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Term Project Summary

Many horse-like species have evolved their phenotypic trait—such as color, body size, and form—naturally in accordance to the environment they were situated in. In today's day and age, the horses are interbred and their pelage colors are artificially made. The zebra, a species in the Equus genus, has a unique phenotypic trait of black and white stripe patterning on its pelage. Many scientists have become interested in this unique patterning and have conducted numerous experiments to track the evolution of the zebra's stripes. Although the clear origins of this remarkable trait are still in question, there are several competing hypotheses about the causes that led the zebra to evolve the pigmentation in its fur. The three theories regarding the emergence of the stripe patterns are: the result of thermoregulation, escape from predators, and avoidance of biting flies.

The zebra species expanded from the equatorial regions to the southern parts of Africa. A particular zebra species called the Plains Zebra has a thicker, bolder stripes pattern on their entire body, including their legs and underbelly. However, the other zebra species present relatively lighter and thinner stripe bands with different distributions all over their body [3]. According to the study of Brenda Larison and her colleague, the variety of the stripe patterns on the zebras may have developed due to the change temperature, an environmental cause. The scientists proposed that the alternative stripe bands of the zebra evolved to regulate the body temperature under the hot climates. Their experiments show that the zebras from the isothermal regions have similar thickness and arrangement of the stripe pattern, but zebras in cooler areas have denser and thinner stripes. This conveys that the distribution of zebra species with alternative stripe patterns depended on the geographic temperature. Additionally, the scientists proposed that the black and white bands receive heat differently; the black stripes would receive more heat while the white stripes would receive less heat. This results in the black stripes getting hit by wind currents harder and stronger compared to the white stripes. Thus, at the point where the two colors meet, a wind current is created which acts as a cooling function for the zebra's body. Therefore, the varying differences of stripe patterns in zebras could have developed from the need for a thermoregulatory system that helped the animals to survive under stifling conditions [1].

Another intriguing idea of the evolution of stripes is that the pattern acts as a coloration and a survival method, which helps the zebra to avoid being detected by predators. As proposed by the scientists Tim Caro and his colleagues, the zebra's stripes can help to camouflage the animal into its background. By blending into the background, zebras can better hide from their predators [5]. Also, from the study of stripe patterns, the movement of stripes can create an optical illusion, called motion dazzle, which creates a high contrast between the colors of the stripe pattern. This illusion distracts the predators and makes it difficult for them to locate their preys. According to another study, a perpendicular stripe patterning actually creates more motion dazzle than the parallel stripe patterning would [4].

Finally, the third hypothesis is that the zebra developed its stripe pattern to avoid biting flies. The zebra species may have suffered from attacks of the biting flies which transmitted fatal

diseases that can kill the zebra. Biting flies use their visual stimuli and olfactory stimuli to know the direction of the hosts. However, in the Savannah, where most zebras are found, the flies' olfactory stimuli become inefficient in sensing the odors of the hosts they are trying to locate. Thus, the flies tend to rely more on its visual stimuli to find the hosts [6]. While they are looking for the hosts, they search for solid-colored surfaces that vividly stands out from the background. In fact, biting flies have are prone to stray away from stripe patterns. The scientist Jeffrey Waage, proposed that the stripe pattern of the zebra has less attraction to the tsetse, a biting fly, compared to the uniformly colored targets [2].

My creative work can be used in a science textbook as a scientific illustration. Each illustrations portray the three hypotheses about the origins of the stripe patterns on a zebra: temperature changes and avoidance of predation and parasitism. With a visual reference, scientists and students would able to understand the cause of the zebra's stripe pattern more easily. Also, with the knowledge of the three theories that have been proposed regarding the origins of the zebra's stripes, scientists may become more interested in finding out the real possible reason for the evolution of the zebra's unique pelage pattern. Moreover, the scientists may also apply their understanding of zebra's patterning evolution to other species who have a similar phenotypic trait.

