



M&M

Science and Math

by the

Science Chics

Presented by
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April, 2004

This CD-ROM is a compilation of activities we have collected during our teaching years. We do not take full credit for the activities presented in this workshop. We want to thank all the great science teachers across the United States that have helped us present the skills to be learned in a fun way. If the source of the activity is known we have given credit. We have changed some of them, but some came from other books and teachers over the past who have worked to make science and math more interesting and exciting for students.

THANKS EVERYONE!!

This CD-ROM is not for sale. It is solely a means of providing you with the activities in a format which you can easily modify the written instructions to meet your situation.



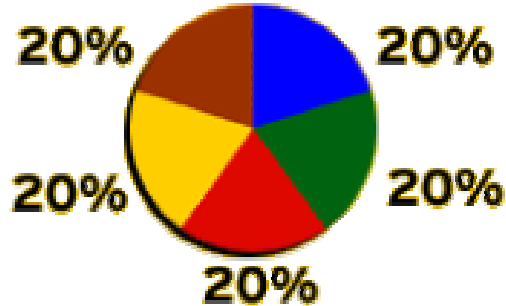
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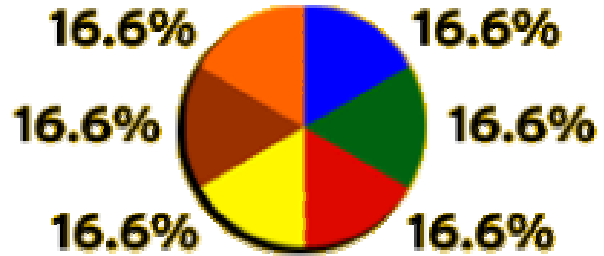
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Actual Color Distribution Comparison

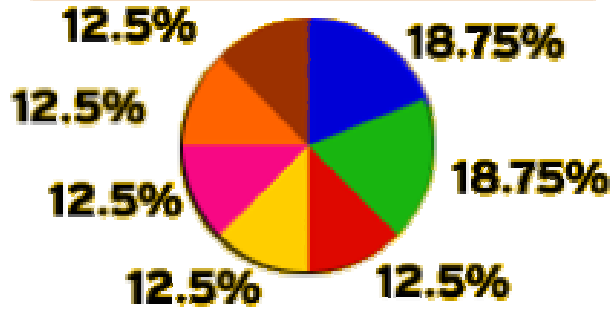
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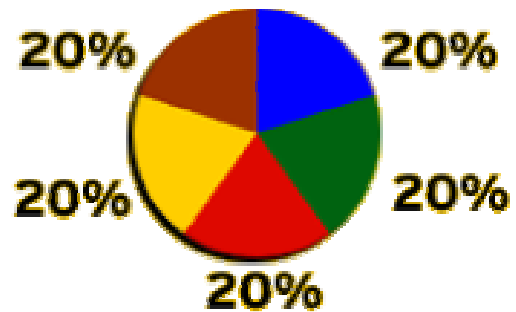
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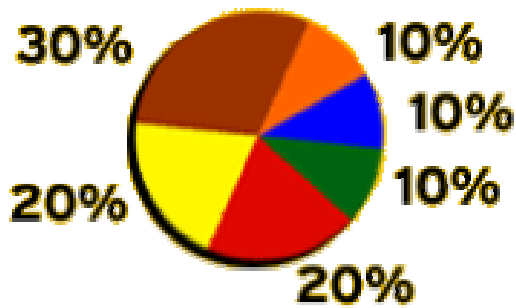
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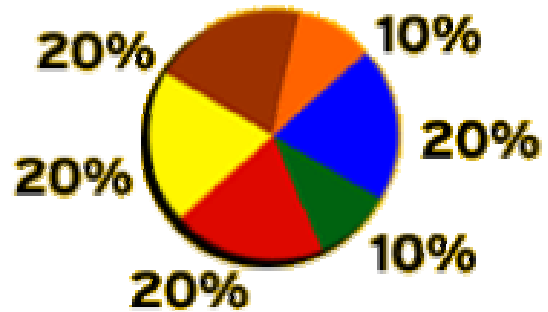
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M&M Counting Sheet

12						
11						
10						
9						
8						
7						
6						
5						
4						
3						
2						
1						
	Red	Blue	Brown	Green	Orange	Yellow

M&M Percent Composition

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Purpose: The learner will calculate the percent composition of familiar items as an introduction to calculating the percent compositions of compounds.

Materials for teacher:

- Overhead transparencies of Data Sheet 1, Data Sheet 2, and Data Sheet 3

Materials per pair of students:

- numbered bag of M&M's
- calculator
- Data Sheet 1
- Double-sided paper with Data Sheet 2 and Data Sheet 3 on each side
- numbered baggie of assorted items that are different colors (ex. paper clips, bingo chips, cut up construction paper, stickers, popsicle sticks, etc.)

Procedure:

1. The teacher will write the word "composed" on the overhead. The teacher will begin a discussion asking students questions like, "What is pizza composed of?" or "What is a pet store composed of?" After students answer a few similar questions, the teacher will ask the class to give a definition of the word "composed," and write the students' definition on the overhead.
2. Next, the teacher will ask the students some questions, preferably using visuals, where they would have to determine percentages. After students give answers the teacher will be sure to ask them how they determined the percentages and write their explanations on the overhead. Some sample questions might be, "What percentage of the students in this class is female?" or "What percentage of the people in the class are wearing jeans?" or "If you were making breakfast and you used 6 eggs out of the carton of a dozen eggs, what percentage of the eggs did you use? What percentage of the eggs was left over? Let's say you were still hungry after eating that huge omelet, and you made some scrambled eggs using 3 more eggs out of the carton. Now, what percentage of the eggs did you use and what percentage is left over?" The teacher will ask the class to provide a definition of the word "percentage," and will record the answer on the overhead.
3. The teacher will tell students that now that they are familiar with the words "composed" and "percentage," the words are going to be combined and the students are going to determine the percent compositions of mixtures of familiar things to them today.
4. On the overhead, the teacher will show the students a mixture of things like bingo chips, screws, bolts, hex nuts, paper clips, etc. The teacher will ask the students what the mixture is

composed of and how many things total there are. The teacher will record this information on the overhead Data Sheet 1. Next, the teacher will ask how many of each individual item is in the mixture, and will record the information in the chart. Next, the teacher will model how to determine the percent composition for each of the objects in the mixture. Then each pair of students will get a chance to practice and will be given a baggie full of different objects and Data Sheet 1. Once the pair is done completing the chart, the data must be shown to the teacher so that the teacher can make sure that the students are on the right track. Once the students are ready, they will be given Data Sheet 2 and a bag of M&M's and they will be instructed to continue their calculations.

5. After students calculate the percent compositions for each of the colors of M&M's, they must obtain the results from 10 other lab partners and record the information on Data Sheet 3. Then, the students need to calculate the average percent composition of each color.

Homework:

1. Create a mixture of four different objects which have the following percent composition:

Object A=11%

Object B=15%

Object C=45%

Object D=29%

Your mixture must be contained in a baggie.

2. Create a mixture of different objects and calculate the percent composition of each type of object. Bring in the mixture, enclosed in a baggie, along with the percent calculations for each object.

Extension:

1. Students could also measure the mass of each bag of M&M's. This allows them to also compare the masses of M&M's in each bag in addition to the number of M&M's.

An adaptation of an activity by Marie Duffin, Jillian Mackey, Elizabeth Tantum, and Jacqueline Bennett.

