The Brainless Blob

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Slime mold, also known as the Blob is a single-celled amoeba-like organism. Its scientific name is *Physarum polycephalum*. Scientists used to think this organism was a fungus or a mushroom because of its appearance, but it belongs to a category called protists (**Fig. 1**) [1,2]. This organism can grow up to several feet long and breaks down decomposing matter like rotting logs to survive. The biology of this organism creates a structure called a syncytium[3]. This structure is one that consists of a membrane containing multiple nuclei floating in the shared cytoplasm. The slime mold has been used as a model system for a variety of research fields and in multidisciplinary studies. Slime molds have been seen to control robots, solve efficiency problems, detect pressure, remember where they have been, heal themselves, and have more than 700 sexes[3,4]. This slime also moves by shuffling its cytoplasm in waves, a process called shuttle streaming. While the mold lacks what we would define as a conventional brain, it has a series of tubes with gel-like walls that seem to take that role. When the mold senses food nearby, it detects the chemicals that are released from the food, and the tubes near the food begin to dilate. The tubes farther from the food shrink and sometimes disappear altogether, becoming internalized by the slime. The slime mold then creeps in the direction of the wide, dilated tubes, migrating until it engulfs its snack. The mold can easily navigate a complicated maze to attain its delicious food (**Fig. 2**)[5]. The mold can also make decisions, sleep, and learn. What is even more astonishing is

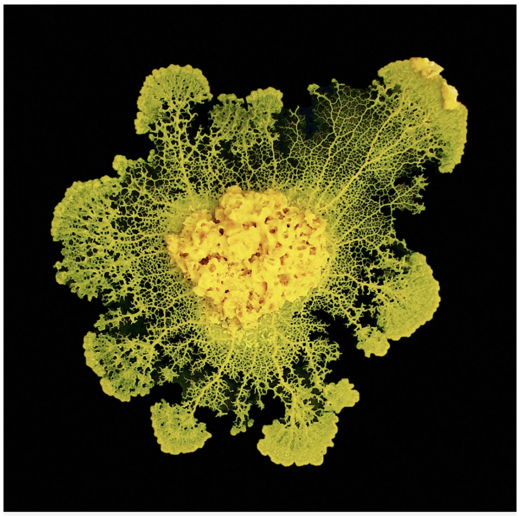

Fig.1: The acellular slime mold, *Physarium polycephalum*.

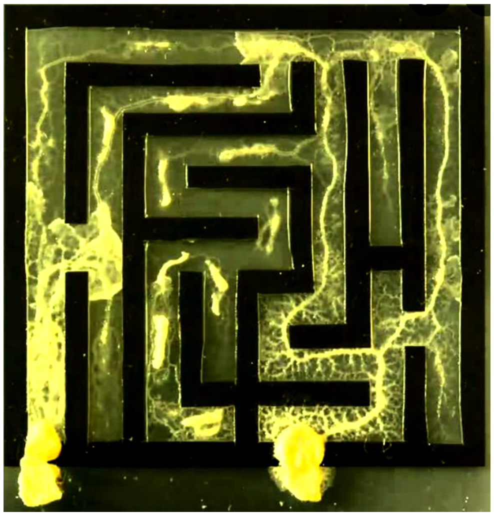

Fig 2: The slime mold navigating a maze to connect two sources of food.

that it can transmit knowledge and information to other slime molds. This slime can grow up to square meters in size, though most laboratory specimens don't grow beyond a few square centimeters or inches. They're found all over the world, usually on the undersides of leaves and logs, where they like to hunt fungi and bacteria [6].

In Aug 10th, 2021, the Blob was launched to the International Space Station (ISS). Scientists hope to study how microgravity impacts its behavior. Once launched, the slime mold underwent a week-long experiment run by the European Space Agency (ESA) to see how microgravity changes the mold. What was amazing about this experiment was that schoolchildren aged 10 to 18 all over Europe followed along, replicating the slime mold experiments in class to see how their slimes on earth compared with the ones in the Space Station under apparent zero gravity[1,7].

Two experiments that were planned to be performed at the ISS and simultaneously on earth were “Exploration” and “Exploitation”. In “Exploration,” a Blob was placed in the center of a circular container without any food. The other experiment named the “Exploitation” had a Blob placed in a similar position but in the presence of food. Both these experiments were aiming to observe how the slime mold grows with and without food in apparent weightlessness. The results from the ISS will be compared to those on the ground [3,2].

