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RADIOACTIVE FUNGI: A NEW HORIZON OF FUNGI

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ABSTRACT

Recent data show that melanized fungal species like those from Chernobyl's reactor i.e *Cladosporium sphaerospermum*, *Wangiella dermatitidis*, and *Cryptococcus neoformans* respond to ionizing radiation with enhanced growth. Fungi colonize space stations and adapt morphologically to extreme conditions. The discovery of melanized organisms in high radiation environments, the space stations, Antarctic mountains and in the reactor cooling water combined with phenomenon of 'radiotropism' raises the tantalizing possibility that melanin's have functions analogous to other energy harvesting pigments such as chlorophylls. Researchers have now found evidence that fungi possess a previously undiscovered talent like protection of astronauts in space from cosmic rays, astronauts might be able to rely on fungi as an inexhaustible food source on long missions or for colonizing other planets, participation in bioremediation of radionuclides and act as sunscreen against harmful solar radiation. In other words, radioactive fungi can be served for other useful purposes, if further attention paid on research and development on them.

INTRODUCTION

Radioactive fungi were discovered in 1991 growing inside and around the Chernobyl Nuclear Power Plant. It was specifically noted that colonies of melanin rich fungi had begun to rapidly grow within the cooling waters of the reactors within the power plant, turning them black. While there are many cases of extremophiles (organisms that can live in severe conditions such as that of the radioactive power plant) microbiologist Arturo Casadevall believed that these fungi were growing because of the radiation rather than in spite of it.Further research conducted at the Albert Einstein College of Medicine showed that three melanin-containing fungi — *Cladosporium sphaerospermum, Wangiella dermatitidis,* and *Cryptococcus neoformans*—increased in biomass and accumulated acetate faster in an environment in which the radiation level was 500 times higher than in the normal environment.

Confirmation of Discovery

- Zhdanova *et al.* (1991) conducted an experiment where fungal samples extracted from the remains of a Chernobyl reactor were inoculated near radioactively decaying 109 Cadmium or 32 Phosphorus radionuclides. At the end of the growth period, 66.7% of the sample had exhibited growth in the direction towards the source of radiation independent of the direction of the food base also present in the growth vessel.
- Dadachova *et al.* (2007) exposed melanin-containing *W. dermatitidis* and *C. neoformans* cells to ionizing gamma radiation 500 times the background levels in normal environments were found to grow at a significantly faster rate than irradiated non-melanized cells or non-irradiated melanized cells.

Some Characteristics of Example Species

A. *Cladosporium sphaerospermum*

- *Cladosporium sphaerospermum* is a psychrophilic fungus, known to grow at temperatures as low as –5 °C with an upper limit of 35 °C (95 °F) and no growth at 37 °C (99 °F).
- The hyphae of *Cladosporium sphaerospermum* are thick walled, septate, and olivaceous-brown in colour. This fungus is xerotolerant as it can thrive in environments with low water activity caused by high salinity (halotolerant) or other dissolved solutes.

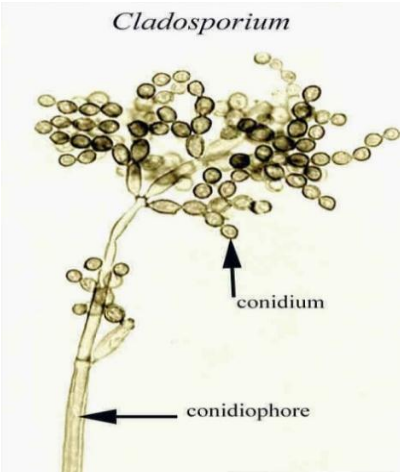


Image courtesy from wikipedia

Image courtesy from wikipedia

***Cladosporium sphaerospermum* on potato dextrose agar after incubation for 14 days at 25°C**

B. *Wangiella dermatitidis*

- Colonies of *Wangiella dermatitidis* grow slowly. On potato dextrose agar and after incubation at 25°C, the colonies are initially moist, yeast-like, and shiny. Aerial hyphae develop after 3 to 4 weeks of incubation. The color is black from the front and the reverse.
- *Wangiella dermatitidis* can grow at temperatures as high as 42°C and does not assimilate potassium nitrate. Microscopically, it has septate, brown hyphae. Conidiophores, phialides, and yeast cells are observed.