Data Sheet 2

Sample Bag # _____

Color of M&M	Number of M&M's	Percent Composition	Average Percent Composition
red			
orange			
yellow			
green			
blue			
brown			
	Total Number of M&M's in the bag		
	Average Number of M&M's in bag		

Data Sheet 3

Sample Bag # _____

M&M Color	Number of M&M's in Bag Sample #	Number of M&M's in Bag Sample #	Number of M&M's in Bag Sample #	Number of M&M's in Bag Sample #	Number of M&M's in Bag Sample #	Number of M&M's in Bag Sample #	Number of M&M's in Bag Sample #	Number of M&M's in Bag Sample #	Number of M&M's in Bag Sample #	Number of M&M's in Bag Sample #	Total Number	Average Number of M&M's	Average Percent Composition
Red													
Orange													
Yellow													
Green													
Blue													
Brown													
	Total Number of M&M's in this Bag	Total Number of M&M's in this Bag	Total Number of M&M's in this Bag	Total Number of M&M's in this Bag	Total Number of M&M's in this Bag	Total Number of M&M's in this Bag	Total Number of M&M's in this Bag	Total Number of M&M's in this Bag	Total Number of M&M's in this Bag	Total Number of M&M's in this Bag			

Data Sheet 1

Sample Bag # _____

Object	Number of Items	Percent Composition

M & M's and the Mole

OBJECTIVE

The student will determine how much of a mole of M&M's is in an average science classroom and how many classrooms would be needed to hold a mole of M&M's.

MATERIALS

dm³ cube
approximately 3 pounds of M&M's
meter stick
calculator
brain

PROCEDURE

1. Count the number of M&M's in one cubic decimeter (dm³) and record with the whole class of students.

_____ M&M's/dm³

2. Measure the length, width, and height of the classroom walls and record.

Length _____ Width _____ Height _____

CALCULATIONS

1. Calculate the volume of the room. (l X w X h)

Volume _____ m³

2. Calculate the number of M&M's in one m³.

$$\frac{\text{M \& M's}}{\text{dm}^3} \bigg| \frac{1000 \text{ dm}^3}{1 \text{ m}^3} = \frac{\text{M \& M's}}{\text{m}^3}$$

3. Calculate the number of M&M's in the room.

$$\frac{\text{M \& M's}}{\text{m}^3} \bigg| \frac{\text{m}^3}{1 \text{ room}} = \frac{\text{M \& M's}}{\text{room}}$$

4. Calculate how much of a mole is in one room.

$$\frac{\text{M \& M's}}{\text{room}} \bigg| \frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ M \& M's}} = \frac{\text{mole}}{\text{room}}$$

5. Calculate the number of rooms that would be needed to hold a mole of M&M's.

$$\frac{1 \text{ room}}{\text{M \& M's}} \bigg| \frac{6.02 \times 10^{23} \text{ M \& M's}}{1 \text{ mole}} = \frac{\text{rooms}}{\text{mole}}$$

ANALYSIS AND CONCLUSION:

1. Does a room hold an entire mole? _____

2. How much of a mole is in a room? _____

3. How many room would be needed to hold a mole of M&M's ? _____

4. Is there enough rooms in Arkansas to hold a mole of M&M's ? _____

5. Why do scientists use moles to evaluate chemical reactions rather than molecules?

M & M's in the package? (% Composition of Colors)

1. Count the total number of MM in your sample. _____

2. Count the number of each color:

Brown _____

Red _____

Green _____

Orange _____

Yellow _____

Blue _____

3. % of each color in your sample.

Brown _____

Red _____

Green _____

Orange _____

Yellow _____

Blue _____

4. Total number of MM in class sample (add all the group totals together) _____

Total of each color in the class sample: (add all the group totals together)

Brown _____

Red _____

Green _____

Orange _____

Yellow _____

Blue _____

5. % of each color in the class sample:

Brown _____

Red _____

Green _____

Orange _____

Yellow _____

Blue _____

Easter Egg Genetics

Anne Buchanan

Preparation:

Get some packages of plastic Easter Eggs (the kind that split into halves to fill with candy-- they are only available at this time of year, regardless of when you plan to do the activity!!!) and some matching-colored gumballs, jelly beans, skittles, etc to fill them. Get enough so that every student gets one or, preferably, two eggs each. Make a genotype and phenotype chart (for them) and key (for you) to accompany them. For example: (these are common colors of eggs that may be purchased)- (the letters represent the color of HALF of the Easter egg)

Chart: PP=purple
pp=pink
Pp=orange
BB=blue
bb=yellow
Bb=green

(an egg may be all purple, thus it is PP crossed with PP, or, it may be orange and pink, representing Pp x pp)

Key: purple x purple (PP x PP)= all PP or purple possibilities
purple x pink (PP x pp)= all Pp or orange possibilities
pink x pink (pp x pp)= all pp or pink possibilities
orange x orange (Pp x Pp)= 1 purple (PP), 2 orange (Pp) and 1 pink (pp)
orange x purple (Pp x PP)= 2 purple (PP) and 2 orange (Pp)
orange x pink (Pp x pp)= 2 orange (Pp) and 2 pink (pp)
etc (for any other colors)

Fill the eggs according to your key. For example, a (phenotypically) half pink and half purple egg would represent the genotypes PP x pp, each half of the egg representing the genetic input of one parent. Then, students would do a Punnett Square to determine what offspring would be possible from such a cross. The Punnett Square calculation reveals that all of the offspring would be genotypically Pp, or phenotypically orange. The candies inside would be appropriate colors to match the results of their Punnett Square so that they could check themselves to see if their calculations were correct. The students then get to eat the candy.

The cost (A bag of eggs is 79 cents, etc) and preparation time are minimal.

The Activity:

Introduce the concepts of dominance, recessiveness, related terms, Punnett Squares, etc. Pass out an egg that you have prepared to each student. (It is fun to let them select the color they like from an Easter basket, if that is politically correct in your environment.) Put a chart up on the board or overhead that indicates what trait is represented by the color of each half of the egg they are holding. Then, students examine their respective eggs, figure out the genotypes of their "parent" eggs, and do a Punnett Square to determine what offspring would be possible from such a cross. The candies inside would be appropriate colors to match the results of their Punnett Square so that they could check themselves to see if their calculations were correct. Collect your eggs back for next year.

Suggestions:

- 1) Have your students handle the eggs carefully, they break/crack easily if dropped or squeezed.
- 2) Have students put them back together before they return them so you don't have to "re-figure out" the halves the next time you set up the activity.

Optional modifications:

You might use white candy to represent albinos or smush some of the candies to represent the incidence of mutation or genetic disease.

M&M Detective Agency

Somewhere, USA

Your application for employment at our detective agency has been received and we are impressed with your credentials. However, as a qualifying test for the job, you must first solve a missing person case for us.

