The fungi are perhaps the least understood of the multicellular organisms, despite being almost ubiquitous in nature. An international team, coordinated by Professor Dr Reinhard Fischer of the Karlsruhe Institute of Technology, Germany, and Professor Dr Meritxell Riquelme from the Centro de Investigación Científica y de Educación Superior de Ensenada, Mexico, is leading attempts to understand the growth and development of these remarkable organisms, shedding light on their medical and ecological applications.

**Mycology: unravelling the riddle of the filamentous fungi**

There may be as many as five million species of fungi worldwide—many more than there are plants. The vast majority of these little-understood organisms are the ‘filamentous fungi’, named because they are composed of a web of filaments called ‘hyphae’. The work of Professor Fischer, Professor Riquelme and their co-workers focuses on how these filaments grow, indefinitely, by extension at each microscopic tip, to form huge networks called ‘mycelia’.

**UNDERRATED ORGANISMS**

Despite their lowly appearance, the filamentous fungi are crucial to the functioning of natural ecosystems. Alongside bacteria, they are the main agents responsible for decomposing dead organic matter, making its chemical components available to the next generation of organisms. What is perhaps less well known is that they play a vital role, not only in generating nutrients, but also in plant nutrient uptake: every metre of plant root in the soil is associated with roughly a kilometre of symbiotic fungal hyphae, known as ‘mycorrhiza’, which take up nutrients and pass them to the plant.

Filamentous fungi are important pathogens of crop plants, and in a few cases cause serious human disease, particularly in the immunocompromised. They have also been harnessed for biotechnological uses, including crucially in the production of antibiotics such as penicillin, other medicines, citric acid, and foods such as soy sauce and cheese. To scientists, fungi are also important due to the similarity of their cells to human cells, making them ideal models to study various aspects of cell function.

Keeping pace with growth

At the tip of each fungal hypha lies a region of active growth. Here, membrane-bound particles (vesicles) containing the raw materials for building new cell walls and membranes—proteins, lipids and other organic molecules, as well as catalytic enzymes—fuse with the cell’s boundary membrane, releasing their precious cargo. However, the highly polarised positioning of this region poses challenges for the fungus. Firstly, how can they transport adequate quantities of these materials to the tip in order to keep up with the rate of growth? Secondly, with such rapid growth occurring at the tip, how does the hypha maintain a stable marker of exactly where, and in what direction, growth is to occur?

**The logistics of transporting materials to the actively-growing hyphal tip are being elucidated by Michael Feldbrügge’s lab at Heinrich Heine University, Düsseldorf, Germany. The length of the hyphae is traversed by a skeleton of fine tubes called microtubules, along which vesicles and their contents travel, facilitated by proteins acting as motors. Feldbrügge has also found that these provide transport routes for molecules of messenger RNA, which translate the genetic information in DNA into functional proteins. Crucially, this means that protein production can be precisely targeted to specific regions within a cell without having to transport large quantities of the proteins themselves.**

The diverse and enlightening findings of this high-profile programme have implications far beyond the fungal kingdom.
and colleagues, have shown, using modern para la Biodiversidad, Guanajuato, Mexico, at the Laboratorio Nacional de Genómica biocontrol agent, Prof Alfredo Herrera-Estrella using the fungus shedding light onto how this may be achieved.

Why is their growth and development such an interesting area to study? The fungal hypha is able to grow indefinitely at the tip. It is one of the few examples of extreme polar growth of individual cells. Other examples are pollen tubes, root hairs and nerve cells. Thus the study of the mechanisms of polar fungal extension may help to improve our understanding of polarity in general. Likewise, simple hyphae are able to differentiate rather complicated structures such as fruiting bodies. This requires massive changes in gene expression. It can be an example for other differentiation processes, e.g., embryogenesis in higher eukaryotes.

What recent technological advances have helped further your research? The advent of molecular biological methods in the 1980s, the use of GFP and other fluorescent proteins since 1994 in combination with steadily improved microscopy techniques and the recent development of super-resolution microscopy techniques have boosted fungal research.

How do the cells of filamentous fungi differ from those of other organisms? Fungi are in many aspects identical to human cells. One important difference, however, is the presence of a rigid cell wall consisting of different carbohydrate polymers, including chitin. Because of this difference, the fungal cell wall or the biosynthesis machinery may be targets for drug development.

What biological features are conserved between filamentous fungi and animals such as humans? Basic cell biological processes such as mitosis, meiosis, the functioning of organelles, or the principles of gene regulation are highly conserved between humans and both filamentous and yeast-like fungi.

How numerous, widespread and significant are the filamentous fungi? Fungi are found in nearly all ecosystems, where they fulfill important functions for nutrient recycling. Some species are important plant pathogens, such as Magnaporthe oryzae or rust fungi. There are also animal pathogens. Many moulds contaminate food and feed and cause tremendous losses due to mycotoxin formation.

State-of-the-art microscopy and molecular biological methods are enhancing our understanding of the mechanisms by which these intriguing and important organisms grow and differentiate.