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BIOLOGY NEWSLETTER

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Hiii everyone! I'm sure we're all very much looking forward to a brief respite from the stresses of school! This month's theme will be centred around light displays in nature, so prepare yourself for a cascade of pretty pictures and information. At the end, I've also added some *ahem* interesting animals if you celebrate Hallowe'en or if you just like slightly random things. Either way, enjoy your holiday and I look forward to Winter term!

As always, if you have any questions, or would like to contribute an article, please don't hesitate to drop me an email!

Enjoy,

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Before we get into some of our specific examples, let's start by going through one of the main principles underlying this month’s issue, as well as cover some important definitions.

Luminescence: the emission of light that is not a product of high temperatures e.g. fire (education.nationalgeographic.org, n.d.). Tends to occur when an atom/ molecule is excited (it gains energy - like the short lived bliss of a sugar rush) and then decays back into a less energetic ground state. This decay emits a photon of light, which we then see as cool colours!

Fluorescence: light is absorbed and reemitted - no chemical reactions here!

Phosphorescence: similar to fluorescence, but has a longer effect - think glow in the dark stickers

Bioluminescence: luminescence as a result of chemical reactions within living organisms. This reaction requires luciferin and luciferase. Coming from the latin *lucifer*, meaning “light-bearer”, luciferase is a broad term for enzymes that catalyse light-emitting reactions, while luciferins are the substrates (what-when-how.com, n.d.). Depending on the species that utilises this pathway, there may also be additional components. Generally though luciferin is oxidised (gains oxygen):

$$\text{luciferin} + \text{oxygen} \rightarrow \text{oxyluciferin} + \text{light}$$

the reaction for which is catalysed by luciferase and other cofactors, to produce oxyluciferin and light energy (mostly a beautiful bluey-green). The excited oxyluciferin decays, and emits photons - the source of the light. This colour can also vary depending on the varying structure of luciferin.

So let's get into some examples!

Horrors of the deep?!

Now while I'm sure many of you will be absolutely horrified to hear me say this - I have not once, not ever, watched "Finding Nemo". When I was doing some preliminary research for this month's newsletter, the first image I saw on google following my badly misspelt search of "agnlerfisch light" was that of this presumably well known film. Personally though, I think anglerfish get a bad rep. I mean, they are in the **order** Lophiiformes, which is such an adorable name, no? This classification groups together bony fish that tend to hunt by dangling orbs of light (called esca) off of fishing rod like structures (called filaments) to lure in prey.

Down in the pitch black of the bathypelagic zone (1000 to 4000m below the surface) many animals form symbiotic relationships with bacteria. Symbiosis means that organisms coexist in a way that mutually benefits both parties in some way or another. In this case, the anglerfish provides the bacteria with a home - the esca - and plenty of nutrients to survive, whilst the host gets the benefits of a source of light to attract mates. It has also been suggested that the anglerfish accumulates these initially free-living bacteria from its environment, since there are only a few different bacterial species that have been found to live with the many species of anglerfish.

> Little (relevant) side note about quorum sensing
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> Bacteria also have their own little sneaky ways of communicating via chemical signals. A prominent example is quorum sensing, which varies the expression of particular genes dependent on the concentration of cells in a particular area. For bioluminescent bacteria, each cell can produce and release a molecule called an autoinducer (Nunes-Halldorson and Duran, 2003). As the number of bacteria in an area increases, the total concentration of these molecules also increases. Eventually this reaches a threshold and triggers the expression of genes that code for enzymes needed for bioluminescence. The actual process of producing this light is very energy consuming, so only if there is a sufficient number of bacteria all releasing light at the same time will there be a noticeable light source, which is why ensuring that there is a sufficient cell density is so essential. It also means that the light is actually beneficial to the anglerfish. (end of sidenote :))

