

The Hollywood Undead: Zombies Interpreted Scientifically

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ABSTRACT

Modern media is fascinated by the undead. *Zombie* movies and shows comprise an entire genre by themselves, and there are many different renditions of the creatures in pop culture. This review was performed with the goal of analyzing the characteristics of zombies from *The Walking Dead*. This is organized around four major topics: organization of the biological hierarchy, energy and matter, interactions between systems, and evolution. These are the unifying principles of biology, and thus appropriate for assessing the biological principles behind zombie physiology. This review aims to show that some common features of zombies are simply exaggerations of preexisting human functions, and that they are not so removed from what we perceive as normal human behavior.

Introduction

Biology is the scientific study of life. The entire biosphere—all life on Earth and places associated with life—is included in the scope of biological investigations. There are five main unifying principles in biology. Organization, information, energy and matter, interactions, and evolution (Urry 3). These overarching concepts create a comprehensive framework for the field at large.

So, if biology is the study of life, how would it deal with the undead?

The origin of zombies is older and less fictional than would be expected. The word ‘zombie’ comes from the Haitian ‘zombi,’ meaning an undead person created through the reanimation of a corpse, traditionally through magic or witchcraft. The word itself was first recorded in 1819, but it has existed throughout Haitian folklore. Zombies were traditionally created when bokors (malevolent priests) reanimated someone who died of acute illness or was poisoned to death. Unlike the violence associated with them today, they were portrayed as mute automatons in Haitian traditions. They represented Vodou religious beliefs about death and spiritual outcomes in the afterlife.

The first instance of a zombie appearing in western media was the 1932 movie *White Zombie*. It followed a plantation owner in Haiti whose slaves were zombies. The movie was meant to reflect the class differences between the white elite and the black workers emphasized by US occupation. The first portrayal of zombies as cannibalistic came a few decades later, as in 1968, George Romero released the first installment of his series, *Night of the Living Dead*. It featured bloodthirsty monsters hunting a group of people trapped inside a farmhouse (Nugent et al.).

Since then, the concept has proliferated into many different forms in almost every type of media imaginable—books, movies, TV shows, video games, and in different subgenres, such as comedy, political intrigue, satire, et cetera. As such, zombies exist in different states of functionality across modern media. The characteristics of zombies from *The Walking Dead* will be used during this review to ensure a consistent set of biological features.

The Walking Dead is a TV show that launched the zombie horror-action genre into mainstream consciousness, airing for 12 years with high viewership ratings and spawning 7 spinoffs. The main characteristics of zombies in the show are enhanced hearing, rudimentary control of limbs, and a strictly carnivorous diet. Their brains retain some form of functionality, as evidenced by these three characteristics and the fact that zombies can only be ‘killed’ by putting their brain out of commission.

This article will analyze the physiology of zombies according to these characteristics and their interactions with the environment, organized by the unifying themes of biology as mentioned in *Campbell Biology*—organization, energy and matter, interactions, and evolution (as zombie DNA is fundamentally the same as human DNA, the theme of ‘information’ was excluded). In doing so, this review aims to create a link between the fictional and the scientific and provide a what-if scenario about the existence of zombies.

Method

Campbell Biology was used to construct the framework for the analysis, such as the division into the major topics or basic background information. Previous literature was researched to supply factual details regarding the biology supporting each characteristic.

Results

Organization

Biological organization occurs on multiple levels. On the largest scale, there’s the biosphere, which includes all life on Earth. On the smallest, there are the molecules that make up every part of the biosphere. A correlation between structure and function exists at every level of the biological hierarchy. For example, hummingbirds’ wings have a unique structure in that they can rotate at the shoulder. This leads to the function of being able to fly backward or hover, which allows them to feed from flowers in midair (Urry 6).

The structure-function correlation can also be seen in zombies. Being bipedal—structure—gives them an advantage over other predators in terms of hunting efficiency—function. As they have to compete with more experienced natural predators for prey, they have to make up for the lack of agility and subtlety through a different advantage.

