Ecology & fungal physiology

Lecture (4)

By

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Ecology & Physiology of Fungi

Environmental conditions for fungal growth

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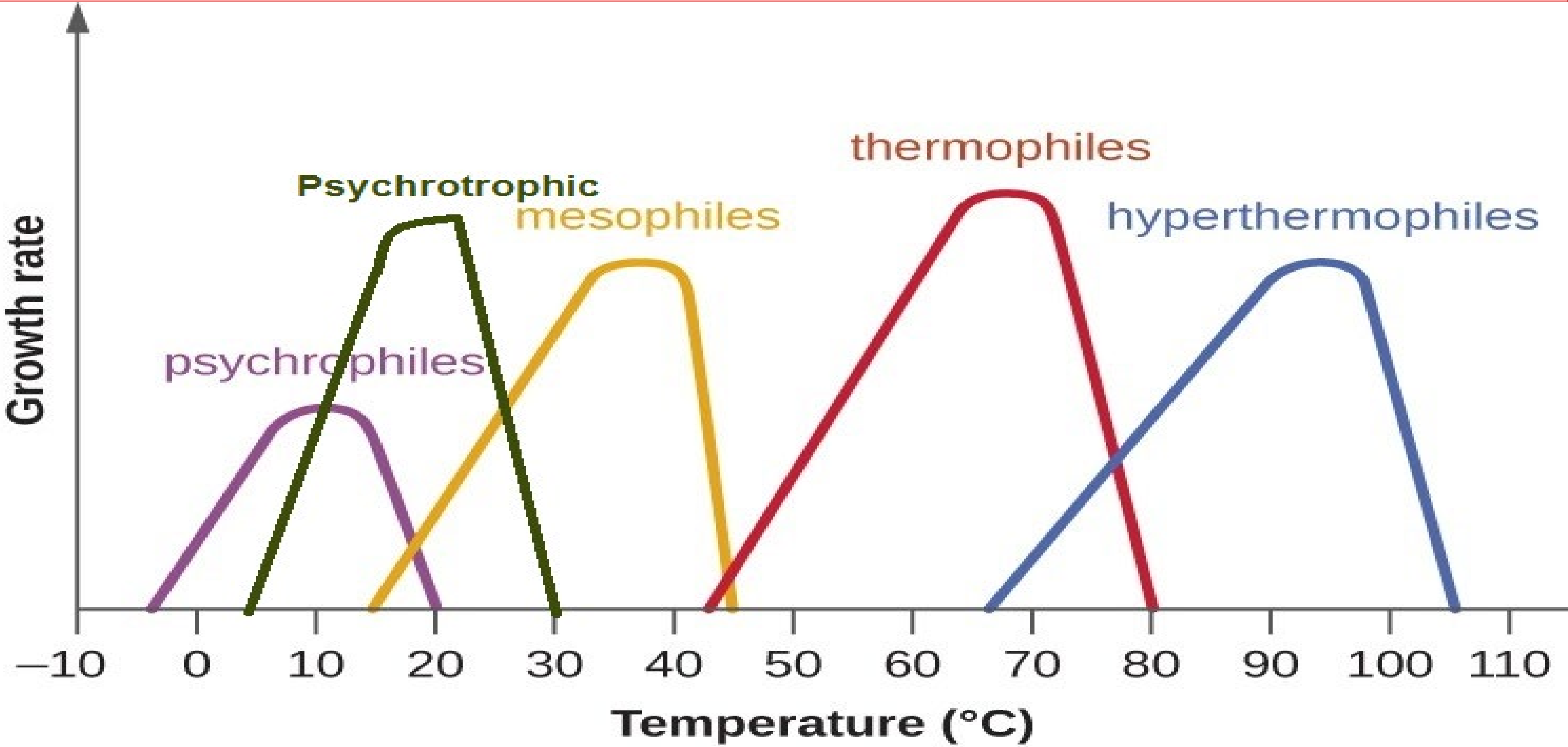
In common with all microorganisms, fungi are profoundly affected by physicochemical factors, such as temperature, aeration, pH, water potential, light and nutrient . These factors not only affect the growth rate of fungi but also can act as triggers in developmental pathways. the effects of environmental factors on fungal growth, including the extremes of adaptation to environmental conditions

Temperature and fungal growth:

