Elizabeth Chen, Gwen Clark, Lauren Weaver, Kunal Gupta **Please read my comments! 94% You did a great explanation on this! Your ordering of what is in the background and what is in the conclusion should be different. There may be a little overlap, but you put most of the explanation in your background.**

AP Biology Period 4

15 October 2017

Planaria Lab Report: Planarians' Reception of Color **Perception? (not "reception" I think)**

Background:

Planaria belong to the phylum platyhelminthes, meaning that they have the characteristics of a flat shape and simple nervous system, to name a few. Another significant trait that members of this phylum possess is ocelli, which are cerebral eyes that connect to their simple brains. These are sometimes known as eye spots as well. Some features of these eyes are photoreceptor cells (opsin), a pigmented cup-like structure, and genes specific to the development of eyes that help with the formation of the eyes. Planaria share common eye biology with humans, thus making them reliable models for studying eye evolution and development (Paskin et. al).

Our experiment tested the reaction of planaria to colors. Although planaria cannot necessarily 'see' color, as humans do, according to a 2014 study (Paskin et. al), planaria exhibit significant behavioral responses to lights of different wavelengths. Planaria are generally photophobic, meaning they prefer less light. However, within this general photophobia, the study found that planarians exhibit a greater photophobic response to light of shorter wavelengths, such as violet, and no response to light of longer wavelengths, such as red. In our experiment, we used colored pencils and colored tape to create green, red, and blue sections in the petri dish rather than colored light. However, since green, red, and blue pigments work by absorbing all other wavelengths of light and reflecting back green, red, and blue wavelengths of light, respectively, the planarian were still exposed, to some degree, to different wavelengths of light. **This is an excellent explanation of this. Very relevant information**

One factor that also may have impacted the behavior of the planaria in our experiment is the tendency of planaria to prefer walls. A 2015 study done at Tokai University found that the planarian species *Dugesia japonica* display a behavior known as "wall preference", or the tendency to cling to the walls of experimental dishes and containers in the laboratory (Akiyama et. al). This is thought to be an evolutionary adaptation that may help planaria survive in the wild; by sticking to the edges of a pond, for example, they are less accessible and therefore less likely to be eaten. In our own classroom, we also observed that the planaria tended to stay near the walls of the jars they arrived in. When we transferred the planaria from the jars to the petri dishes, it is possible that part of the reason for their movement was due to their searching for a wall to stay near.

The reaction of planaria to color is relevant in real life situations **(you don't really need to spell out for the reader "in real life situations,"** because although they do not have 'color vision' due to their relatively simple eye structures, they are still able, to some extent, to sense different wavelengths of color. In ponds and other habitats in the wild, this ability to detect color provides planaria with additional information about their environment that they can then interpret and use to make decisions about their behavior and reaction to various stimuli **what would be an example of a stimulus they may react to?** within that environment.

The extent to which planaria are able to detect color, and what colors they prefer, which we will attempt to find out in our experiment, is important to our understanding of how planaria interact with their environment, as well as how much information they can actually detect. For example, we know they have the ability to detect light, which is less complex, but the ability to distinguish between different colors, even when that color is not in the form of colored light, is more complex. **Very good observation**

In addition, since planaria and humans share common eye biology, knowing if planaria distinguish between colors could also help us understand if there are/are not additional biological adaptations that humans have that also allow humans to see color. If planaria are unable to distinguish between colored pigments(from the tape and colored pencils), then this would help establish that humans have additional adaptations that planaria lack in eye structure that allow them to see colored pigments. Finally, the preference for certain colors might suggest that planaria use color to navigate their environments(e.g if planaria prefer green, it might be because they see it as a possible source of food(algae)). **I think you did an EXCELLENT job and a thorough explanation for this! Everything that you included is relevant here to this experiment! 14/15**

Objective:

The objective of this experiment is to determine whether or not planaria have a preference for red, blue, green, or white colored environments, by allowing them to choose a location within those four colors in a petri dish. At a broader level, we would like to determine whether or not planaria can distinguish between different colors, and use their behavior as a method of determining this. **5/5**

Materials:

- Two petri dishes
- Red, blue, green, and white colored paper
- Tape (colored)
- Distilled water
- 35 Planaria (only 30 are needed, but the 5 extra planaria can serve as backup)
- 1 cut-off pipette
- Stopwatch
- Scissors **5/5**

Procedure:

1. First, gather all materials (listed above). Set up experimental petri dish by "splitting it up" into 4 equal sections.
    a. Cut out a piece of white paper equal to the size and shape of the petri dish and color the 4 sections (1 blue, 1 red, 1 green, and one left white). Be sure to leave a circular-shaped space in the middle that is just white. This is where the planaria will start. Tape this to the bottom of the petri dish.

