



*Experimental
Electronics + Signal
Processing
with Slime Mould*

What is a *slime*
mould?

(It's not actual mould!)



900+ kinds of slime mould, related only by the fact that some part of their life exists as a gelatinous slimy state



Physarum polycephalum

The “many-headed” slime

Kingdom Protista

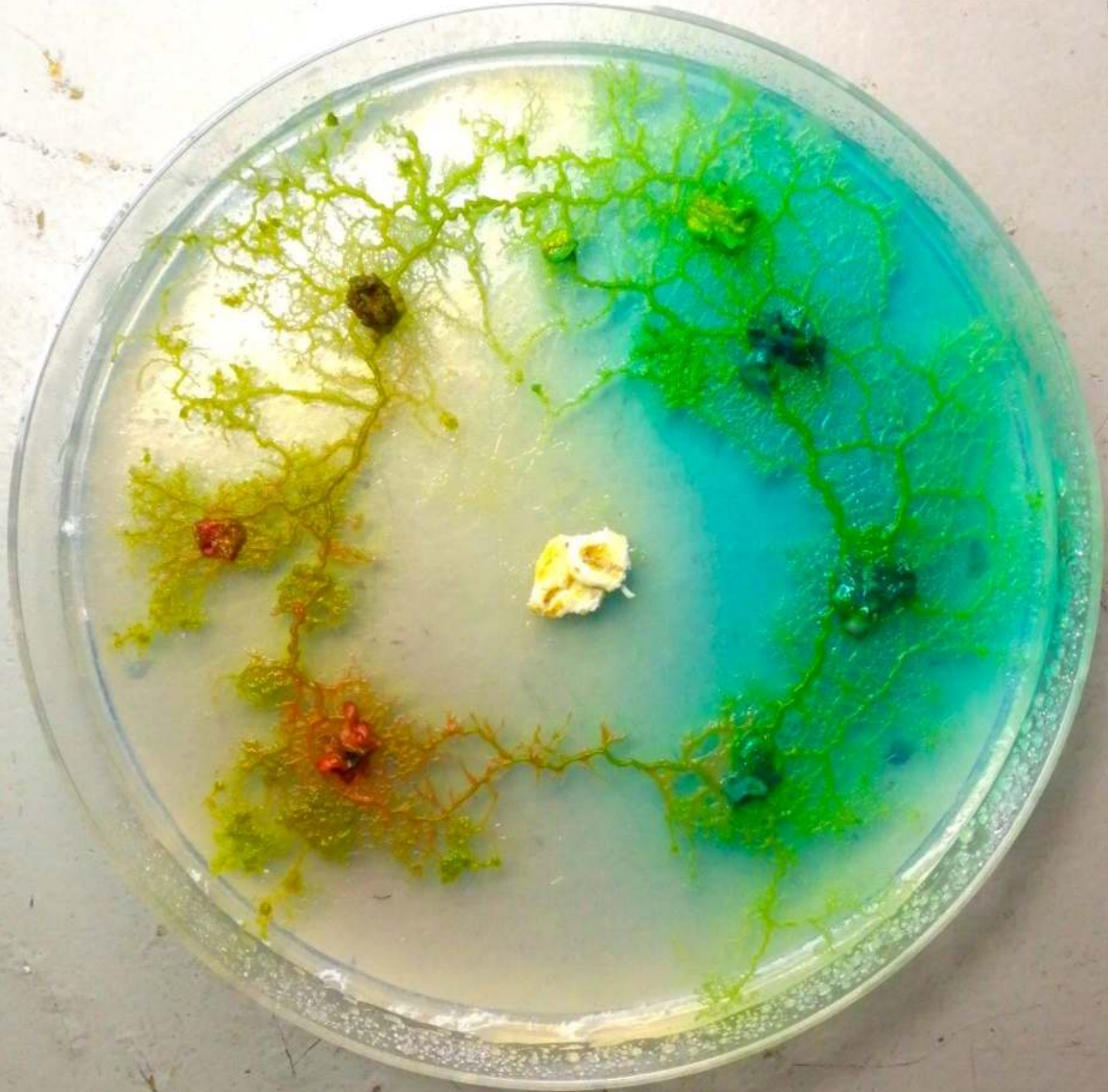
single celled creature



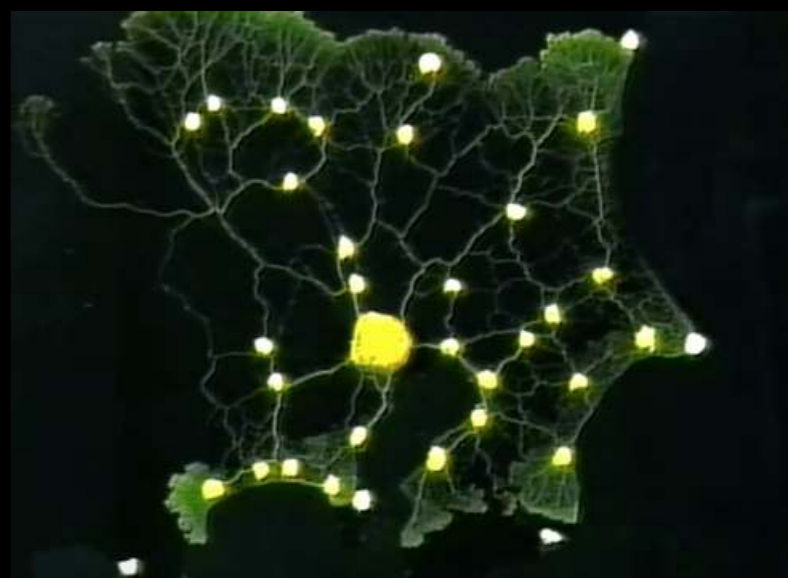