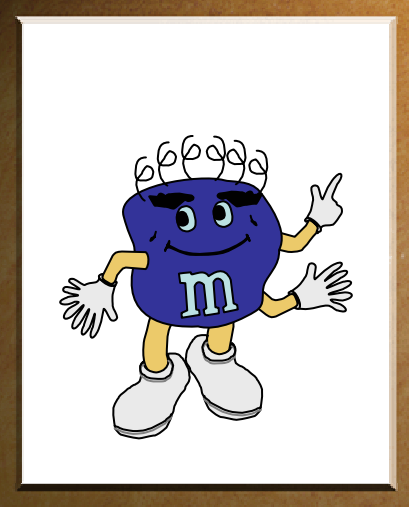
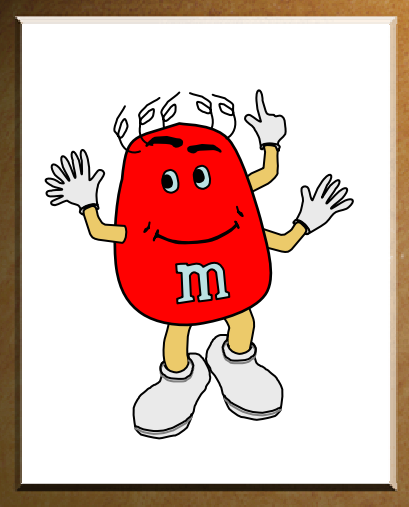
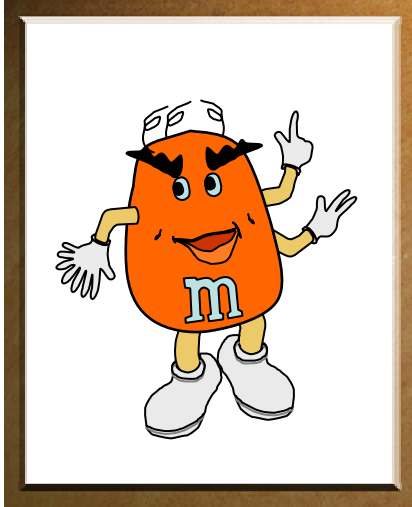
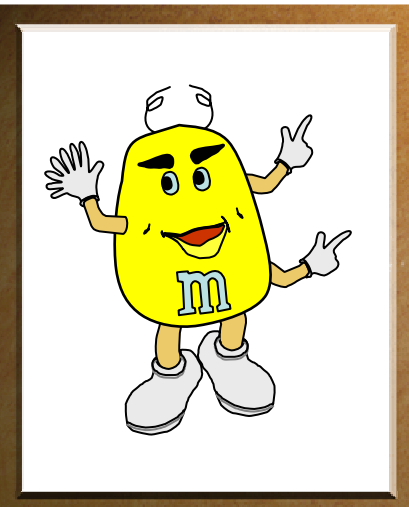
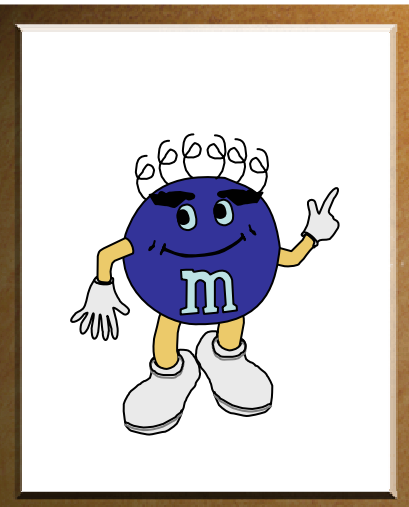
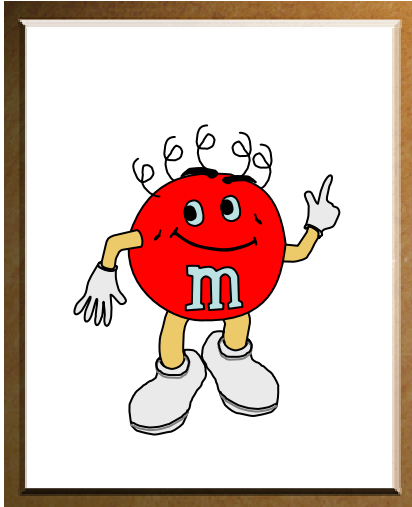
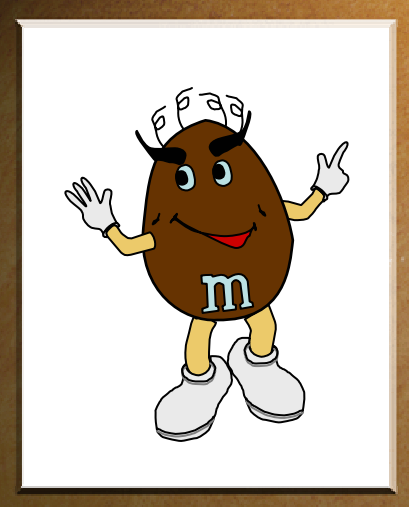
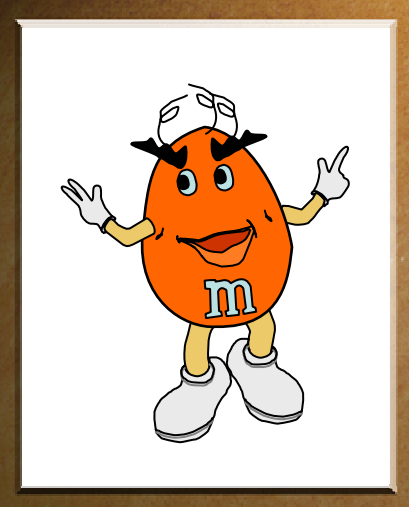
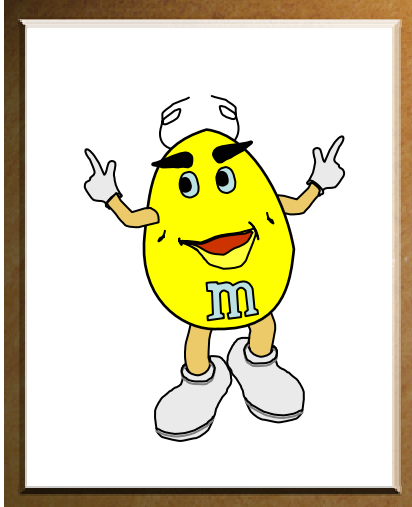
On Sunday, we were alerted by his family that a Mr. X is missing. However, there are no photographs of the person - only photos of the rest of the family.

