Appendix A.1
Design Activity

Name _____ Name _____

Name _____

- A **hypothesis** is a proposed explanation for a natural phenomenon. A **prediction** is a statement of what one expects to observe in a specific situation. A **null hypothesis** specifies what we should observe when the hypothesis being tested is wrong.
- There are several types of **variables**. Factors that are kept the same in experimental and control treatments—and which might affect the result—are called **controlled variables**. The variable that you manipulate—the one that differs between experimental and control groups—is the **independent** (or explanatory) variable. The independent variable is the factor that you think is driving change in a **dependent** (or response) variable.

You have been watching two different fields of poppies for the past month. You notice that poppies in one field (field #1) are growing at a different rate than the same species of poppies growing in a second field (field #2). You ask yourself the general question: Why do some poppies grow faster than others?

1. What are some possible explanations for your observation?

2. You develop a **hypothesis** about what causes changes in poppy growth rate (there are many different possible hypotheses). State your hypothesis in a complete, grammatically correct sentence. Remember that your hypothesis should explain your observation.

3. State one **prediction** that can be made from your hypothesis in a complete, grammatically correct sentence.

4. Think of an experiment you could perform to test your prediction and then answer the questions below.

   - What different conditions will you grow your plants in? Be as specific as possible about any conditions you will change e.g. time (hours), amounts (grams) you will use.

   - How many poppies will be grown in each condition (i.e. **your sample size**)? _____

   - Why did you choose this number of poppies?

- What variable will you measure (i.e. what variable do you expect to change during the experiment)?

  - How will you measure this variable? Be as specific as possible.

  - List 3 variables you will keep constant in your experiment (i.e. your controlled variables) and explain why you need to control these variables.

5. Should you repeat your experiment? Why or why not?

6. What are the **independent** and **dependent** variables in your experiment?

Independent variable = _____

Dependent variable = _____

7. Graph what you would expect to observe if your results supported your hypothesis. Be sure to label both axes and include units.

8. Describe what conclusion(s) you could make if your results **supported** your hypothesis:	9. Describe what conclusion(s) you could make if your results **did not support** your hypothesis:

***Please turn the completed exercise in to a T.A. (and **make sure that your names are legible in order to receive credit**!) ***

Appendix A.2
Design Activity KEY

Name _____ Name _____

Name _____

- A **hypothesis** is a proposed explanation for a natural phenomenon. A **prediction** is a statement of what one expects to observe in a specific situation. A **null hypothesis** specifies what we should observe when the hypothesis being tested is wrong.
- There are several types of **variables**. Factors that are kept the same in experimental and control treatments—and which might affect the result—are called **controlled variables**. The variable that you manipulate—the one that differs between experimental and control groups—is the **independent** (or explanatory) variable. The independent variable is the factor that you think is driving change in a **dependent** (or response) variable.

You have been watching two different fields of poppies for the past month. You notice that poppies in one field (field #1) are growing at a different rate than the same species of poppies growing in a second field (field #2). You ask yourself the general question: Why do some poppies grow faster than others?

1. What are some possible explanations for your observation?
Sunlight, soil conditions, nutrient levels etc. may be different in the two fields

2. You develop a **hypothesis** about what causes changes in poppy growth rate (there are many different possible hypotheses). State your hypothesis in a complete, grammatically correct sentence. Remember that your hypothesis should explain your observation.
One possible hypothesis:
Poppies that are exposed to longer periods of sunlight convert more CO_2 into sugar and therefore grow at a faster rate.
Note: A hypothesis is not specific to a single situation but is valid under a broader set of conditions

3. State one **prediction** that can be made from your hypothesis in a complete, grammatically correct sentence.
Poppies germinated and grown under long hours of sunlight will grow at a faster rate than those germinated and grown under shorter hours of sunlight

4. Think of an experiment you could perform to test your prediction and then answer the questions below.

- What different conditions will you grow your plants in? Be as specific as possible about any conditions you will change e.g. time (hours), amounts (grams) you will use.
Plants will be germinated in two different conditions: 18 h light/6 h dark or 14 h light/10 h dark

- How many poppies will be grown in each condition (i.e. **your sample size**)? ____*>10*_____

- Why did you choose this number of poppies?
The experiment should be performed with a large enough sample size to minimize effects due to natural variability from one poppy to another.