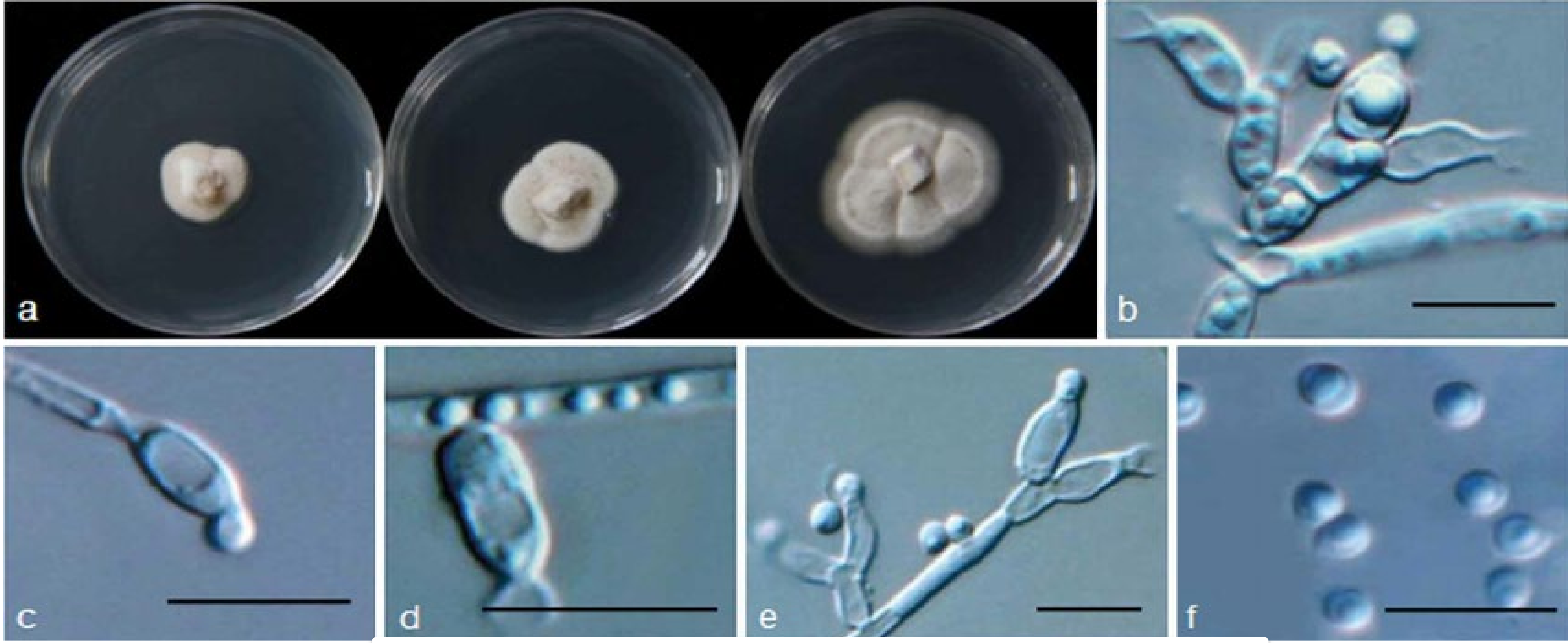
Microorganisms are often grouped into five broad categories in terms of their temperature ranges for growth:



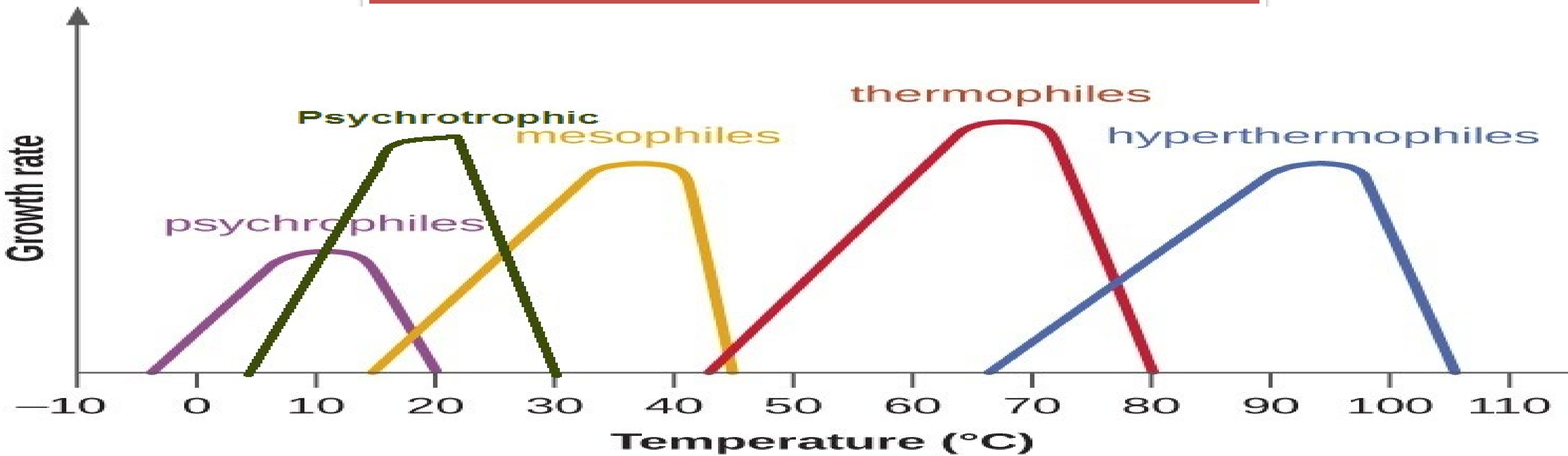
Psychrophiles (cold-loving): fungi are defined as having optimum growth at no more than 16°C and maximum growth of about 20°C. In many cases they would be expected to grow down to 4°C or lower, and usually do not survive at temperatures above 20 °C. There are many environments that could suit these organisms, including the deep waters of the oceans. the polar and alpine regions. Because they are active at low temperature, such as

