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Term Project Proposal

The stripe pattern of zebra

My term project will focus on the stripes pattern on the zebra. Zebra is phylogenetically classified as a genus *Equus* in the family *Equidae*. According to a recent study of ancient equid, it presented an analysis that the extant equids species have evolved their descended phenotypical traits, such as the pelage color, body size, and body form, within the selection either natural or artificial. Therefore, the coated colors are variations between the existing equid species, and also in these days, humans can interbreed the domesticated horses to select the horses' coated colors artificially [7]. With the idea of color, the zebra has the most mysterious and remarkable pelage color within its genus, the black and white stripes pattern. The zebra's stripe pattern is a type of coloration, which is an adaptive characteristic that the pigmentation of the fur as a function that adapts the situated environment and develops its appearance over time through the generation for the survival. Many scientists had studied and conducted field experiments on the zebra stripes to figure out the evolution of its presenting pattern and the function. The scientists brought several competing suggestions, which the emergence of zebra stripes are as a result of the thermoregulation, escapement from predators or avoidance of biting flies. These suggestions may not fully explain the evolution of zebra's stripe pattern, however, with the ideas we can assume three functions that could lead the zebra species to have the unique pattern. Therefore, in my creative artwork, I will be going to illustrate a zebra is moving through three conditions to show the zebra variates its stripes to control the body temperature, to escape from carnivorous predators and the biting flies. To describe more about my creative work, I have researched several studies about the zebra stripe.

The zebra's striping pattern correlates with its geographical variation. Generally, the variety of model presented via the breed of zebra, and its subspecies. In the equatorial region the Plains zebra has very vivid bold black and white striping pattern on their entire body, include their legs. Descend to the south, the Chapman's zebra has shadow stripes, which is a lighter band, between the black and white stripes. Moreover, in South Africa, Burchell's zebra, the subspecies of plains zebra, has reddish black bands, and the extinct species, quagga had stripes only half of its body and had no leg stripes [3]. This presentation of different varieties of lines on zebra's body on different regions suggests the environmental factor, such as temperature, may play a role to select and determine the stripe patterns. The scientists Brenda Larison and her colleague presented a hypothesis the variation of striping pattern can be explained by the environmental conditions, which the characteristic of the stripe accompanied with the temperature, predation and biting flies. They conducted several experiments to see the coloration of zebra associate with the predation and biting flies, but they found no supporting evidence to verify the hypothesis that the stripe evolved to escape from the predator or avoid the biting flies. However, the scientists came up with a suggestive idea that the potential driver of zebra's stripe pattern is the temperature. They pointed the temperature of the environment associated with the variation of lines for thermoregulation. The

experiment predicts the distribution of the stripe lines varied within the geographic temperature. In the isothermal region, the zebra has a similar arrangement of stripe pattern and thickness, but in the colder area, the shape of the stripe presented differently. The zebra's black and white bands also conduct the heat of its climate condition differently, which the scientists referred the differences between the bands can create wind current on the body as a cooling function to keep the stable body temperature. Therefore, the zebra may also survive in a stifling condition [1].

The stripe pattern is coloration characteristic that makes zebra incapable of captured by predators' sights. The stripes provide camouflage in vegetation field in low light conditions, and also in woodland, the zebra can mimic the background with its pattern [3]. Moreover, the movement of stripe pattern may create an optical illusion to the predator. There is a hypothesis that the stripe pattern with the high contrast color forms 'motion dazzle' that makes predators difficult to judge the location of a striped animal in motion. The different orientations of stripe pattern may allow disturbing the predators to capture the preys' movements. The perpendicular or oblique stripes would create motion dazzle more than the parallel pattern; this suggests that in a unique formation, the patterned species can escape from predator easily. However, since the predators' motion signals mislead by the striped pattern, where if multiple striped targets are in a group, they are easily perceivable; thus, the predators have no significant disturbance to capture the trajectory of the preys. [4]. Furthermore, over the decades, the stripe pattern of zebra discussed its function as an antipredator defense. The Tim Caro and his colleague experimented with a hypothesis that the zebra's stripe pattern interrupts the visual systems of predators that make them undetectable. The hypothesis was suggesting the distance of zebra with its coated fur may blend in the background, which the predators cannot detect the prey distinctly. However, the result only applied to the humans, rather than their main predators, the lions. The predator in any distance vividly captures Their silhouettes. Even in low light condition, most of the predators have a potential of night vision, that suggests the stripes cannot be a form of antipredator defense [5].