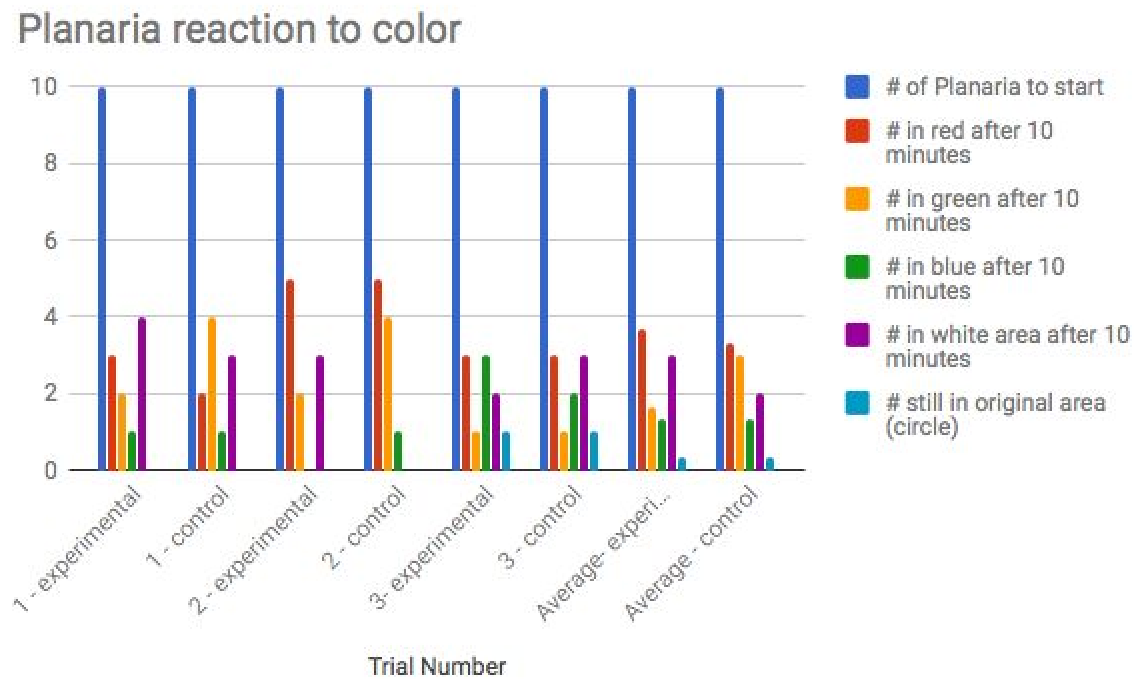
    b. Next, using the colored tape, line the sides of the petri dish with the color that coordinates to the colors of the bottom of the dish.
2. The next step is to set up the petri dish of the control group.
    a. Cut out a piece of white paper equal to the size and shape of the petri dish and this will be all white, but in order to assure control, split it into four equal sections (can just be lines drawn with a pencil). Each of the four sections will correspond to one of the colored sections to ensure consistency within the results, even though all of the sections in the control dish will be white rather than colored. Draw a dotted-line circle in the middle of the paper to ensure that the planaria in both the control and experimental groups start in the same location in the petri dish.
3. Place the petri dishes on the table in the same orientation as one other (eg. blue section of experimental facing the same direction as "blue section" of control group). This will ensure that direction is not a factor in the decision-making of the planaria.
4. Fill each of the petri dishes almost to the top with distilled water
5. Using a pipette with a cut-off tip, remove 10 planaria (1-2 at a time), and place them in the center (in the designated circle) of the petri dishes. Do this for both the experimental and the control group.
6. Observe the movement of the planaria for 10 minutes and record the final locations (section) of each of the planaria at the end of the time. Do this for both groups.
7. Repeat steps 5 and 6, removing the planaria from the previous trial and placing planaria back in the middle to begin a new trial.
8. Repeat steps 5 and 6 again, leaving the experiment with a total of 3 experimental trials and 3 control trials. **20/20**

Data: **I think this table could have been a bit more concisely made. It is a little difficult to read the way you have it set up. I like the idea of your control setups that you used, but it needs to be easy to read...maybe put differences from the control in a separate table?**

Your data section should include the photos you attached (you probably could have chosen just a couple) or a reference to them attached at the end as "Fig. 1" for example. You also may have wished to include a photo of it in your procedure.