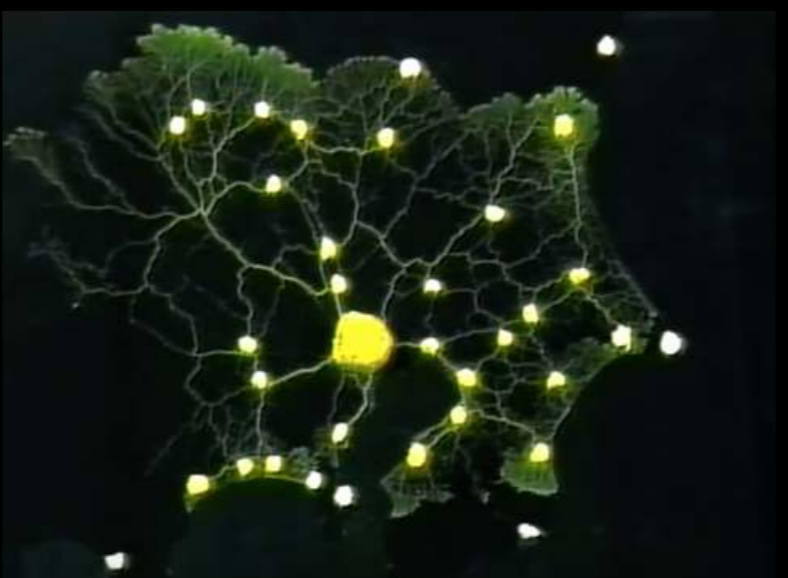
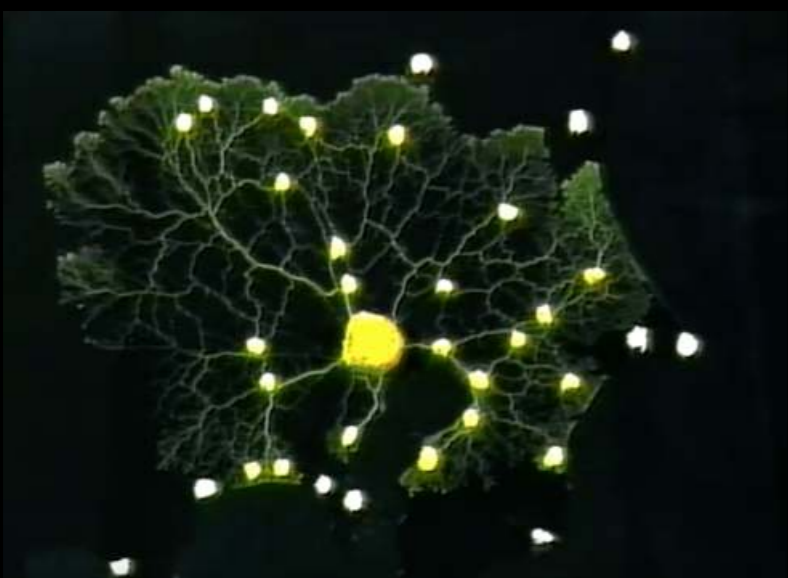
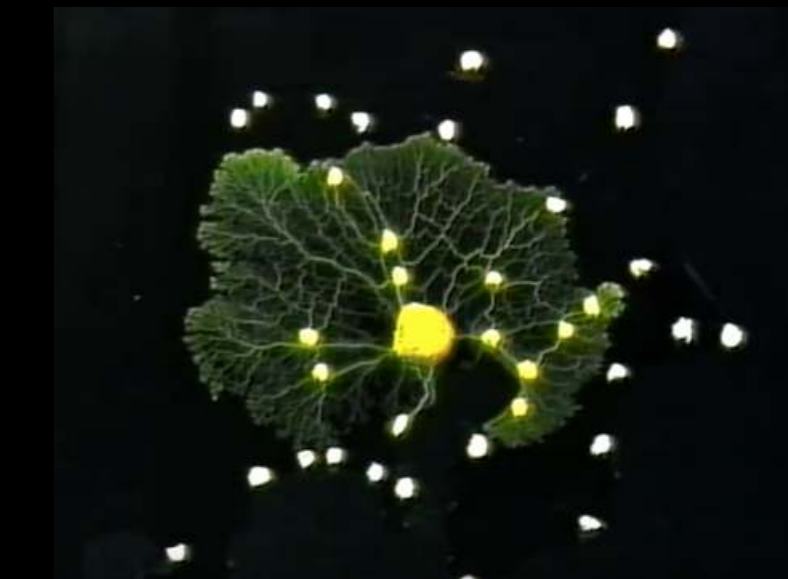
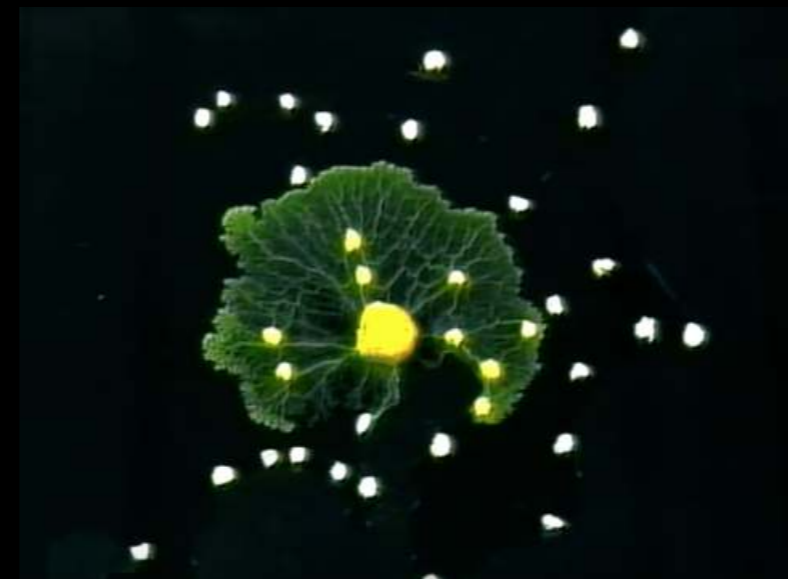
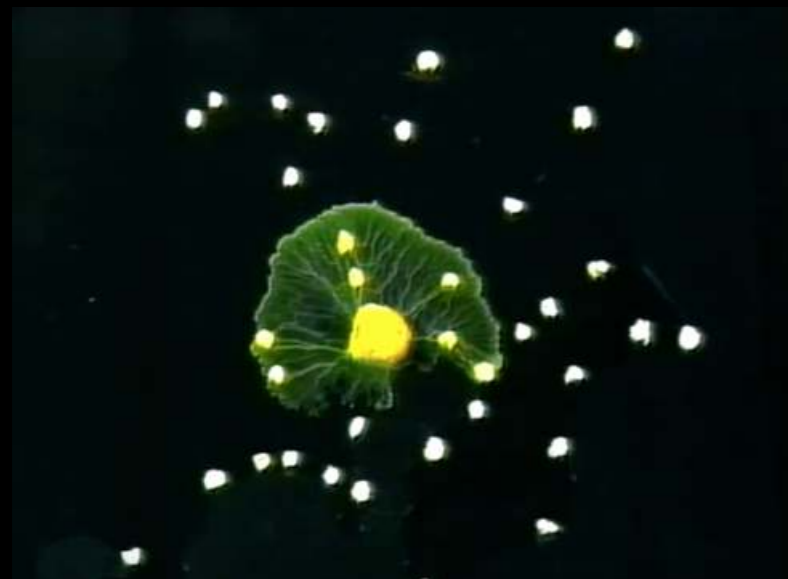
3-4 cm up to 30 cm!