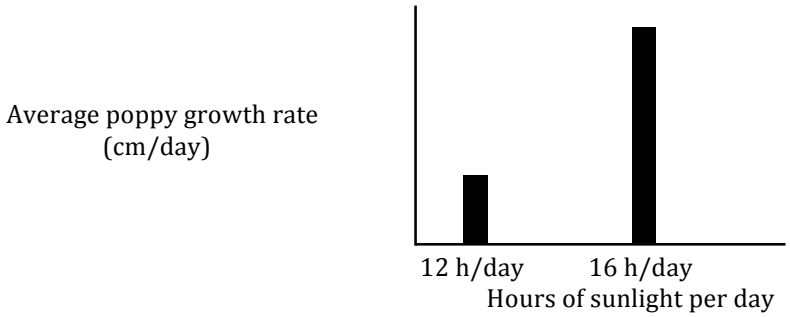
- What variable will you measure (i.e. what variable do you expect to change during the experiment)?
Poppy growth rate
  - How will you measure this variable? Be as specific as possible.
Length of stem in centimeters/day after germination
  - List 3 variables you will keep constant in your experiment (i.e. your controlled variables) and explain why you need to control these variables.
Many possibilities: amount of water each plant receives, fertilizer each plant receives, type of soil (e.g. clay, peat etc.), temperature, humidity, wavelength of light, exposure to insects etc.). These variables should be controlled because they represent viable alternative hypotheses i.e. differences in fertilizer may also influence poppy growth rate.

5. Should you repeat your experiment? Why or why not?
Yes, this experiment should be repeated several times. Consistent results indicate that the finding is repeatable and not due to any unforeseen variables that were not controlled e.g. time of day seeds were planted, location of plants within the greenhouse or differences between plots of land poppies were grown on outdoor

6. What are the **independent** and **dependent** variables in your experiment?

Independent variable = _____*Hours of sunlight*_____
Dependent variable = _____*Growth rate*_____

7. Graph what you would expect to observe if your results supported your hypothesis. Be sure to label both axes and include units.



8. Describe what conclusion(s) you could make if your results **supported** your hypothesis:	9. Describe what conclusion(s) you could make if your results **did not support** your hypothesis:
Increased length of sunlight results in increased poppy growth rate ***under these conditions, however a hypothesis cannot be proven, only supported or disproven.***	*Increased length of sunlight does not influence poppy growth rate* ***under these conditions***

***Please turn the completed exercise in to a T.A. (and **make sure that your names are legible in order to receive credit**!) ***

Appendix B.1
Analyze Activity

Name _____ Name _____

Name _____

- A **hypothesis** is a proposed explanation for a natural phenomenon. A **prediction** is a statement of what one expects to observe in a specific situation. A **null hypothesis** specifies what we should observe when the hypothesis being tested is wrong.
- There are several types of **variables**. Factors that are kept the same in experimental and control treatments—and which might affect the result—are called **controlled variables**. The variable that you manipulate—the one that differs between experimental and control groups—is the **independent** (or explanatory) variable. The independent variable is the factor that you think is driving change in a **dependent** (or response) variable.

1. You are given the data from Experiment #1 shown below. Each test group included 10 poppies of the same species, germinated in the same type of soil in a greenhouse. Plants were grown under controlled temperature conditions. The experiment was repeated three times with equivalent results.

Experiment #1

Variable	Test Group 1	Test Group 2	Test Group 3	Test Group 4
Water	10 ml	10 ml	5 ml	5 ml
Sunlight	8 hours	12 hours	8 hours	16 hours
Fertilizer	10 grams	20 grams	20 grams	20 grams

Results of Experiment:

Average growth of poppies per day	0.5 cm	1 cm	1 cm	1 cm

- How many poppies were included in each test group in Experiment #1? _____ (this is **the <u>sample size</u>**)
- Why is sample size important?