Trial Number	# of Planaria to start	# in red after 10 minutes	# in green after 10 minutes	# in blue after 10 minutes	# in white area after 10 minutes	# still in original area (circle)
1 - experimental white/red/green/blue w/ planaria starting in the white circle in the middle	10	3	2	1	4	0
1 (control) all white, divided into 4 sections, starting in the middle	10	2 in "red"	4 in "green"	1 in "blue"	3 in "white"	0
2 (same as 1) - experimental	10	5	2	0	3	0
2 (control)	10	5	4	1	0	0
3-Experimental	10	3	1	3	2	1
3 (control)	10	3	1	2	3	1

Average-Experimental	10	3.67	1.67	1.33	3.00	0.33
Average control)	10	3.33	3.00	1.33	2.00	0.33



In hindsight, maybe making a table with differences from the control should be included. I think it would be a lot easier to interpret. 18/20

Results:

From our experiment, we gathered that there was not too much of a trend between the trials, and that the results varied between each and every one. In general, in the experimental groups, the sections in which the most planaria ended up was the white section, with an average of 3.00 planaria at the end of the ten minutes, and the red section, with an average of 3.67 planaria after 10 minutes. For the control, the section that lined up with the red section of the experimental group averaged the most planaria at the end of each trial, with an average of 3.33, but not far behind was the “blue” section, with an average of 3.00 planaria. Throughout the experiment, we observed that the planaria seemed to quickly adapt to the new environment and that their movement seemed random. We also saw that they tended to move along the walls of the petri dish, rather than the bottom.

(In addition, note photos of each trial after 1 minute and after 10 minutes at the very bottom, below citations) **15/15**

Conclusion:

From our results, it can be concluded that planaria do not have a preference for color. The results of the experimental and control trials were relatively similar in that red was the most “preferred” color, and that blue was the least “preferred” color. However, since the distribution of planaria between each color was fairly similar, it can be concluded that the planaria do not have a preference for color. If planaria did have a preference for color, the data for one color would appear to be significantly higher than the other colors, but this was not the case. In the experimental trials, the most preferred color amongst the planaria was red (3.67 average), but this preference was not significant enough to conclude that the planaria have a preference for color, as there were 10 planaria in each trial. For the control trials, red (the section in the same location as the red in the experimental trials) was again the most preferred color (3.33 average), but still not significant enough to conclude that planaria have a preference for that color.

As the planaria in the experiment showed to not have a preference for color, it can either be concluded that their eyespots (ocelli) are not able to sense color or that planaria do not have a preference for any particular color. The photoreceptor cells (opsin) are not able to determine actual color, but they are able to determine color variation in light. Although it has been proven that planaria prefer different colored lights (Paskin et. al), this experiment proves that planaria do not prefer different colored pigments. Because the eyespots of planaria are not highly evolved, their sense of vision is not at the same level compared to other animals. Therefore, this could be the reason the planaria are only able to sense different colored lights, and not different colors themselves. If this is the case, it would be the direct reason that the results of the experiment were inconclusive.

One question that the results of our experiment raises is if planaria can detect colors(pigments) to begin with; our results, being inconclusive, suggesting that they cannot. If this experiment were to be done again, it would be better to use different colored lights to test the preference of color in planaria in this way. As stated before, planaria are able to sense colored light better than actual colors themselves. Therefore, this would give a more accurate representation to if planaria have a preference for color. A question raised by this experiment that our group formulated is if wall preference played a factor in the results. In the background information, it was stated that planaria have a preference for walls, and this may have influenced the results because the movement of the planaria may have been attributed to them trying to find a wall, rather than them having a preference for color.

