root system (Fig. 1.1). These haustoria are developed as outgrowths from the vegetative body of the parasitic fungi. These haustoria are generally penetrated into the host's living cells through minute pores punctured in the cell wall. The formation of haustoria is probably a response to the contact stimulus as well as to the stimulus of nutrients. Fungi parasitising animal tissue are not known to produce haustoria. Among fungi, different degrees of parasitism and saprophytism can be noted, viz.—

(a) Some fungi obtain their food entirely from the living protoplasm of the hosts and maintain their mode of life throughout their life cycle only as parasites—this type is called *obligate parasite*, e.g. *Puccinia* (rust fungi), *Peronospora*, etc. But when organisms obtain their food only from dead organic matters and maintain their mode of life throughout the life cycle as saprophytes, the organisms are called *obligate saprophytes* or *obligate saprobes*, e.g. *Saprolegnia monoica*. Obligatory saprophytes are incapable of infecting other living organisms.

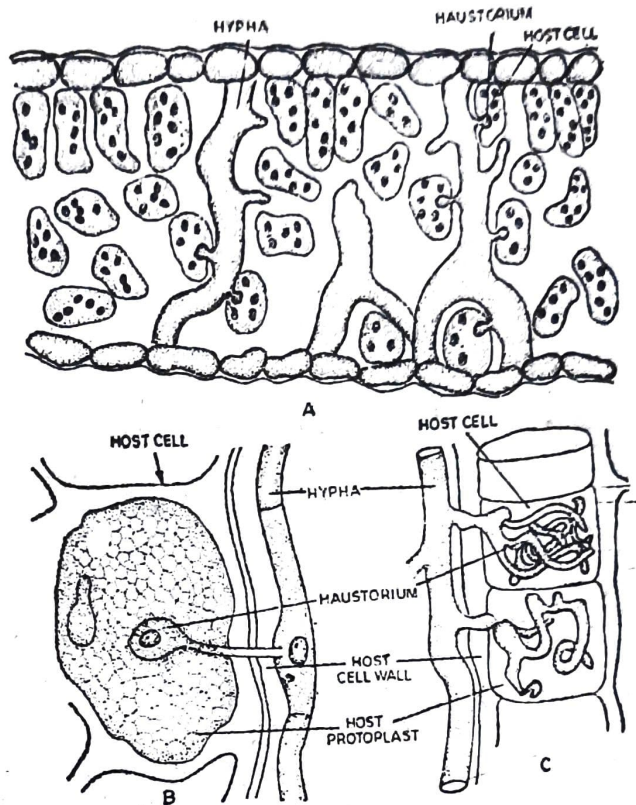


Fig. 1.1—Different types of haustoria. A—Knob-like short haustoria. B—Long flattened type of haustorium. C—Branched root-like haustoria.

(b) While some fungi are normally parasitic in their mode of life but later on, according to circumstances, may pass their mode of life as saprophytes also—this type is called *facultative saprophyte* or *facultative saprobe* (e.g. *Ustilago*).

(c) *Facultative parasites*—When fungi passing their mode of life as saprophytes in the beginning and later on, under certain conditions become also parasites causing diseases, they are called *facultative parasites*, e.g. *Pestalotia*.

Parasitic fungi again may be :—

(1) *Ectoparasites*—When parasitic fungi grow superficially on the surface of the host plant without penetrating the host tissue, they are called ectoparasites. Ectoparasitic fungi are provided with special organs of attachment known as *appressoria* (singular: *appressorium*). According to Priston and Gullegly (1954), an appressorium is a flattened, hyphal pressing organ from which a minute infection peg grows and enters the epidermal cell of the host ; with the help of this structure ectoparasites obtain nourishment from the protoplasts of the host tissue.

(2) *Endoparasites*—When fungi penetrate the host and ramify their vegetative body within the tissues of the host, they are called endoparasites.

The parasitic fungi which spend their entire life cycle on a single host plant are called *autoecious* and those which require more than one host to complete their life cycle called *heteroecious*.

The fungi, like all other plants are divided upto species level. If necessary species are splitted into further units of classification e.g. varieties, biological strains, physiological or