- What variable was being measured in Experiment #1? _____
- How was this variable measured? _____
- How many times was the experiment repeated? _____
- Why do you think the experiment was repeated?

- Aside from the variables listed in the table, what additional variables were controlled?

- Why was it important to control these other variables?

- Can Experiment #1 be used to test the statement "the amount of sunlight poppies are exposed to influences their growth rate"? (circle one) YES NO

If YES,	**If NO**, explain why not, and describe the experiment you would need to perform in order to test this statement.
1) State which test groups should be compared to test this statement : Test group # _____ and Test group # _____ 2) For the test groups you compared, list the following: Independent variable: _____ Dependent variable: _____ 3) Explain whether the results support or refute the statement and why	

- Are there any other conclusions about poppies that can be made based on the data shown in the table? Explain.

2. You are given the data from Experiment #1 shown below. Each test group included 10 poppies of the same species, germinated in the same type of soil in a greenhouse. Plants were grown under controlled temperature conditions. The experiment was repeated three times with equivalent results.

Experiment #2

Variable	Test Group 1	Test Group 2	Test Group 3
Water	5 ml	5 ml	10 ml
Sunlight	8h	16h	16h
Fertilizer	10 grams	20 grams	10 grams

Results of Experiment:

Average growth of poppies per day	0.5 cm	1 cm	1 cm

Can Experiment #2 be used to test the statement "the amount of sunlight poppies are exposed to influences their growth rate"? (Circle one) YES NO

If YES,	**If NO**, explain why not, and describe the experiment you would need to perform in order to test this statement.
1) State which test groups should be compared to test this statement : Test Group # _____ and Test Group # _____ 2) For the test groups you compared, list the following: Independent variable: _____ Dependent variable: _____ 3) Explain whether the results support or refute the statement and why	

- Are there any other conclusions that can be made based on the data shown? Explain.

***Please turn the completed exercise in to a T.A. (and **make sure that your names are legible in order to receive credit**!) ***

Appendix B.2
Analyze Activity KEY

Name _____ Name _____

Name _____

- A **hypothesis** is a proposed explanation for a natural phenomenon. A **prediction** is a statement of what one expects to observe in a specific situation. A **null hypothesis** specifies what we should observe when the hypothesis being tested is wrong.
- There are several types of **variables**. Factors that are kept the same in experimental and control treatments—and which might affect the result—are called **controlled variables**. The variable that you manipulate—the one that differs between experimental and control groups—is the **independent** (or explanatory) variable. The independent variable is the factor that you think is driving change in a **dependent** (or response) variable.

1. You are given the data from Experiment #1 shown below. Each test group included 10 poppies of the same species, germinated in the same type of soil in a greenhouse. Plants were grown under controlled temperature conditions. The experiment was repeated three times with equivalent results.

Experiment #1

Variable	Test Group 1	Test Group 2	Test Group 3	Test Group 4
Water	10 ml	10 ml	5 ml	5 ml
Sunlight	8 hours	12 hours	8 hours	16 hours
Fertilizer	10 grams	20 grams	20 grams	20 grams

Results of Experiment:

Average growth of poppies per day	0.5 cm	1 cm	1 cm	1 cm

- How many poppies were included in each test group in Experiment #1? *__10 plants*_____ (this is **the <u>sample size</u>**)
- Why is sample size important? *The experiment should be performed with a large enough sample size to minimize effects due to natural variability from one poppy to another.*
- What variable was being measured in Experiment #1? _____*growth rate*_____
- How was this variable measured? _____*cm growth per day*_____
- How many times was the experiment repeated? _____*3*__
- Why do you think the experiment was repeated? *Consistent results indicate that the finding is repeatable and not due to any unforeseen variables that were not controlled e.g. time of day seeds were planted*
- Aside from the variables listed in the table, what additional variables were controlled? *Temperature, species, soil conditions*
- Why was it important to control these other variables? *These variables represent viable alternative hypotheses i.e. differences in soil may also influence poppy growth rate.*
- Can Experiment #1 be used to test the statement "the amount of sunlight poppies are exposed to influences their growth rate"? (circle one) **YES** NO