We may have experienced several sources of error when we completed this experiment. For example, in our first trial, we did not use distilled water in our petri dishes. Although planaria are flatworms that can survive in environments that seem much more difficult that tap water, the tap water we used had a severe effect on the planaria. All of them rolled into balls as a defense mechanism, and many eventually died. If we had continued to use tap water for the rest of our trials, it could has skewed our results as the planaria would have stopped moving, just like they did in this trial. (We discarded our first trial results and redid the first trial because with the effects of the tap water, the results were meaningless).

Another potential source of error we may have experienced was the amount of time that it took us to add all the planaria to the petri dish. We were not capable of adding them all at the same time, so we added them individually or in pairs and did not start our ten minute timer until all ten planaria were in the petri dish. This means that the planaria could have been exposed to the colors for longer than the ten minutes that the timer accounted for, which would have created an unequal amount of time across trials spent choosing a sector of the dish. Also, if the planaria we added later to the petri dish, they may have either followed the rest of the planaria or avoided the others, which could have influenced where they traveled to in the dish. Our experiment did not take this into account, and to counteract this source of error we could have added all the planaria at the same time, which may have been difficult to accomplish, or we could have tested each planarian individually, in their own petri dish.

We added the planaria to the petri dishes by pipette, and with this method, water was added to the petri dish along with the planarian. When we squeezed the pipette to get the planarian into the petri dish, the water that was forced out along with it may have pushed the planarian towards a certain section of the dish. If the planarian were pushed towards a section of the dish, and every planarian was pushed towards the same section, they may have chosen to stay there, therefore influencing our results. For instance, our results show a slight preference for the color red, but this could be a consequence of an error like this one or simply just a coincidence, since planaria are not capable of seeing color, only colored light.

Our group faced several possible sources of error in our completion of this experiment. Between our failed first trial, the timing differences when planaria were added to the petri dishes, and the effect of current on the section of the petri dish the planaria chose, many factors may have influenced our results. Some of these factors could have been better controlled, but in our experimental environment, we could not have complete control over what influenced our experiment. For example, we could have done a better job at adding the planaria either all at the same time or testing them individually, but we could not control if a current pushed the planaria in a certain direction because we used pipettes. These sources of error could have contributed to the slight preference for red that we observed in our planaria, because as we stated earlier, since planaria cannot see colors, no preference should be determinable.

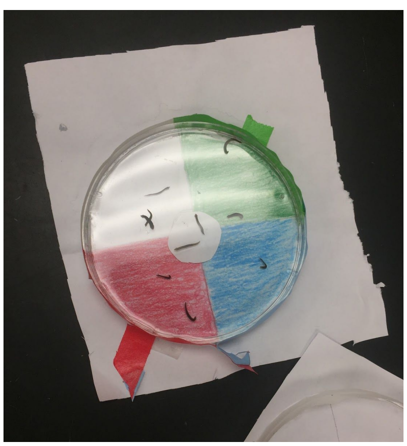
On the other hand, we did many things to ensure control in aspects of our experiment, such as using the same size and shape petri dish between all trials (both control and experimental), the same species of planaria throughout all trials, and using distilled water in all trials (after of course, initially we made the mistake of using tap water, but discarded those results). We also tried to keep the direction of the petri dishes consistent with one another, meaning that the blue section of the experimental group for example, was oriented the same way on the table as the marked “blue” section of the control group. These things that we worked hard to control created less opportunities for error, as well as differences in data that would not be contributed to the actual trials. **You did a nice job explaining how you could have done**

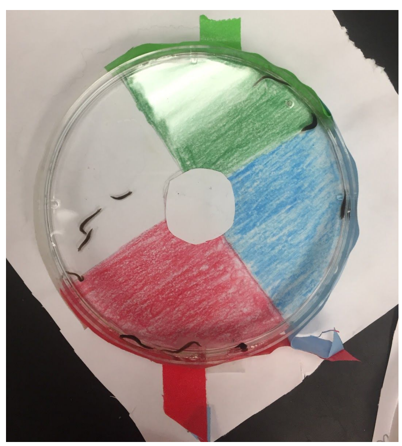
things differently and sources of error. It is also necessary to reference back to your other experiments that you cited earlier or an additional experiment that may give similar findings. I think you ended up putting a lot of your explanation in your background when it really should have gone here. This would be a good place to explain why they are not able to perceive the colors and what the limitations of their eye/photoreceptors are. 22/25