Image courtesy from M.McGinnis(drfungus.org)

Microscopic Picture of *W.dermatitidis*

C. *Cryptococcus neoformans*

- It is an encapsulated yeast and an obligate aerobe that can live in both plants and animals. It is a filamentous fungus belonging to the class Tremellomycetes. The cells of these species are covered in a thin layer of glycoprotein capsular material that has a gelatin-like consistency, and that among other functions, serves to help extract nutrients from the soil.
- *Cryptococcus neoformans* grows as a yeast (unicellular) and replicates by budding. It makes hyphae during mating, and eventually creates basidiospores at the end of the hyphae before producing spores.

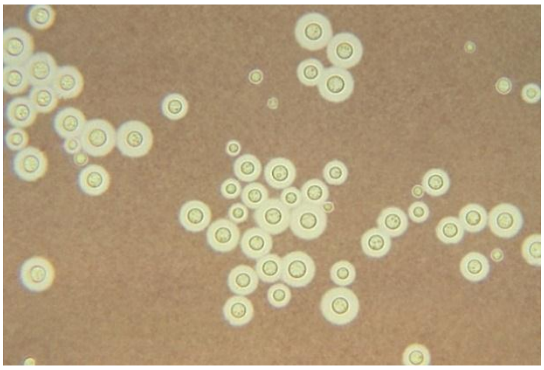
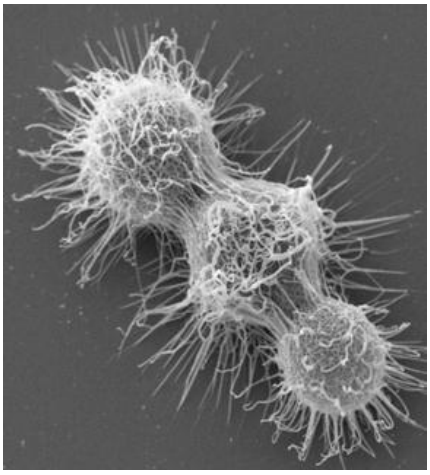


Image courtesy from CDC

***C.neoformans* using a light india ink staining.**



Scanning electron micrograph of the fungus *Cryptococcus neoformans* (Photo courtesy of the Albert Einstein College of Medicine).

