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Front Cover: Jim Tallon
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Brownian motion is the random movement of particles. They move because other particles, like those of the surrounding fluid, bump into the particles, causing them to vibrate and shake. All particles that have a temperature, and this is always the case above absolute zero, will move. Particles in a solid will vibrate as well, but are locked into place. To observe Brownian motion, therefore, it is necessary to suspend the particles either in a fluid or a gas.

Particles which are larger are also subjected to these forces, but because of their larger mass, their movement is not visible and they tend to stay put. If the particles are small enough, however, then they can be seen vibrating under the microscope.

If you want to observe Brownian motion, then you need to have suspended particles in water. Because of the small movement, it is necessary to use a high magnification, such as 400x.

Brownian motion is also responsible for diffusion effects. In diffusion, particle move from an area of high concentration to low concentration.

Brownian motion is named after botanist Robert Brown. He observed, while observing pollen grains under the microscope, that particles trapped in the water move about. This was in 1827. He could not explain the cause of this motion, however. Much later, in 1905, Albert Einstein published a paper, in which he explained the causes of this motion. Brownian motion therefore already hinted towards the now well established fact, that matter is made of atoms and molecules, which bump into each other.

**Method**

Dilute one to four drops of milk in about 5ml of water. If you use undiluted milk, then the concentration of the fat droplets is too high to see them move freely. Place one drop of the dilute milk on the microscope slide and place a cover slip on top of it. Observe under the microscope in bright field and in dark field. It is also possible to change the temperature by placing the slide into the refrigerator or by warming it up. The Brownian motion is temperature dependent and should increase with increasing temperature.

**Reference**

Brownian Motion. Wikipedia, the free Encyclopedia.
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**Observing Brownian motion**

The fat droplets of diluted milk can be seen shaking and vibrating due to Brownian motion.

Mary Kelly

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**Figure 1: The small dots are fat droplets in diluted milk. They can be seen shaking due to Brownian motion. 40x objective.**
I am fortunate to have enjoyed field microscopy on holiday with my family gathering in New York's northern country. Please enjoy my St. Lawrence River sample, which I collected at Cranberry Creek inlet. This is a geologically young river.

Sense the cottage on the river shore and the pleasure of evening field microscopy as the sun sets to the river at the Canadian western shore.

We grilled local produce and local meats outdoors, we repast at the cottage's outdoor picnic table and its bench, we watched all of our sun settle onto our neighbor, Canada. Everyone retreated at dusk into screen enclosed porch of the cottage, facing the river. The evening mosquitoes are voracious.

On the cottage porch, the drumming of nocturnal insects seeking entry could be heard. The rhythmic slosh of huge commerce ships river wakes impacted our cottage shore rock landing.

Meanwhile, my circa 1950's student field microscope showed both colonial protozoans (with protist body morphology), and colonial rotifer (metazoan body morphology) and sporting symbiotic photosynthesizing *Chlorella* algae.

Often times our domestic indoor plants “reach for the light”. Do these river host colonial protozoa and colonial rotifers behave similarly, to best allow their symbiotic algae to “reach for the light” as well?

The partnership of algae with host protists, rotifers, flatworms, molluscs, and other phyla… it is a primeval pact between host and the symbiotic algae. Each pairing - a “mini-ecosystem”.

References


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Figure 1: Cranberry Creek inlet to the river.
St. Lawrence River Microscopy

Figure 2: No dogs allowed at bench!

Figure 3: River sample at my bench.

Figure 4: Colonial peritrich with symbiotic algae.

Figure 5: Agatha waits for microscopy the session.
Figure 6: Colonial peritrich with symbiotic algae.

Figure 7: Peritrich dispersal phase (a teletroch) with symbiotic algae, yes!

Figure 8: The symbiosis is of a *Chlorella* species epibiont with the colonial rotifers.

Figure 9: A colonial rotifer with symbiotic algae

Figure 10: A 1950’s Meopta Praha cased field microscope, Czechoslovakia.
Microscopic gardeners of the sea:
Marine nematodes and their bacterial symbionts

There are many different ways how animals acquire their food but one group of marine nematodes found a way to "farm" it on the outside of their bodies.

Oleksandr Holovachov

There are many different ways in which animals acquire their food. Among them, growing its own food is not uncommon, but very efficient and safe strategy. It makes animals more independent from the uncertainties of nature, can be more energy-efficient, is considered an important and complex adaptation. In the most common case, organism used for food is grown within the body of the host animal, often inside the digestive system or even inside the individual cells. The host animal provides its food organism with necessary nutrients, and in turn consumes some of the food organism for its own good. Body of the host animal creates suitable conditions for the growth of its food organisms and provides additional physical protection. Much less common is when these organisms, the “host” and the "food", live separately, but in some kind of physical contact. In this case animal too provides its food organism with nutrients and protection. Humans are the best example of such behavior. We farm our food animals and plants, create special environment for them, provide them with nutrients and protection from bad weather, pests, parasites and predators. But we are not the only one in the world to do
so. Ants are the second most popular example – they can "farm" fungus deep inside their nests or "herd" aphids for their sweet honeydew. The world of microscopic organisms has its "farmers" too...