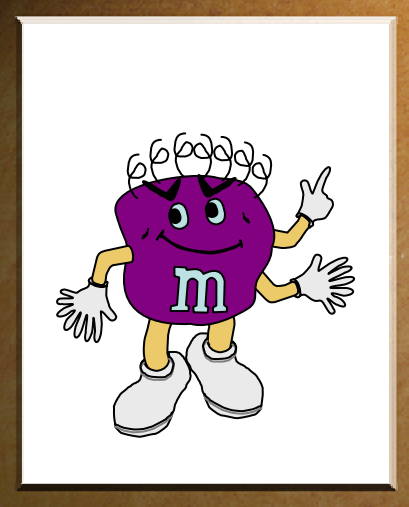
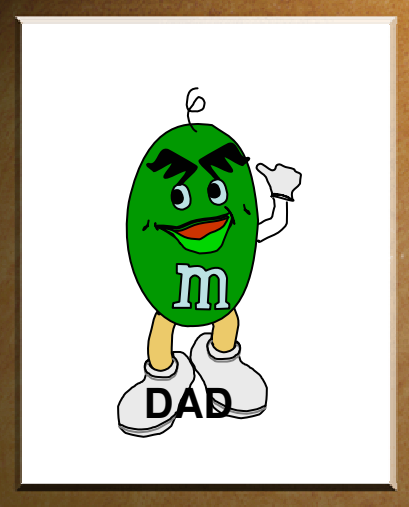
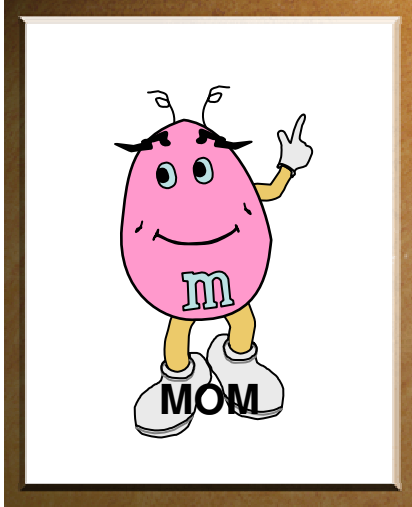
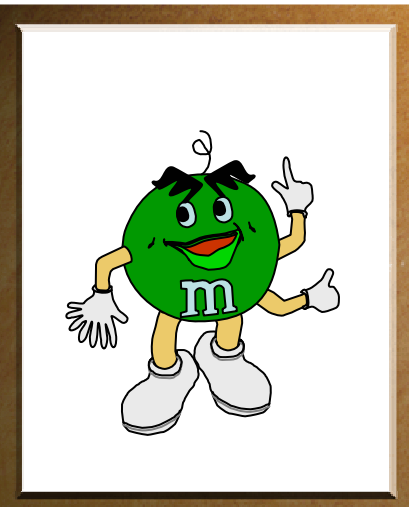
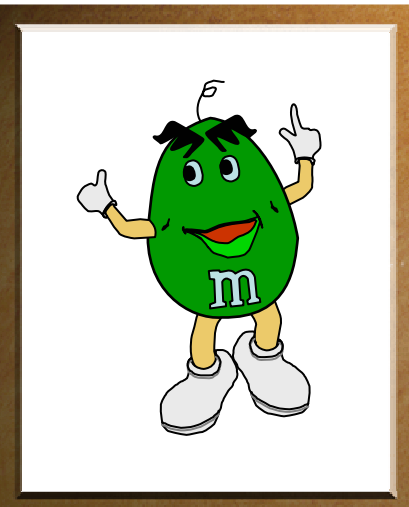
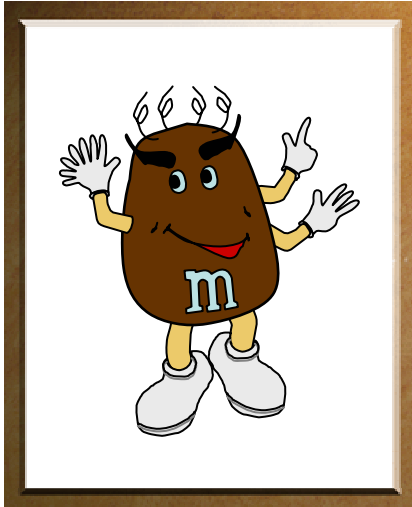
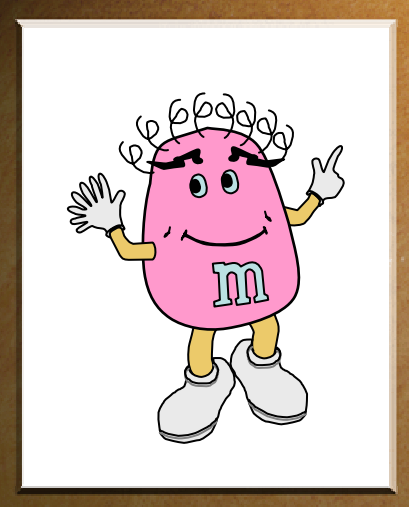
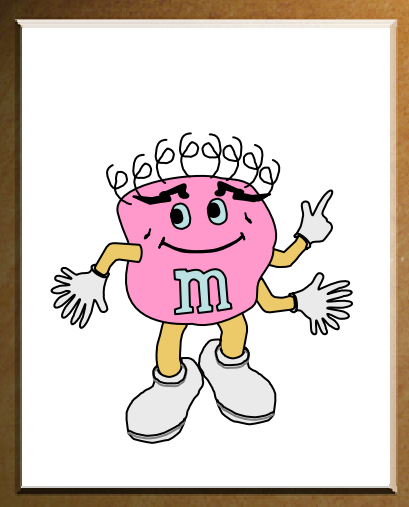
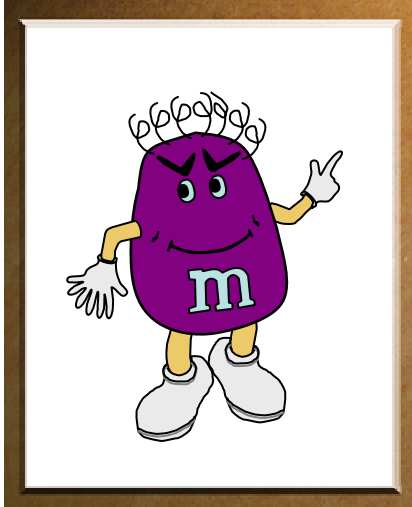
Your test for employment is to arrange the attached "photographs" of the family members in such a way that you can draw the missing person for us. Please let us know of your progress in this case ASAP.

Sincerely,

A handwritten signature in cursive script that reads "Miles + Michnowicz".

Miles and Michnowicz
Detective Team





The Science of M&Ms: Making Predictions

Activity Sheet

Problem I:

What would you like to know about the one pound bag of M&Ms?

Given the 1.6 oz. bag of M&Ms, can you predict how many M&Ms there are in the one pound bag?

Introduction:

How many people have seen and/or eaten M&Ms?

Based on your prior knowledge what can you tell me about them?

Data Collections:

No. of M&Ms

Colours

How many different colours?

How many each colour?

Of which colour are there the most M&Ms?

Objectives:

- Distinguish between observation, inference and prediction
- Form predictions based upon the given information
- Construct tests for predictions

Materials:

- 1.6 oz. bag of M&Ms
- Work Sheet: Its In The Bag

Procedure:

Part A

1. Given the 1.6 oz. bag of M&Ms bag and without opening the small bag predict how many M&Ms are in it.
2. Record your predictions on the worksheet- Its In The Bag

Part B

1. Without opening the small bag predict the colours of the M&Ms in the bag
2. Record our predictions on the worksheet
3. Without opening the small bag, predict the number of M&Ms for each colour predicted
Record your prediction
4. Now, ask yourself "how do I check my predictions?"
5. Open the bag of M&Ms to determine the actual number of M&Ms for each colour
6. How close were you to your predictions?

Part C (break into groups of four or five)

Given a one pound bag of M&Ms and based on the data you now have, can you predict how many M&Ms are in the one pound bag?

1. What is your plan to solve the problem for the one pound bag?
 - What is the problem?
 - What background information do I already have?
 - What new information do I need?
 - What procedure or sequence of actions do I need to follow?
 - How will I know when I have solved the problem?
2. What mathematical procedures would you need to conduct?
 - Averaging. Why?
 - Division of one pound bag by the weight of the smaller bags. Why?

Problem II:

Given the 1.6 oz. bag of M&Ms can we predict how many of each color there are in the one pound bag?

Procedure:

1. What is your plan to solve the problem for the one pound bag?
2. Record your prediction of color and the number of each color for the one pound bag?
3. How can we check your predictions?
4. How close were your predictions of the one pound bag of M&Ms?
5. What else would be necessary to confirm your results? (Is it necessary to compare results with the other one pound bags of M&Ms?)

Extension:

Black Box Syndrome: Is it necessary to open the one pound bag of M&Ms to check your predictions?

K-6: open one pound bag and check predictions

Need for immediate and positive reinforcement

Need for immediate positive feedback

IS/JHS: Is it necessary to actually open the one pound bag?

What about scientists working on theories or "Things that can't be seen."

Conclusions:

Learning is facilitated when students experience an intrinsic "need to know."

How do we establish this "need to know?"

One way is to design our instruction around a "discrepant event" which students seek to solve.

Its In The Bag Worksheet

Make your predictions about a bag of M&Ms in the columns opposite the questions:

	Predictions	Result
How many M&Ms are in the bag?		
How many _____M&Ms are in the bag?		
How many _____M&Ms are in the bag?		
How many _____M&Ms are in the bag?		
How many light M&Ms are in the bag?		
How many dark M&Ms are in the bag?		
How many _____M&Ms are in the bag?		

