Mycology Answers

What Factors influence the Germination and Outgrowth of fungal Spores?

Fungal spore germination marks the resumption of vegetative development and the formation of a new individual or colony. Germination, usually following a period of dormancy, is said to have occurred when a new developing hypha, known as a germ tube, can be seen emerging from a spore. This represents the start of a new cycle of development. However, prior to the outgrowth of the germ tube, metabolic activity will already have begun, leading to the re-integration of biochemical processes, followed by morphological changes in the spore, and ultimately the resumption of vegetative growth Many spores are subject to variable periods of dormancy. Some require that environmental conditions are favourable (exogenous dormancy) whereas others, with longer term survival mechanisms (consititutive dormancy) may require specific activation treatments before germination can be initiated. In some instances a period of physiological maturation must occur prior to germination. The period of low metabolic inactivity, necessary for overwintering, must be broken, by specific activation stimuli, leading to the restoration of biochemical processes which were absent or non-functional during the dormant period.

The requirements for activation are often predictable. Dormant spores are relatively dehydrated and prior to germination most species will require the presence of liquid water or conditions of high relative humidity. As activation occurs spores will take in large amounts of free water, rapidly at first, leading to spore swelling. This increase in diameter (sometimes to several times the spore diameter during dormancy, e.g. *Cunninghamella elegans*) and a concomitant increase in dry weight is a prelude to germ tube emergence; a first visible sign of impending germination. Cycles of wetting/drying and soaking, such as must occur on leaf surfaces, may also serve to wash away, or dilute, chemical inhibitors to germination. The close proximity of other spores may be inhibitory to germination, probably owing to levels of inhibitors, but it is also the case that the germination of some spores is stimulatory to neighbours (e.g *Rhizopus stolonifer* spores). Newly germinated spores are very vulnerable to desiccation and it is therefore essential that appropriate moisture levels are present to support continued outgrowth. In addition, spores absorb water-soluble nutrients (simple sugars and amino acids), which may be used to fuel subsequent metabolic activities and associated processes. In some cases, the presence of suitable substrates or exudates to support growth (particularly in the case of pathogens) acts as a further trigger to the resumption of outgrowth. Most spores also require oxygen for outgrowth to occur. In other instances environmental changes function as activation treatments. These may relate directly to the normal ecological habitat. Temperature shocks will often act as triggers to spore activation. Some spores germinate following exposure to high (+40°C) or low (-50°C) temperatures. Conditions which result in the activation of spores probably cause changes in key biochemical components of metabolic pathways, or alterations in membrane permeability, particularly the plasma membrane of the spore. For a time many of these changes can be reversed if external conditions do not remain conducive but eventually spores pass a 'point of no return'; activation has occurred and germination must ensue. It is clear that there is no universal mechanism for either the maintenance or for the breakage of dormancy.

In general, a spore is said to have germinated once a germ tube has emerged and reached a length equal to the diameter of the swollen (fully hydrated) spore. Most spores produce a single germ tube although spores of some species give rise to more than one. Spore walls are often multilayered, frequently thickened and pigmented. New wall components must be synthesised before outgrowth can begin. Polarity is always established prior to the germination of spores. Vesicles aggregate at the site(s) of germ tube emergence in activated spores,probably carrying cell wall components and synthetic/lytic enzymes involved in cell wall synthesis. It is likely that a combination

of swelling due to water uptake, enzyme action and physical force gives rise to the rupturing of the spore wall as germination proceeds. In some instances germ tubes are formed directly as extensions of the inner spore wall. In other cases and probably of more frequent occurrence, a new wall layer may be laid down and extended out from the spore to form the germ tube.

Other changes also take place concurrently within germinating spores. In addition to new wall material, new membrane components are also synthesised and there is an increase in the amount of endoplasmic reticulum present. Biochemical processes which do not occur (or ocurr at extremely low levels) in dormant spores are quickly resumed. Mitochondria are seen to increase in size, number and maturity and rates of respiration rise dramatically. As germination is initiated most of the energy used is derived from storage compounds laid down in spores. Lipids, glycogen and trehalose are utilised to fuel initial outgrowth. Simultaneously there is an increase in the amount of protein synthesis ocurring and key enzymes are synthesised rapidly or released from compartmentalisation. Essential enzymes are often present in dormant spores but as inactive forms or bound to spore components so that they are not able to interact with substrate. In *Neurospora crassa*, trehalase which converts trehalose to glucose is associated with spore walls and is separated from the substrate until it is released by activation processes. All types of RNA are synthesised early as germination progresses and the spore nucleus increases in size. Perhaps surprisingly, the synthesis of DNA is not a prerequisite of germination (e.g. *Neurospora crassa, Uromyces phaseolus*). However, it is essential for the continued outgrowth of the germ tube and for colony development and normally occurs fairly early after extension has begun.

Germ tube emergence usually takes place a few hours after initiation of the germination process. Initially the young hypha will extend rapidly across the new substrate, eventually forming branches and developing into a colony. Each hyphal branch will tend to diverge away from other tips (negative autotropism) and neighbouring hyphae so that each can draw on it own area of substrate and continue to support outgrowth.

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