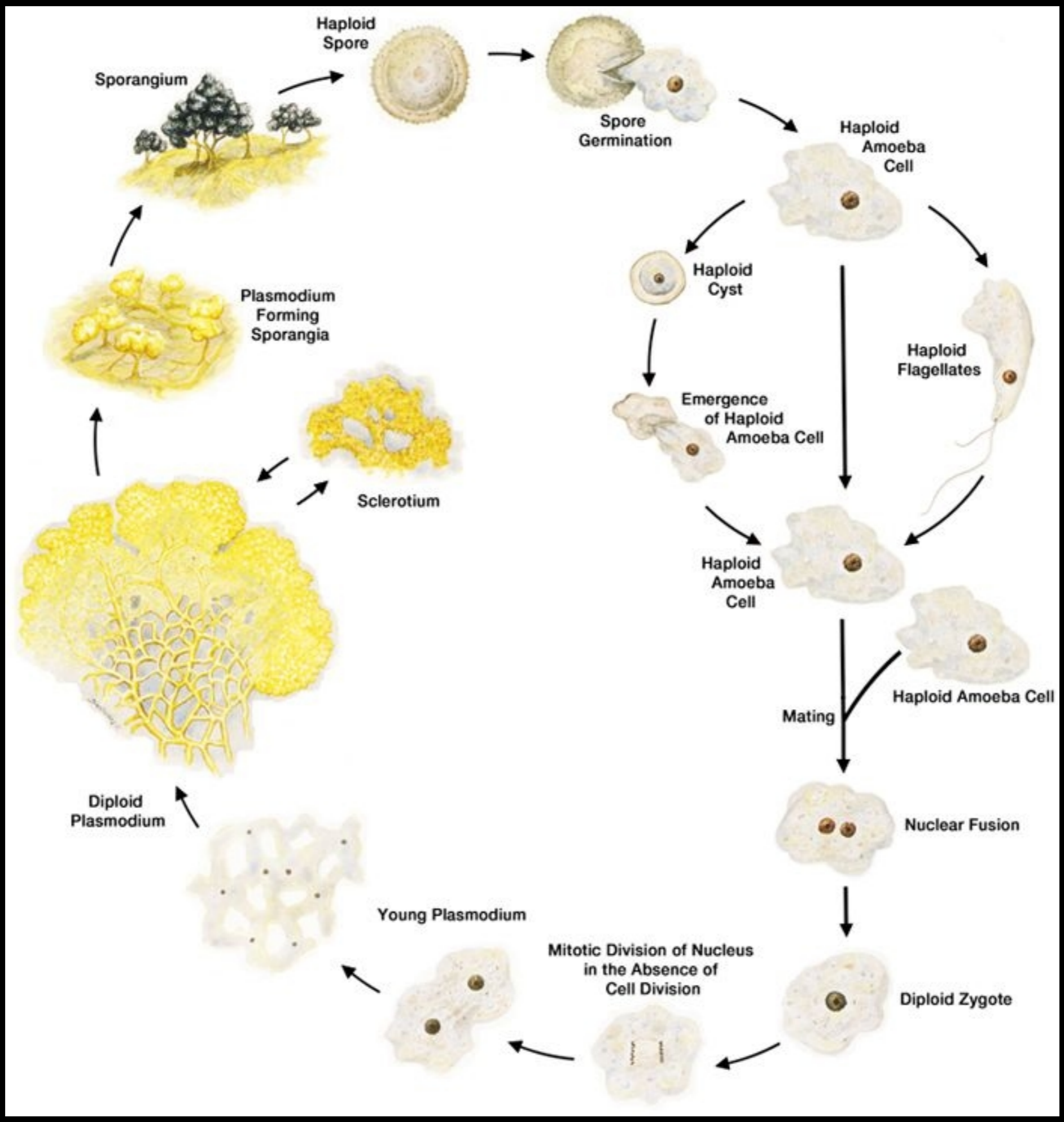


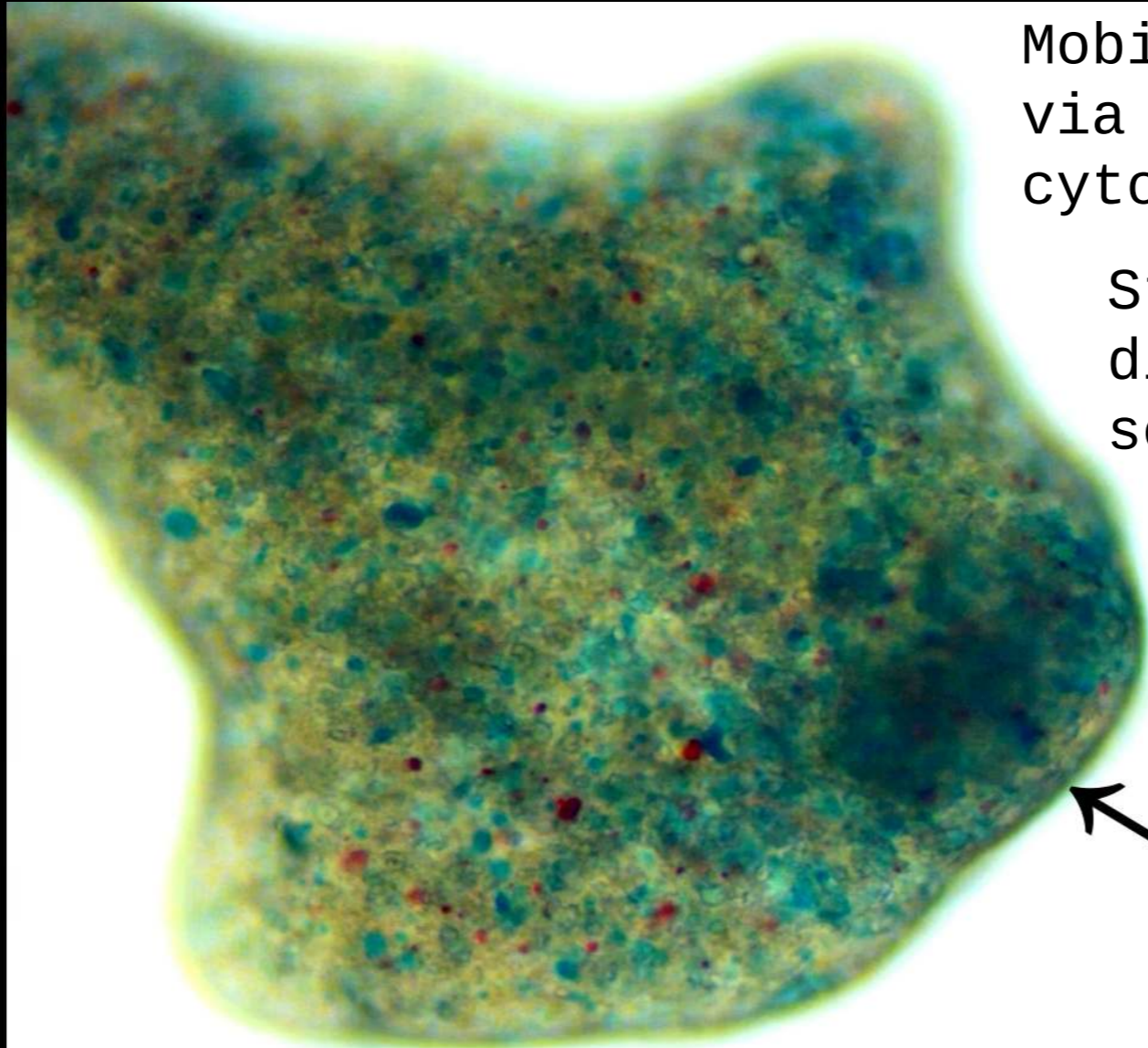