Recently, the slime mold has been demonstrated to sense touch and perform long-range spatial decision-making using mechanosensation[6]. The first author of this paper, Dr. Nirosha Murugan conducted this ground-breaking study in Dr. Michael Levin's laboratory at Tufts University. Dr. Murugan now is a principal investigator running her own laboratory in Algoma University in Ontario, Canada pursuing interdisciplinary research in neuroscience, regenerative medicine, cancer biology, and biophysics. In an interview conducted for this article, Dr. Murugan says "mechanosensation is when the mold receives information based on physical information such as stress and vibration and it is then converted into some sort of chemical information". The mold can then make decisions about distant objects in its environment based on this information. Dr. Murugan described the movement as "the segment of the slime, called the front, pushing towards masses with a higher density"[6].

The *Physarum* is one big cell with millions of nuclei; when it undergoes mitosis only the nuclei divide, and the structures grow. The growing front senses the environment and the entire *Physarum* pulsates because the liquid inside the slime moves in a pulsatile manner. In Dr. Murugan's experiment, she examines how the slime mold uses mechanosensation to grow in the direction of "heavier, substrate-deforming, but chemically inert masses" (**Fig. 3**).[6]

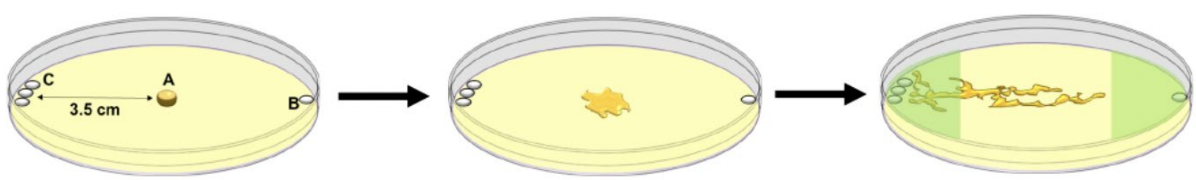

Fig. 3: The experimental set up to demonstrate mechanosensation in the slime mold. Slime mold is grown in a petri dish with agar. Three inert discs are placed in one periphery and one inert disc is placed in the diametrically opposite side. Slime mold navigates to the three discs.

She also found that this long-range sensing of the slime mold is disrupted by "gentle rhythmic mechanical disruption". Overall, her experiment identified the behavior of the slime and how it uses physics to regulate its growth and shape to suit its needs.

Dr. Nirosha Murugan has also studied under Dr. Audrey Dussutour, currently at the French National Centre for Scientific Research (CNRS), a pioneer for studies using the slime mold as a model system. Dr. Murugan described her unpublished work like the recent space experiment where she created a mini vacuum chamber to observe the slime mold's growth. Her finding was that "the slime mold grew upside down" and tried to reach the cap on the agar plate. Describing her research work and her interest in biophysics, Dr. Murugan emphasizes that the commonality between all living beings are the laws of physics.

In another case, we can use the slime mold to solve real world problems. In an experiment at Tokyo University, scientists used the slime mold to model the Tokyo train system. The experiment entailed setting up food with the same proportional distance as the actual city in Tokyo with the slime mold in the agar plate. Astonishingly, when the slime mold created its paths to the food, it resembled almost exactly, the Tokyo train system. The reason why this is astonishing is because engineers took years to create the most effective train system possible, but the slime mold was able to create the same system in roughly several hours. It essentially found the most efficient way to link together multiple points. The reason why this is important is because in future studies the slime mold could theoretically advise the engineers and help society with problems regarding efficiency.[8]

Do the acellular slime molds have cognition and memory? This is a controversial topic. There are several experimental pieces of evidence that suggest that slime molds have memory, can sense the environment, and hence display cognitive ability. Slime molds seem to store information about food in their "memory". For example, it reorganizes all its tubes to center around its food source. However, after acquiring the food, their tube network retains its architecture. This means it stays in place and its structure is the same. However, when again presented with food somewhere else, they dissolve their tubes. Next, they reconstruct their tube network to adjust for the new food in a similar manner as before[6].

With such a diverse set of abilities, what more can this mold do? Dr. Murugan commented that "the slime mold can open up a whole new world of biocommunication and an opportunity for an interdisciplinary approach to truly shine". Currently, multiple teams around the world are exploring this question and the results are sure to further our knowledge on aneural, acellular organisms and hopefully further knowledge about our own brains as well.

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