I BET YOU DIDN'T KNOW...

Miracle healing could come from the axolotl

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links **cutting-edge research** with the **principles of primary science**

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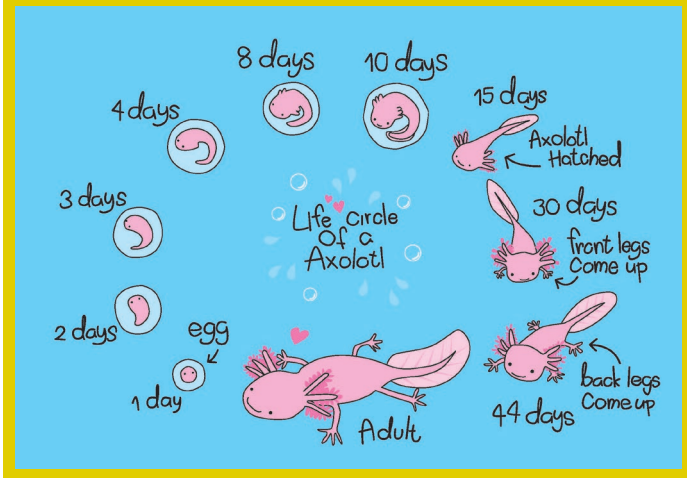
Would you like to be able to regenerate a new leg, arm or even a jaw if it was damaged or lost? Well maybe the answer to this lies within one unique animal's genome (an organism's complete deoxyribonucleic acid (DNA) code). That animal is the axolotl.

What is an axolotl?
It is commonly known as a Mexican Salamander, in Latin, *Ambystoma mexicanum*, and is the national symbol of Mexico (Figure 1). It is an unusual amphibian that does not typically undergo full metamorphosis (a dramatic change in form), unlike a frog or toad. In fact the axolotl can spend its whole life in water (Figure 2).
What is an amphibian?
Can you think of other examples?
How do amphibians change during metamorphosis?

If an axolotl is exposed to a chemical called thyroxin it will undergo metamorphosis. It loses its gills and starts to breathe which means that it can go on land as other amphibians do. **Can you think what changes must happen to make this possible?** This aggressive, cannibalistic creature has an astonishing ability to regenerate body parts and if it loses a limb, it will grow a new, identical one within weeks. Many people keep axolotls as pets and scientists have been fascinated by them for well over 150 years. However, the species is currently on the brink of extinction.

Figure 1. An axolotl.

Figure 2. Life cycle of an axolotl. The adult axolotl retains some juvenile features (neoteny).



What can you find out about this unique creature?
You may wish to consider these questions:

- What does metamorphosis mean for an axolotl?
- How do axolotls compare with other vertebrates and amphibians?
- Is an axolotl a carnivore, herbivore or omnivore?
- What does its food chain look like?
- How are axolotls suited, adapted and evolved to live in their environment/habitat?
- Why do you think axolotls are endangered?
- How has the axolotls' environment changed and how has this has posed dangers to their very existence?

Using pictures of the axolotl provided by a teacher, pupils could draw what they think the axolotl's environment might be like.

Why are scientists interested in the axolotl's DNA?
For over 150 years, scientists have been fascinated by the fact that axolotls can regrow body parts and, as with all living things, the answer to this lies in its DNA (deoxyribonucleic acid).

Researchers in Dresden, Heidelberg and Vienna have worked to assemble, annotate and interpret the genome sequence (the full DNA code) to discover why the axolotl is so unique. It was difficult for the scientists because an axolotl's genome is extremely large, 32 giga-base pairs long (10x longer than that of the human genome). A 'base pair' is a unit of length of DNA and is the molecular 'building block' for DNA. To get an idea of the length of the sequence tell the children a giga-base is a billion (thousand million) base pairs. **Can you write this number – and compare it with other large numbers?** In 2018, these scientists finally presented to the world the fully sequenced axolotl genome.