M&M Camouflage Game

Play an M&M camouflage game by mixing M&M's and candy corn in a bowl. (The corn candy camouflages the yellow and orange M&M's.) Ask each student to pick out the first five M&M's they see. Instruct the students not to eat the candy until the activity is concluded. Once each student has chosen his or her M&M's, make a class tally of the number of each color chosen. In most cases the orange and yellow M&M's will have lower numbers because they blend in with the corn candy. Discuss why some colors were chosen more often than others. Talk about how camouflage helps protect insects and animals in nature.

The Half-Life of M&Ms™

Lee Marek

Topic: Half-lives of radioactive substances

Time: 45 minutes to 1 hour

Materials

- 200 M&M's™ candies (“M&M's” is a registered trademark of Mars, Incorporated.)
- shoe box
- Half-life of M&M's Worksheet

Procedure

1. Place 200 M&M's™ chocolate candies in the shoe box, lettered sides up. The candies will stand for atoms of a hypothetical radioactive element.
2. Cover the box and shake it vigorously for 3 sec. This is 1 time interval.
3. Remove the lid and take out any atoms (candies) that have “decayed,” that is, that are now showing lettered sides down. Record on the data table the numbers of decayed and remaining atoms.
4. Replace the cover on the box, and shake for another 3-sec time interval. Record the number of “radioactive” atoms remaining.
5. Keep repeating time interval trials until all atoms have decayed or you have reached 30 sec on the data table.
6. Repeat the whole experiment a second time, and record all data. Average the number of atoms left at each time interval by adding the results from the two trials and dividing by 2.
7. Make a graph of your data showing the average number of atoms remaining versus time (follow the scale shown).
8. After how many time intervals (shakes) did one-half of your atoms (candies) decay?
9. What is the half-life of your candies?
10. If the half-life model decayed perfectly, how many atoms would be left after 12 sec?
11. If you increased the amount of atoms (candies), would the overall shape of the graph be altered?
12. Go back to your data table and for each 3-sec interval divide the number of candies decayed by the number previously *remaining* and multiply by 100. This will give you the percentage of candies decayed during each half-life. If the model worked perfectly, at every point exactly 50% of the candies would decay. Did it work perfectly? If not, what do you notice about how close the percentage came to 50% at each time interval? About how close did it come during the intervals of 3 to 12 sec? How close did it come during the intervals of 18 to 30 seconds? If you see any pattern, can you guess a reason for it?

What's Going On

The half-life of your candies should be about 1 time interval, or 3 sec. To solve this, first you need to know how many half-lives occur in 12 sec, in this instance 4. Then divide 200 by $\frac{1}{2}$ four times. This will give you a dividend of 12.5. So after 12 sec or four half-lives, you will have 12 to 13 atoms left. Since the half-life of an element is always consistent for that element, there will be no change. It would still take 3 sec for half your sample to decay, and it would take the same amount of time for another half to decay, and so on.

The shape of the graph would be the same. The model does not work perfectly. Generally the percentage of candies decayed is consistently close to 50% in the first few time intervals. At later intervals, it may vary widely. This is because this method of averaging depends on having a large sample—a large number

of candies for accuracy. With just a few candies, the percentage decayed can easily shift. This reflects a similar situation with actual radioactive half-life, which only works very accurately for large samples of atoms. Since atoms are so tiny, even a very little sample of a radioactive element will contain millions of them. In fact, if you had only 5 or 10 atoms of a given substance, the half-life of that substance would be useless for predicting when those individual atoms would decay, for the same reason that your model became inconsistent when you had only a few candies left.

Connections

All radioactive matter decays—that is, becomes non-radioactive over time. Scientists have found that each different radioactive element has a unique rate of decay. Half-life is a measure of these rates. The half-life of a radioactive substance is the period of time it takes for half a sample of that element to change into a non-radioactive element. Knowing the half-life of a substance does not tell us how long it takes for a single atom of that element to decay, which is unpredictable. Instead, half-life describes a sort of average: the time it takes for about half a large group of atoms to decay. Since the scale of atoms is so small, any visible sample of radioactive material contains a large number of atoms. This is why half-life is a useful concept for radioactive decay in our world. In this experiment, you investigated a model of half-life to find out more about how it works.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say “be careful with hot liquids” or “don’t cut yourself with the knife” does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don’t use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.
- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

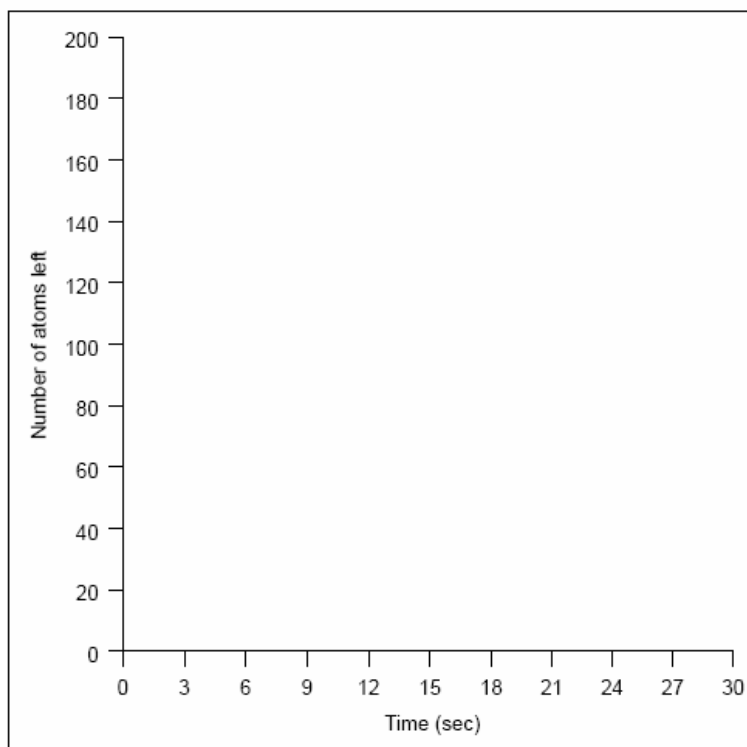
FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don't dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES

Half-life of M&M's Worksheet

DATA TABLE					
Trial 1			Trial 2		
Time (sec)	Atoms decayed	Atoms left	Time (sec)	Atoms decayed	Atoms left
0			0		
3			3		
6			6		
9			9		
12			12		
15			15		
18			18		
21			21		
24			24		
27			27		
30			30		



Radioactive Decay: A Sweet Simulation of a Half-life

Purpose

To demonstrate that the rates of decay of unstable nuclei can be measured, that the exact time that a certain nucleus will decay cannot be predicted, and that it takes a very large number of nuclei to find the rate of decay.

Context

This is the second lesson in a three-lesson series about isotopes, radioactive decay, and the nucleus. The first lesson, [Isotopes of Pennies](#), introduces the idea of isotopes. The final lesson, [Frosty the Snowman Meets His Demise: An Analogy to Carbon Dating](#), is based on gathering evidence in the present and extrapolating it to the past.

To do this lesson and understand half-life and rates of radioactive decay, students should understand ratios and the multiplication of fractions, and be somewhat comfortable with probability. Games with manipulative or computer simulations should help them in getting the idea of how a constant proportional rate of decay is consistent with declining measures that only gradually approach zero. The mathematics of inferring backwards from measurements to age is not appropriate for most students. They need only know that such calculations are possible. (Benchmarks for Science Literacy, [p. 79](#).)

In this lesson, students will be asked to simulate radioactive decay by pouring small candies, such as plain M&M's® or Skittles®, from a cup and counting which candies fall with their manufacturer's mark down or up. The exercise they will go through of predicting and successively counting the number of remaining "mark-side up" candies should help them understand that rates of decay of unstable nuclei can be measured; that the exact time that a certain nucleus will decay cannot be predicted; and that it takes a very large number of nuclei to find the rate of decay.