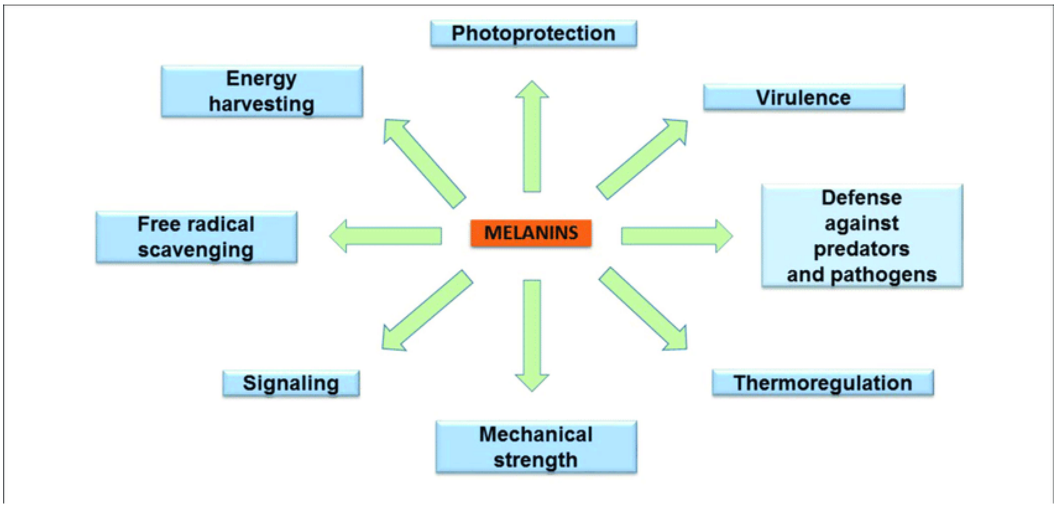
Distribution

- Radioactive fungi have been observed to inhabit some remarkable environments on the planet where high levels of radiation naturally occur, including the Arctic and Antarctic regions, as well as high altitude terrains.
- Interestingly, orbiting spacecrafts in outer space are another environment where radioactive fungi are found.
- They are able to grow extensively despite the high levels of ionizing radiation present beyond the

protective shield of the Earth's atmosphere, as seen in the fact that the Russian orbital station, Mir

Role of Melanin

- Melanin's are a family of ancient pigments with radio-protective properties that is generally dark brown/black, and it is naturally occurring
- This pigment can transduce and shield energy, therefore it can absorb electromagnetic radiation and absorb light. This quality means that melanin can protect melanized fungi from ionizing radiation. The energy transduction enhances growth in the fungi as well, meaning that melanized fungi grow faster.
- Melanin is also an advantage to the fungus in that it helps to survive in many different, more extreme, and varying environments
- The scientists even found that fungi were able to safeguard their DNA and utilize ionizing radiation as energy for DNA repair in some extreme cases.
- The growth can be at least partially explained by melanin's ability to catalyze an oxidative-reduction reaction typical of cell metabolism.



- Dadachova *et al.* hypothesized that ionizing radiation could change the electronic properties of melanin and observed that irradiated melanin was found to have manifested a 4-fold increase in its ability of reduce NADH in comparision to the non-irradiated form. This would theoretically lead to more efficient energy transduction from radiation to another usable form of energy, which may enhance the growth of melanised fungi.
- This hypothesized mechanism of energy transfer was noted similar as the pigment chlorophyll in photosynthesis. However, whether radiotrophic fungi carry out the rest of the energy transduction process in a similar multi-step pathway as photosynthesis remains an area of active research.

Radiotropism

- The term 'radio tropism' refers to the ability of several fungal species to harvest usable energy from forms of ionizing radiation, such as gamma radiation emitted from nuclear reactors.
- Ionizing radiation is emitted from high energy sources, and is composed of particles that individually carry enough energy to liberate electrons from an atom's orbit upon interaction with said atom.
- In this event, the chemical bonds in the atom can be changed, producing ions that may be especially reactive As this is generally thought to inflict great chemical and biological damage on living organisms, the existence of radiotrophic/radioactive fungi that can harvest the energy present in ionizing radiation lends itself to the exciting exploration of novel ways by which organisms can sustain themselves.

Applications

Bioremediation of Radionuclides: Fungi have been shown to be useful adsorbers of heavy metal and radionuclide contaminants of industrial effluents, where dead mycelia have been used as filters (Tobin *et al.*, 1984; Singleton & Tobin *et al.*, 1996).

Use in Human Spacelift: It is hypothesized that radioactive fungi could potentially be used as a shield to protect against radiation specifically in affiliation to the use of astronauts in space or other atmospheres.

- Along with the applications like helping patients undergoing chemotherapy and protecting nuclear power plant workers, the fungi could be used to develop a sunscreen that protects against harmful solar radiation. If it can store energy, the fungi could be used to develop an alternative to solar panels.
- Research by NASA is going on currently for the use of melanin of these fungus in conjunction with water to convert electromagnetic radiation into electrical energy. This technology will probably find its place in biotechnology as it is non-toxic and biocompatible.

CONCLUSION

- While radiative effects on fungal cells are only moderately understood, one thing is certain: specific types of melanized fungi are able to respond favorably to increased amounts of radiation. This will be a breakthrough to various ongoing work.
- More studies will be needed to confidently explain the consequences of chronic radiation on fungi, but preliminary research suggest powerful results show how supernatural organisms like radioactive fungus that live among us can be benefitted to mankind

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