Pseudogymnoascus ; pannorum

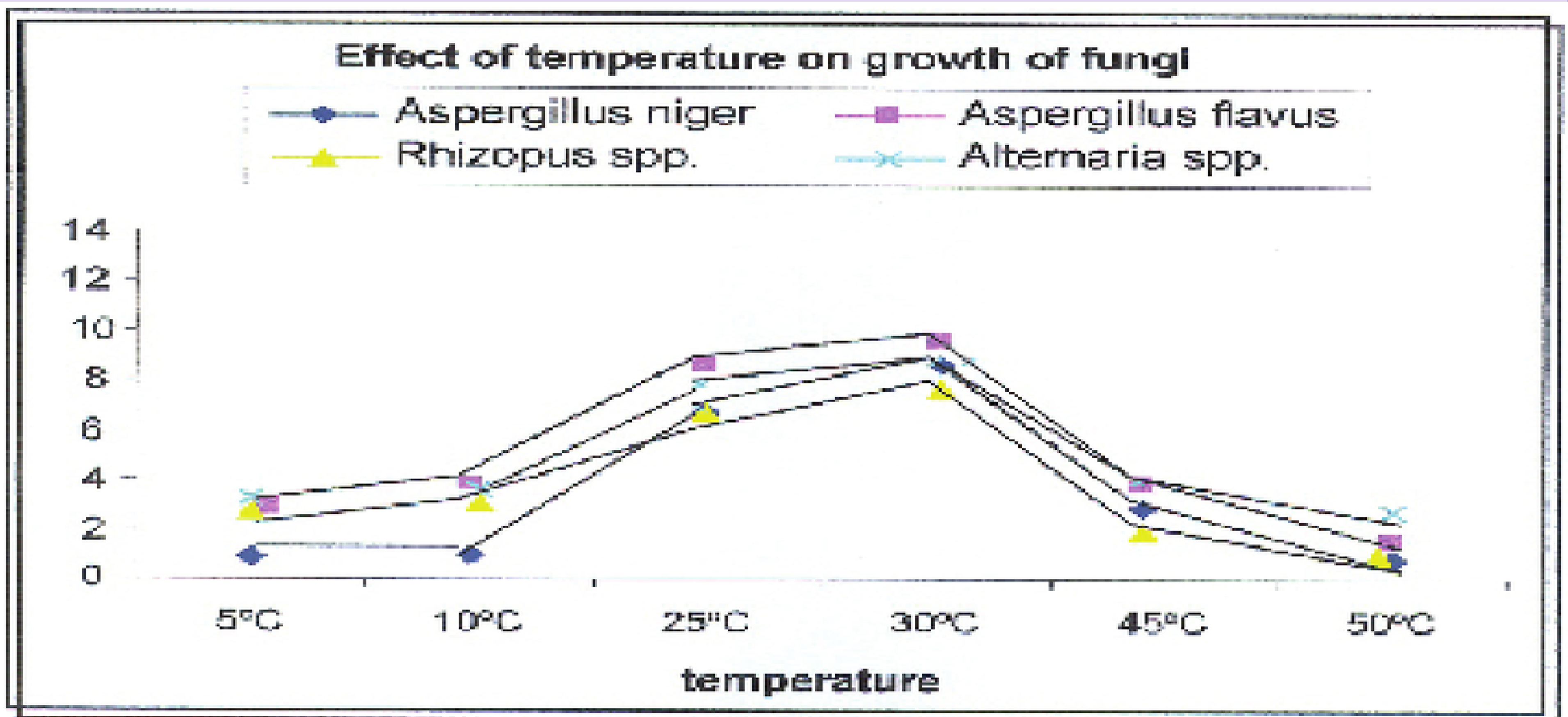
Psychrophila ; Antarctic



Psychrophila antarctic

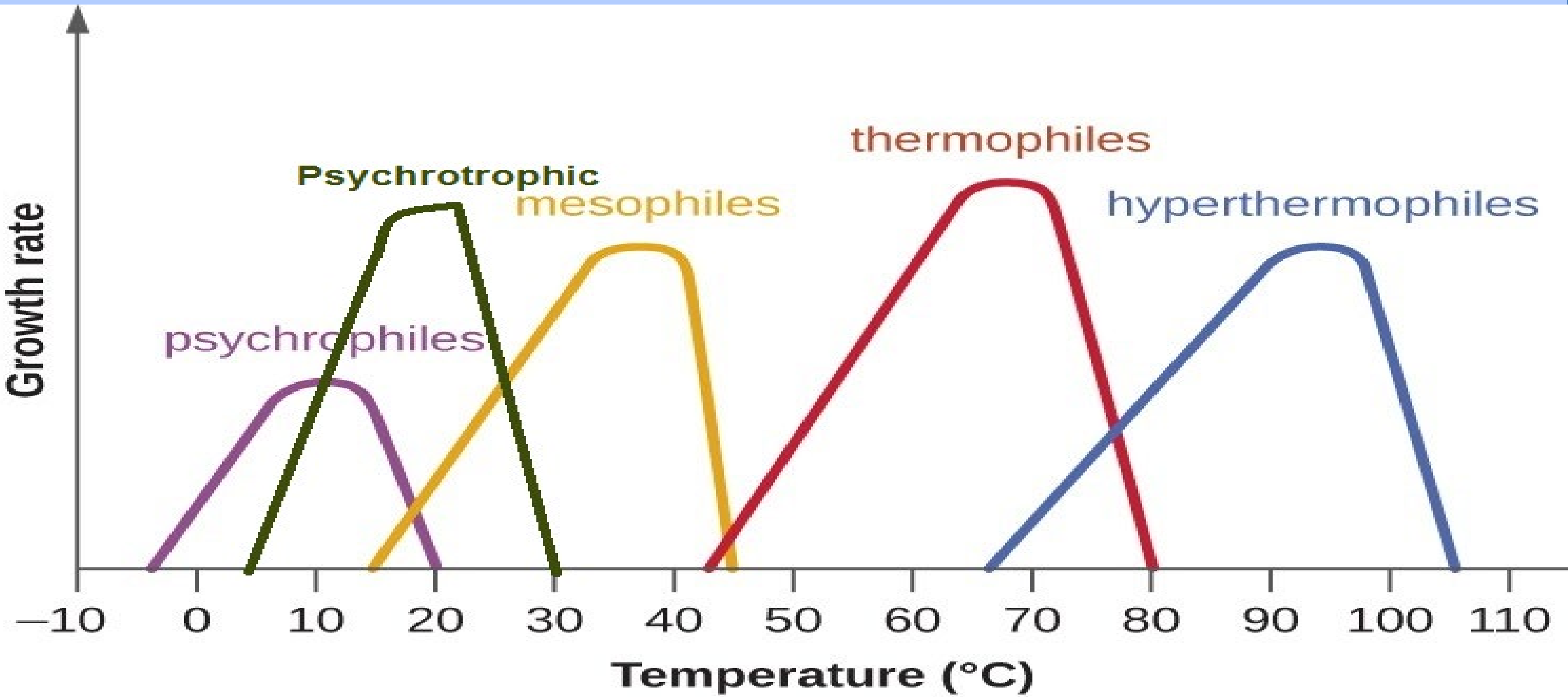


Mesophiles (which grow at moderate temperatures),Most fungi are Mesophilic commonly growing within the range 10–40°C, though with different tolerances within this range. For routine purposes these fungi can usually be grown at room temperature (22–25°C). Two important examples shown in Fig. 1 are *Aspergillus flavus*, which produces the potent aflatoxins in stored grain products, and *Penicillium chrysogenum*, used for the commercial production of penicillins.