If YES,	**If NO**, explain why not, and describe the experiment you would need to perform in order to test this statement.
1) State which test groups should be compared to test this statement : Test group # __*3*__ and Test group # __*4*__ 2) For the test groups you compared, list the following: Independent variable: _____*hours of sunlight*_____ Dependent variable: _____*growth rate*_____ 3) Explain whether the results support or refute the statement and why *The results refute the statement because there was no observed change in poppy growth rate when water and fertilizer were held constant, while hours of sunlight were increased. However, further experiments which tested other light conditions could build support for this statement.*	

- Are there any other conclusions about poppies that can be made based on the data shown in the table? Explain.
- *No. No conclusions can be made about the influence of fertilizer or water on poppy growth rate because there are no test groups which can be compared which hold other variables constant and only alter either fertilizer or water levels.*

2. You are given the data from Experiment #1 shown below. Each test group included 10 poppies of the same species, germinated in the same type of soil in a greenhouse. Plants were grown under controlled temperature conditions. The experiment was repeated three times with equivalent results.

Experiment #2

Variable	Test Group 1	Test Group 2	Test Group 3
Water	5 ml	5 ml	10 ml
Sunlight	8h	16h	16h
Fertilizer	10 grams	20 grams	10 grams

Results of Experiment:

Average growth of poppies per day	0.5 cm	1 cm	1 cm

Can Experiment #2 be used to test the statement "the amount of sunlight poppies are exposed to influences their growth rate"? (Circle one) YES **NO**

If YES,	**If NO**, explain why not, and describe the experiment you would need to perform in order to test this statement.
1) State which test groups should be compared to test this statement : Test Group # _____ and Test Group # _____ 2) For the test groups you compared, list the following: Independent variable: _____ Dependent variable: _____ 3) Explain whether the results support or refute the statement and why	*There are no test groups in which water levels and fertilizer are kept constant while sunlight is varied.* *You should repeat test group 1, but increase the fertilizer to 20g.* *You could then compare poppy growth rate between test groups 1 and 2 to determine whether sunlight influences poppy growth rate.*

- Are there any other conclusions that can be made based on the data shown? Explain.

No. No conclusions can be made about the influence of fertilizer or water on poppy growth rate because there are no test groups which can be compared which hold other variables constant and only alter either fertilizer or water levels

***Please turn the completed exercise in to a T.A. (and **make sure that your names are legible in order to receive credit**!) ***

Appendix C.1

Expanded EDAT (E-EDAT) prompt:

Advertisements for an herbal product, ginseng, claim that it promotes endurance. Prior to accepting this claim, and to determine whether or not this claim is fraudulent, you decide to perform a scientific experiment. Describe your proposed experiment and provide justifications for each aspect of your experimental design. Lastly, state whether the results of your experiment could prove the hypothesis that ginseng promotes endurance. This should take you approximately 10-15 minutes to complete.

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EXPANDED EDAT (E-EDAT) SCORING RUBRIC			
	0 points given	1 point answer	2 point answer
1. Identifies variable which will be manipulated	Other than Ginseng	Ginseng OR herbal product Note: not required to state that this is the independent variable	N/A
2. Identifies variable which will be measured	Other than endurance	Endurance Note: not required to state that this is the dependent variable	N/A
3. Describes how dependent variable will be measured	Not mentioned OR too subjective and unable to be verified (e.g. "give subjects a survey")	Reasonable outcome measure stated but no specifics/units provided. An activity with variable intensity should specify time and/or distance to receive 2 points. Examples: "run on a track or treadmill" without specifying time "run till tired" without specifying rate of running since subjects could be running at very different speeds	Reasonable outcome measure stated with specifics/units provided. Examples: "distance run in 30 minutes" "heart rate after 20 minute run" "time it takes to run 1 mile" "time run on treadmill with constant speed" "number of push-ups completed before getting tired"
4. Realization that other variables need to be held constant	Not mentioned OR Related to independent variable e.g. type of ginseng administered	Stated one reasonable variable that would be controlled Examples: -Related to subjects in trial (e.g. age, gender, ethnicity, fitness level, athleticism) -Related to environmental conditions during test (e.g. humidity, temperature, time of day) -Related to test itself (e.g. holding time constant between ginseng ingestion and endurance test) -Using same group of people for control group and test group (inherently controlled) -Randomly assigning individuals to control and treatment group (implying need to control subjects' attributes) -Acknowledgement that other variables need to be held constant without naming them specifically e.g. "many variables have to be controlled"	Stated two or more reasonable variables from examples under "1 point answer"