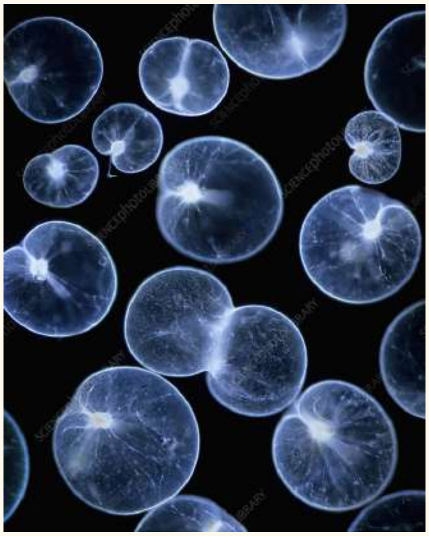
Anglerfish females are actually the only ones to have this 'lantern' of sorts. The males are much smaller, and live in a parasitic relationship with their female counterparts (Donna Lu, 2020). This is an example of extreme sexual dimorphism, which is the systematic differences between sexes - horses, for example, are minimally sexually dimorphic, since both mares and stallions have very similar anatomy. The male, often only the size of your thumbnail, attaches itself to the body of the much larger female. In some species this is temporary but in others it is permanent, and the males' circulatory system becomes one with the females' and then fully depends on her for nutrients. The question this has raised though, regards the immune response - surely these individuals should reject each other? Actually, it's been found that anglerfish lack certain immune system genes - those for the adaptive immune system. This adaptive immune response involves B and T-cells which would ordinarily detect foreign pathogens and produce antibodies against these. Those that permanently attach are missing *rag* genes which are required to assemble T-cell receptors, whilst those that temporarily attach have non-functional *aicda* genes which help antibodies mature. Each to their own, I guess?

Glow, glow, glow little beetle

As pictured on the title page, fireflies create wonderful light displays during mating seasons, using specialised organs located just under their abdomen (which contain - surprise - luciferin). Whilst not all adults glow, the larvae often do, which serves as an aposematic warning signal to predators. They contain a steroid that makes them not particularly tasty, and the light reminds any hungry predators of this fact.

Kind of like the bacteria, the fireflies often sync their light displays to optimise their chances at finding mates in pitch black forests, and each species has a particular sequence of flashes. It's actually the most efficient light production in the natural world, and has inspired many improvements to commercial LED lights (Zyga and Phys.org, 2016). The main reason found for this efficacy is the presence of nanostructures on the beetles' cuticle. Arranged in a hierarchical fashion (the best example I could come up with were roof tiles and how they are layered? If you think of a better one hit me up :)) this asymmetrical contraption ensures that the maximum light is released to the surroundings instead of being trapped within the lantern. By altering the surface of conventional LEDs from smooth to asymmetric, some studies have reported a "60% increase in light extraction efficiency" - basically they're more energy efficient!

Burning of the sea



Noctiluca are a species of plankton incredibly common in coastal regions, which bioluminesce, particularly during a bloom (a rapid increase in population) (Rogers, 2017).

They are roughly 1-2mm in diameter, and are single celled spherical organisms. Branching out in all directions from the centre to the edge, their network of cytoplasmic strands becomes covered in granules which contain our luciferin and luciferase. The bioluminescence is triggered by mechanical disturbances, such as the movement of water, or in a stunning display captured by the camera crew of Blue Planet, when mobula rays swoop through them, resulting in patches of light that dance across a black canvas.

Other interesting things I read!

In a really self-preserving manner, certain species of deep sea animals can detach the parts of their body that are luminescent and lob them at other fish. Predator follows light on unknowing fish, you don't die, happy days!

Evidently, in some situations, being two-faced can be good sometimes, as demonstrated by counterillumination. In the mesopelagic zone (200-1000m below surface) where some light still reaches, predators often hunt by looking up. To use a standard example (without luminescence) penguins have a white shirt and a black coat. From above, they blend in with the dark sea; from below they blend in with the light entering at the surface. This principle is echoed by certain fish and crustaceans. They use structures called photophores to light up their bellies (ventral surfaces) which then disguises their silhouettes from any predators lurking below…

And because I'm sure you haven't quite gotten enough of fantastical creatures, may I introduce the Skeleton Panda Sea Squirts - and yes they are real! A type of Ascidian, aren't they just adorable?

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