The first illustration is of the hypothesis which states that the zebra evolved its pelage color into stripe pattern for thermoregulation. I drew two zebras in two different environments, which describe by the thermometers that show the different temperatures. The zebra in the higher temperature has thick, bold stripes on its entire body. Comparably, the zebra in the cooler environment has thinner bands of the stripes. To show the wind current that regulates the body temperature, I used red and blue arrows to express the air created between the bands. To display the differences, I drew more bigger arrows on the zebra with the thick stripes and less arrows on the zebra with the thin stripes. The second illustration represents the second hypothesis which states that the zebra evolved its stripe patterning in order to escape from predators. Inside the woods, I drew a zebra hiding behind numerous trees. This shows how the zebra can camouflage itself inside the woods. Also, I created a moving image of a zebra which repetitively moves to form an optical illusion that blurs the animal into the background and makes the zebra difficult to detect while it's in motion. The third illustration represents the last hypothesis which states that the stripe pattern was evolved to avoid the biting flies. I drew a zebra, an animal with black and white stripes, and a gazelle, an animal with a solid brown pelage, to show how the biting flies are more attracted to solid-colored surfaces. I drew biting flies moving from the zebra to the gazelle to further emphasize the biting flies' behavior of avoiding striped patterns and drawing near to solid surfaces.

Work Cited

[1] Ryan J. Harrigan, Henri A. Thomassen, Daniel I. Rubenstein, Alec M. Chang-Golston, Elizabeth Li, Thomas B. Smith. 2015. How the zebra got its stripes: a problem with too many solutions. Royal Society Open Science 2:140452.

There are several suggestions about the evolution of the stripe pattern on the zebra. The scientists had a hypothesis that the pattern has evolved to escape from predators, avoid biting flies, or for thermoregulation. Plain zebra has different patterns varied by regionally. One has heavy black and white stripes over its body, in others have reduced coverages of patterned with thinner and lighter lines. The scientists differentiated that the varies of striping patterns on the zebra is a regional factor, such as the temperature of its environment in Africa. The zebra's torso stripe, as an expectation, is a mechanism to differentiate the temperatures between black and white bands which produce air as cooling effect to lower the body temperature. The more the intense colors create more differential in temperature that the zebra in tropics with high temperature has the most significant color saturation.

[2] Caro, T. et al. 2014. The function of zebra stripes. Nature Communications. 5:3535.

Many scientists interested and hypothesized that the black and white striping pattern on zebra's pelage is a form of crypsis, the coloration of its surrounding environment to avoid from its predators. In this research, the motion of zebra pattern causes a disturbance on the eye detection, and those flies, tsetse flies, stable flies and tabanid biting flies who threat zebra's life, are less likely to lend on black and white surface compare to plain surfaces.

[3] Craig Holdrege. 2017. Why Does a Zebra Have Stripes? In context #37. Pg17-23.

Zebra belongs to the genus of Equus, which its structure is similar to the horses and asses. There are four zebras, such as plains zebra (Equus quagga), Grevy's zebra (Equus grevyi), mountain zebra (Equus zebra) that each one of them has different shapes and thickness of their stripes. Many scientists have discussed the evolution of the zebra pattern and came out a few suggestions. The pattern as a coloration that the zebra uses its stripe to camouflage the environment. Also, the temperature of tropics may have caused the pattern. Lastly, the biting flies which infect fatal diseases that threaten the zebra to extinct thus the pressure may arouse the stripe pattern. These opinions are all hypothesis that does not explain the cause of the evolution of zebra pattern.

[4] Hughes et al. 2015. The role of stripe orientation in target capture success. Frontiers in Zoology 12:17.

Study about target capture and the role of an orientation of stripes, that the direction of striping pattern may appear motion dazzle that makes difficult to judge the animals' motion. However, if there are many targets with stripes are easier to capture.

[5] Melin AD, Kline DW, Hiramatsu C, Caro T (2016) Zebra Stripes through the Eyes of Their Predators, Zebras, and Humans. PLoS ONE 11(1): e0145679.

The stripes of zebra in several decades that it helped to survive from carnivorous predators. Scientists have experimented with subjects, human, lion, hyena, and zebra, to see how the zebra pattern disturbs the visual systems in several distances and luminosity. However, through the eye capturing experiment, compares the sight to the lions and humans that zebra's

pattern did not present as an anti-predator factor because the predators, mostly lions, have night vision that at night, they can clearly distinguish the silhouette of zebras to hunt.

[6] Jeffrey K. Waage. 1981. How the zebra got its stripes - biting flies as selective agents in the evolution of zebra coloration. Journal of the Entomological Society of Southern Africa, Volume:44. Pg351-358.