Bipedalism allows for more mobility and dexterity in the forelimbs. It also allows the organism to strike downward rather than upward when fighting. This can increase the power of the limb since limb retractor muscles (accelerates motion) have a greater capacity for positive work than limb protractor muscles (brakes motion). In a study by the University of Utah, where they tested the fighting advantages of bipedalism, they found that subjects striking downward and upward from a bipedal posture did 44 and 47% more work, respectively, than from a quadrupedal posture. Peak forces averaged 49% greater from a bipedal posture when performing punching motions, and when striking sideways, peak forces averaged 64% greater (Carrier).

Thus, although bipedalism isn’t strictly a zombie trait—it’s more of a human trait—it gives them an advantage in competition with quadrupedal predators. Furthermore, since zombies target humans (who are, of course, bipedal), being able to utilize their hands may allow them to disable the humans’ defenses more effectively.

Energy and Matter

All living beings require energy to perform the basic cellular activities that keep them alive. Producers, such as plants, produce energy in the form of food molecules through photosynthesis. This energy is then passed onto consumers, organisms that feed on other organisms or their remains. Energy is returned to the environment by decomposers that break down the waste products or bodies of dead organisms into chemicals that can be absorbed by producers again (Urry 9). Although zombies are not quite ‘living beings,’ they are still consumers and need an intake of energy at regular intervals.

Zombies are widely known to crave flesh. Human flesh seems to be their primary target, but they’ve also been seen eating other small critters. The carnivorous diet of zombies likely comes from craving protein. There are a

total of twenty amino acids that are required to make a complete set of proteins, eight of which cannot be synthesized by a human's body. These are the essential amino acids and must be obtained from food (Urry 899).

When protein is consumed, it's broken into amino acids in the digestive system. First, the stomach produces the protease pepsin that cleaves the protein into polypeptides. Then, in the small intestine, pancreatic trypsin, chymotrypsin, and pancreatic carboxypeptidase further break down the polypeptides. Dipeptidases, carboxypeptidases, and aminopeptidases from the intestinal epithelium split off one amino acid at a time from a polypeptide, completing the breakdown of proteins into amino acids. The molecules are then absorbed by the small intestine to be utilized in various bodily functions (Urry 908-909). One example of a function is serving as the structural elements of cells and tissues. Actin filaments and microtubules, for example, are made from actin and tubulin, which are both proteins. In the muscle, actin provides the scaffolding against which myosin can produce muscle contraction (LaPelusa). Protein undernutrition can result in stunted growth, anemia, physical weakness, and more. (Wu).

Zombies appear to be continuously on the move without resting, which is about as extreme as activity could get. If the decomposing state of their body is taken into account, they would require more protein than an un-undead human to keep their muscles intact. However, they have a lower chance of achieving their daily protein intake goal, so the cravings increase the longer they starve. Digestibility may explain why they crave meat specifically instead of plant proteins. For one, the digestive tract of humans cannot break apart the cell walls of plants, decreasing the amount of nutrients and calories that can be attained from eating plants. For another, the digestibility of protein itself is higher in animal proteins than in plant proteins by 20 percentage points (Dallas).

Interactions

Interaction of different systemic components is important at all levels of the biological hierarchy. No system can run smoothly without communication and integration between its parts. Examples from the ecosystem can easily be found. Take a tree, for example. As a producer, it provides nutrients for consumers in the form of leaves or fruits. Fallen leaves can be beneficial to the decomposers breaking them down in the soil. It also uses water and minerals from the soil in order to perform photosynthesis. These are all interactions a tree has with the larger system it belongs to (Urry 9-10). Two examples of zombies interacting with the ecosystem are decay and response to sensory stimuli.

Decay

One of the most apparent traits of zombies is that their bodies show extensive and rapid decay. Humans are perpetually decomposing, but when they are alive, their tissues regenerate faster than the rate of decay and thus maintain an un-corpselike appearance. Dead humans do not have that kind of luxury.