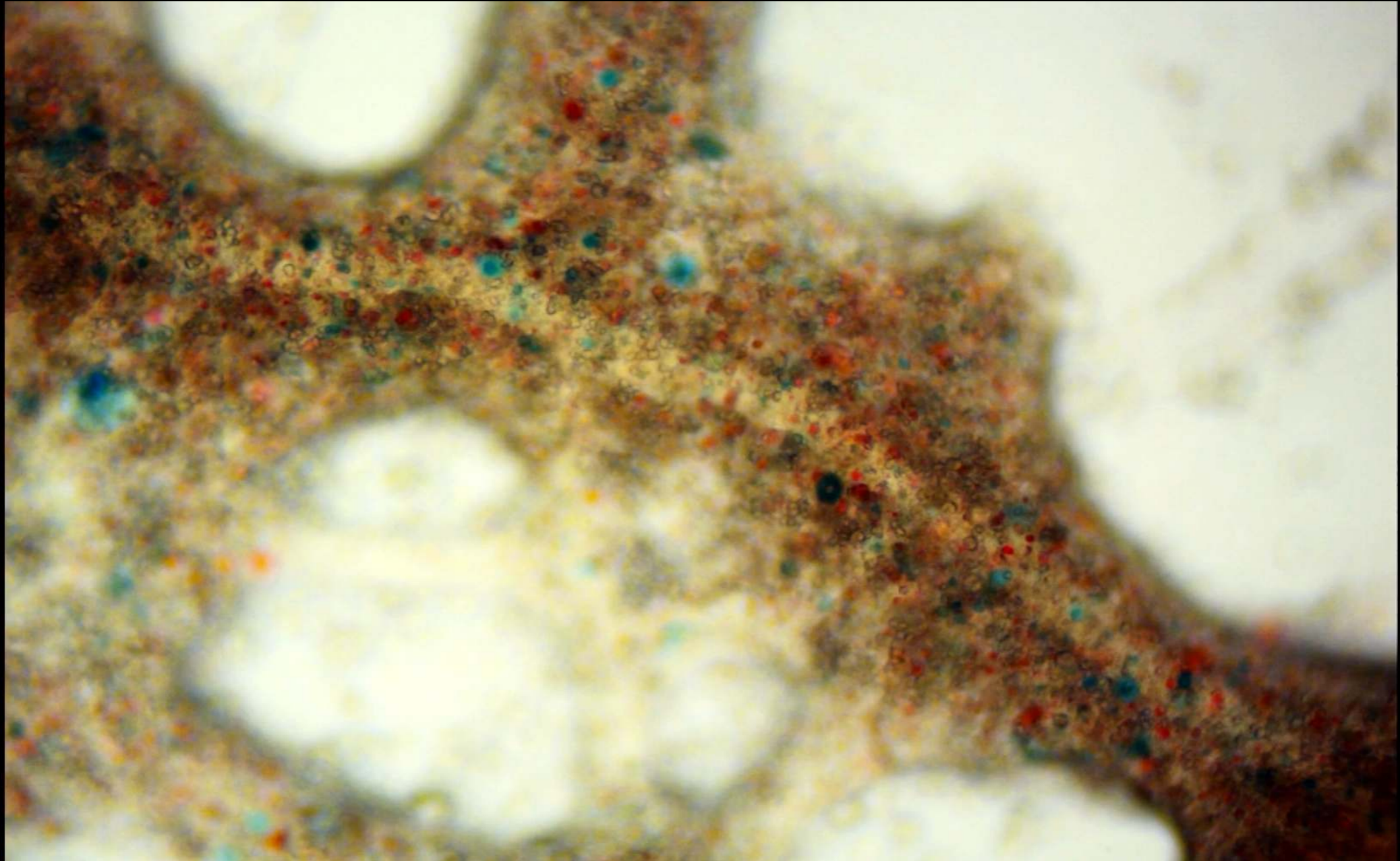


