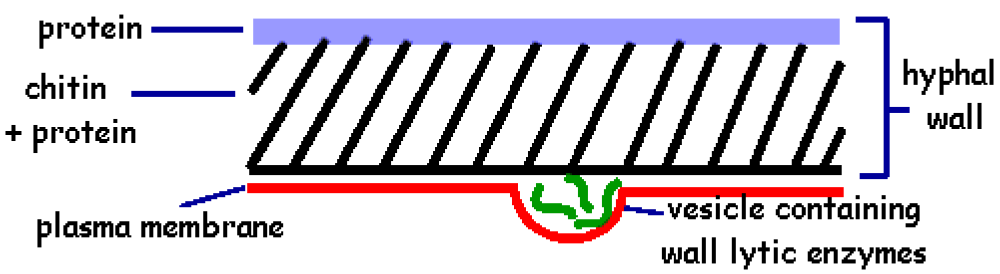
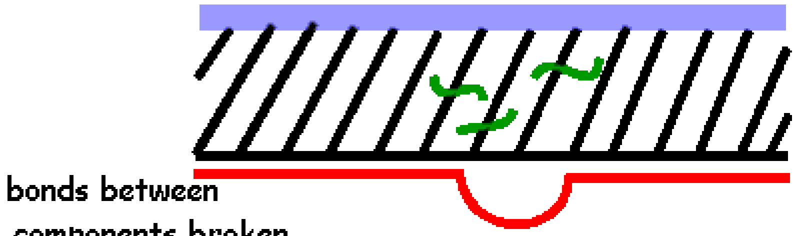
# Introduction to Hyphal Growth

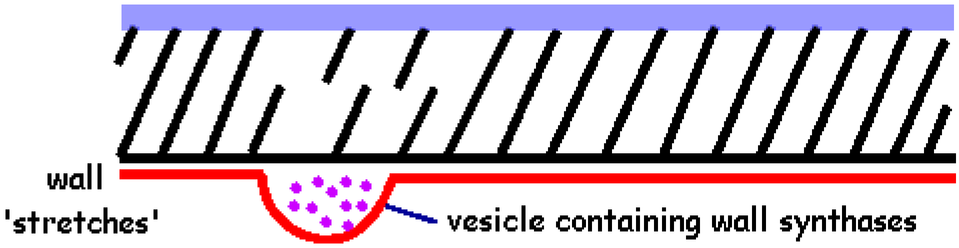
# Apical Growth

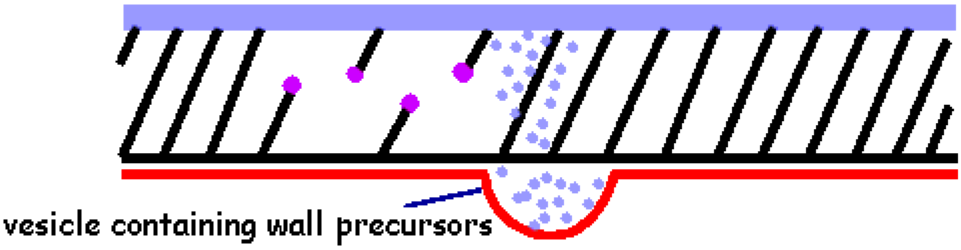
- To understand the mechanisms involved in apical growth of a hypha we need to look again at the HYPHAL TIP.
- We already know that the growing hyphal tip is structurally and functionally different from the rest of the hypha .
- BUT - the hyphal tip (like the rest of the hypha) is surrounded by a wall - although the wall may be thinner and simpler in structure than the mature lateral wall of the hypha further back .
- We also know that growth of a hypha is closely linked to the presence of vesicles which form the APICAL VESICULAR CLUSTER (AVC):
    - when a hypha stops growing, these vesicles disappear
    - when growth of the hypha resumes, the vesicles reappear.
- In addition - the position of the vesicles is linked to the direction of growth of a hypha:
    - when a hypha is growing straight ahead, the vesicles are positioned in the centre of the hyphal tip
    - movement of the vesicles to the left or right side of the hyphal tip is accompanied by a change in direction of growth of the hypha
- So it's clear that the vesicles play a key role in apical growth.
- Vesicles of the AVC contain:
- wall PRECURSORS - the sub-units or buildng blocks of the wall polymers - e.g. uridine diphosphate N-acetylglucosamine, the sub-unit of chitin
- wall LYTIC ENZYMES - which help breakdown and separate wall components - e.g. chitinase, glucanase
- wall SYNTHASE ENZYMES - which help assemble new wall components and so increase the size of the wall – e.g. chitin synthase, glucan synthase.
- TWO MODELS have been proposed to explain the mechanisms of apical growth - they differ in whether or not wall lytic enzymes are necessary.
- Model 1 - involvement of wall lytic enzymes:
    - According to this model, if the hypha is going to be able to extend at its tip, there will have to be:
- some softening (lysis) of the existing wall, and
- the synthesis and incorporation of new wall material.
    - But these processes will have to be finely balanced - otherwise, the wall may become too weak or too rigid for further growth
    - The following series of diagrams helps illustrate what may happen:
    - 

- Vesicles containing lytic enzymes or wall precursors move through the cytoplasm towards the hyphal tip, where they fuse with the plasma membrane, releasing their contents into the wall.
- The lytic enzymes released into the wall attack the polymeric fibrils.

