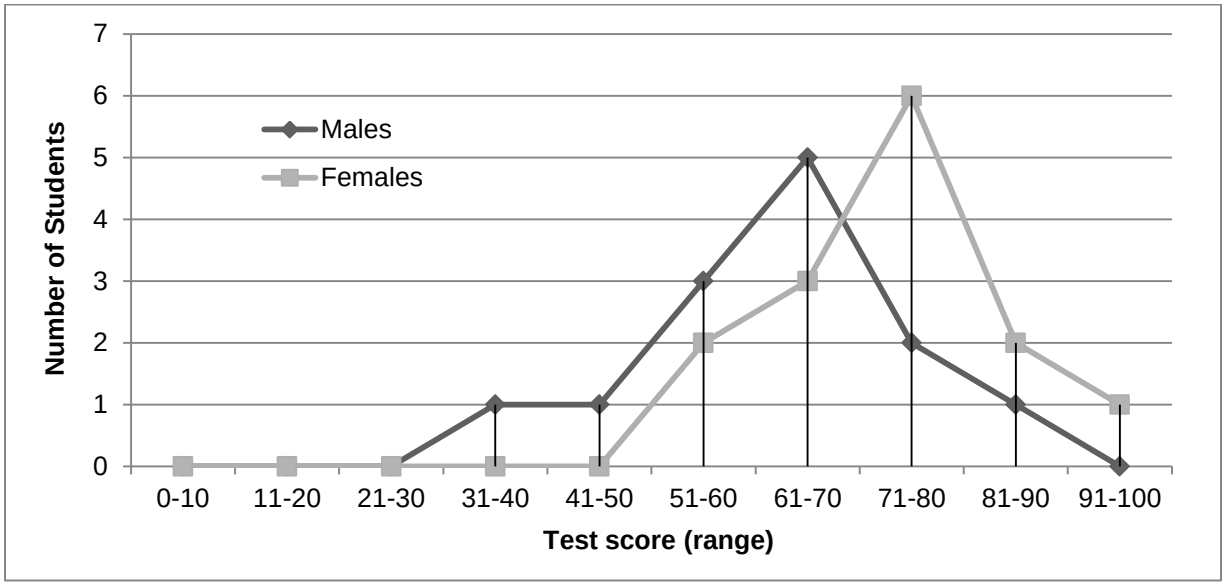
Part 1: Don’t get testy!

Introduction:

Ms. Smith, the high school English Language Arts teacher, made a graph of the exam scores from a recent test she gave her 27 students as she always did. This time, however, she decided to plot the results for the 13 males and 14 females separately. While there was considerable overlap in performance between male and female students, on average there was a slight difference between the groups.



1. As a group, who performed better on the exam males or females?

   _____

2. What is one possible reason that could explain the different performance of males and females on this English test?

   _____

   _____

3. Think of Ms. Smith’s English test as an experiment.

   a. What is the independent variable? _____

   b. What is the dependent variable? _____

Part 2: Do Male and Female Brains Work Differently?

Overview:

The following two neurological tests have been developed to test different types of memory. After taking one or both of the tests, compare the results for males and females in the class to determine if the results support the idea that male and female brains work differently.

Student Instructions

Memory Test #1 Instructions

1. Listen to the list of words read by your teacher.

2. Wait one minute after the last word is read.

3. Write as many of the words that you just heard as you remember in the table provided.

Scoring the test

4. After you finish writing the list of words, the teacher will read all of the words again. Place a mark next to all of the words that you remembered correctly.

5. Record your total # correct in the space provided.

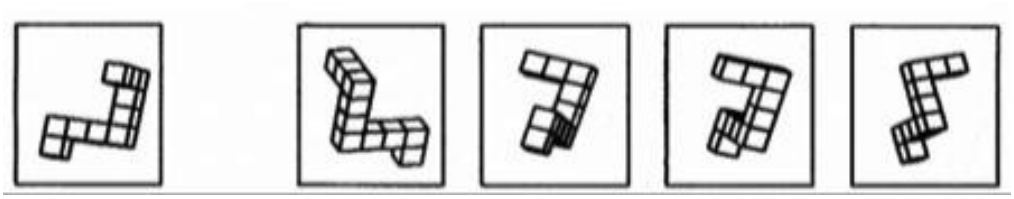
YOUR RESULTS	
Monday's Grocery List	Correct (√)
Your Total Number Correct	

Memory Test #2

1. The shape on the left is your model.

2. Of the 4 shapes on the right, 2 are the same as the model but have been rotated at a different angle.

3. Mark with an X below the 2 shapes that match the target. An example is given below.



X X

4. There are 8 total problems and you will have 5 minutes to complete them.

   Don't be upset if you don't finish as this is common.

