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Pokémon Evolution: Creating Vaporeon from Foxes

Freddie McCann
Natural Sciences (Life and Physical Sciences), School of Biological Sciences, University of Leicester
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Abstract
In the Pokémon universe, a multitude of creatures each possess unique attributes, abilities and appearances. Vaporeon is one of Eevee's many evolutionary forms, with Eevee transforming from a fox-like animal into a more aquatic and fish-like creature. This paper delves into the use of CRISPR-Cas9 technology to incorporate genes into a fox's genome to create a real-life Vaporeon.

Keywords: *Computer Game; Biology; Molecular Biology; Genetic Modification; Pokémon; Vaporeon*

Introduction

Vaporeon, shown in figure 1b, is one of many evolutionary forms of the Pokémon Eevee, which resembles closely to a fox from the human world [1] (as seen in figure 1a). Eevee's evolutionary forms are known to differ in appearance and ability due to their different elemental types. Vaporeon is deemed as a water type Pokémon, suited to an aquatic habitat shown through adaptations as seen in its appearance (figure 1b). This paper will explore the ability to alter a fox's genome using CRISPR-Cas9 technology to be able to create a real-life Vaporeon. This will be explored by altering genes to incorporate scales and fins, as well as altering the pigmentation of the fox.

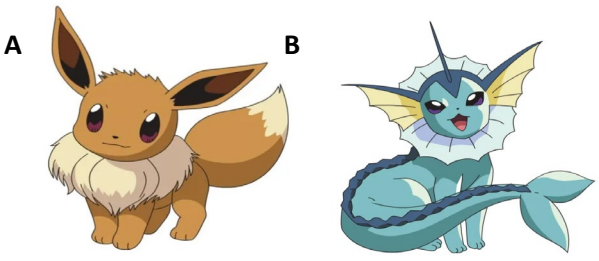

Figure 1 – (A) The Pokémon Eevee. (B) Vaporeon, one of the Eevee evolutions [2].

CRISPR-Cas9 Technology

CRISPR-Cas9 technology is widely used in gene modification, allowing for the incorporation of desired genes into a genome so that specific traits are exhibited. CRISPR-Cas9 uses a guide RNA (gRNA) which is designed to match the specific DNA sequence which is to be targeted as seen in figure 2. This binds precisely due to the gRNA being complimentary to the target DNA sequence [3]. The gRNA and the Cas-9 protein are usually inserted into the target cells via plasmids. The Cas-9 protein is an endonuclease which creates a double-strand break within the targeted DNA, which is crucial to enable for the incorporation of the desired genes into the genome. Once cut, the cell's DNA repair mechanism will be activated allowing for the inserted sequence to be incorporated into the genome [4].

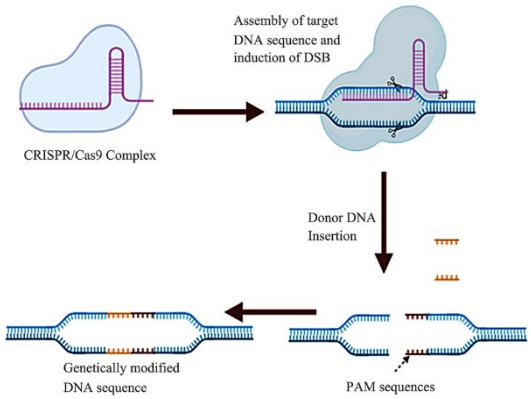

Figure 2 – A diagram showing the mechanism of the CRISPR-Cas9 system [5].

Aquatic Skin Adaptation

To transform a fox's fur to shiny skin, the genes responsible for fur growth must be disrupted, enabling for a smooth water-resistant skin to form. The keratin associated protein (KRTAP) gene is the

main regulatory gene regarding the development of fur, with 13 potential KRTAP genes being potentially involved in fur development [6]. By editing these genes to reduce fur production, it is possible to achieve smooth skin as illustrated in Figure 1b. The skin of Vaporeon appears to resemble the skin of dolphins or sharks, which makes sense given that it's a water-type Pokémon. To create this 'dolphin-like skin,' we could remove the keratin genes K1, K2, and K10, and replace them with keratins K6 and K17, which are prominent in dolphins [7]. Dolphins' epidermis is notably thick—approximately 50 times thicker than human epidermis. This type of epidermis is known as stratified epithelium, which forms hydrophobic properties, creating an impermeable barrier that protects the animal's internal environment from the external aquatic environment [8]. By implementing the K6 and K17 genes after deleting the fur-promoting genes, we could potentially enable the production of waterproof skin similar to that of dolphins.

Fin Development

The external structures along Vaporeon's back resemble multiple connecting fins, which enhance its ability to swim underwater and potentially make it more streamlined. The genes responsible for fin development are *Meis1, Hoxa11,* and *Hoxa13*, which are crucial for the formation and development of fins. This has been observed in zebrafish, as detailed in this paper [9]. Additionally, the bumps down Vaporeon's back could be likened to the scutes found on crocodile spines. These scutes manipulate the water, ensuring no ripples are visible on the surface when they swim underwater [10]. This adaptation would be advantageous for Vaporeon in battles, providing it with effective camouflage.

Blue Pigmentation

Mutations within the melanin genes would enable for the creation of the blue skin which would give the Vaporeon camouflage within its water environment. To be able to give the Vaporeon its blue colouration, we can look to reptiles to be able to give suggestions on how to create the blue skin. By incorporating genes responsible for scattering mechanisms, as seen in iridophores of reptiles, a blue colour can be achieved [11]. Furthermore, enhancing the expression of melanin within melanophores, similar to the blue morphs of *S. u. erythroceilus* would help to create a more intense blue colour. The alteration of hormonal levels could also be an aid, with an increase in testosterone being able to boost dermal melanisation which could create an even more intense blue colouring. Therefore, this would produce a blue colourisation of the creature giving it a more similar look to Vaporeon [11].

Limitations

Using CRISPR-Cas9 for complex genetic modifications in mammals presents practical limitations. Coordinating precise edits across multiple genes for traits like skin texture and fin development is challenging. Additionally, off-target effects may cause unintended modifications. Ethical considerations are crucial, as genetic changes could lead to health issues, behavioural disruptions, and ecological impacts. Altered organisms may disrupt local ecosystems, affect biodiversity, and compete with or displace native species possibly affecting food chains. A thorough analysis of these implications is needed to balance benefits with minimising harm.

Conclusion

In conclusion, using CRISP-Cas9 technology, it is possible to be able to alter a fox's genome to create a real-life Vaporeon. By editing genes responsible for fur development, we can transform a fox's fur into smooth, water-resistant skin similar to dolphins. Additionally, incorporating genes for fin development and scutes would enhance the fox's swimming capabilities and provide camouflage. Lastly, modifying melanin genes and using structural colouration techniques from reptiles would enable the creation of blue skin, completing the transformation. If this were to occur in real life, it would have to have major ethical considerations due to some of these alterations may cause possible unwanted health conditions, or cause for a species which could alter a food chain which could be detrimental to other species.

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