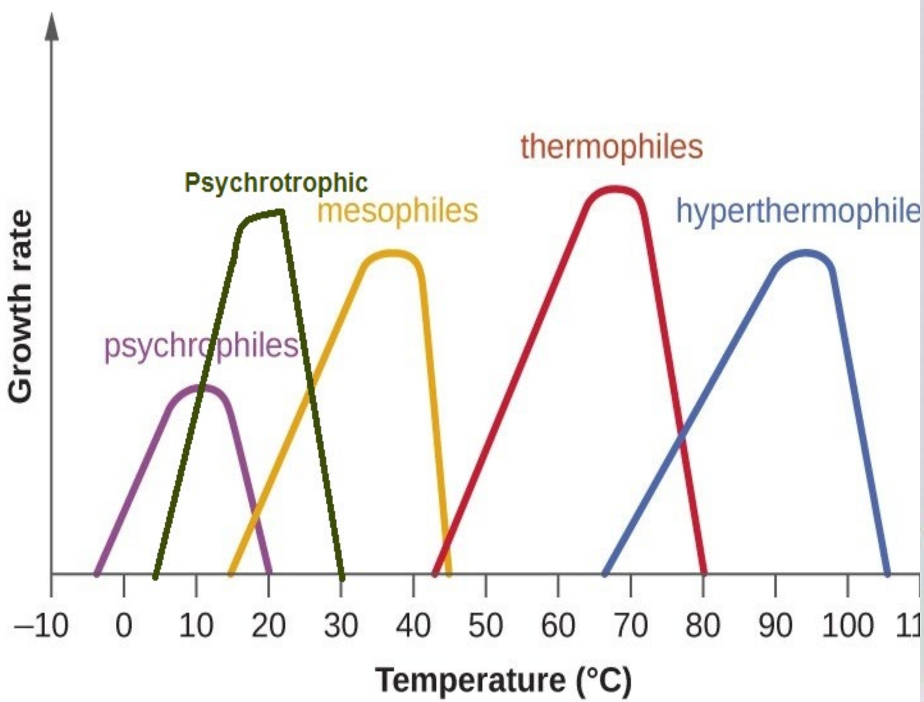


Psychrotrophic fungi would be those that can grow at low temperatures but also above 20°C (5-30°C) .

Note: Psychrophiles and Psychrotrophs are important decomposers in cold climates .



Thermophiles (heat-loving) Organisms that grow at optimum temperatures of 50 °C to a maximum of 80 °C are defined as having a minimum growth temperature of 70°C or above, a maximum growth temperature of 50°C or above, and an optimum in the range of about 40–50°C. *Aspergillus fumigatus*, *Rhizomucor pusillus*