<u>Scoring the test</u>

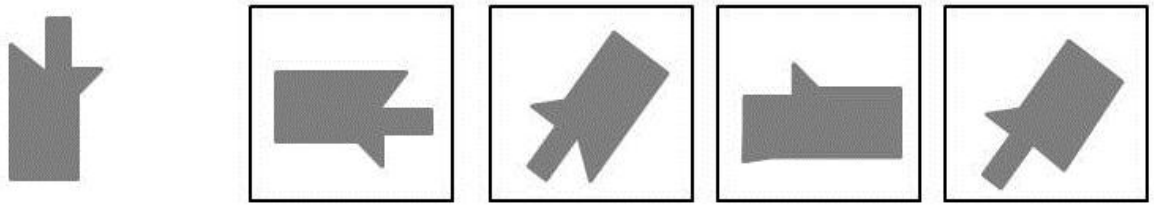
5. To score the test, you receive 1 point for each question in which you correctly identified BOTH of the matching models.

6. No points are awarded if one or more choices are incorrect.

Mark with an X below the two figures on the right that match the one on the left.

There are 2 pages and 8 total questions.

1.



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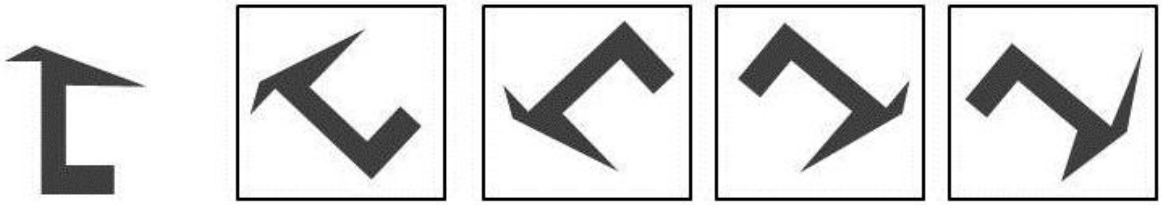

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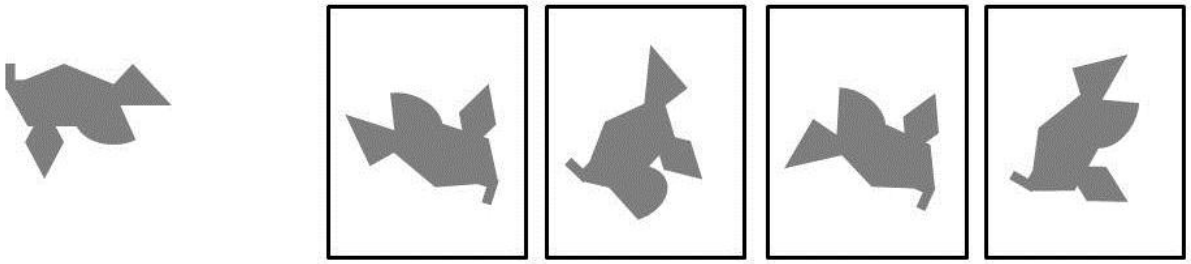

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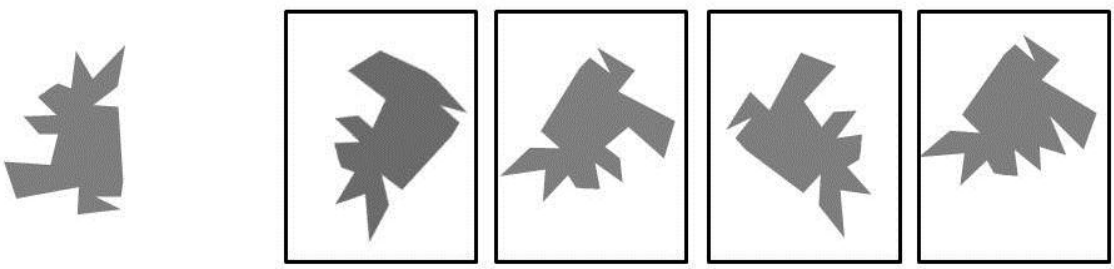