A deceased body goes through several stages of decomposition driven by its microbiome and dehydration. During early decay, the intestines and surrounding tissues are digested by symbiotic bacteria. Enzymes within the somatic cells also begin autolysis. Then bacteria undergo anaerobic respiration and produce gases such as hydrogen sulfide, methane, cadaverine, and putrescine. The buildup of these gases causes the cadaver to inflate and forces fluids out, marking the shift from early decomposition to late decomposition. This is called the purging event. After this stage, either the preservation of tissues through mummification or accelerated decay due to destruction caused by larval flies can happen. Decomposition eventually concludes with skeletonization, which zombies usually have not approached yet. Depending on where the cadaver is and what conditions it has been exposed to, the specific phyla of bacteria may vary. Studies have found that as decomposition progresses, the microbiome shifts from aerobic bacteria, such as *Staphylococcus* and Enterobacteriaceae, to anaerobic bacteria, such as *Clostridia* and *Bacteroides*. Obligate anaerobes *Clostridium* and *Bifidobacterium* were the most abundant microbial species during putrefaction within the GI tract. *Clostridium* breaks down lipids and complex carbohydrates within human tissue, and its lipases significantly contribute to the hydrolysis of fat in warm and moist conditions. Hydrolytic enzymes in *Clostridium* also convert carbohydrates to organic acids and alcohols (Hyde et al.).

It can be inferred from scientific evidence that zombies decompose much more slowly than normal human bodies. Otherwise, they couldn't be intact enough to chase live humans after being exposed to natural elements for such a prolonged time.

Response to Sensory Stimuli

Fast responses to sensory stimuli can be a valuable survival mechanism in the wild. Zombies respond to auditory stimuli at a rate that far exceeds an average human. Their enhanced hearing likely compensates for the damage their eyes have sustained due to a lack of control of bodily movements and continuous walking through obstacles at face height.

This compensation can happen through neural remapping. Areas of the brain usually dedicated to processing visual stimuli, such as the visual cortex located in the occipital lobe, may be repurposed for processing sound in individuals with loss of vision. A study by the Universite de Montreal found that when nineteen individuals—seven sighted and twelve blind—were tested for monaural sound localization, five blind participants accurately localized sounds monaurally, while the sighted participants could not. The participants with monaural localization skills showed increased cerebral blood flow in the visual cortex during the experiment. Sighted participants, on the other hand, showed decreased cerebral blood flow in visual cortical areas. This is in line with previous research that shows engaging one brain center with sensory stimuli could inhibit the activation of others. The study indicates that these inhibitions may be reduced in blind persons, which accounts for why they're better at localization through hearing (Gougoux et al.). Enhanced hearing in the place of sight may even give zombies a hunting advantage in settings where more coverage renders sight ineffective, and it is easier for their prey to make noise. Forests, due to the leaves and twigs, would be an example of such a setting.

Evolution

The definition of evolution is “a process of biological change in which species accumulate differences from their ancestors as they adapt to different environments over time” (Urry 11). Evolution accounts for the diversity found in life. Charles Darwin's theory of evolution focused on natural selection, a process in which certain inherited traits give individuals a survival advantage, leading them to reproduce more and those traits to proliferate. These advantageous traits were called adaptations. Through natural selection, populations would acquire adaptations specific to their environment (Urry 472-473).

It's difficult to think of zombies as an evolving population, but zombies are organisms that must adapt to the environment to hunt and survive. Although they don't reproduce in the traditional manner, infecting more humans could be considered a form of producing offspring. The sheer number of them compared to surviving humans (approximately a 9:1 ratio in *The Walking Dead*) creates a statistical problem in that while zombies have to constantly eat, a dead human doesn't last very long before also turning into zombie. 'Relative fitness' in this context would entail a better chance at infecting more humans without being eliminated. Furthermore, in the case of a prolonged apocalypse, humans start to design tactics to keep the zombies at bay, such as barbed wire and walls loaded with weaponry. In the face of such obstacles, zombies with enough brain function and coordination to use basic tools prevail.

Tool use requires functions such as hand-eye coordination, function representation, and executive control. This indicates that some areas of their brain, such as the anterior supramarginal gyrus (aSMG) and the posterior parietal cortex (PPC), may be somewhat functional. The left aSMG contains an area devoted to the execution and observation of tool actions. Observing tool use of other humans activates the aSMG through inputs from different parts of the dorsal and ventral streams (Orban and Caruana). The posterior parietal cortex is associated with spatial awareness and planning movements, especially in response to visual stimuli (Shomstein).