<u>Sources:</u>

Paskin, T. R., Jellies, J., Bacher, J., & Beane, W. S. (2014). *Planarian Phototactic Assay Reveals Differential Behavioral Responses Based on Wavelength. PLoS ONE*, *9*(12), e114708. http://doi.org/10.1371/journal.pone.0114708

Akiyama Y, Agata K, Inoue T (2015) *Spontaneous Behaviors and Wall-Curvature Lead to Apparent Wall Preference in Planarian. PLoS ONE*, 10(11): e0142214. https://doi.org/10.1371/journal.pone.0142214

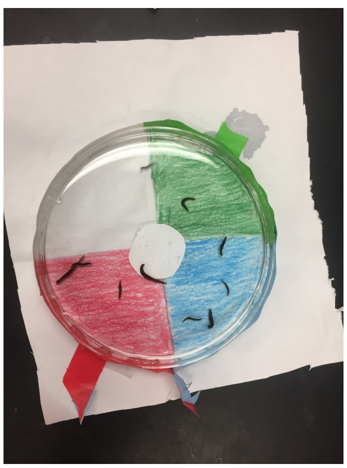


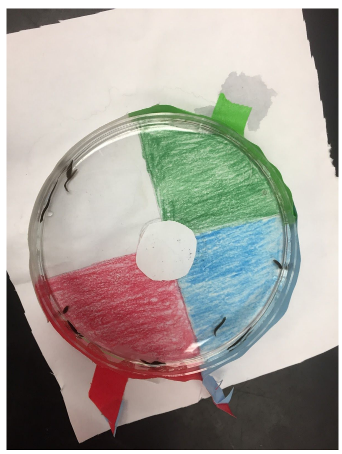


Trial 1 after 1 minute　　　　　　　Trial 1 after 10 minutes

Trial 1 (control) after 1 minute

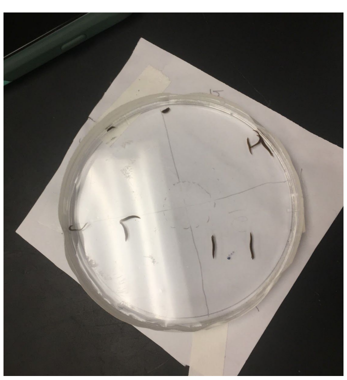
Trial 1 (control) after 10 minutes

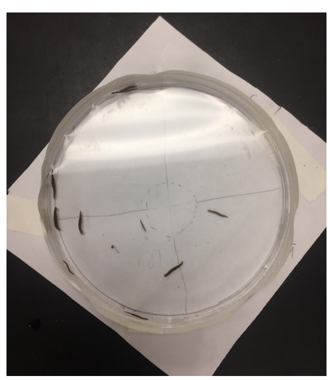




Trial 2 after 1 minute

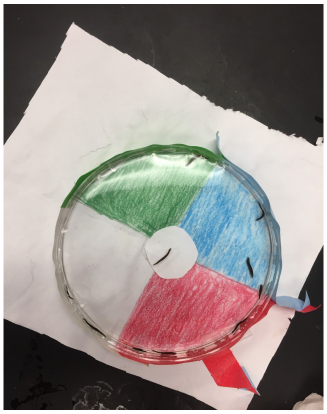
Trial 2 after 10 minutes



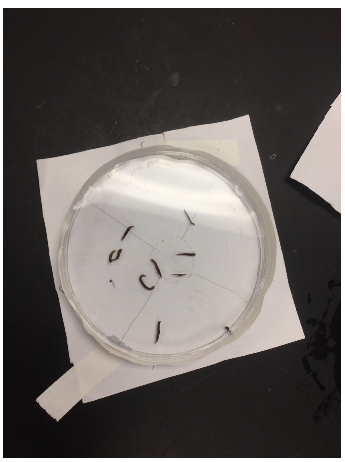


Trial 2 (control) after 1 minute

Trial 2(control) after 10 minutes



Trial 3 at start Trial 3 after 10 minutes



Trial 3 (control) at start Trial 3(control) at end