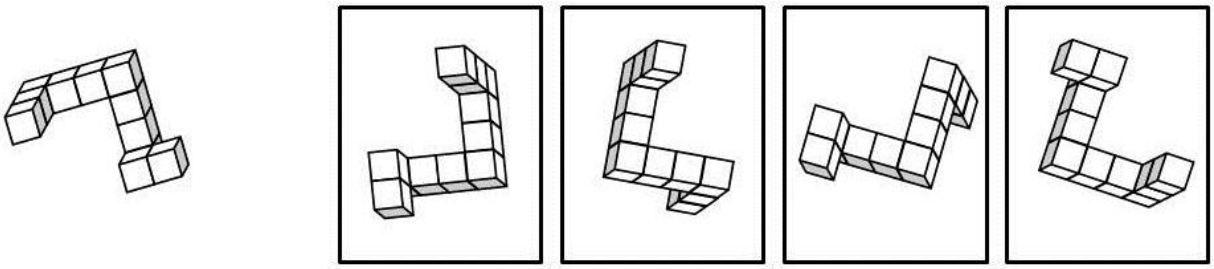

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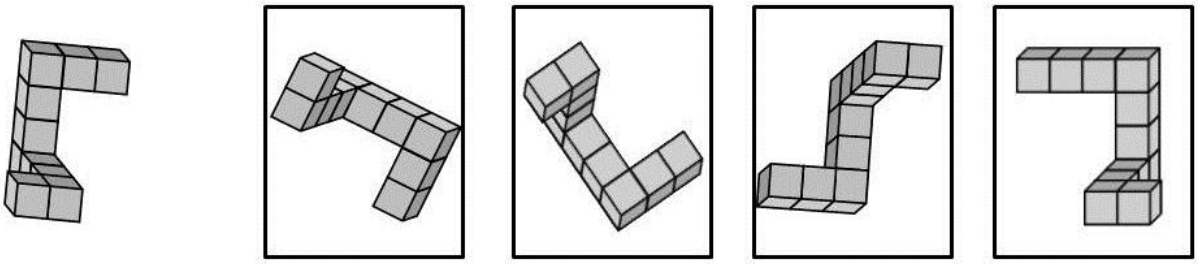

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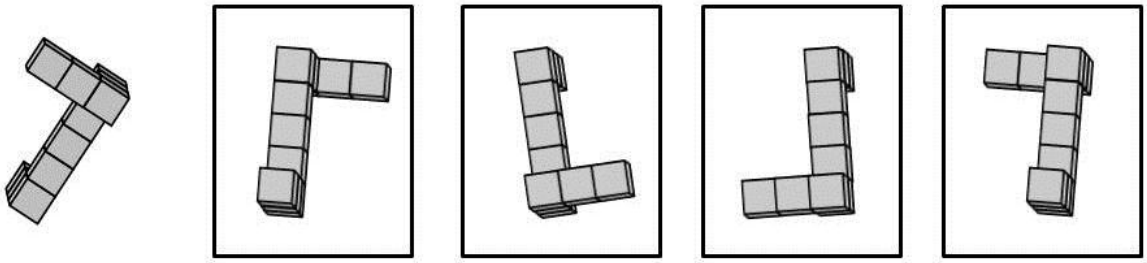

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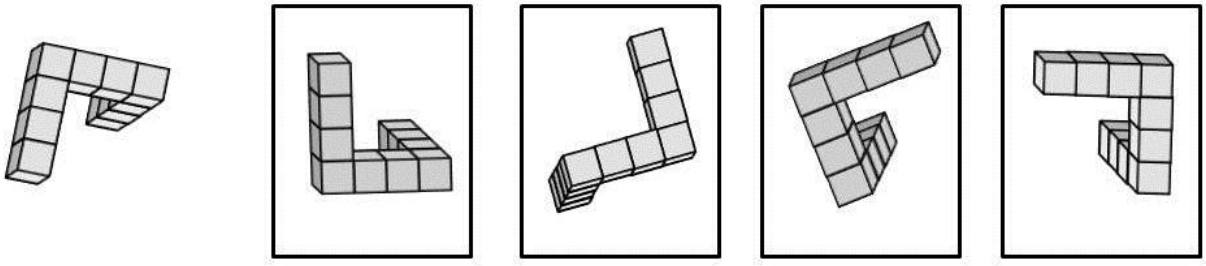


8.

