DECEMBER 2021

# BIOLOGY NEWSLETTER

Hi guys!

Welcome to the rebirth of the Biology newsletter. Read on for some cool discoveries and other Biology-related things. 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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Have a nice Christmas,

Lucia

## Xenobots - Biological robots of the future??

One thing that I love about Biology, is all the cool shapes that nature gives us to ooh and aah at. Sadly though, these robots are artificially designed, which by no means means that they should be disregarded!

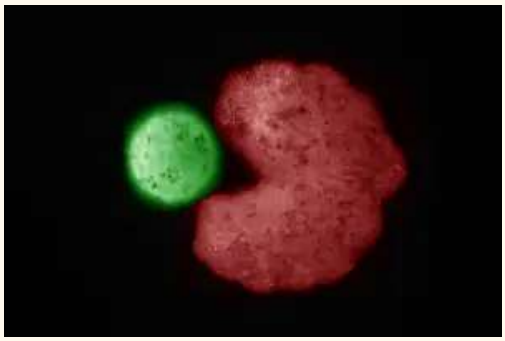
The shape and components of these cute little pac-man shaped blobs were designed by an AI program. The algorithm used, known as an evolutionary algorithm, mimics the processes of natural selection to synthesize lifeforms that perform desired functions. The most promising combinations are then further mutated and tweaked, and the final designs built by hand, resulting in living systems that exhibit predicted behaviours. The cells used were frog skin and heart muscle cells, which were sourced from the embryos of the African frog, *Xenopus laevis*, then pieced together by hand. In only two years, the design and the approach to synthesising Xenobots has massively changed. Now, researchers have found that skin stem cells, when put into a dish together, will self-assemble into Xenobots. Collections of cells join forces to form spheres, and after a few days some adapted and grew means of movement. While the hand built version  needed the contractions of additional heart muscle cells to move, Xenobots 2.0 are now self-propelled and use hair-like projections to push themselves about. These structures, called cilia, are generally found in surfaces that excrete mucus, and are used especially in human lungs to sweep out pathogens and other foreign bodies.

Michael Levin, a Professor of Biology at Tufts University, has said that this discovery of self-assembly showcases the “remarkable plasticity of cellular collectives”.  Adult stem cell plasticity refers to the ability of stem cells to be a tissue type different to the one that their genome programmed them to be. In this case, the cells have the genome of a frog, but freed from these constraints they are able to “reimagine their multicellularity”. This is remarkable considering that these cells were supposed to work together to create a frog embryo, but now seem to have a mind of their own, creating new shapes and functionalities. All this is able to happen without the extended periods of time that would usually be required to gain new cellular features, as is the case in conventional evolutionary biology.

On top of all this, the assembled Xenobots can self-replicate. The AI algorithm discovered that C-shaped cell clusters would result in the highest number of generations produced, causing researchers to create a pacman-like shape. The resulting 'mouth' is used to collect surrounding stem cells and push them into a suitable conformation, which then becomes a new bot. The bots work together in swarms to do this. This form of replication, whereby new multicellular beings are created when free cells are compressed into functional self-copies, is known as kinematic replication.

So what is the point of all this effort, apart from scaring people into thinking that there might be a generation of self-replicating killer robots on the horizon…

Well, considering that Xenobots are constructed from biological material, they will decompose at rates much faster than those of conventional robotics. As they are a living organism, they are able to self-heal, meaning that they can repair themselves when they are damaged, resulting in a significant advantage over their metallic counterparts. The cells can survive for around 10 days on their embryonic energy stores, and for longer if kept happy in a nutrient broth. When an RNA molecule is incorporated, the bots have molecular memory, which could be used to detect and record the presence of radioactive material. All of these properties can be exploited in many ways. The ability to work as a team to round up debris into neat little piles, could be used to free the ocean of microplastic and other toxins. These could accumulate into larger patches of plastic, enabling more traditional machines to locate and remove them. Other, more therapeutic uses could include designing custom made Xenobots using patient cells, which would then have the advantage of being able to avoid the immune system when in use. Drug delivery to cells and scraping out plaque in arteries may also be applications in the not too distant future.