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5. Placebo or Vehicle effect: Recognition that "control" group should be kept as similar as possible to experimental groups	Not mentioned	Recognize need for placebo control but do not provide reasoning or provide incorrect/insufficient reasoning Examples: -Mention the word "blind" but do not explain what subjects are blinded from or why this is important (e.g. "do a blind experiment" -"participants should not be told what the study is testing i.e. ginseng effect on endurance" -"participants should not be told that they are in an experiment" -"placebo given to control for psychological effects"	Recognize need for placebo control and provide correct reasoning for this control Examples: "give one group a sugar pill and one group a ginseng pill" (implied that these are indistinguishable) "give both groups a similar looking treatment e.g. water and water + ginseng"
6. Sample size	Not mentioned	State large sample size but no reasoning or incorrect/vague reasoning provided Examples: "enough people for the study to make sure your results are accurate" "to increase accuracy " or "reduce distortion" "to obtain an average" "to get more valid data" "to eliminate outliers" (this is inaccurate since you do not eliminate the outlier, you decrease the effect of outliers) "more data is always better"	State large sample size and provide correct reasoning Examples: Need large numbers to obtain statistical significance, decrease effect of outliers **OR** to account for natural variability which exists within a population
7a. Repeat experiment	Not mentioned OR "NO", OR a possibility e.g. "experiment can be repeated"	YES, recognizes need to repeat an experiment	N/A
7b. Reasoning for repeating experiment	No explanation given OR incorrect reasoning e.g. "to increase sample size" or "so that a different variable can be changed"	Recognition that repeating an experiment will increase validity of results, but not making it clear that they understand why this is the case Examples: "to have more numbers" "more data is better" Need to repeat experiment to have more numbers/obtain statistical significance/**increase sample size** (recognition that repeating experiment will increase validity of results, but not making it clear that they understand **why** this is the case)	Provided appropriate justification for why it is important to repeat an experiment Examples: Recognition that there are external environmental or procedural differences impacting the study that may not have been recognized or controlled for (e.g. time of year, time of day, person implementing the trial, equipment used for measurements, other factors impacting participants)
8a. Conclusions that could be drawn	Not mentioned OR stated only as part of hypothesis/prediction	States what conclusion can be drawn but does not qualify the conclusion	States what conclusion can be drawn and qualifies the conclusion indicating an awareness that there are possible sources of

Appendix C.2

8a. Conclusions that could be drawn	Not mentioned OR stated only as part of hypothesis/prediction e.g. "we predict that people given ginseng will have increased endurance"	States what conclusion can be drawn but does not qualify the conclusion Example: "this study will show whether ginseng increases endurance" Note: 1 pt credit given for 8a if students make a hypothetical statement after they describe their experiment e.g. "if ginseng works we expect to see increased endurance" since many students did not consider their proposed experiment to have been completed.	States what conclusion can be drawn and qualifies the conclusion indicating an awareness that there are possible sources of error and that there are limits to generalizing a conclusion. Example: "under these conditions" "with this set of people" Note: 1 point credit given for 8a if student qualifies the potential findings even if no conclusion explicitly stated
8b. Results cannot prove your hypothesis	Not mentioned OR YES, can prove hypothesis	Recognition that you cannot prove a hypothesis but did not provide any reasoning/explanation Example: "No, this experiment alone cannot prove the hypothesis" Note: 1 pt credit given for "this experiment could show that	Recognition that you cannot prove a hypothesis but can only disprove a hypothesis or build support for a hypothesis Examples: "If ginseng increases endurance more than placebo this would suggest that the hypothesis is correct"

Total points = 17