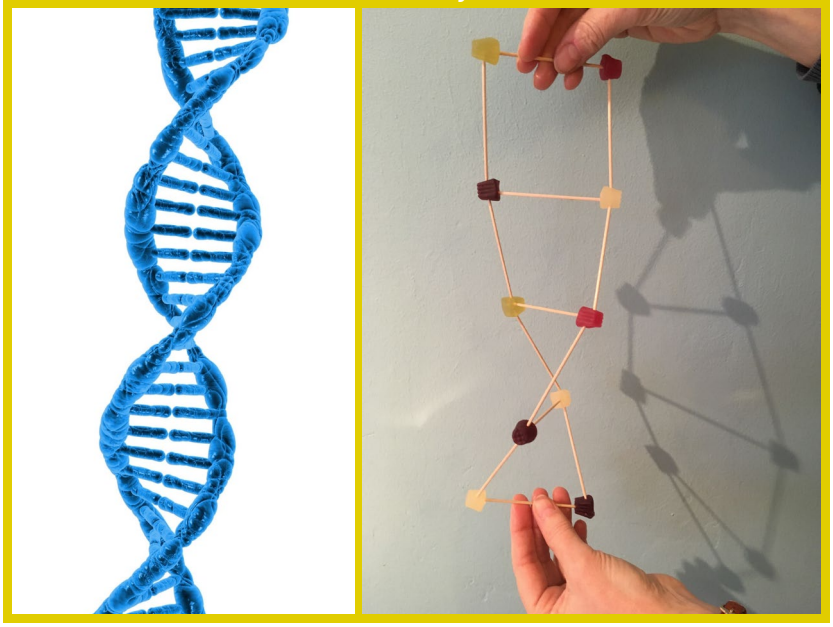
How does the DNA code work?
DNA is a two-stranded molecule which has a 'double helix' shape, like a twisted ladder (Figure 3A). Each strand is composed of long sequences of four nucleotides. The bases on one strand of the DNA molecule pair with 'complementary' bases on the opposite strand and form the rungs of the ladder. Before cells divide, the DNA strands separate, and a 'complementary' copy of each strand is made.

Children could explore how the DNA code is replicated and create complementary strands of DNA.

They could also investigate the structure of the DNA molecule by building models of the double helix (Figure 3B).

See the teacher guide for details of both these activities.

Figure 3. A: The double helix structure of part of a DNA molecule showing the bonds between the complementary bases on each strand. B: A model of the DNA double helix.



The fully sequenced axolotl genome now provides a valuable biological resource that will help scientists, throughout the world, to compare, contrast and identify specific genes (the genetic information that controls the development of the characteristics that are passed from parent to offspring) which allow the axolotl to regenerate, why other animals don't, and answer many more questions.

You may like consider what the scientists could do next:

- **Why do you think knowing the full genome sequence will help scientists in the future?**
- **What if we could identify the genes that enable axolotls to regenerate?**
- **How could this information help us as humans?**
- **Why don't the scientists know straightaway which genes are responsible for regeneration?**

Even though the axolotl has a unique genetic makeup that has helped the axolotl to survive in its natural environment, it has not stopped it becoming endangered.

- **Can you suggest reasons why?**
- **Would you prefer to be a human or an axolotl? Why?**

You might want to consider how scientists have worked together on this project:

- **Did you know that so many scientists work together to research one scientific question?**
- **How do you think they communicate as a team?**
- **How do you think they help each other?**
- **Who do you think started the work first?**
- **Can you work together in a team to answer your own science question?**

Glossary

Genome	An organism's complete set of genetic instructions made of a chemical called deoxyribonucleic acid (DNA for short).
Nucleotide	One of the structural components, or building blocks, of DNA and RNA. A nucleotide consists of a base (one of four chemicals: adenine, thymine, guanine, and cytosine) plus a molecule of sugar and one of phosphoric acid.
Complementary	The bases on one strand of the DNA molecule always pair together with specific bases on the opposite strand of DNA to form the 'rungs' of the DNA 'ladder': adenine (A) always pairs with thymine (T), cytosine (C) always pairs with guanine (G).
Neoteny	An organism reaches maturity without losing all of its juvenile characteristics.

The research paper that generated this work was:
The axolotl genome and the evolution of key tissue formation regulators.

By Sergej Nowoshilow[1,2,3†*], Siegfried Schloissnig[4*], Ji-Feng Fei[5], Andreas Dahl[3,6], Andy W.C. Pang[7], Martin Pippel[4], Sylke Winkler[1], Alex R. Hastie[7], George Young[8], Juliana G. Roscito[1,9,10], Francisco Falcon[11], Dunja Knapp[3], Sean Powell[4], Alfredo Cruz[11], Han Cao[7], Bianca Habermann[12], Michael Hiller[1,9,10], Elly M. Tanaka[1,2,3], and Eugene W. Myers[1,10]
Nature vol. **554**, 50–55

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