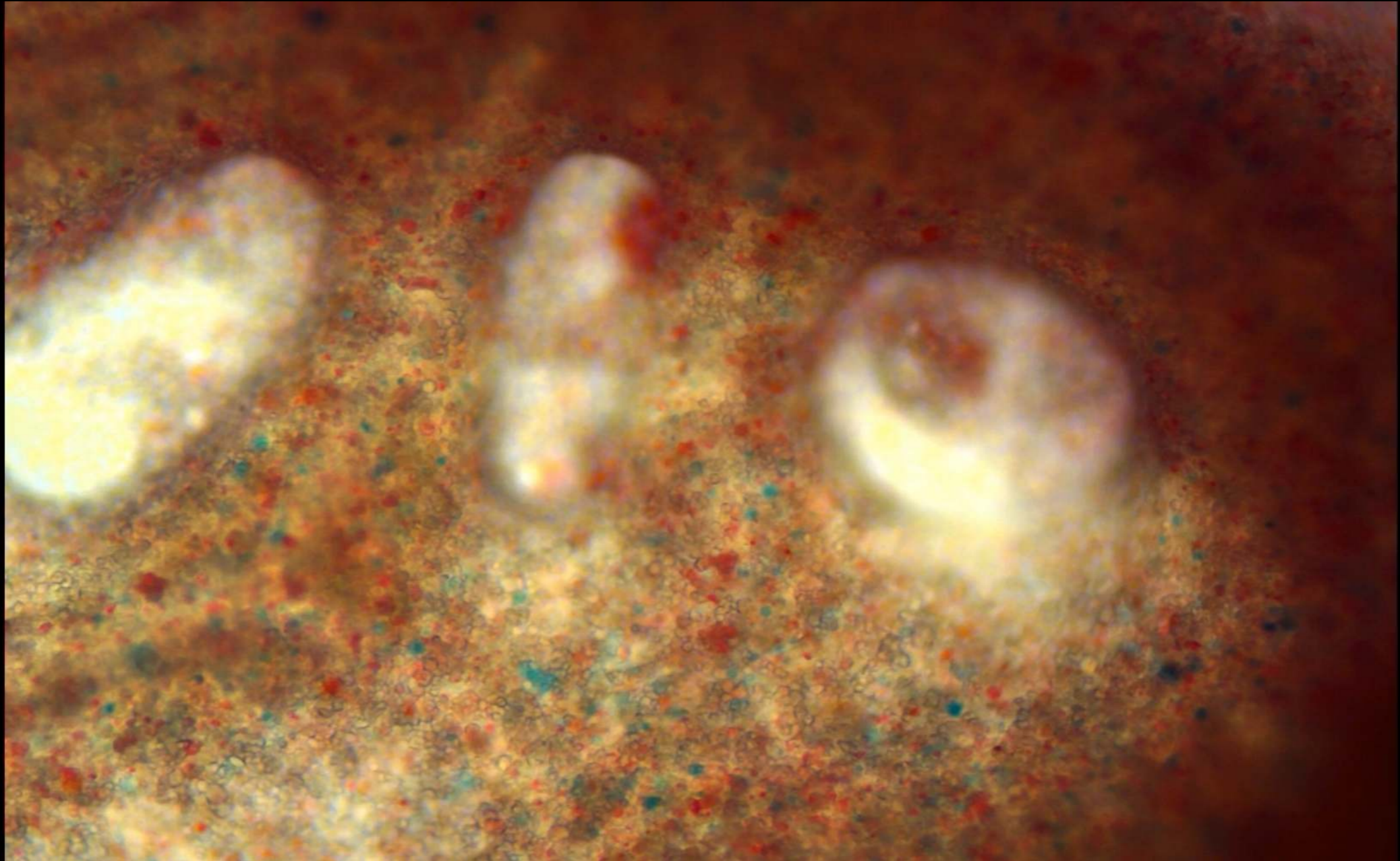
Mobility and circulation
via
cytoplasmic streaming