Planning Ahead

Materials:

[Radioactive Decay: A Sweet Simulation of Half-life](#) student sheet—one copy for each student

For each pair of students, you will need:

- a cup containing about 80 small candies such as plain M&M's® or Skittles®
- a paper towel

Preparation:

Before the lesson, you will have to weigh out about 80 candies for each group of students. If you count ten and weigh them, then multiply by 8, you will know how many grams of candy to weigh out for each group.

Duration:

This lesson can be done in two, 45-minute class periods. It may be combined with the [Frosty the Snowman Meets His Demise: An Analogy to Carbon Dating](#), which can be done while students are flipping their candies. In your planning, be sure to include time at the end of the lesson for students to post their data and share the class data.

Motivation

To help students understand the history of radioactivity, have them go to [Radioactivity: Historical Figures](#), on the Access Excellence Classic Collection site, to read about the contributions of Wilhelm Roentgen, Antoine Becquerel, Marie and Pierre Curie, and Ernest Rutherford.

As students read about these scientists, ask them to think about the following questions:

- What important discovery was made by Wilhelm Roentgen?
- What material did Antoine Becquerel work with in his own investigations of X rays?
- What did Becquerel discover through his experiments?
- What two elements were discovered by Marie and Pierre Curie?
- Why is Ernest Rutherford considered the father of nuclear physics? List Rutherford's major achievements.

Students can supplement this site with a visit to [Isotopes Project](#). Have them go directly to the Nuclear Structure Systematics Home Page. Once to that page, students should then go to the Isotope Discovery History, a graph of the number of known isotopes versus the date, and to the Chart of Aristotle and Plato (found at the bottom of the page), which the site planners cleverly call "the first chart" of isotopes.

Development

Tell students: "Today we will simulate radioactive decay to understand what we mean by half-life. Radioactive decay, also known as radioactivity, is the spontaneous emission of radiation from the unstable nucleus of an atom."

Ask students:

- In your own words, what do we mean by nuclear decay?
- What do you think is emitted during radioactive decay?

Have students go to the [Isotopes Project](#) website to look for more information about radioactive decay. Have students look at the [Glossary of Nuclear Science Terms](#) for alpha and beta decay.

Ask students to explain the terms in their own words.

Tell students: "Radioactive decay is a random process, like flipping a coin or other object that has its sides marked differently."

Ask students:

- What is the chance of getting heads on any flip?
- What do we mean by random?

After students have discussed these questions, tell them:

"We measure our rate of speed in a car in miles per hour. This method of measuring a rate won't work for radioactive decay. We know that radioactive substances disintegrate at a known rate, however. We call this rate the isotope's half-life. It is the length of time required for the disintegration of one-half of a given number of nuclei of a radioactive element. Let's begin with a small number. Suppose we have 100 nuclei of a radioactive isotope. After one half-life, half of the nuclei will have disintegrated, leaving 50 nuclei."

Ask students:

- How many nuclei will be left after the second half-life?
- How many would you predict will be left after the third half-life?

Have students write their answers to these questions in their science journals. At the end of the lab, give them the opportunity to revisit these questions and change or justify their answers.

Procedure:

Give each student a copy of the laboratory procedure called [Radioactive Decay: A Sweet Simulation of Half-life](#). You may group them in any size, but working in pairs is optimal for this exercise. Weigh out 80 candies for each group into cups before students arrive, as described in the Planning Ahead section above. Students should complete the Analysis section of the lab sheet, which will be used as part of their assessment.

Advise students to read through the simulation first so that they understand what they should do. After students have completed the activity, discuss the answers to the analysis questions with the whole class. Also, return to the questions you asked in the introduction to the lesson and allow students to revise their answers. If they haven't changed their answers, ask them to explain why.

Assessment

In addition to using answers to students' analysis questions and their graphs for assessment, consider having them respond to the following in their science journals or as a homework assignment:

Strontium is chemically similar to calcium. If you lived in a city where there had been a nuclear accident, you and your family might be exposed to strontium-90, which is the principal health hazard in radioactive fallout because it can easily get into the water supply or milk and then be ingested by people. Write about how the strontium-90 might accumulate in your body (teeth and bones) and how it might affect you. Include your ideas about how its half-life of 28.8 years would be important. Suggest ways that government agencies, such as your state's department of health, might test for strontium-90. Where in your environment might scientists look for large concentrations of strontium?

The Dating Game: Radioactive Half Half-Life and Dating Techniques

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Adapted from Darnell Giron M&M half-life in Earth at Hand A collection of articles from NSTA's journals. Collected by Sharon M. Stroud and Jeffrey C. Callister

Overview

Students will:

- employ a simplified model of radioactive decay to understand the concepts of decay,
- half life and absolute dating.
- construct a graph of the radioactive decay of an imaginary element and of ^{14}C
- use this new found knowledge to date an actual or contrived problem.

Grade Level/Discipline

Grades 7-9 Geology, Biology

National S Standards tandards

1. Content Standard B -Physical Science
2. Content Standard C - Life Science
3. Content Standard D - Earth and Space Science

Pre Pre-activity set set-up

Materials

For each group of 2-4 students:

a container (tupperware, shoe box etc. - NOT lab ware)

100 M&M's There must be exactly 100 M&M's for this activity to work successfully.

graph paper

pencils for each student

rulers to make data tables

map of Dry Valleys or TEA website (tea.rice.edu), (optional)

Time Frame

- 30 minutes of student work plus discussion.
- Follow up activities take about 30 minutes plus discussion.

Engagement and Exploration (Student Inquiry Activity)



Hillary Tulley saw these seals when she was in Wright Valley on January 27, 1999. Photo by [Elissa Elliott, TEA 1998/1999](#).

How far from the ocean are the seals? How can we find out? - Students will probably have a good idea how to do this. Invite a few students to calculate this using a map of Antarctica or of the Dry Valleys.

How old do you think these seals might be? How can we find out? How do we know? Now is the time to introduce the concept of absolute dating and half- life. (See Background).

Distribute student sheets and graph paper.

Go over student directions - sheets follow.

Before going into lab, students will make a data table, using a ruler and pencil.

Elicit suggestions from the class as to what needs to be in the data table:

- a title
- headings for the trials, "unchanged atoms."
- students will ask how many trials they should include in the table. Suggest 20 to start with and they can add if they need to.
- Ask students to suggest how they will find how many atoms are "unchanged." "Will they count them every time or subtract from the previous total? Subtraction will be easier! If your class requires an example, then give it to them.

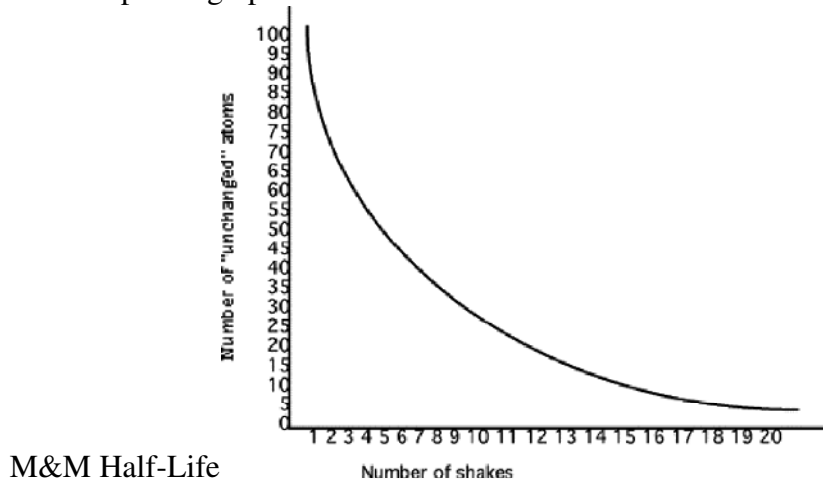
Trials	Number of "unchanged" atoms
1	
2	
3	
4	
5	
6	
etc.	