This suggests that the zombie population evolved around traits requiring more brain function than is commonly credited to them. Thus, the brain's plasticity could be a factor in their adaptation and natural selection.

Discussion

Organization gives the structure-function argument that on every level of the biological hierarchy, there is a correlation between the structure and the function of a particular feature. In zombies, the structure of bipedalism gave them the function of an advantage over other predators hunting humans in the wild. Bipedalism allows for more powerful forelimbs and a higher fighting stance, giving zombies the ability to strike down with greater force. The usage of two free hands may also help them get through human defenses more easily, as they were created or being enacted by creatures also with two hands.

Energy and matter deals with the consumption and use of energy in living beings. Zombies consume human flesh to supply necessary amino acids, because although they are corpses, they require energy to maintain skeletal muscle and keep walking. If their muscles deteriorated too much, they would no longer be able to hunt for food and be put out of commission. Their digestive tract also has to remain intact, as it breaks down the meat into absorbable components (amino acids). This indicates a slower tissue breakdown or some regeneration of intestinal tissue, as the epithelial lining is typically replaced every 4 to 5 days in the small intestine (Umar).

Interactions between organisms is what keeps the ecosystem flowing. There are two major ways in which a zombie interacts with the environment. First, its flesh interacts with decomposers, albeit at a slower rate than actual corpses. Many microorganisms contribute to breaking down its body. The types of microorganisms differ depending on the organ or location on the body and whether or not oxygen is freely accessible. Second, it responds to auditory stimuli. It can pick up on very small sounds made by humans that the average human would not be able to decipher from background noise. This can be seen as compensation for the degradation of other senses, such as sight or touch. Real life evidence can be seen in the example of blind people developing sharpened senses as a result of neuronal plasticity that reallocates visual areas to auditory processing.

Evolution is a process of descent with modification. Adaptations allow a population to survive better in their given environment, and natural selection amplifies those adaptations throughout the generations. Zombies cannot reproduce in the way a human does, but they do infect other humans, thereby creating the 'next generation.' Over the course of many such generations, zombies may evolve to retain some functionality in their hands, as tool use is advantageous to breaking down human defenses. This implies that their brains are able to process observational learning and intentional movement to some extent.

Conclusion

Zombies are, quite obviously, fictional creatures. A real corpse's flesh would decompose too fast to be mobile, not to mention the degradation of the nervous system that would render a zombie useless. However, with some suspension of disbelief that comes with the territory of consuming fictional content, their characteristics can be interpreted as real human aspects taken to the extreme. Thus, scientific research can be applied to explain parts of their physiology and behavior. Analyzing zombies like this shows that they hold more value than simple jump scares or bloody action. By exaggerating or eliminating some of what we perceive to be normal human features, they can provide an interesting look into human physiology.

Limitations

The Walking Dead showcases only one type of zombie in popular culture. While it provides the foundation for many other media, it doesn't encompass the characteristics seen in more irregular types of zombies. For example, the six types of fungi-based creatures from the video game and TV show *The Last of Us* presents an entirely different set of biological questions that this paper does not delve into. Further research is needed to determine the similarities and differences between the physiologies of zombies across franchises.

Furthermore, inconsistencies in the show itself present a challenge in determining the extent of functionalities the zombies possess. Characterization of these creatures have changed throughout the seasons. The main characteristics mentioned above (enhanced hearing, rudimentary control of limbs, and a carnivorous diet) remained consistent, but details such as sensory sensitivity or the degree of limb control have varied over the seasons of the show. No experiments have been conducted in-universe to determine these details, so this analysis had to rely on visual clues and inference.

One aspect of *The Walking Dead* that has not been mentioned previously is that every human on Earth has been infected with a virus that turns them into zombies once they're deceased. The virus remains dormant throughout the human's life. This is not a direct characteristic of a zombie, but exploring the mechanism of this virus in commanding a dead body may explain how a zombie is made and what parts of human functionality it retains.

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