Journal of Interdisciplinary Science Topics

PX-41 – Potential Biological Mechanisms and Contents

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09/03/2022

Abstract
This paper looks at the potential biological mechanisms in which the PX-41 serum from the film *Despicable Me 2*, would be able to physically and behaviourally alter the minions. Epigenetics, hormones and disease are all looked at in the context of changes such as sudden growth, change in colour and extreme hunger. Although these mechanisms make sense as a plausible explanation there is still much doubt into the contents of the Serum, and the science used by PX-labs, its creator, is fortunately still largely a mystery.

Keywords: *Films; Biology; Physiology; Cellular Biology; Epigenetics; Despicable Me 2; Minions.*

Introduction
PX-41 is a mutagen engineered by PX-Labs in the film *Despicable Me 2* [1, 2]. It is the primary weapon of the antagonist of the film "El Macho", who uses it to alter the appearance and characteristics of Gru's Minions to fit his evil plan, to dominate the world. Upon injection or consumption of PX-41, the minions turn from docile yellow creatures into larger aggressive purple creatures, with sharp teeth and an ability to consume an appeared infinite volume of matter. This paper will delve into the possible components of PX-41 and how they function to alter the minion's appearance and behaviour.

Physiological Mechanism of Changes to Aggression
The minions changes are notably reversible, suggesting there is no permanent change to the genotype of the minion, only the phenotype. This is commonly done through epigenetics. Epigenetics causes changes in an organism's phenotype but not genotype through processes such as methylation. Methylation of DNA bases inhibits the binding of DNA polymerase to the DNA, stopping the process of transcription. Demethylation works the opposite way and allows the transcription of the DNA.

A potential cause of aggression of the minions may be an impaired function of oxytocin receptors, something commonly seen in rat behaviour [3]. Epigenetic modification of the oxytocin receptor gene through DNA methylation has been linked to mental disorders associated with social impairments, as seen with the purple minions. It is plausible that a substance in the PX-41 gene causes methylation of the oxytocin receptor gene OXTR potentially causing aggressive anti-sociable behaviours seen in the purple minions.

Size and Strength
The second most notable characteristic is the sudden increase in muscle mass and strength, especially seen during the injection of PX-41 into a rabbit. Muscle cells are also likely regulated partly by epigenetics. This is shown through a process known as muscle memory, where muscles previously trained to a high level of physical activity, such as riding a bike, or lifting weights, return quickly to their original strength and mind-muscle connection in a much shorter time than originally took to implement the skill. Research has identified that human skeletal muscle possesses an epigenetic memory of earlier acute and chronic anabolic stimuli when encountering later muscle hypertrophy [4]. Another method for extreme muscle hypertrophy often illegally used by athletes is the use of growth hormone or anabolic steroids. Overdose of growth hormone leads to increased muscle synthesis, mediated by IGF-1 (insulin-like growth factor 1) [5], which stimulates growth in almost every cell in the body. Anabolic steroids mimic the effects of testosterone, a hormone that increases protein uptake of muscle cells and therefore increase muscle mass. In the film, the minions undergo a large increase in not only the size of muscles but arm length and overall height. This strongly suggests they

have undergone the physiological effects of a large overdose of growth hormone, although this effect is likely not easily reversible.

Appetite

The purple minion's main ability is their ability to eat almost anything no matter the size or material. This includes explosives or even cars. For this to occur we also propose an epigenetic mechanism. Specifically, for the GHRL gene. This gene encodes the proteins for ghrelin and Obestatin, two hormones. Grehlin is an appetite stimulator that is initiated when the stomach is empty. It also helps promote gastric acid secretion and gastrointestinal mobility [6]. By promoting and amplifying the GHRL gene you could dramatically increase the appetite and digestive strength of the minions to assist in this consumption. Demethylation or histone modification may influence the expression of this gene.

Skin Colour

Skin colour is primarily controlled by the concentration of melanin in the skin. A higher concentration of melanin creates a darker skin tone. However, in mammals (assuming minions are that) purple skin only usually appears during an affliction called cyanosis, where there is not enough oxygen being carried to the blood by red blood cells. It is likely that physiological changes to the minion's size and behaviour are putting a large toll on the circulatory system of the minions, reducing the system's capacity to carry oxygen to the minion's tissue. In ectothermic animals chromatophores are responsible for generating skin and eye colour. Specifically, cyanophores produce the blue colour seen in animals like octopuses. Chromatophores are not so easily transmittable to another species, and from what we know minions do not possess the DNA available to simply alter epigenetics and expression. There is also no colour that simply mixes with yellow to get purple, making a simple pigment mix awkward to produce.

Contents of Injection

Now we have looked at potential mechanisms that can be altered we need to look at what is injected into the minions to implement these changes. Synthetic and vector-based short interfering RNAs can induce sequence-specific DNA methylation in human cells [7], this occurs due to a process known as RNA-directed DNA methylation (rdDM). rdDM involves the production of sRNAs, which then recruit DNA methylation machinery to specific target loci in the DNA. Research has shown that the 2b protein encoded in the cucumber mosaic virus vector can facilitate epigenetic modifications through the transport of short interfering RNA to the nucleus [8]. It is a possibility that the PX-41 serum may contain virus vectors that code for short interfering DNA to cause methylation at the specific promoter regions associated with oxytocin receptors and the GHRL gene. To cause such physical growth the serum likely contained a large amount of growth hormone, causing a large increase in overall size and muscle mass.

Conclusion

Although we can speculate potential mechanisms of the PX-41 serum, all effects shown in the film occur almost instantaneously, something that doesn't happen with most physical changes, especially growth which generally takes up to several months. The changes exhibited are also instantaneously reversible with an unspecified antidote. The serum must also be able to influence its changes through consumption as well as injection. PX-labs, the creators of PX-41 may have the knowledge and resources to create a serum with contents and effects we simply do not understand or know how to recreate, meaning we can theorise the possible mechanisms they take advantage of but not truly understand how they are altered or with what they are altered with.

Repression of oxytocin receptors is highly feasible and is shown to cause aggressive and antisocial behaviours in adult rats and has been seen in humans with mental disorders associated with social interaction. They have been seen to be repressed through epigenetics, specifically, methylation which recent research has shown can be controlled through rdDM. Upregulation of the GHRL gene may help with the minion's sudden increase in appetite and digestive strength, although it is doubtful this is enough to eat cars or explosives. The introduction of growth hormone and its effect on the minions would cause similar growth as seen during injection of PX-41, although further modifications in the speed of the effect is unknown. This increase in size and expenditure of energy in aggression may take its toll on the minion's cardiovascular system, with a reduction in oxygen transported to their tissue. This causes a condition known as cyanosis, where due to a lack of oxygen supply, the tissue turns a dark blue or purple.

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