Part of the fun of this lab is eating the M&M's. Students can eat the daughter or "changed" M&M's. Encourage equitable sharing. However, if this is not something that you want to encourage, you can use pennies instead.

After students have completed the lab and recorded data in the tables, it is time to produce the graphs. Again, elicit from students what things need to be included in a graph.

- a title (M&M half-life?)
- labeling of the axes. This leads naturally into a discussion of the dependent and independent variables. The dependent variable is usually graphed on the "y" axis and the independent variable is placed on the "x" axis. Which is independent in this case? Trial number. Which is dependent? Number of "unchanged" atoms."
- Title the graph, label and number the axes.

An example of a completed graph follows:



Explanation (Discussing)

During the student's work and/or as a separate step after the graphs are completed, have the students explain what they have figured out about radioactive decay, half-life, isotopes, etc. from the exercise. In this model of halflife decay each shake is comparable to the passing of time; the number of "unchanged" candies is comparable to the number of unchanged atoms.

Which kind of the M&M's would be called parent? The "unchanged"

Which would be the daughter? The "changed."

Relate this to radioactive atoms.

Have them explain how they think scientists could use radioactive decay to determine time since an organism's death. Design a way for all students to demonstrate understanding by this point. How many "shakes" old would an organism be that had 15 "unchanged" atoms left? If we convert the shakes to years, could we use this to tell time?

Elaboration (Polar Applications)

Catch conceptual problems here or the rest of the activity will not teach what it is designed to teach.. This is a stop point if you have short class periods. Here I often have students gather information on radioactive decay to share the next day.

Use these assignments to see if the students can transfer what they should have learned to a new situation. The situation presented is based on a true finds but have been embellished to make more useful scenarios.

Teacher Discovers Death in Wright Valley, Antarctica

Students will be ready and eager to discover the age of the mummified seal from Wright Valley. Show the picture of the seal again and tell students that they will be able to determine the age of the seal by using the decay of carbon isotopes.

Eventually the scientists requested a ^{14}C radioactive dating test done on the seal's body. To their astonishment the test found that for every 100,000,000 ^{12}C atoms present in the seal's body, 4,100 radioactive ^{14}C atoms were present, instead of the 10,000 atoms expected for a recently deceased seal.

How long ago did the seal die? _____.

If your class can do it, give them the minimal information required: ^{14}C half-life is approximately 5,700 years and let them create their own table, graph and solution to the problem. Some classes may need the following table, but all can generate the ^{14}C graph on their own.

Radioactive Decay of Carbon-14

Years since death	^{14}C atoms remaining per 1.0×10^8 ^{12}C atoms
0	10,000
5700	5000
11,400	2500
17,100	1250
22,800	625
28,500	312
34,200	156
39,900	78
45,600	39
51,300	20
57,000	10
62,700	5
68,400	2

II. Murder Above the Arctic Circle

The body of a man wearing the traditional clothes of the Saami people was found at the bottom of one of the many peat bogs that remain from the last glacial retreat. Buried in the back of his skull was a stone ax, made in the archaic style. The stone ax head was sharpened by chipping and the blade was bound to a forked wooden handle by crisscrossed hide strips. Bog acid has tanned the man's skin. Although his skin is wrinkled and tightly drawn over his facial bones, his features are still distinguishable and his clothes and internal organs are still intact and available for police analysis. The withered condition of the body has convinced the police that the homicide happened at least 10 years ago. From forensic evidence, we can conclude that he was murdered in a different place, dragged to the bog and tossed in.

After months of investigation no new evidence or information was turned up Eventually the police requested a ^{14}C radioactive dating test done on the victim's body and clothes. To their astonishment the test found that for every 100,000,000 ^{12}C atoms present in the man's body, and clothes only 3,000 radio-active ^{14}C atoms were present, instead of the 10,000 atoms expected for a recently deceased person. This has greatly confused the police who had assumed that the murder was a recent event. How long ago did the murder take place?_____.

If your class can do it, give them the minimal information required: C^{14} half-life is approximately 5,700 years and let them create their own table, graph and solution to the problem. Some classes may need the following table, but all can generate the C^{14} graph on their own.

Radioactive Decay of Carbon-14

Years	^{14}C atoms remaining
since death	per 1.0×10^8 ^{12}C atoms
0	10,000
5700	5000
11,400	2500
17,100	1250
22,800	625
28,500	312
34,200	156
39,900	78
45,600	39
51,300	20
57,000	10
62,700	5
68,400	2

Exchange (Students Draw Conclusions)

Evaluation (Assessing Student Performance)

- Other scenarios you could create using radioactive decay rates:
- How old is the buried ice in Beacon Valley, Antarctica? Potassium/Argon Dating was performed. See background for half-life information. It was discovered that for every 100,000 atoms of Potassium 40, there were 1500 atoms of Argon-40.
- Burial grounds of Native Americans in your area.
- Mummies (Egyptian and Andean), baskets, pyramids, tombs
- Boat remains from Vikings
- Archaeologists from the future sifting through our landfills.

Rock of Ages- A Half-life Analog

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Grades: 6-12

Overview of Lesson: This exercise studies a half-life analogy and applies it to radioactive decay analysis. This large scale model will clarify how radiometric age dating is used to accurately date once living organisms or the age of rocks. The Parent atom and Daughter atom relationship will be examined.

Suggested Time: 45 minutes for data and graphing

Students' Prior Knowledge: Students should be familiar with the concepts of perimeter and area and also with using a grid for measuring. (Previous lessons on mapping and scale from this site are helpful).

Background Information: In radiometric dating, different isotopes are used depending on the predicted age of the rocks. Samarium-deodymium dating is used for very old rocks since these elements have a half-life of 108 billion years. Potassium/Argon dating is good for rocks 100,000 years old since Potassium 40 has a half-life of 1.3 billion years! And finally, Uranium/Lead dating since U-238 has a half-life of 4.47 billion years. It is used for dating zircon crystals in igneous rocks.

By comparing the percentage of an original element (parent atom) to the percentage of the decay element (daughter atom), the age of a rock can be calculated. The ratio of the two atom types is a direct function of its age because when the rock was formed, it had all parent atoms and no daughters.

Radiocarbon dating uses Carbon-14 which has a half-life of 5730 years. This is used for organic things such as wood, human artifacts made from once living organisms, and modern bone. Modern isotopic counting techniques (accelerator mass spectrometer) can date things as old as 70,000 years. This is done by counting individual C-14 atoms (the parents) remaining in the once living organism. A very accurate age can be determined. The daughter atoms (Nitrogen-14) are lost to the atmosphere as elemental nitrogen.

Materials:

- Gallon Ziplock bags
- M&M's
- Reese's Pieces
- Paper
- Pencil
- Graph Paper
- Graphical Analysis Computer Program

Student Activity

This lab has four parts: acquiring data, recording data, graphing data, and interpreting data. Each student will have a specific task during this lab. Everyone must complete the data table and graphs.

Student Tasks: Work in groups of three.

Person one (_____) is responsible for keeping track of the number of Parent Atoms. These will be represented by the M&M's.

Person two (_____) is responsible for counting the Daughter Atoms. Reeses Pieces will be used for these.

Person three (_____) is responsible for getting graph paper and organizing the group's graphing activity which will be done by all.