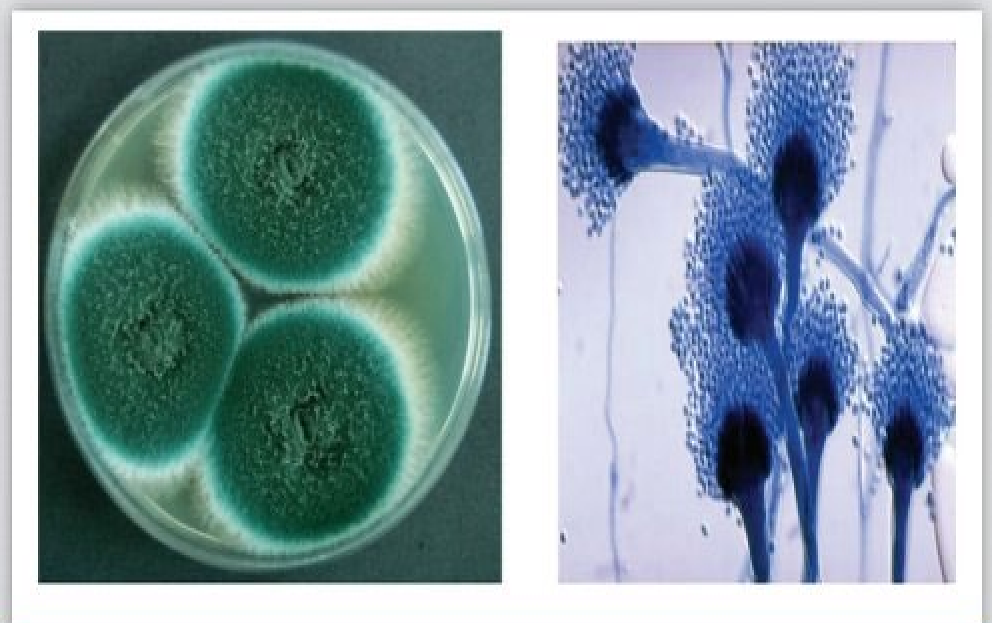
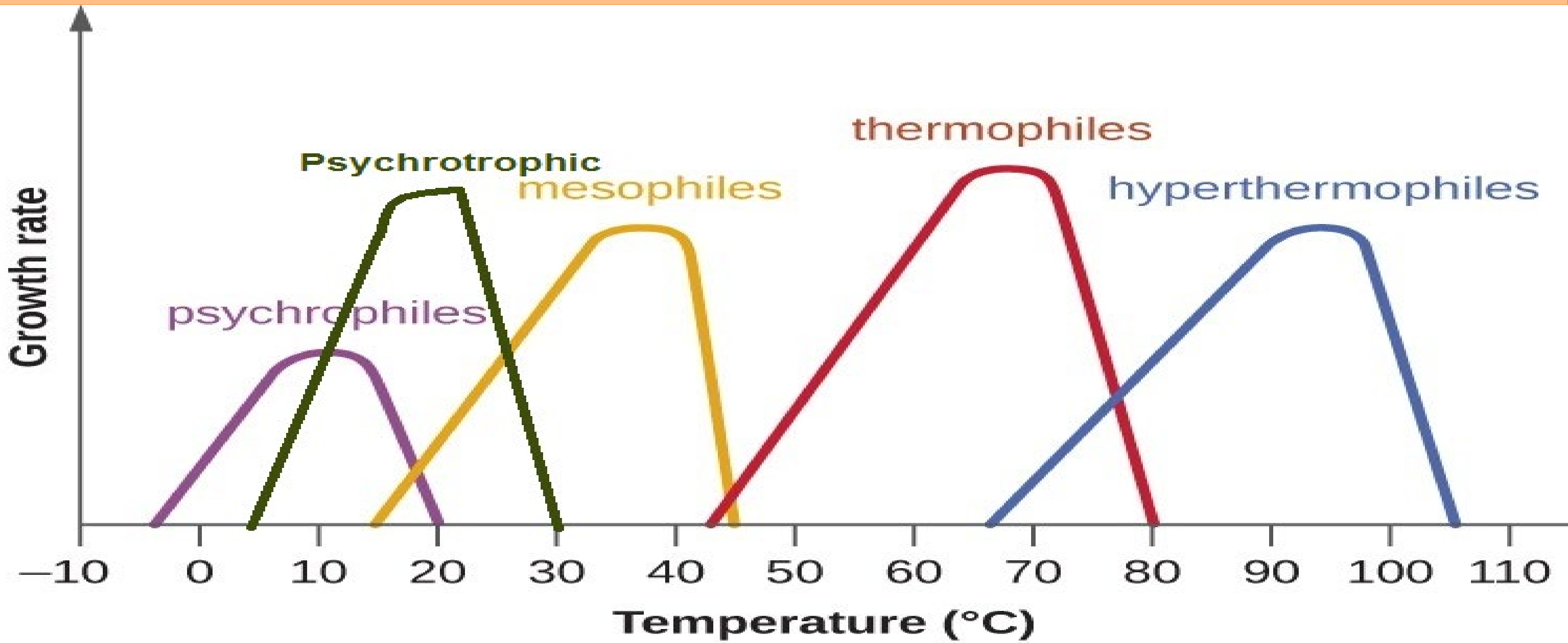


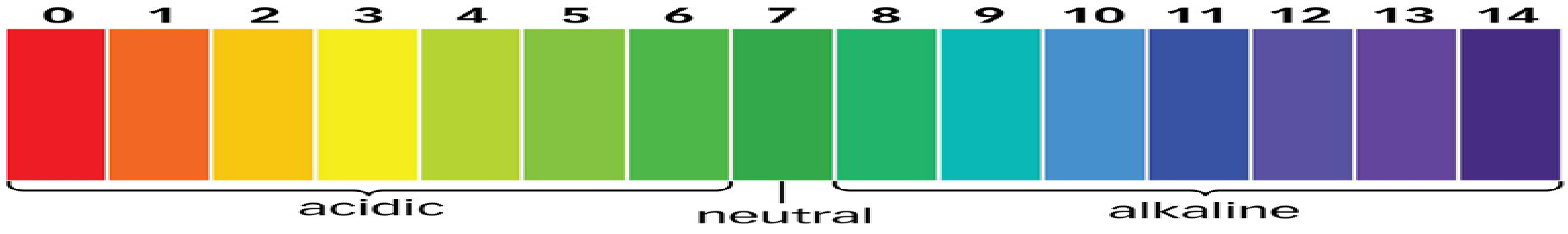
Figure 1. Asperigillus fumigatis

Hyperthermophiles: which are characterized by growth ranges from 80 °C to a maximum of 110 °C, with some extreme examples that survive temperatures above 121 °C, the average temperature of an autoclave. The hydrothermal vents at the bottom of the ocean are a prime example of extreme environments, with temperatures reaching an estimated 340 °C ((NO fungi can grow at this temperature)) the cell membrane contains high levels of **saturated fatty acids** to retain its shape at high temperatures



Hydrogen ion concentration and fungal growth

The responses of fungi to culture pH need to be assessed in strongly buffered media, because otherwise fungi can rapidly change the pH by selective uptake or exchange of ions. Mixtures of KH2PO4 and K2HPO4 are commonly used for this purpose. It is then found that many fungi will grow over the pH range 4.0–8.5, or sometimes 3.0–9.0, and they show relatively broad pH optima of about 5.0–7.0. However individual species vary within this "normal" range, as shown by the three representative examples in Fig. 4. Several fungi are **acid-tolerant**, including some yeasts which grow in the stomachs of animals and some mycelial fungi (*Aspergillus, Penicillium,* and *Fusarium* spp.) which will grow at pH 2.0. But their pH optimum in culture is usually 5.5–6.0. Truly **acidophilic** fungi, able to grow down to pH 1 or 2, are found in a few environments such as coal refuse tips and acidic mine wastes; many of these species are yeasts.