So although it looks like there may be many uses for these bots, for now they will be primarily used for research. One of the most exciting of these projects is the use of Xenobots to understand the processes and communications between cells that allow them to come together and form larger organisms. Like frogs for example :)))

References:

https://www.newscientist.com/article/2273516-living-robots-made-from-frog-skin-cells-can-sense-their-environment/#ixzz7ENOsx2Oz
https://www.pnas.org/content/117/4/1853/tab-figures-data
https://www.ted.com/talks/michael_levin_the_electrical_blueprints_that_orchestrate_life/up-next
https://now.tufts.edu/news-releases/scientists-create-next-generation-living-robots

Also, if you'd like to see Xenobots in action, here is a very cool video of them "cleaning up" their petri dish in preparation for kinematic replication:
https://www.youtube.com/watch?v=C1eg-jgLx5o

## The Science Behind Christmas

As fans of the festive season, we wanted to delve deeper into the biology behind our favourite christmas carols. At the inaugural KS5 BioSoc presentation of this academic year, we decided to celebrate our love for both the joy of Christmas and our fascination with Biology.

### *Mistletoe - Bringing together lovers and wildlife*

With 1000 species of mistletoe, the plant is evergreen and grows all year round. But what is the biology of this plant that plays an important role in our Christmas traditions?

In the wild, mistletoe can be described as a partly parasitic plant, relying on their modified roots called (how-store-ria) haustoria to penetrate tree bark and siphon off the water and minerals trees carry up their trunks. It can also be referred to as a "hemiparasite", meaning that it generates some of its own resources through photosynthesis – it just needs an energetic kick from the sun to invade the tree in order to be able to steal its resources and complete its life cycle[1].

Mistletoe depends on birds and other creatures to disperse its seeds, so that it can colonize new trees. It is distributed by these flying animals through the excretion of its seeds onto another tree.

This resilient plant stays lush, even when its host loses its surrounding leaves, appearing present among the empty branches of more than a 100 species such as oaks and red maples[2] during the winter. And despite it's parasitic tendency on trees, it is an important plant as it maintains the diversity of wildlife.

As a keystone species, it is eaten by a diversity of animals, such as deers, squirrels and porcupines. Some mistletoe species provide dense bushes, which are great nesting sites for birds. Additionally, mistletoe helps a range of other plants prosper, for example, juniper sprouts nearby to benefit from the fruit eating birds that visit the mistletoe for its pearly white berries.

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1 https://theconversation.com/mistletoe-might-be-festive-but-its-actually-a-tree-plundering-parasite-128734

2 https://chatham.ces.ncsu.edu/2014/12/does-mistletoe-harm-trees-2/

## *Rudolph's Nose*

Everyone knows the tale of Rudolph the red-nosed reindeer and his very shiny nose. But what was it that caused this feature of Rudolph's that made the other reindeers exclude him from the reindeer games?

Two theories hypothesise that Rudoph's bright nose was caused by a pathogen.

One of these theories suggests how a bacteria may have gotten onto Rudoplh's nose. Some bacteria are bioluminescent, meaning that they use energy to produce light and glow. Some of this bacteria could have infected Rudolph and made his nose shine brightly. Alternatively, the glow may have come from the herbivore's nutrition. A reindeer's diet mainly consists of mosses, herbs, ferns and grasses. Whilst reindeer's often eat the aptly named reindeer moss, luminescent moss also grows in the northern hemisphere in dark places. Rudolph may have encountered some of this 'goblin's gold' when searching for food under stones, and could have gotten some on his nose, making it shine.

The second of these theories suggests that a stimulus for example a pathogen or an irritant may have affected Rudolph and caused inflammation, thus his nose shone bright red. There are two types of inflammation: good and bad. Acute inflammation is most times beneficial, helping to heal cuts via the inflammatory response. However, chronic inflammation is bad and can develop in several ways, the most common being an autoimmune disorder, which occurs when the immune system destroys healthy body cells as it mistakes them for a foreign substance. Therefore, Rudolph might have had a bright red nose as he was feeling a bit under the weather, or he has a chronic condition. The former may have excused the other reindeers from wanting to be near him, as I don't believe that the equipment to determine whether the pathogen is communicable works in the north pole. But it is important to note, that this inflammatory response specifically occurs in humans, and while reindeer are mammals, they may have a different inflammatory response.