The stripes of the zebra are traditionally thought as an anti-predator trait to extend their life from lions and hyenas. Against this idea, another hypothesis suggested that the striped pattern arbitrates visually the observance of biting flies, which selected the trait to avoid the biting flies. The biting flies tend to avoid stripe pattern, and they are attracted more on solid black and white surfaces that visually perceive clear contrast on the background.

Creative work
https://youtu.be/lHDLZe9gzZw

Illustration I

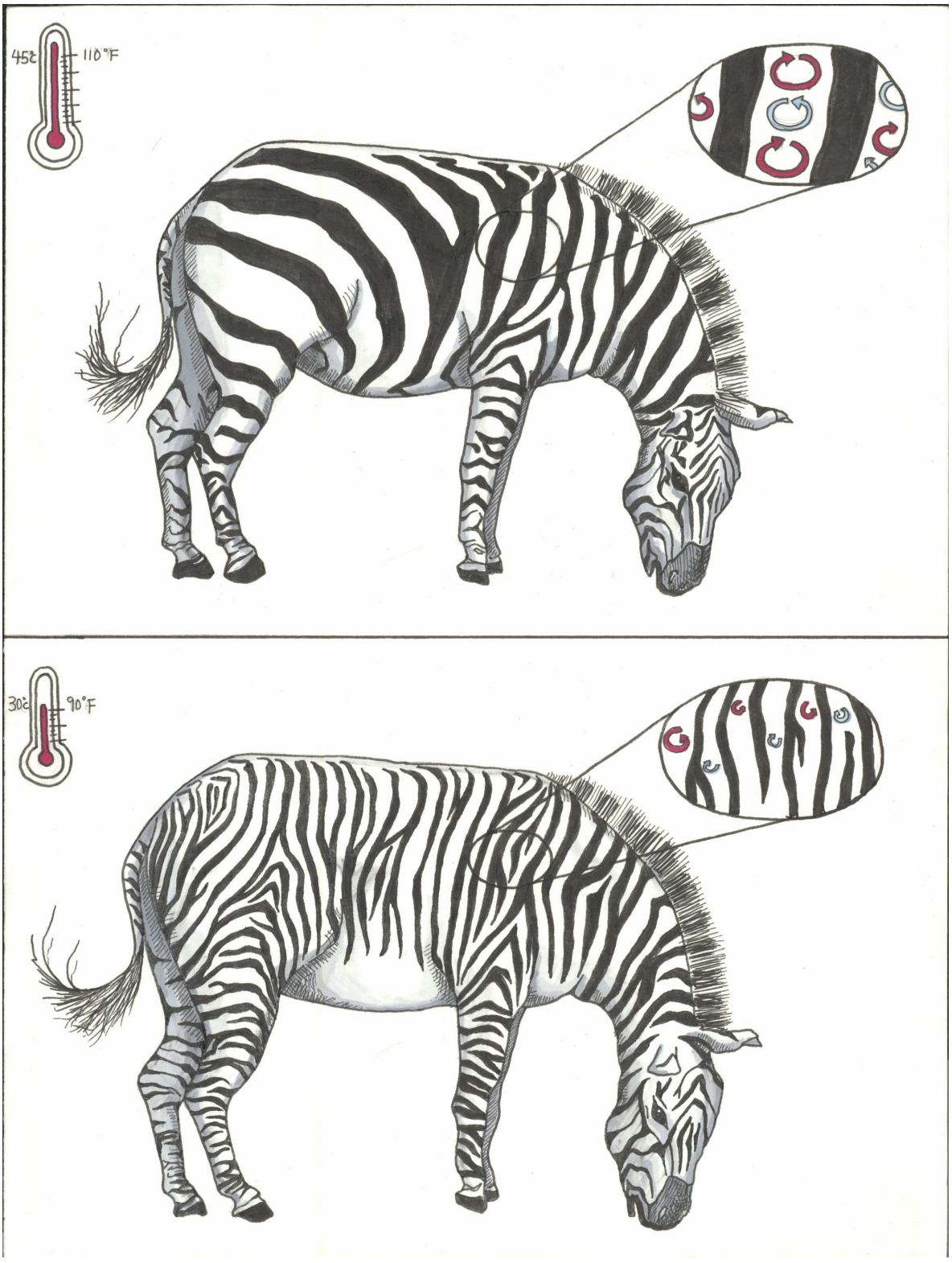

Illustration II

Illustration III