The different types of zebra that I listed above can suffer from the attacks by biting Diptera, such as horse flies, and tsetse, which they can infect fatal diseases bring to death. This phenomenon derives the severe survival problem of the zebras, that may the zebra selected to adapt the stripe pattern for its avoidance from the ectoparasite. The diurnal Diptera, as known as, biting flies, captures the direction of the hosts with their visual stimuli and olfactory stimuli. The plain zebras mostly composed in the Savannah, the environment is humid, and no wind occasionally blows, that the condition inefficient to the biting flies to sense the odors from the hosts to locate them. Thus the flies are relying host finding on their visual stimuli [6]. Also, the biting flies are attracted to the compact, bold colored surface, such as black and white colors, that present vivid contrast to its background. And they have shown a propensity to avoid black and white striped surfaces [3]. Therefore, the visual component, the stripe pattern of zebra, may interfere with the biting flies' visual stimuli, and it may reduce the attractiveness of zebras to the flies as a favorable host. A scientist Jeffrey Waage, with his field experiment, discussed the striped coloration of zebra had less attracted to the tsetse's visual stimuli compares to the uniformly colored targets. Also, he suggested the most abundant distributions of biting flies, mostly tsetse to the plain zebras, conveyed a selective pressure that interference with the location of the most distributed orientation of zebra's stripe patterns [4].

Overall, refer to the three competing hypothesis, the most distinctive phenotypical trait of zebra which is the stripe pattern has evolved by adapting the critical environmental factors such as the climate condition, predator evasion, or prevent biting flies. These adaptations also demonstrate the functions of the stripe pattern that the zebra regulates its body heat under hot weather. The pattern also may mimic the background or may disturb the visual system of the predators to escape and survive. The black and white stripe pattern makes imperceptible with its environment that with the biting flies' behavior of being less interested with the striped surface suggests the adaption of zebra coloration. There is no right evidence to support and explain the cause of the evolution of stripe pattern, however, under all these three circumstances, the zebra presents its fitness and suggests either can be a vital attribute of the eruption of the stripe pattern.

Correspond to the three hypothetic environmental factors which may give rise of the evolution of zebra's stripe pattern, and my creative work may provoke people's curiosities to the mysterious coloration of zebra which has not yet comprehensively defined. Therefore, my creative work will be going to describe three circumstances that interact the zebra to present the possibilities of evolution of the stripe pattern and its advanced functions to make the zebra survived from its surrounding. The first scene will show a situation, where the climate gets hotter, to illustrate the zebra changes its stripe's thickness and orientation within the changing temperature to control the thermoregulation. I am also going to demonstrate the wind currents created between the black and white bands to show the function to cool down and regulate the body temperature. The second scene is going to be present an image of zebra escaping from its predators. In this scene, I will illustrate a zebra camouflaged its environment to demonstrate how the stripe pattern can imitate the background objects, such as wood and tall grass, that the predators cannot detect them. Also, I will illustrate the motion dazzle that creates when the pattern in motion to convey the movement of the stripe may or may not cause the evolution of the coloration to be extant. The third circumstance will be going to suggest the avoidance of biting flies that cause the evolution of the stripe. The illustration will convey the tsetse transmit diseases that can kill the hosts, and this results that the zebra starts get its pelage design. To be more specific, I will draw an image of zebra shown without tsetse, and the overcrowding of tsetse on certain types of ungulate, such as horses. This illustration will also convey the biting flies are more attracted to the solid surface that vividly contrast from its background.

Work Sited

[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 land 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.

[7] Ransom, Jason, and Petra Kaczensky. Wild Equids : Ecology, Management, and Conservation. Johns Hopkins University Press, 2016. EBSCOhost, login.ezproxy.pratt.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=1083516&site=eds-live.

Zebra is phylogenetically types of Equide. The ancestor of equid passes the pelage color, the phenotype trait, that increase the idea of the population of the ancient horse within its body structure and size.

Project Table

Scientific Idea:	How this idea could be incorporated into your creative work:
-Under the hot climate condition, the zebra species have different thickness and orientation of striped pattern. This difference may be evolved by the temperature that the black and white bands creates different heat to create wind current to cool down and control the thermoregulation.	-The zebras have different thickness, and orientation of stripe pattern compares to the different climate condition of the environments. Thus, illustrate thick stripe in the hot situation and the thinner stripe in less hot condition. Also, draw wind current between the bands to convey the cooling function to regulate the body temperature.
-The stripe pattern, as an evasion tendency, creates optical illusion to the predators. The stripe pattern may camouflage the natural features to escape, and it establishes motion dazzle with the high contrast color to mislead the predator's visual stimuli.	-Create an image that conveys optical illusion with zebra stripes to show the difficulty of sight in a condition.
-The diseases which infected by biting flies are fatal to zebra's existence, to survive they came up with stripe pattern, which the biting flies tend to avoid the stripe pattern.	-The biting flies tend to avoid striped surface, and more attracted in the plain surface. Therefore, present two species, one zebra and one ungulate with solid black color to show the attractiveness of biting flies.