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A scientific analysis of Dragon Ball's Fusion Dance

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Abstract
The fusion dance is one of the most powerful techniques in the Dragon Ball series, created by Akira Toriyama. This paper will explore biological and chemical principles that could explain how the fusion dance functions as well as its limitations.

Keywords: *Anime; Manga; Biology; Fusion; Cell fusion; Energy balance; Oxidative stress; Dragon Ball*

In memory of Akira Toriyama (1955-2024)

Introduction
The fusion dance is a technique from the Dragon Ball series. It involves two characters merging with each other to form a stronger entity [1].

Before undergoing the fusion dance, both characters must perform dance moves symmetrical with each other (figure 1). If performed correctly, the fusion would occur successfully, leading to the formation of a stronger fused character (figure 2), with the fusion lasting 30 minutes. Failure to perform the fusion dance correctly leads to the formation of a weaker fused character with an obese or skinny appearance. This paper will analyse the biological and chemical principles behind the fusion dance, specifically how fusion would work in terms of cell fusion, how the formation of a weaker obese or skinny character could be explained by energy balance issues, and lastly, how oxidative stress could be the reason why the fusion ends after 30 minutes.

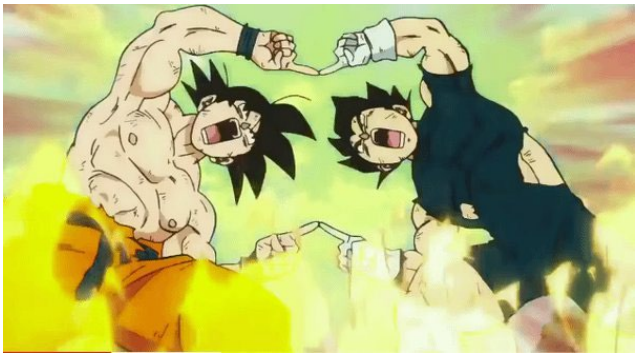
Figure 1 – Goku and Vegeta performing the fusion dance technique [2].


Figure 2 – Gogeta, the fused version of Goku and Vegeta following a successful fusion dance [3].

Cell fusion
The concept of the fusion dance in the Dragon Ball series can be explained by the real-life biological principle known as cell fusion. The fusion of cells that are of the same type leads to the formation of a syncytium, which is a single cell formed by the fusion of multiple cells and contains shared genetic material [4]. In the Dragon Ball series, the fusion of Goku and Vegeta, known as Gogeta, shares physical features from both characters [5], allowing us to infer that genetic material is shared.

Cell fusion can also explain the healing properties caused by fusion, as the battle damage of Goku and Vegeta in figure 1 is not present for Gogeta in figure 2. This can be explained by exploring muscle cells, which are formed by the fusion of their precursor myoblasts which can fuse and lead to

muscle regeneration in adults [6], which could be an explanation of how Goku and Vegeta are able to heal after performing the fusion dance.

Energy balance

As mentioned in the introduction, the fusion dance can fail if the technique is not performed correctly, the failed fusion would have either a skinny or an obese appearance, such as in figure 3.

Figure 3 – The failed fusion of Goku and Vegeta [7].

Energy balance could be a biological explanation for a failed fusion, the concept of energy balance refers to the equilibrium between energy intake and energy expenditure. A positive energy balance means that the energy intake is higher than energy expenditure, leading to weight gain, while a negative energy balance means that the energy intake is lower than energy expenditure, leading to weight loss [8]. In the world of Dragon Ball this concept could apply in terms of the energy needed for the characters to fuse, which could cause issues with energy balance, subsequently leading to a fusion that is weaker and has either a skinny or an obese appearance.

Oxidative stress

The fusion dance in Dragon Ball has a time limit of 30 minutes, this could be explained by the biological principle of oxidative stress. Oxidative stress is caused by the production of reactive oxygen species (ROS) [9], which include:

- Superoxide anion, which is produced during cellular respiration in mitochondria.
- Hydrogen peroxide, which is formed by the dismutation of superoxide ions.
- The Hydroxyl radical, which is the most reactive free radical and causes the most damage.

As the fusion utilises a lot of energy, a lot of ROS may be produced, leading to increased oxidative stress, which can cause damage to lipids, proteins and DNA in the body. This could lead to extensive damage that may end the fusion as enough oxidative stress is accumulated in 30 minutes, therefore causing the fusion to break up.

Conclusion

The fusion dance is one of the most powerful techniques in the Dragon Ball series, there are many scientific factors that can explain how it works, such as the concept of cell fusion, energy balance, and oxidative stress. However, it must be considered that most of the characters in the Dragon Ball series are not human, therefore the scientific principles which apply to humans, may not necessarily apply to Dragon Ball characters. Clothing also cannot be explained by scientific principles as the fused character's clothing is completely different compared to the two characters who are fusing.

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