Streaming reverses
direction every 50-200
seconds

Will creep 1-5mm per
hour

← growing/receding edge





Why

Physarum?

A simple organism which exhibits complex behavior

Tolerant of variations in environment

Resilient & self-healing

Can directly observe computation over time

Accessible and allows for ethical bio-experimentation

Non-invasive and non-toxic

What can it solve?

Computational geometry

plane tessellation, concave and convex hull

Image processing

contouring, filtering, erosion, dilation

Graph-theory

proximity graphs, spanning trees, triangulations

Arithmetics

binary arithmetic circuits

Logics

universal logical circuits

General purpose computing

storage modification machines

(Kolmogorov and Schoenhage machines)

*Color
Sensor*

Physarum is photo-sensitive. It changes pattern of electrical potential oscillatory activity when illuminated [38, 126]. Moreover the Physarum distinguishes the colour of illumination [16]. We placed Physarum between two electrodes and illuminated it with red, green, blue or white light. We also illuminated Physarum with white light via transparent lens. Amount of light on the blob was 80-120 LUX for each colour. We say the Physarum recognises a colour of the light if it reacts to illumination with the colour by a unique changes in amplitude and periods of oscillatory activity. We found that Physarum recognises when red and blue light are switched on and when red light is switched off. Red and blue illuminations decrease frequency of oscillations. Red light increases amplitude of oscillations but blue light decreases the amplitude. Physarum does not differentiate between green and white lights. Switching off red light leads to increase of period and decrease of amplitude of oscillations [16].

