JANUARY 2022

BIOLOGY NEWSLETTER

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Hi guys!

Welcome back from your (hopefully!) refreshing break! Biiiig apologies for the technical issues last time, fingers crossed it works this issue… Here is the January newsletter, fresh from the printing press and ready for your consumption. I hope you enjoy reading it, and if you have any queries, suggestions or even better - articles that you'd like to share, please me email at:

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It's great to be back,

Lucia

Colour!!!

I don't know about you, but I'm already longing for spring, and all the bright tones it brings. And so, in an attempt to brighten up these cold January days, I'm going to introduce you to some of my favourite uses of colour.

Pigments are often the culprits behind plant colour. By selectively absorbing and reflecting different parts of the white light spectrum, **biochromes** are able to help plants display a multitude of colors. The molecule chlorophyll, for example, reflects the green part of white light, resulting in a plant that appears green. The carotenoids result in orange/red, and anthocyanins in purple. If you were a plant, you'd want your fruit to be as enticing as possible by making it nice and colourful, so as many animals as possible would eat them. Their droppings disperse your seeds, meaning that you'll soon have a little plant army to divide and conquer your surroundings. Apart from making a plant look snazzy, pigments are also vital in processes like photosynthesis. The most abundant pigment in photosynthetic organisms is chlorophyll *a*, with other accessory pigments helping to absorb a wider range of wavelengths - aka they help the plant get more energy from the sun.

However, as I'm sure you've noticed, there are some colours which aren't all that common. While abundant in our surroundings, blue is only expressed in around 10%[1] of the 280 000 flowering plants on Earth. This may be due to the high energy cost needed to synthesize a blue pigment. In order to produce blue, the wavelength of the light absorbed by the pigment has to be quite long (red/orange). In order to absorb these lower energy wavelengths, the plant would have to synthesize large and overly complex **conjugated systems**, which admittedly seems like much effort for little reward. Having rare colours only provides a relatively small evolutionary advantage in terms of attracting pollinators.[2]

But now you might be thinking, well actually - what about bluebells, cornflowers and hydrangeas - they're all blue, so surely they have blue pigments? Well, many flowers that appear blue contain anthocyanins that have been modified through pH changes. Low pH means red, high pH tends towards a blue colour. (If you're interested, you can actually see this for yourself using red cabbage - see the link in the wider reading section below…)

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[1] https://sciences.adelaide.edu.au/news/list/2019/08/20/why-is-the-colour-blue-so-rare-in-nature
[2] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8068391/#B9-plants-10-00726

Moving completely away from pigments for the time being, there are some species that make use of structural features to give the impression of blue colours. Butterflies, birds and some tropical plants use these mechanisms, aptly named “structural colour”, to utilise light to play tricks on the eyes.

The brilliant iridescence of a butterfly wing, for example, is the result of minute physical structures that cover the scales. These form ridges, which, if you were to take a cross section of, would look like little Christmas trees. Apart from looking cute, the specific spacing in between the layers reinforces certain wavelengths of light, while cancelling out others. This leads to a perceived blue colour.

Some plants use similar mechanisms, such as those at home on the floor of tropical forests. As the majority of blue and red light is absorbed by the big trees in the canopy, these plants have found other ways to maximise the available light. Iridoplasts are organelles similar to chloroplasts. The membranes within these iridoplasts are organised into neat, layered rows, and are designed to absorb green light - part of the spectrum that chlorophyll disregards. The spaces between the membranes correspond to the wavelength of green light, slows down its velocity, and thus makes it easier to absorb. The structure of the iridoplasts also means that the available green light is focused onto the light-harvesting complexes, maximising the plant’s photosynthetic capabilities.[3]

Some other examples of **photonic** structures can also be found in our everyday lives. CD’s for example, look like a rainbow due to diffraction grating. Little dips in the surface act like prisms to split visible light into separate colours. The constant haphazard changes of colour means it makes the ideal scarecrow on a windy day…

[3] Hodder Education, Biological Sciences Review, April 2020, Volume 32, Number 4, pg 7-10

"Grün, grün, grün sind alle meine Kleider"

All things considered, mammals can often be overwhelmingly dull in terms of their colours. So why aren't they, say, neon green?