Your Total Correct _____

VERBAL MEMORY--CLASS DATA		
	Total Correct	
Student #	Females	Males
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
AVERAGE		

SPATIAL ROTATION TEST--CLASS DATA		
	Total Correct	
Student #	Females	Males
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
AVERAGE		

1. Based on the class data, does it appear that males or females are better at either the verbal memory task or spatial rotation memory test?

_____

_____

Part 3-Are There Physical Differences in Girls and Boys Brains?

There have been a number of studies comparing the size of brain regions in males and females. More work still needs to be done, but there appear to be some differences in the sizes of some brain regions between male and female brains. **THESE REPRESENT AVERAGES OF MANY MALE AND FEMALE BRIANS. INDIVIDUAL MALES AND FEMALES MAY BE MORE SIMILAR TO EACH OTHER.**

Examine the **Brain Map** and answer the questions below.

1. Which brain region(s) is/are involved in memory?

   _____

2. What is/are the function(s) of the amygdala?

   _____

3. Place the **Male** and **Female Brain Map Overlays** over the **Brain Map** to identify regions of the brain where the average male and female brain may be different.

   - If the region appears only purple it indicates that region is similar in size between average male and female brains
   - **Where the pink overlay extends beyond the purple** indicates regions which tend to be **larger in female brains**
   - **Where the blue overlay extends beyond the purple** indicates regions which tend to be **larger in male brains**

Use the Brain Map and Male and Female Brain Map Overlay to complete the table below.

Brain Region	Function(s)	No difference or Larger in Males or Larger in Females
Amygdala		
Cingulate gyrus		
Hippocampus		
Hypothalamus		
Inferior temporal gyrus		
Lingual gyrus		
Prefrontal cortex		
Thalamus		

Part 4-Neurological Disease in Males and Females

Biology Brief: Understanding Human Neurological Disease

Biology and math are combined in the field of **epidemiology** (EPPY-DEE-ME-OLOGY). Epidemiologists study disease rates among the population. These types of studies have revealed that there are some neurological diseases that are more common in males and others that are more common in females (**Table 1**).

Table 1: Percentage of Males and Females in U.S. Population with Neurological Conditions

Neurological Condition	Females	Males
Parkinson's—Loss of motor control	0.01%	0.02%
Multiple Sclerosis	0.1%	0.03%
Mood Disorders (Depression)	5.9%	3.9%
Tourette's Syndrome	0.08%	0.23%
Autism	0.2%	0.8%

Questions:

1. Which neurological conditions affect more males than females?

   _____

2. Which neurological conditions are more frequent in females?

   _____

3. Provide two possible explanations for the differences in neurological disease rates between males and females? Explanations can include information presented in this lesson or other sources?

   _____

   _____

   _____

   _____

   _____

4. Provide an explanation for why there are no neurological diseases that affect only males or females?

   _____

   _____

   _____

Part 5-Hormones and the Brain

Biology Brief: Sex Hormones and the Brain

Hormones, chemical messengers released by specialized organs called endocrine glands, can travel throughout the body through the circulatory system. Hormones affect the development and function of other organs including the brain.

Humans have about 50 different hormones including some that are produced by the sex organs (testes and ovaries) called sex hormones. Testosterone and estrogen are two sex hormones that play important roles during development from embryonic stages through puberty and into adulthood. These hormones are best known for inducing the formation of secondary sex characteristics but testosterone and estrogen can also affect brain development. The level of sex hormones changes throughout development and can affect brain cells in different ways including:

- **Promote cell division** (mitosis)
- **Increase cell growth** (change in cell size and shape)
- **Induce cell death** (apoptosis)
- **Increase cell communication** (nerve firing)
- **Direct cell differentiation** (development of specific types of neurons)

There are many different types of nerve cells in the brain (like cortex nerve cells, hippocampus nerve cells, amygdala nerve cells). Different nerve cells may respond in different ways to the same hormone.

Questions:

1. Hormones are released by _____.

2. Answer the true false questions below.

Sex hormone levels do not change throughout development	TRUE	FALSE
Sex hormones are active only during puberty	TRUE	FALSE
Sex hormones can affect cell division in the brain	TRUE	FALSE

3. List three ways that sex hormones like testosterone can affect brain cells.

_____ _____

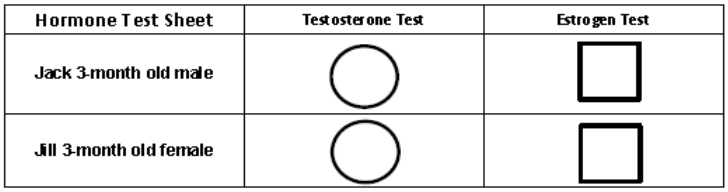
_____ _____

Overview:

The hormones testosterone and estrogen can be detected in the blood plasma (liquid part of the blood). Your lab kit contains samples of blood plasma collected from Jack and Jill, 3-month old male and female fraternal twins. Your goal is to determine if there are any differences in testosterone or estrogen at this critical stage of brain development.