Oxygen and fungal growth

Most fungi are strict aerobes, in the sense that they require oxygen in at least some stages of their life cycle. Even *Saccharomyces cerevisiae*, which can grow continuously by fermenting sugars in anaerobic conditions, needs to be supplied with several preformed vitamins, sterols and fatty acids for growth in the absence of oxygen. *Saccharomyces* also requires oxygen for sexual reproduction. Having established these points,

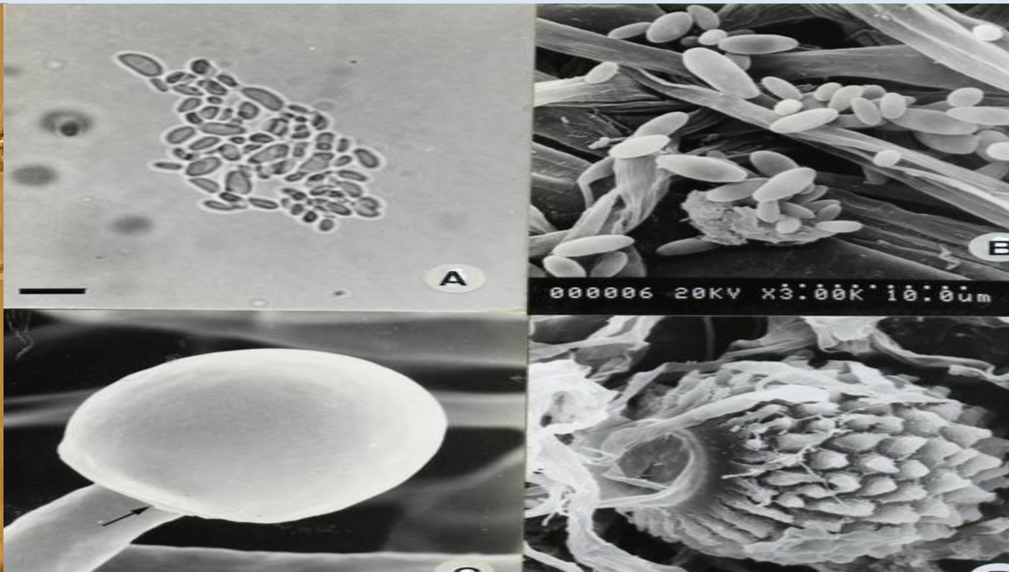
we can group fungi into four categories in terms of their oxygen relationships.

1- Many fungi are **obligate aerobes**: their growth is reduced if the partial pressure of oxygen is lowered much below that of air. growth of the take-all fungus of cereals is reduced. This gives the highest energy yield from the oxidation of organic compounds.

2- Many yeasts and several mycelial fungi (e.g. *Fusarium oxysporum, Mucor hiemalis, Aspergillus fumigatus*) are **facultative aerobes**. They grow in aerobic conditions but also can grow in the absence of oxygen by fermenting sugars. The energy yield from **fermentation** is much lower than from aerobic respiration, and the biomass production is often less than 10% of that in aerobic culture. However, a few mycelial fungi can use nitrate instead of oxygen as their terminal electron acceptor. This anaerobic respiration can give an energy yield at least 50% of that from aerobic respiration.

3 -A few aquatic fungi are **obligately fermentative**, because they lack mitochondria or cytochromes (e.g. *Aqualinderella fermentans*,Oomycota) or they have rudimentary mitochondria and low cytochrome content (e.g. *Blastocladiella ramosa*, Chytridiomycota). They grow in the presence or absence of oxygen, but their energy always comes from fermentation.

4- A few obligately anaerobic : phylum Neocallimastigomycota they play an important role in the degradation of plant material. such as *Neocallimastix*



Water availability and fungal growth

All fungi need the physical presence of water for uptake of nutrients through the wall and cell membrane, and often for the release of extracellular enzymes. Fungi also need intracellular water as a milieu for metabolic reactions. However, water can be present in an environment and still be unavailable because it is bound by external forces.

Light

Light in the near-ultraviolet (NUV) and visible parts of the spectrum (from about 380 to 720 nm) has relatively little effect on vegetative growth of fungi, although it can stimulate **pigmentation & spore form** . In particular, blue light induces the production of carotenoid pigments in hyphae and spores of several fungi, including *Neurospora crassa*. These **carotenoids**, which also occur in algae and bacteria, are known to quench reactive oxygen species, discussed earlier. The pigments serve to minimize photo-induced damage. **Melanins** similarly protect cells against reactive oxygen species and ultraviolet radiation.