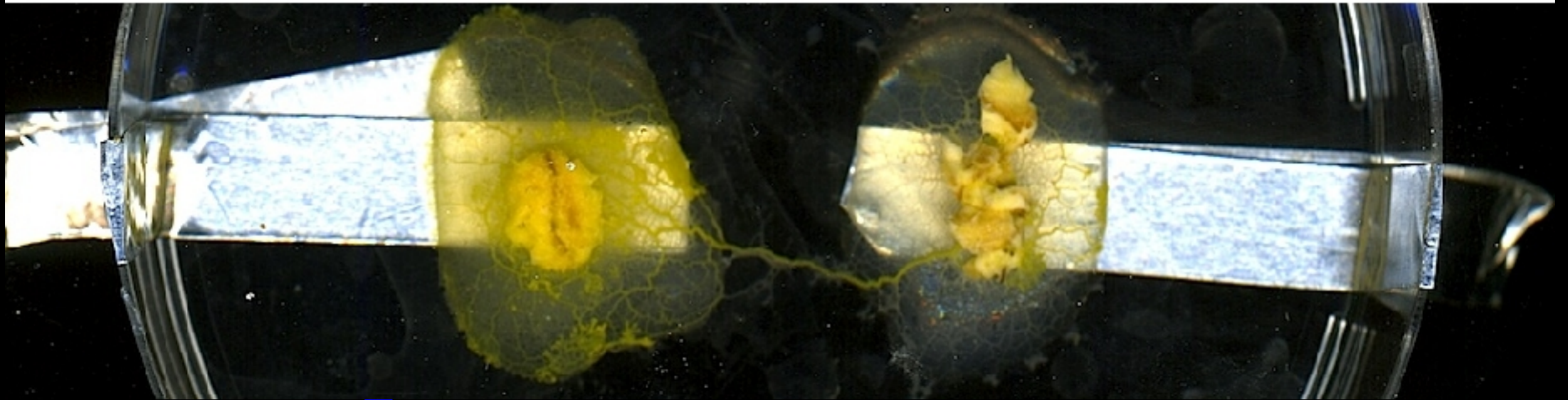
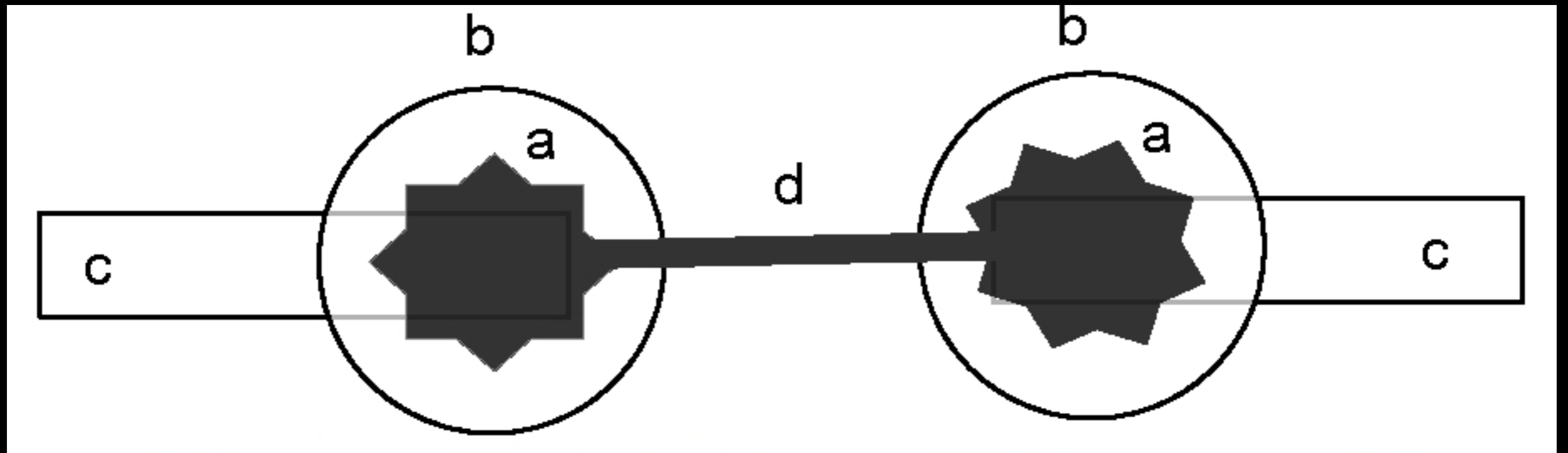
*Chemical
Sensor*

A chemical sensor is a device that gives a selective response when exposed to a target chemical substance. Physarum senses and responds to volatile aromatic substances [9, 11, 22]. Physarum increases frequency of electrical potential oscillations when exposed to strongest attractants — farnesene, tridecane, s(-)limonene, cis-3-hexenylacetate. Exposure to repellents — linlool, ben-zyl alcohol, nonanal — leads to a decrease of oscillation frequency, and, for linlool and benzyl alcohol, increase of the oscillation amplitude. Physarum chemical sensor discriminates individual chemicals by changing amplitude and frequency of its electrical potential oscillations; it can detect chemical from a distance of several centimetres [123].

Self Healing

Wire

Top: A schematic of our experimental setup. (a) Physarum, (b) agar blobs, (c) electrodes, (d) protoplasmic tube. All parts of Physarum shown in dark grey form a single cell.



Bottom: A snapshot of agar blobs occupied by Physarum and connected by a protoplasmic tube.

Issue

Still highly experimental field

Biological substrates are

unpredictable

Slow running compared to digital

computing

Difficult to ensure reproducibility of

results

Under the most rigorously controlled conditions of pressure, temperature, humidity, and other variables, the organism will do as it damn well pleases.

- *Anonymous*

Cultivation Techniques

A hydrated surface to move over

Porridge oats

Optimal growing temps are **22-25° C**

Cultivated in darkness

The Simplest Synth

IC chip as oscillator

resistor

capacitor

FM *Synthesis*

Frequency modulation (FM) synthesis creates sounds by modulating one waveform with the frequency of another

Signal Processing

Audio signal processing is a subfield of signal processing that is concerned with the electronic manipulation of audio signals.