Another theory more specific to the animal points towards reindeer's anatomy. In Svalbard, Norway, which can get as cold as -40$^0$C the sea-shell shaped nasal structure of reindeer was investigated. This ingenious network of many blood vessels allow reindeer's to cool their warm breath upon exhaling to conserve as much body heat as possible. With an

internal body temperature of $38^0$C this is very impressive! The extensive web of blood vessels retaining heat can be viewed under a thermal camera and appear bright red, explaining the bright red nose of the reindeers. Perhaps Rudolph had a special mutation or even gene replacement theory that made him have much more capillaries in his nose, allowing him to be a much more efficient reindeer, due to the larger surface area, allowing him to be a better fit to guide Santa's sleigh.

In addition, Rudolph would have most likely been female as while both male and female reindeers finish growing their antlers at the same time[3], male reindeers shed their antlers in November and regrow them back in spring, whilst females keep their antlers throughout the winter. Therefore, on the 25th of December, Rudolph must have been female to boast impressive antlers whilst Santa delivers presents.


Aahana Jain 12M

[3] https://www.fda.gov/animal-veterinary/animal-health-literacy/fun-facts-about-reindeer-and-caribou

## *12 Days of Christmas - Is this biologically accurate?* -

*Sahana Jain*

The 12 Days of Christmas song is a very popular Christmas song that dates back to 1780. But are the descriptions of the birds in this song accurate?

Partridges, or more specifically grey partridges, are native to the UK, but they are strictly ground birds and unlikely to be found in trees! Their main foods are weeds and grass, so they are also unlikely to find the pears in the pear tree appetizing. And in winter they are found in coveys of 6-15 partridges, so unlikely to be alone. This is the most biologically inaccurate lyric of all in the song.

Turtle Doves are birds that are slightly larger than a blackbird and have a mottled chest. European turtle doves winter south of the Sahara desert and only come to the UK for spring and summer, so the gift-giver of this song must have been in Sub-Saharan regions of the world. They also exist in large flocks until mating season in April, so a pair of them alone is unlikely to exist in winter.

The reason that it is french hen specifically in this song is because historically, these chickens were a luxury import from France and a prized table bird. The gift-giver must've been rich to send three of them for 10 days! The hens are specifically Bresse chickens with characteristic blue legs. They're reared only for consumption so there is not much to comment on their natural existence.

Through decades of singing, the lyrics may have been changed to calling birds, but it was originally four colly birds, which is another name for the European blackbird - "coaly" like the fuel for black. They mostly winter in the UK (some stay all year round, some migrate in from Scandinavia), so this is accurate, and they form large flocks in winter, so it wouldn't be difficult to pinch four of them together.

Five gold rings could relate to goldcrests - UK's smallest bird. They do winter in the UK together in flocks for warmth, however the cold kills up to

80% of them so to give 5 of them is a lot considering their dwindling numbers in the winter.

Barnacle geese come from the arctic in large droves in winter, so it is realistic to get six of them. However geese do not lay eggs in winter, their egg-laying season is in spring, so this is biologically inaccurate.

A sure sign of winter is the migration of whooper swans from Iceland. However, they migrate in a wedge while flying, therefore the seven swans must've been seen once they had settled in the UK and not during migration.

## Glossary

Stem cells: a type of cell that has the potential to become many different types of cells, through a process called differentiation.

Organoids: miniature and highly simplified organs grown in a laboratory, using stem cell technology. Used to model disease development, perform research and in general spark wide public interest about the fact that we may one day be able to grow patients their very own heart replacement. All jokes aside, they are very cool.

Xenobot: synthetic life form made by assembling several 1000 cells from a frog embryo into clusters around 1mm in size - aka living robots

Keystone species: an organism that helps define an entire ecosystem

Hemiparasite: an organism that obtains or may obtain part of its food by parasitism

Gene replacement therapy: gene therapy is a medical field which focuses on the genetic modification of cells to produce a therapeutic effect or the treatment of disease by repairing or reconstructing defective genetic material