There is a small group of marine nematodes, the subfamily Stilbonematinae (Figures 1, 4 and 7), which are unique in their symbiotic coexistence with bacteria [1]. These nematodes are commonly found in many places throughout the world oceans and seas, including for example the Skagerrak (where Eubostrichus and Leptonemella were found) and the Gulf of Mexico (where Laxus lives). Usually, these creatures can be found in the coarse sand, and, when present, they can be very abundant. Their bodies are very long and thin, even by nematode standards, and are covered in bacteria "from top to bottom", e. g. from the very anterior part and all the way to the tail. Only the head and the tip of nematode's tail are free. These bacteria are attached to the nematode body by the slime-like substance, which is produced by special glands in the nematode body wall.

In general, bacterial cells are rather variable in shape, but only three kinds can be found on these nematodes. On these pictures you can see two common types. More interesting visually but less common are long and thin, crescent-shaped bacteria (Figures 1 and 3). They are usually attached to the nematode body in a regular manner, creating a pattern seen on the Figure 3. More common are small rod-shaped cells that are arranged in a single dense layer along...
the nematode body (Figures 5-6, 8-10). Interestingly, shape of bacteria, and the manner they attach themselves to the nematode body are specific to a certain group of nematodes – for example crescent shaped bacteria live on the cuticle of *Eubostrichus* nematode (Figures 1-3), while rod shaped bacteria are found attached to *Leptonemella* (Figures 4-6) or *Laxus* (7-10).

There is not much known about the origin of these bacteria. All we know is that they are closely related to the type of bacteria that live inside the bodies of some deep-sea animals [2]. Both bacteria types are sulfur-oxidizing chemoautotrophic organisms. In other words, they use hydrogen sulfide and oxygen from the water to obtain energy that they need to synthesize other vital molecules. But there is a problem – oxygen and hydrogen sulfide are located at different depth within the sand layer on the bottom of the ocean and it is hard for bacteria to absorb both compounds at the same time. Oxygen is available in the upper layer, and hydrogen sulphide is concentrated in the lower layer of sand, meeting only in the very thin area. So how do bacteria obtain both ingredients? It appears as if the nematodes are actively helping bacteria to obtain these two chemicals and there are even two competing hypothesis that explain how.

In the first scenario scientist showed that nematodes regularly crawl between oxygen-rich and hydrogen sulfide-rich layers of the sediment [3], giving bacteria an opportunity to "stock-up" on the ingredients of chemosynthesis, one chemical at a time. The other hypothesis says that the nematode can anchor itself with the special sticky excretion from the tip of its tail, and just stretch its long and thin body to reach one layer, or coil itself back to the other layer of sand, also allowing bacteria...
to absorb either oxygen or hydrogen sulphide [4]. Nothing prevents nematodes to use both techniques, and, in any case, bacteria are able to receive both nutrients needed for its growth and multiplication. Unfortunately, there is no evidence yet that bacteria and nematodes can communicate with each; that bacterial can somehow signal to nematodes, and indicate when they require one of the ingredients (oxygen or hydrogen sulphide) for chemosynthesis, stimulating the nematode to move up or down in the sediment. We do not know how the nematode adjusts its movement between oxygen-rich and hydrogen sulphide-rich layers of sand. Nonetheless, this migration does provide bacteria with what they need – the "fuel" for energy production. It also creates the impression that nematodes are "farming" these bacteria.

The reason for such complex coexistence of two organisms is simple – food. All known evidence suggests that the nematodes eat these bacteria. Mouth parts of these nematodes are very simple (Figure 2), not suitable for ingesting food larger than small bacterial cells, and cells similar to cells of bacterial symbionts are often seen inside the intestine of these nematodes. By hosting bacterial symbionts on their body, nematodes are providing themselves with practically endless supply of easily accessible nutrition. This is an interesting example of how seemingly simple organisms can be engaged in rather complex survival strategies.

Figure 7: Head end of the nematode Laxus sp. from the Gulf of Mexico (Leitz Orthoplan with ICT optics, scale bar equal to 10 µm).

Figure 8: Single layer of rod-shaped bacterial symbionts attached to the exterior of the nematode Laxus sp. (Leitz Orthoplan with ICT optics, scale bar equal to 10 µm).
OBSERVATIONS

Marine nematodes

References:


Granite, an igneous rock

The photos in this article are of a thin section of Granite.

Carl Hennig

The signature rock of Earth deserves some bright attire and nothing adds pizzazz better than a Lambda plate. Granite is probably the most common mineral in the Earth’s crust and as can be seen in the Plane polarized light photo, rather unimpressive.

