Group name:

Group members:

You are a food scientist for Hershey. The Marketing Department has just come in and told you that Van Halen has boycotted brown M&Ms, and they are getting calls to remove Brown M&Ms from the package by fans. The Marketing Department does not know what to do, and wants you to see if brown M&Ms actually taste different from other colors. If it does, they will have to revise the coating or withdraw the color, costing the company millions of dollars.

**Hypothesis.**

State your hypothesis, and your null hypothesis for this experiment (Please refer to the handout on hypothesis for guidance).

Hypothesis:

*Brown M&Ms taste different than other M&Ms.*

Null Hypothesis:

*Brown M&Ms taste the same as other M&Ms.*

Now turn to your classmate, and share your hypothesis with one another. Are they the same? What is the difference? Which more closely, directly and simply relates with the scenario described? Why do you think a hypothesis should be direct and simple?

*Hypothesis should be as simple and direct as possible because this allows it to be more easily tested and proven correct or proven wrong. This allows a new hypothesis to be formed and tested. Thus science advances.*

**Experimental Design**

In your assigned group, work together, discuss and design an experiment to test your hypothesis.

*(Experiments should directly test the hypothesis stated. The results of an experiment should either support the hypothesis, or disprove it. Start with discussing the following questions within your group.)*

*The experiment should be that one of you (the subject) will be asked to eat a number of M&Ms.*

What question should the subject be asked after (s)he eats each M&M? Remember, this question should directly test the hypothesis.

*Was the M&M you just ate a brown M&M?*

**Statistical Confidence.**

When planning an experiment, one important step is to identify possible results, and if those results will support or falsify our alternate hypothesis.

*(Note: For the general module described here, confidence is descriptive, and not mathematical. If you are teaching the Statistical Analysis and Confidence Interval sub-teaching unit, the Math behind this can be found in Faculty\_StatSig).*

What is your expected result if the null hypothesis is correct?

*That 50% of the guesses would be correct.*

What is your expected result if your alternate hypothesis is correct?

*That the number of correct guesses would be higher than 50%. Discussion: What does it mean if it is much lower than 50%?*

How many M&Ms should the subject taste during the experiment? Are more M&Ms tasted more likely to make you believe the results?

*The larger the sample number, the more believable/confident of the results*

A subject identified the color of the M&M (brown or not brown) correctly 60%. A second subject, using the same experimental conditions, correctly identifies the color of 80% of the M&Ms. Which do you believe more; ie, Of these two results, which one would give you greater confidence that your alternate hypothesis is correct? Why?

*80%. It is further away from the expected result if the null hypothesis is correct.*

In one experiment, one subject correctly identifies 70% of tasted M&Ms.

Does this support your alternate hypothesis?

You decide to repeat the experiment with the same subject again. Now he correctly identifies only 50% of M&Ms? Does this make you more or less confident of your results?

Another group in your class now reports that they found that someone in that group correctly identifies 75% of M&Ms. Does this make you more or less confident of your results?

*Reproducibility is an important concept in Science. Why is it important to be reproducible? Factors might include some experimental error in the first group, but not the second. (Note: IF using the Philosophy of Science sub-teaching unit, this reinforces the idea of objectivity in science; facts independent of time and space and scientist.)*

Put all these answers together. What factors determines how much you believe/ are confident that the results from an experiment are *real* and not simply a fluke?

*Deviation from expected (null) results, sample size in each experiment, number of repeats/reproducibility.*

**Experimental Conditions.**

Many different factors can affect the results of an experiment beyond the hypothesis that the experiment is supposed to test. Therefore, it is important to identify factors that might affect your results, and to plan experimental conditions that minimize these factors.

How many of the M&Ms tasted should be brown? How does this change the expected result if the null hypothesis is correct?

*Half the M&Ms tasted should be brown. If the subject knows that not half of them is brown, (s)he is more likely to guess the uneven number, and therefore, more likely to guess correctly.*

In each experiment, only one subject (one of your group-members) should taste the M&Ms, to determine if (s)he can identify the brown M&Ms correctly. Why not have each and every group member taste M&Ms and combine into one experiment?

*That would complicate the experiment, as each person might have different taste-buds, or different abilities to taste. By using multiple tasters in one experiment, if only some of the tasters can taste the difference between the M&Ms, that result will be hidden.*

*Alternatively, if there are multiple experimental repeats (i.e different subjects in each experiment), then results can be compared between subject. If results across subjects agree, this would mean the experiment is validated. However, if experiments do not agree, this might suggest that there are problems with the experimental design, or that there might be some subjects who are able to taste the difference. Further experiment necessary.*

*(Note: There is a large body of literature on science of taste; and it might be interesting to go down this path if you want to talk about sub-population and large number of experiments using multiple subject).*

Should the non-brown M&Ms all be one color? Why or why not?

*There are some assumptions that are inherent in any experiment. Here, if you decide to compare brown to non-brown, the assumption is that all other M&Ms taste different than Brown M&Ms. Furthermore, it would suggest that all other color of M&Ms taste the same. However, if you choose only one color, you are ONLY testing if Brown M&Ms taste different from that other color that you chose, and does not test other colors.*

*(Note: This question is important if you are teaching the Philosophy of Science sub-teaching unit. These are assumptions inherent in the experimental set-up, but are different from paradigms identified later. Paradigms are assumptions inherent in the hypothesis itself, not merely assumptions in the experimental design).*

Should the subject (taster of the chocolate) be able to see or be told what color the M&M is?

*No. It should be a blind taste test, e.g. Coke v. Pepsi, so that the taster’s answers are not biased.*

Should the person who gives the M&M to the subject be able to see what color the M&M is? Why?

*No. Concept of double-blinded. Prevent inadvertent hints to the subject of the color of the M&M, including giggling etc. This is especially true when the tester has a bias as to what the outcome should be.*

Should the subject first be trained (i.e., allowed to eat a number of brown and non-brown M&Ms such that the subject knows what they taste like. How many of each M&M should be allowed during training?)

*Yes. If there is a difference between the brown M&M, then subject needs to be trained to tell the difference between brown and non-brown. However, if the number of correct guesses in the experiment is significantly below 50%, this would suggest there is a difference between brown vs non-brown, it’s just that the blinded subject was not properly initially trained. The number should be about 6-8 each, enough such that the subject is familiar with the taste of Brown vs. Non-brown M&Ms (Note: training not needed if experiment suggested is if the second M&M is the same or different color than the first).*

In a question above, we said that there will be greater confidence of results if the subject tastes more M&Ms. What is the limiting factor for the number of M&Ms tasted by each subject?

*Limiting factors include the number of M&Ms available, and the taste-bud/ability to eat M&Ms of the subject (Note: this level of understanding is sufficient for core exercise. However, if you are teaching the Hypothesis testing and Experimental Design in the Real World sub-teaching unit, this discussion is crucial for the later follow-up when we have limitations on resources).*

Write your protocol below. Record your experimental results as well.

Result:

Percentage of correct identification of color of M&Ms:

Conclusion:

Another important part of scientific experiments is to consider what experiments would come next based on the results of the previous experiment. What should we test next? Suggest a new hypothesis