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The Biology of The Doctor

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Abstract
The Doctor is estimated to be over 2000 years old. Although humanoid in appearance The Doctor is of a different species entirely, Time Lords, *Dominus temporis* [1]. Humans and Time Lords share many similar physiological and genomic traits but they also massively differ. We cannot dissect or sequence the genome of Time Lords therefore we must use examples found in nature to explain some of the traits Time Lords and The Doctor have. This paper looks at these examples and how they explain certain features found in Time Lords.

Keywords: *TV programme; Biology; Genetics; Regeneration; Time Lord; Doctor Who*

Introduction
The Doctor a character from the TV show Doctor Who looks distinctively like a human being on the outside however on the inside the Doctor is far from human. In fact the Doctor is a Time Lord from the planet Gallifry located in the constellation of Kasterborous [2]. The Time Lord's biology is impressive and not entirely impossible as some characteristics within time lords can be observed in nature. From observations in nature it is possible to speculate what the Doctor's biology and genetic difference to us may be. Although previous sites have attempted to explain the biology of the doctor this paper aims to explore some of the genes that could be behind the biological differences [3].

Regeneration
Another trait of the Time Lords is their ability to regenerate when injured or dying. This can only be stopped when they are killed during their regeneration. Regeneration is the changing of the body with regards to Time Lords. A famous example in nature is the immortal jellyfish, *Turritopsis dohrnii* , they are able to regenerate through the process of transdifferentiating which is the dedifferentiation of a differentiated cell back to a stem cell and then differentiation into another cell [4]. One difference between Time Lord regeneration and jellyfish regeneration is that in jellyfish regeneration they revert back to polyps stage whereas Time Lords regenerate back into adult form and they also change their appearance and sex. This is advantageous to Time Lords as regenerating and not reverting to infant form means that upon regeneration, they are not left vulnerable and needing care most the time although they do need a cooling period which can leave them drowsy. This can be solved by being given things like tea as seen by the tenth doctor in The Christmas Invasion [5].

Figure 1 – 10 regeneration. Regenerations can be a destructive affair and can cause mass damage to the surrounding environments especially in closed spaces. During regeneration the body changes many of its characteristic creating a practically new person. Regeneration requires high amount of energy therefore a cooling off period is required to allow the body to stabilise and fully take form [6].

A possible gene and signalling pathway that could be found in Time Lords is the Wnt signal that can induce regeneration upon injury. The St- specific Wnt3 is secreted by apoptotic cells at the start of regeneration after injury or death is induced [4].

Regrowing limbs

The Doctor is also able to regrow limbs as seen in the Christmas invasion where the tenth doctor hand is cut off by a Scaryx. The hand was then able to regrow [5]. This could have been done by unidirectional regeneration which is the regeneration of a lost limb, this can be seen in species of starfish. A possible molecule involved is SRAP- star regeneration-associated protease- DNA. The sequence is similar to a gene flow plasmin which is a protein found in humans that is important for embryonic development [7]. A mutated version of this gene could be found in timelords explaining why they are able to regenerate lost limbs.

Ageing

The Doctor can live for a long time and they age very slowly showing they have longevity. An example is in the tortoise which can easily live to over 100 years. There are several interacting genes that could be involved in this for example the duplication of the NEIL1 a protein involved in base excision repair a process linked to extended to lifespans. Time Lords having mechanisms that allow them to repair DNA damage is important in keeping their longevity. Also having a variant is XRCC6 where the lysine is changed can lead to longevity so this may be seen within the timelord genome [8].

Two beating hearts

One of the most notable differences between Time Lords and humans is that the timelords have two hearts. An example in nature an animal having multiple hearts is the octopus that have three hearts consisting of two single chambered branchial hearts that pump to the gills and one main systemic heart that pumps blood to the rest of the body. In addition to this if one heart stops for an octopus during breeding and exercise they are still able to continue with just the one heart [9]. This is also seen in The Doctor as shown by the tenth doctor when the witches stab one of his hearts stopping it from beating. This meant that having two hearts is advantageous as even if one heart fails a Time Lord can continue although at a weakened capacity [10]. It also means they can disguise themselves as human which means they hide from other creatures that are meant to cause them harm. This is seen in the Family of Blood where the Doctor disguises himself as a human called John Smith [11].

Figure 2 – Images of the doctor in various forms after each regeneration. The Doctor can change practically anything about their appearance from body shape, race and sex [12].

Although humans don't naturally have two hearts there are examples of people who have multiple hearts. An example of this is when a person has cardiomyopathy. To combat this a surgeon must perform a heterotopic heart transplant that provides a second heart that compensates for the heart that doesn't work as efficiently [9]. This shows that it is feasible for The Doctor to have two hearts as the morphology is similar so there is room in the chest cavity for both hearts to be placed and function.

Sensing their surroundings

In multiple episode the Doctor can label his surroundings purely by tasting the air. This implies that there are sensors on their tongue that allows them to detect certain feature of their area. This behaviour is also observed in snakes which use their tongues as sensors. They receive chemicals from their environment which goes to the brain this helps them recognise the chemicals as smells so they can build up a picture of their surrounding area [13].

Conclusion

Overall although the Doctor and Time Lords look like humans their biology are significantly different in several respects like their use of two hearts. Time Lords also have several mutations and differences in their genomes that allow them to regenerate and regrow limbs. Combing all these highlights how Time Lords are a fascinating species with a fascinating biology.

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