One answer is that it mostly comes down (yet again - I'm sorry) to pigments. Mammals just don't have the necessary colour palate to make green. They are hairy, and the pigments that determine the colour of these hairs, eumelanin (brown-black) and pheomelanin (yellow-red)[4], evidently won't combine to make green.

Another suggestion takes into account that dead leaves are brown, not green. Smaller mammals often live closer to the floor, within the leaf litter, and are in greater need of protection from larger, more predatory mammals. This camouflage technique is referred to as "background matching"[5], and is one of the more common tactics of disguise in the animal kingdom.

Also, considering that many predators have limited colour vision, there isn't really any benefit for green prey in terms of blending into their surroundings. The near-colorblindness of a lot of mammals comes, by the way, from our small, nocturnal ancestors during the Mesozoic Era. These would have been more concerned with finding food during the night than having to compete for it during the day time with reptiles. Since colours are virtually impossible to see in the dark, the use of noses and ears was just more useful than trichromacy.

"Green" sloths have a symbiotic relationship with some types of algae and fungi.

[4] https://www.nwf.org/Magazines/National-Wildlife/1995/Questions-and-Answers-About-Wildlife
[5] https://www.nationalgeographic.org/encyclopedia/camouflage/

Light in lieu of Red Bulls

Mitochondria, aka the "powerhouses of the cell", are the site of aerobic respiration, and use structures called ATP synthase pumps to make ATP[6] - essentially a sort of universal energy currency within organisms. If we use the turbines of a hydroelectric plant as an analogy, in organisms the flow of protons down a gradient can be likened to the action of water as it pushes against the turbines, forcing them to turn and generate electricity[7]. Deep within the liquidy insides of mitochondria, the enzyme components rotate due to the proton flow, and the energy generated from this used to synthesize ATP.

And now to the fun part: research has shown that certain wavelengths of light are able to boost the performance of ATP synthase pumps. The winning wavelength of light, coming in at 670 nanometres, is known as deep red. Water molecules absorb it, get slapped in the face with a dose of caffeine, and as a result become less sluggish. This allows the pumps to rotate faster. More turning equals more ATP generated, equals higher energy efficiency.

These principals have resulted in therapies known as photobiomodulation. They have been shown to stimulate healing in mice, and so may be used to mitigate some aggressive side-effects of cancer treatments. Also, shining red lights into the eyes of people may also be able to improve declining performance of the retina, as this contains a very high mitochondrial concentration.

On a slightly more amusing note, beekeepers are advised to invite their bees to daily sessions of red light therapy, to boost their resistance against insecticides and increase average lifespan.

[6] https://www.newscientist.com/article/2298723-red-light-therapy-could-improve-eyesight-that-has-declined-due-to-age/
[7] https://earth.callutheran.edu/Academic_Programs/Departments/BioDev/omm/jsmolnew/atp_synthase/atp_synthase.html

Wider Reading

[How Red Cabbage Changes Color - The Science of Blue, Pink and pH - FoodCrumbles](#)

[A Progressive Zoom-In on the Blue Morpho's wings](#)

Glossary

Conjugated system: (More chemistry than biology - so read at your own risk!) A molecule in which bonds are arranged in a repeating series of single - double - single etc bonds. When visible light is absorbed by a molecule, electrons get excited and jump to a higher energy level. In conjugated systems, less energy is needed to excite electrons, as there is a smaller distance between the ground state of electrons and its excited state. This means that wavelengths of lower energy are absorbed.[8] This in turn results in the complementary wavelengths of light being reflected: if high energy blue is absorbed, the lower energy orange/red is reflected and can be seen. This is the mechanism of how many pigments produce colour.

Photonic: Structures with optical properties

Biochrome: aka pigment: substances produced by living organisms that have a colour that is produced due to selective colour absorption

[8] https://people.chem.umass.edu/samal/269/color.pdf