

Mycology Answers

In terms of cell structure and function, how do the fungi differ from other microbes?

The term microbe is used to describe an organism composed of a single cell or group of cells that are able to live independently. These microscopic organisms include the bacteria, algae, protozoa and fungi. The range of forms and life styles that occur in the microbial world is enormously diverse. The ordering of living species on the basis of evolutionary relationships is known as phylogeny and the development of molecular methods has made it possible to compare large molecules in living organisms. The use of such techniques (molecular phylogeny) has resulted in the definition of three kingdoms now known as domains, each distinctly different from the others. All organisms belong in one of these domains, namely Bacteria (formerly Eubacteria), Archaea (formerly Archaeobacteria) and Eukarya (including animals, plants, fungi, and protists).

Cells are the basic units of living organisms. They are bounded by a cell membrane that acts as a semi-permeable barrier from the surroundings and many cells are also protected by an outer cell wall. A major distinguishing feature of cells is the arrangement of the genetic material (genomic DNA) in the cytoplasm. In eukaryotic cells (members of the Eukarya) linear chromosomes are contained within a membrane bound nucleus. In prokaryotes (Bacteria and Archaea) that lack true nuclei, the genetic material is free in the cytoplasm and organised as a single circular chromosome. The prokaryotic microbes are also smaller than eukaryotic microbes (algae, protozoa and fungi). Additionally, cells of the Bacteria and Archaea lack the discrete structures (organelles) associated with specific biochemical activities that occur in the cytoplasm of members of the Eukarya.

The Bacteria and Archaea are microscopic and all are prokaryotes, but members of these two domains are quite distinct from one another. The Archaea are mostly anaerobic organisms, able to grow where oxygen is unavailable or present in very low amounts, and are found in unusual habitats and extreme environments. Some have a high requirement for salt, some

require high levels of sulphur and some grow at extremely high temperatures (100 - 110°C). Some (methanogens) produce methane under anaerobic conditions. Archaea are found in hot springs, geothermal vents and volcanic habitats, regions which would be regarded as hostile for the organisms we encounter most often. Members of the Bacteria are also found in an extremely wide range of habitats. The mycoplasmas lack cell walls and the actinomycetes have a filamentous, ramifying growth form. The remaining bacteria can be divided into two groups depending on the structure of the cell wall, general morphology and nutritional behaviour. Bacterial cells have a simple structure. Morphologically the cells are usually spherical (cocci), rod shaped (bacillus), curved (vibrio) or spiral (helix). The cell walls characteristically contain peptidoglycan with varying amounts of lipopolysaccharide. Bacteria can use a wide range of organic chemicals as energy sources. The cyanobacteria and photosynthetic bacteria use light energy for metabolism. Some can make use of inorganic energy sources and have a vital role to play in the cycling of elements in the environment on a global scale. Many are also capable of growth in anaerobic conditions.

In the Eukarya the microorganisms (algae, protozoa and fungi) are generally larger than the prokaryotes. Most of the algae contain chlorophyll and use light energy for photosynthesis. Many are small and unicellular although some marine algae can grow to reach much larger sizes. Many algae or their gametes (germ cells) move (are motile) by means of flagella and some aggregate and co-operate together in colonial forms. Algae grow well in aquatic environments, in soil and on damp surfaces. They are divided into groups by the pigments they contain and by the composition of the cell walls which contain cellulose, xylans and mannans. Protozoa are unicellular and motile but lack a protective cell wall. They are also found in aquatic habitats and very damp situations where they obtain nutrients by the ingestion of other microbes or particulate organic materials. Some

are of great importance because they cause serious diseases in man and animals (e.g. malaria, amoebic dysentery, giardiasis).

Hyphae, the units of fungal growth, are fine (1-30 μm , but usually 5-10 μm diameter) and are essentially tubular with a characteristic internal structure that enables invasive growth and substrate exploitation supporting the fungal mode of life. Most hyphae are surrounded by a cell wall containing chitin and glucan (some contain cellulose and glucan). This has an important role in maintaining the shape of the hypha and is a protective layer against osmotic changes and potential bursting. Hyphae contain true nuclei, although they are typically very small and not easily seen using a light microscope. They also have mitochondria (sites of respiratory activity and energy metabolism), endoplasmic reticulum (extensive systems of membrane, sites of protein synthesis), vacuoles (membrane-bound storage compartments) and vesicles (very tiny membrane-bound bodies that probably carry specific enzymes and/or cell components). The arrangement of these organelles is very specific and related to the growth form. Fungal hyphae grow by extension of the cell wall at the apex only. Growing tips are particularly rich in vesicles (clusters of vesicles are seen at growing apices), almost to the exclusion of other organelles. These vesicles probably provide wall components for the extending tip. Immediately behind these, active mitochondria are present, usually arranged with their longitudinal axes lying in the same direction as the hypha. Nuclei will be found much further back, away from the growing region, and vacuoles are formed further away.

Since physiological and biochemical activities tend to be compartmentalised and associated with organelles there is a zonation of activity along fungal hyphae. Some enzymes are also associated with the fungal cell wall. Tip regions that have newly extended into fresh substrate will be involved in nutrient digestion and uptake whereas more distal zones will be associated with nutrient storage and the processes of differentiation and/or sporulation. There is some mixing of cytoplasmic contents by streaming action from one part of a hypha to another. This streaming probably counters problems that might otherwise occur with relatively long

distance diffusion. Some hyphae are able to grow, sometimes for extended periods, over substrates with little nutrient and water content. This allows the eventual exploitation of new regions of substrate but would not be possible without the initial maintenance of hyphal connections. Many growing fungal colonies will eventually produce spores (by sexual or asexual reproduction). These may be agents of rapid dispersal or may be resting structures, with thickened pigmented walls, designed to withstand adverse conditions (overwintering). Fungal spores are often highly resistant, representing an interruption in the developmental sequence of a fungal colony, and are a very efficient means of survival. Spores also contain all the components necessary for the resumption of growth although the organelles present may be immature or temporarily non-functional. When growth resumes the fungal character will quickly be re-established.

Fungi lack chlorophyll and derive energy from pre-formed organic compounds. They absorb soluble nutrients through the cell wall and membrane. However, they are able to exploit a very wide range of habitats and can use a wide variety of substrates as nutrient materials. The fungi demonstrate an invasive growth form, penetrating into the substrate. Owing to their life styles they act as agents of decay, nutrient recycling, and disease production, and also have great industrial importance.

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