Follow these instructions to determine the levels of testosterone and estrogen in each of the blood plasma samples.

1. Place 1 drop of Jack's plasma sample in the top circle and the top square.



2. Using a clean dropper place 1 drop of Jill's plasma sample to the bottom circle and bottom square.

3. Using a clean dropper add 1 drop of Testosterone Test Solution to both of the circles. Use the COLOR CHART to record your results below.

4. Carefully place a piece of the Estrogen Test Paper onto both of the squares. Use the COLOR CHART to record your results below.

Patient	Testosterone Level (nanograms/100 ml)	Estrogen Level (nanograms/100 ml)
Jack, 3-month old male		
Jill, 3-month old female		

4. Based on the information in the data table:

- Which hormone (testosterone or estrogen) is most different between males and females at this stage? Explain your answer.

_____

_____

- Are either testosterone or estrogen secreted in only males or only females? Explain your answer.

_____

_____

Part 6-Sorting out the Signals

Biology Brief: The Steps of Hormone Signaling

Scientists are still trying to understand how exactly testosterone signaling can influence cells in the brain and perhaps lead to differences between male and female brains (**Figure 1**).

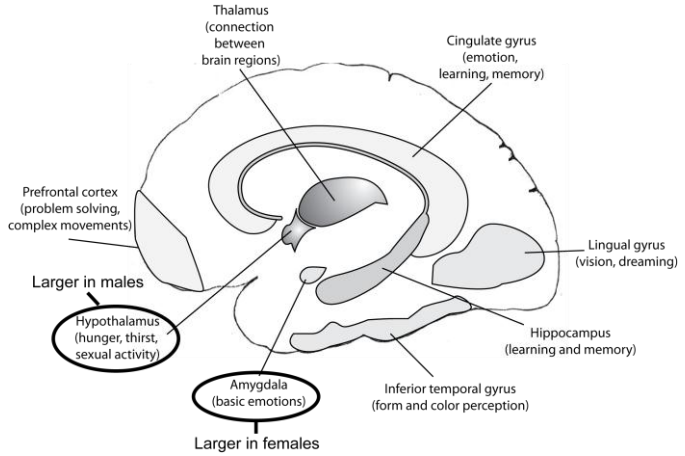


Figure 1: Testosterone signaling may contribute to differences between male and female brains.

Some of the major steps have been worked out. They include the following:

1. In the brain, testosterone can bind to proteins called testosterone receptors within neurons. Unlike many receptors, testosterone receptors are found in the cytoplasm not at the plasma membrane.
2. After binding to the testosterone, testosterone receptors enter the nucleus. In the nucleus, testosterone receptors bind to DNA and other specialized proteins to turn on or off transcription (expression) of other genes.
3. Genes activated by testosterone signaling are then translated into proteins in the cytoplasm by ribosomes.
4. Proteins turned on or off by testosterone signaling can then affect neuron functions such as:
    - **cell division** (mitosis)
    - **cell growth** (change in cell size and shape)
    - **cell death** (apoptosis)
    - **cell communication** (nerve firing)
    - **cell differentiation** (development of specific types of neurons)

The effects of testosterone can be different in different nerve cells because these cells may already have different proteins present before receiving the testosterone signal. These other proteins may then change how the cell responds to the testosterone signal.

Activity- Following the Signaling Steps

Overview: The goal of this activity is to help demonstrate how testosterone can affect neurons in different brain regions in different ways. This may help explain the average differences in size observed between males and females in certain brain regions like the hippocampus and the amygdala.

Instructions:

- Obtain the following supplies from your teacher
  - **Hippocampus Neuron** sheet
  - **Amygdala Neuron** sheet
  - **Testosterone Signaling Pathway** overlay
- With the **Hippocampus Neuron and Amygdala neuron** models in front of you determine if the following cell parts are present and where they are located within the cells.