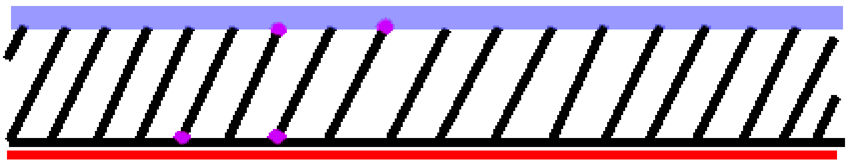



- The weakened fibrils stretch out and become separated from one another due to the turgor pressure of the protoplasm.

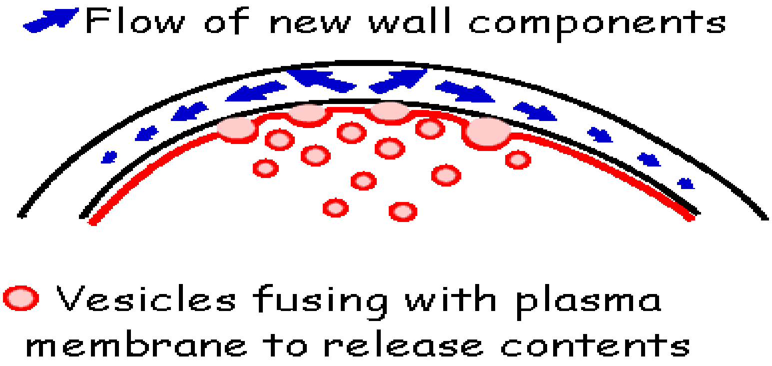



- Synthase enzymes and wall precursors build new fibrils and synthesise additional amorphous components of the wall.
- The surface area of the hyphal wall increases. Fusion of the vesicles with the plasma membrane ensures that the fomer contribute to the increase in surface area of the latter.



- Model 2 - steady state:




- According to this model:
- lytic enzymes are NOT involved in apical growth
- because the newly formed wall at the extreme tip of the hypha is VISCOELASTIC (essentially fluid)
- so that as new wall components are added at the tip, the wall flows outwards and backwards (see adjacent diagram)
- and the wall then RIGIDIFIES progressively behind the tip by the formation of extra chemical bonds.

# Hyphal Branching

- Although each hypha exhibits apical growth (i.e. extends at its tip), it doesn't continue growing as just a single filament - it will eventually BRANCH and as the branches become progressively longer they too will branch, as illustrated in this movie clip from the Fungal Cell Biology Group based at the University of Edinburgh.
- Features:
- Hyphal branching is necessary for efficient colonization and utilization of the substrate upon which the fungus is growing.
- A branch arises when a NEW GROWTH POINT is initiated in the existing lateral wall of the hypha - this is accompanied by the ACCUMULATION OF VESICLES.
- Branch formation almost certainly involves wall lytic enzymes (model 1), since the branch will emerge through a mature, rigid area of the hypha's lateral wall.
- Branches normally EXTEND AWAY FROM ONE ANOTHER, filling the gaps between existing hyphae, because they're:
    - responding to nutrient gradients - growing out of areas where nutrients have become limited around existing hyphae, into areas where nutrients are more plentiful
    - growing away from areas which have become staled by the metabolic by-products of existing hyphae.
- The extent of hyphal branching, i.e. the density of a fungal colony (number of hyphal branches formed per unit area), is directly related to the concentration of nutrients in the substrate or growth medium:
    - a sparsely branched colony (low hyphal density) will develop on a nutritionally weak substrate or growth medium

  - a densely branched colony will develop on a nutritionally rich substrate or growth medium.
  - BUT:
- RADIAL GROWTH of the colony is NOT influenced by the concentration of nutrients (within limits).
- So a colony will reach approximately the same diameter in a given time interval whether growing on a nutritionally rich or poor growth medium (again, within limits).
  - THE REASON? - BECAUSE:
- Existing hyphal tips at the colony margin (which determine the diameter of a colony) have priority over all other hyphal tips (i.e. the branches) for the available nutrients.
- Only nutrients in excess of those required by the marginal hyphal tips are available to support branching.
- Therefore, the more nutrients that are surplus to the colony margin's requirements, the greater the hyphal densit