Viewing Granite through Crossed Polars brings the rock above the "common" label. Inserting a Lambda (full wave) plate raises Granite to the "Belle of the Ball" status.

The difference between Crossed Polars and the full wave plate can be seen in these two photos of the same area of the Granite specimen. Figure 5 is with Crossed Polars at 25x. Figure 6 is the same area with the full wave plate inserted. Different light. Different details.

Details

Camera: Canon 5D MkII
Eyepiece: Meiji 2.5x
Microscope: Labomed LB-592
Objectives: Plan, Pol, Infinity x & 10x
Specimen: Granite
Image capture: Canon EOS Utilities
Post Processing: Colour Science
Editor: Carl Hennig
Author: Carl Hennig, © March 2015

Figure 1: Granite, Plane Polarized light, 5x.
Figure 2: Crossed Polars, 5x.
Polarization microscopy of minerals

OBSERVATIONS

Figure 3: Crossed Polars and full wave plate, 5x
Figure 4: Crossed Polars with full wave plate, 10x
**OBSERVATIONS**

**Polarization microscopy of minerals**

Figure 5: Crossed Polars. 25x

Figure 6: Including full wave plate. 25x
Top: Sidewalk chalk in polarized light, wet-mount. 20x.

Left: Paramecium. The paramecium was slowed down by adding a drop of glycerin to about 15 ml of sample water. This also killed many. 20X objective and Canon 60D.

Images by Jim Tallon.
Using a CD-ROM lens for microscopy

The lens of a CD-ROM or DVD player can be placed on a mobile phone camera for basic microscopy.

Oliver Kim

CD-ROM or DVD drives contain a laser, which is focused by a small plastic lens. A CD-ROM or DVD disk contains very small pits (holes), which reflect the laser differently, than those places that do not contain these pits. The laser passes over the rotating disk and the pattern of reflected light is picked up by the sensor.

I found an old CD-ROM drive, when I cleaned up my cellar. Before throwing it away, I decided to give it a try and to use the lens of the laser for microscopy with my iPad or mobile phone.

Taking apart the drive

Taking apart the drive was quite easy, as I removed every single screw I could find. I disconnected the cables and removed the main board of the drive. The lens can be found on a movable part, indicated by the arrow (Figure 2).

I disconnected this part, in the process salvaging all of the motors I could find (there are several of them). Figure 3 shows the movable reading-head of the CD-ROM drive, which carries the lens. I removed the component and then had to use an object to press the lens out of its casing. In order to avoid scratches, I wrapped a some tissue paper around a small stick to push the lens out.

Figure 1: An old CD-ROM drive

Figure 2: Cover and board with electronics removed. The arrow shows the position of the lens.
Improvised CD-ROM lens microscopy

I discovered, that the lens is flat on one side and that the curvature is almost a hemisphere. The diameter of the curved surface is about 4 mm and therefore significantly larger than the objective of my iPad. This is good, because otherwise the full field of view can not be used. If the lens were smaller than the objective, you would not get a screen-filling picture.

**First attempts**

I placed the lens on the camera lens of my iPad and placed everything flat on the kitchen table, with the lamp right on top. I tried to center the lens as much as I could. Everything was evenly illuminated. I then took a permanent slide and held it above the lens and rested the two fingers, which held the slide, also on the sides of the iPad (Figure 5). This significantly increased the stability and made it much easier to move the slide up and down for focusing.

The first results can be seen in Figures 5-8. The images do lack resolution, not surprisingly, but I was able to obtain magnified images nevertheless. Some of the images are out of focus on one side. This is because it was very difficult holding the slide horizontally above the lens. The blur could also be due to the lens not being perfectly centered over the camera’s objective.

I also tried to take a picture of permanent slides containing malaria parasites, but the results were disappointing. The resolution is not high enough to resolve the individual red blood cells.
Improvised CD-ROM lens microscopy

Figure 6: The lens is placed over the camera objective and the slide is held at the correct distance. Corn root.

Figure 7: Cells of the female pine cone.

I tried several permanently mounted slides. Not all specimens were suitable. The best results were (not surprisingly) obtained from specimens that had a high contrast. The contrast of the images is already quite low, possibly due to stray light.

Concluding thoughts

This was an interesting proof of concept, but there are some basic issues that yet have to be resolved for this to be a serious alternative for low-cost microscopy.

There must be an easy way to center the lens and to hold it in place. Second, there must be an easier way to focus the image. Holding the slide
Improvised CD-ROM lens microscopy

with one hand and operating the shutter release with the other, is simply not sufficiently practical.

It might be worth a try to use the lenses of disposable cameras (should any of these still be available), or small glass beads.

Figure 8: Ovary of the female pine cone.

Figure 9: Cross section of the male pine cone. Pollen grains are visible.
What's this? Answer on page 2.