Nutrition

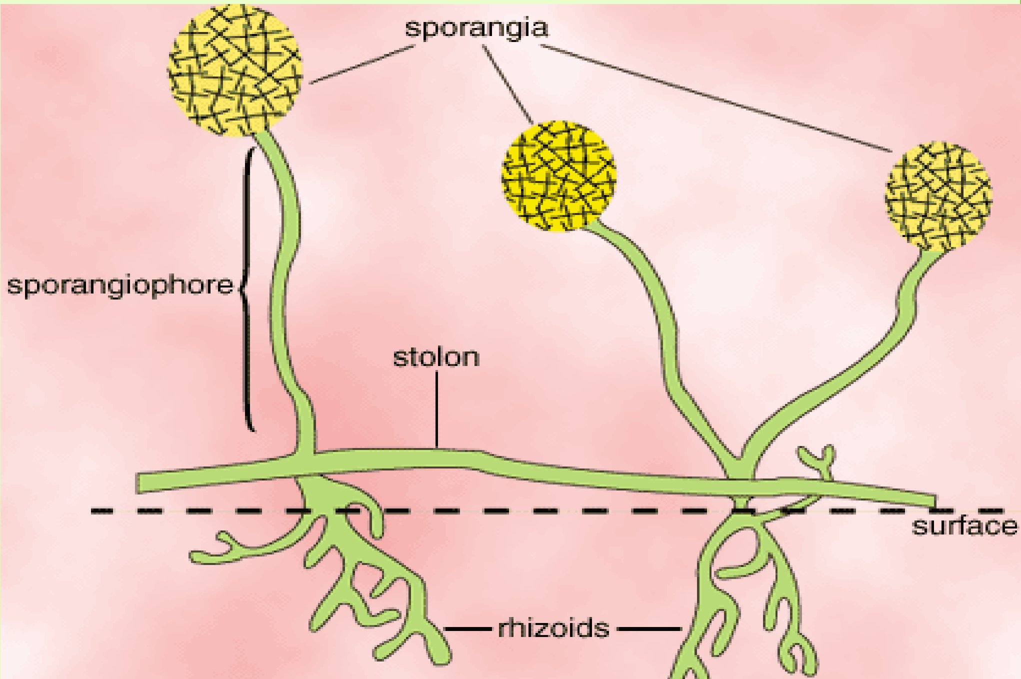
Unlike plants, which use carbon dioxide and light as sources of carbon and energy, respectively, fungi meet these two requirements by assimilating preformed organic matter; carbohydrates are generally the preferred carbon source. Fungi can readily absorb and metabolize a variety of soluble carbohydrates, such as glucose, xylose, sucrose, and fructose. Fungi are also characteristically well equipped to use insoluble carbohydrates such as starches, cellulose, and hemicelluloses, as well as very complex hydrocarbons such as lignin. Many fungi can also use proteins as a source of carbon and nitrogen. To use insoluble carbohydrates and proteins, fungi must first digest these polymers extracellularly.

Saprotrophic fungi obtain their food from dead organic material; parasitic fungi do so by feeding on living organisms (usually plants), thus causing disease.