	Hippocampus Neuron		**Amygdala Neuron**	
Cell Part	**Present** (√)	**Location** (plasma membrane, cytoplasm or nucleus)	**Present** (√)	**Location** (plasma membrane, cytoplasm or nucleus)
Protein B <u>GENE</u>				
Testosterone Receptor				
Protein B				
Ribosome				

Questions:

1. What cell part(s) is/are the same in both the Hippocampus and Amygdala neurons?

_____

_____

2. What cell part(s) is/are different between the Hippocampus and Amygdala neurons?

_____

_____

Instructions (continued)

- Model the effect of hormone signaling by positioning the **Testosterone Signaling Pathway Overlay** onto the **Hippocampus Neuron** so that the testosterone molecules (resembling a T) are fit into the Testosterone Receptors.
- Cut out the **Signaling Step Tags** below and place them in the spaces near the numbers on the **Testosterone Signaling Pathway Overlay** to identify what is happening at each step.
- Complete the table below when you are finished.

Step	Label used
1	
2	
3	
4	

Questions:

3. What may happen to the Hippocampus Neuron in response to testosterone signaling? (Hint: refer to step 4)

   _____

Note that we can only what MAY happen to the cell because the result will depend on the exact timing and amount of testosterone signal received by the neuron.

Instructions (continued)

- Repeat this process with the **Amygdala Neuron** model and the testosterone.
- Answer the questions below using the model and the information in **Part 6-- Biology Brief: The Steps of Hormone Signaling**

Questions

1. Describe what happens in Step 2 of the model?

   _____

   _____

   _____

2. What may happen to the amygdala neuron exposed to testosterone?

   _____

Signaling Step Tags

cut along dotted lines

Translation

Receptor Binding

Transcription

Cell Effect

Extension Questions

1. How might testosterone's effects on these nerve cells contribute to the average differences between male and female brains presented in PART 2?

_____

_____

_____

2. Given what we know about the brain and male and female differences do you think that male and female students should be treated differently? Graded separately?

_____

_____

_____

_____

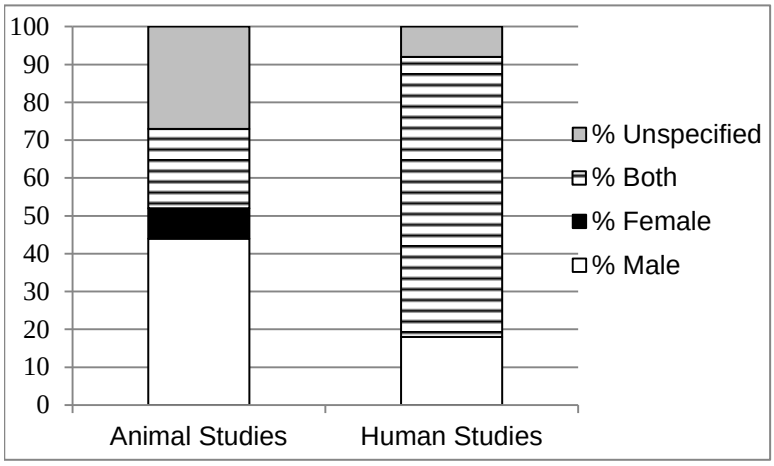
_____

_____

Part 7: Bias-ology

Animal models, like mice and rats, are one of the most critical ways that scientists can understand the causes and potential cures of human diseases. Though there are clearly diseases that are more common in females than males, most animal research is performed with male animals. A recent examination of published biological research revealed that in the field of neuroscience males were used 5 times more often than females in single sex animal studies.

Figure 1: Percentage of male and females included in published neuroscience research papers in 2009.



(Beery and Zucker, 2010, Neroscience Behavior Research)

Some scientists say using males is less expensive and easier than using female animals. For one, the hormonal cycle of female animals requires that hormone levels be measured and matched among experimental groups. This requires more time, animals, and money, which researchers argue is in short supply.

Others believe that animal studies must include male and female animals and compare them separately to determine if there are differences between the sexes. One possible negative consequence of not studying females is that new drugs that work in males may have unanticipated side effects in females. Supporters of female research also argue that studying females may benefit both males and females. In one case, researchers found that pregnancy decreased symptoms of multiple sclerosis in female mice. This has led to studies exploring whether female sex hormones can help treat this disease in males.

1. Approximately what percentage of non-human animal studies included females? _____

2. What are the arguments against using female animals to study disease?

   _____

   _____

   _____

3. What are the arguments for using females in animal research studies?

   _____

   _____