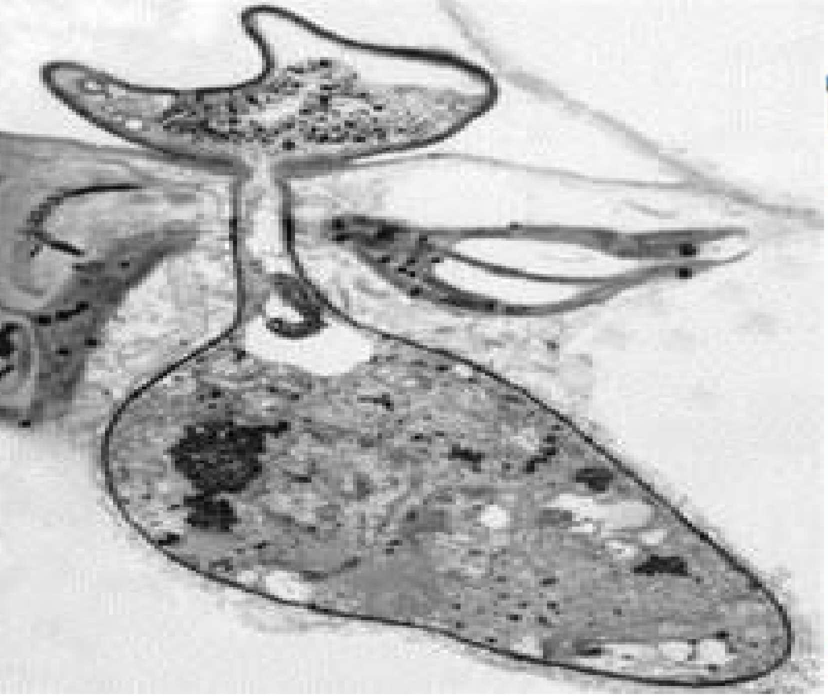
Specialized Somatic Structures

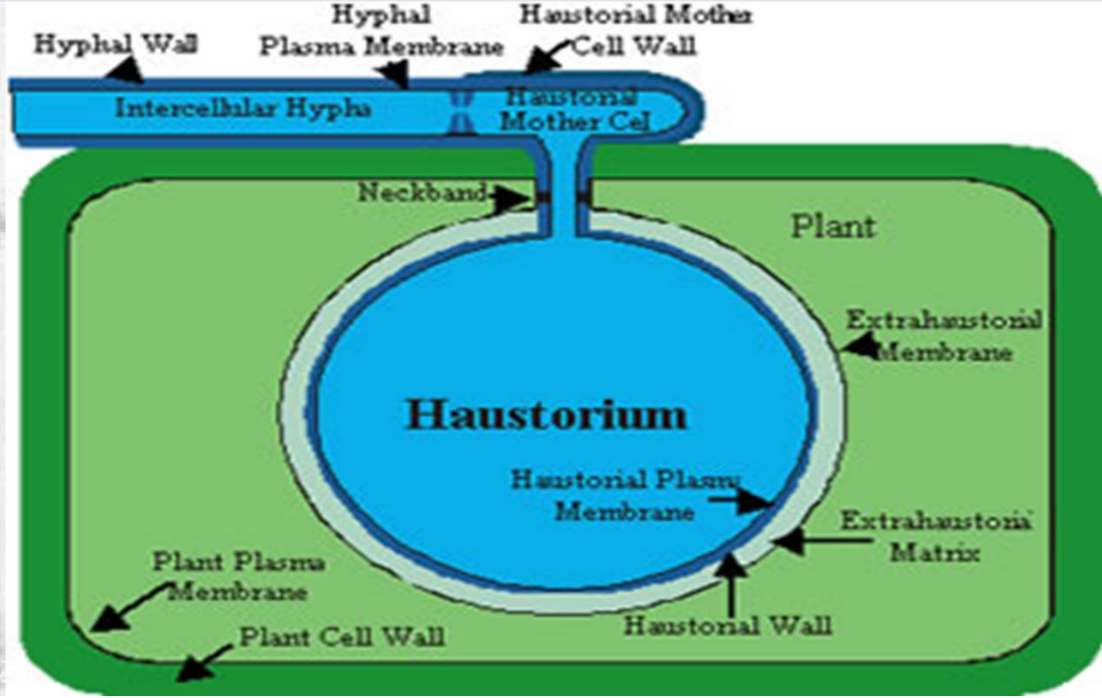
1- Rhizoid : A rhizoid (Gr. *rhiza* = root + *oeides* = like) is a short, root-like filamentous outgrowth of the thallus generally formed in tufts at the base of small unicellular thalli or small porophores. Rhizoid serves as anchoring or attachment organ to the substratum and also as an organ of absorption of nutrients from substratum. Rhizoids are short, delicate filaments that contain protoplasm but no nuclei. Rhizoids are common in lower fungi like Chytridiomycetes, Oomycetes and Zygomycetes. Some species produce a many-branched rhizo-mycelium. This is an extensive *Cladochytrium* sp.

Function: anchor the thallus to the growth surface and probably also absorb food

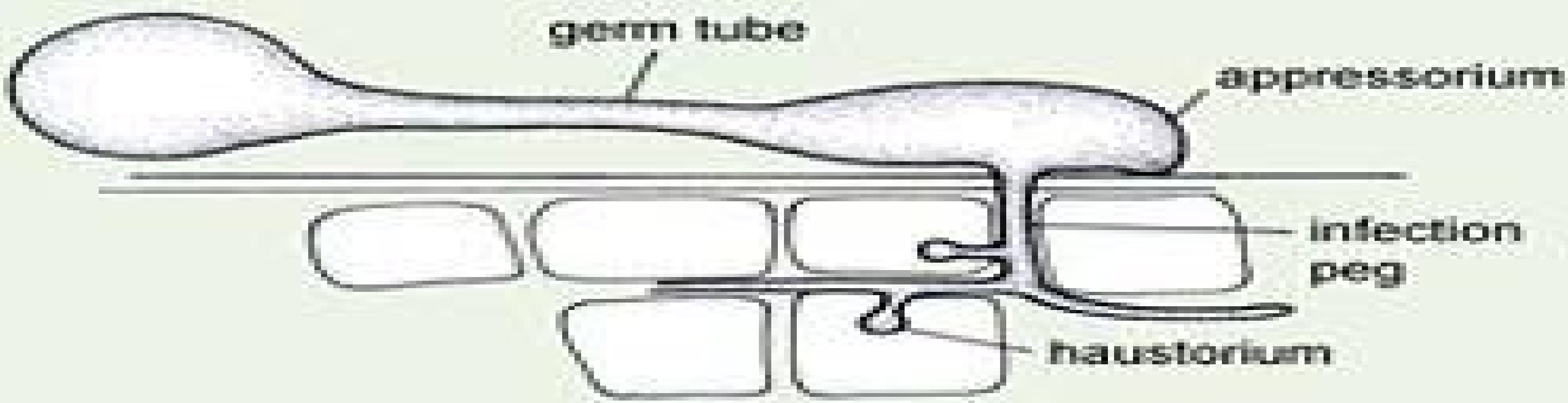


2- Haustoria: (sing. Haustorium) are special hyphal structures or outgrowths of somatic hyphae sent into the cell to absorb nutrients. The hyphal branch said to function as haustorium becomes extremely thin and pointed while piercing the hast cell wall and expands in the cell cavity to form a wider, simple or branched haustorium. Haustoria may be knob-like or balloon – like in shape, elongated or branched like a miniature root system.





3- Appressorium: is a simple or lobed structure of hyphal or germ tube and a pressing organ from which a minute infection peg usually grow and enter the epidermal cell of the host. It helps germ tube or hypha to attach to the surface of the host or substrates. These appressoria are formed from germ tubes of Uredinales (rust fungi), Erysiphales (powdery mildew fungi) and other fungi in their parasitic or saprophytic stages. In addition to giving anchorage,



- **<u>Note</u>**

Nutrient requirements for moulds may vary from mould to mould. Some moulds may thrive well on substrates with high sugar or salt content. Some may prefer simple sugars while others have the ability to utilize complex sugars.

- **Barophiles (organisms that grow best under pressure), and Halophiles (organisms that require NaCl for growth)**

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