Procedure:

1. Place the M&M's (supplied by your teacher) in the ziplock bag and seal it. These candy pieces represent the _____.
2. Your group's total number of Parent Atoms = _____.
3. Shake the bag for several seconds and lay it on the table. Open it and remove only the candy pieces with the "M" showing. These are the Parent Atoms which transmute (decay) to a new element, the Daughter element.
4. Count the remaining and removed Parent Atoms. Record the numbers in the data table below. Do not put the removed Parent Atoms back in the bag. (DO NOT EAT THEM YET!)
Teacher Signature: _____ (necessary to continue)
5. Replace the removed Parent Atoms with an equal number of Reese's Pieces. These new candy pieces are the Daughter Atoms.
6. Record the number of Daughter Atoms added in the table below. Check your progress. The total number of M&M's and Reese's Pieces in your bag must be the same as the number of M&M's you started with.
7. Seal the bag and shake it for several seconds. Open it. Count and remove only the Parent Atoms with the "M" showing. Fill in your data table. Do not put the removed Parent Atoms back in the bag. (DO NOT EAT THEM YET!)
8. Replace the Parent Atoms you removed with the same number of Daughter Atoms.
Teacher Signature: _____ (necessary to continue)
9. Repeat the above procedure until all of the Parent Atoms have changed into Daughter atoms. This process is called transmutation.
10. At each step record the Parent Atoms removed and the Daughter Atoms added.

Data Table

Shake#	Total parent atoms	Total daughter atoms	atoms Number of half-lives	Calculated age (years)
0	0	0	C-14	K-40
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				

Graphing Data: Prepare a graph by labeling the X-axis with half-life (_____) and the Y-axis with radioactive elements (_____).

Complete both graphs.

Number of Half-lives VS. Total Parent Atoms.

Number of Half-lives VS. Daughter Atoms.

When you complete your graph, write your data on the board for each student to copy.

Summing Up:

1. Approximately what percent of the remaining PARENT Atoms did you remove after each shake? Why?
2. Each shake represents a "half-life" for the "M&M" PARENT Atoms. What does half-life mean? (Put this meaning in your own words. Check what your book has to say.)
3. If you started with 100 "M&M's", would the half-life change? Please explain.
4. Use a calculator to complete this question. In nature, Parent Atoms decay into Daughter Atoms in a predictable mathematical order. Half-life is defined as; "The time required for half of any given amount of a radioactive substance (Parent Atoms) to decay into another substance (Daughter Atoms)".

Try multiplying $\frac{1}{2} \times \frac{1}{2}$ over and over to determine if you ever get to zero.

$$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$$

5. Will a small amount of the Parent Atom always remain? Yes or No Carbon-14 has a half-life of 5730 years. How old would a real fossil be after eight Carbon-14 half-lives? Show your work. (Hint: Refer to your graph for help.)

Teacher Notes: Carbon-14 analysis of organic materials is of keen interest to paleontologists and the lay person alike. Recent development in the uses of accelerator mass spectrometry has greatly extended the usefulness of this technique. Currently, single atoms of C-14 can be counted and dates pushing 70,000 seem to be the limit. The element carbon has three isotopes, carbon-12, carbon-13 and carbon-14.

Both C-12 and C-13 are stable isotopes (C-12 has 6 neutrons and C-13 has 7 neutrons in the nucleus), however C-14 is unstable and radioactive. It decays through the loss of an electron (beta decay) into its daughter element, elemental nitrogen-14. The half-life of C-14 is 5730 years and is the time it takes any given amount of C-14 to change back to N-14.

Carbon -12 and 13 make up the vast majority of the carbon reserves in the Earth's oceans, atmosphere, fresh water and biosphere. This carbon exchange reserve consists of over forty trillion metric tons. Of that total, a mere sixty tons is C-14.

Due to the short half-life of C-14, the entire reserve would be exhausted in a few thousand years. Therefore, in order for C-14 to be used it must be continually renewed. This renewal happens when cosmic rays bombard the upper atmosphere and convert small quantities of nitrogen into C-14. As C-14 is lost through decay it is being created at a constant rate which creates a steady amount of C-14, the 60 tons mentioned before.

Since all green plants use carbon as basic building blocks during the process of photosynthesis, C-14 is present plant materials and animals who directly or indirectly depend on them. Once an animal or plant dies, the amount of C-14 in their tissues is not replaced. The C-14 begins to diminish at a constant rate. After 5730 years, half of the original amount has changed into N-14.

A theoretical difficulty with using C-14 is the assumption that the rate of cosmic radiation striking the Earth's upper atmosphere has remained constant over time. Clearly fluctuations have occurred, however enough is known about these changing rates for them to be allowed for.

Student Procedure: Have students work in groups of three and assign each a task. Have them write their names in the blanks and answer the questions #1. The total number of Parent Atoms will vary from group to group. A small plastic or paper cup filled about half way will yield about 25 plain "M&M".

The Teacher signatures serve two purposes. The first is to slow them down until each student has a chance to read the background. The second is to allow you a chance to see to it they understand the difference between parent and daughter atoms.

The second Teacher signature is a moment in time when you check if they are replacing the parent atoms with daughter atoms. This is when each group is given an equal number of Reeses Pieces which will be used as Daughter atoms.

Please note: This step is important because students must be reminded of the Law of Conservation of Mass. Atoms are neither created or destroyed. Parent atoms change into Daughter atoms and in this lab, students physically replace the parents with daughters. This models the Law of Conservation of Mass.

Date Table: Each shake represents a half-life. The total parent atoms will vary from group to group depending on the number of M&M's each is given. The Parent Atom data table column is wide enough so students can enter their group data and class totals. By completing both, the students begin to realize the significance of the definition of half-life when it mentions, "any given amount of radioactive material". No matter how much they begin with the calculated age remains the same for each parent atom.

The Calculated Age column is to be used by students to calculate the half-life years for two isotopes of different elements. The C-14 data will be used for student's to analyze the age of organic materials and the K-40 data will be used for the analysis of the age of rocks.

Graphing the Data: Students can use traditional methods to graph the data or computer programs to assist. In either case, it is recommended each student has his/her own graph. The parent and daughter curves must be labeled. Since the curve will be used for all types of decay, labeling them is not necessary.

Summing Up:

1. 50%, Each candy piece has two sides, therefore the chances of either side landing face up is 50%.
2. Half-life is defined as the amount of time necessary for half of any given amount of radioactive material (parent atom) to decay into another atom (daughter atom).
3. The half-life will not change. One can start with "any given amount".
4. Yes, a small amount of the parent Atom will remain. This concept is successive halves. No matter how far you multiply, a fraction of the whole will remain. In the case of C-14, eventually only a single atom will remain.
5. $5730 \text{ years} \times 8 = 45840 \text{ years}$.

National Science Education Program Standards:

A: All elements of the K-12 science program must be consistent with the other National Science Education Standards and with one another and developed within and across grade levels to meet a clearly stated set of goals.

B: The program of study in science for all students should be developmentally appropriate, interesting, and relevant to students' lives; emphasize student understanding through inquiry; and be connected with other school subjects.

D: The K-12 science program must give students access to appropriate and sufficient resources, including quality teachers, time, and materials and equipment, adequate and safe space, and the community.

E: All students in the K-12 science program must have equitable access to opportunities to achieve the National Science Education Standards.

F: Schools must work as communities that encourage, support, and sustain teachers as they implement an effective science program.

National Science Teaching Standards:

A: Teachers of science plan an inquiry-based science program for their students.*

D: Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. *

National Science Assessment Standards:

B: Achievement and opportunity to learn science must be assessed.

D: Assessment practices must be fair.

National Science Content Standards:

K-4: As a result of activities in grades K-4, all students should develop,

A - (Science Inquiry): abilities necessary to do science inquiry and understanding about science inquiry.

D - (Earth and Space Science): an understanding of properties of earth materials.

5-8: As a result of activities in grades 5-8 all students should develop,

A - (Science Inquiry): abilities necessary to do scientific inquiry and understandings about scientific inquiry.

D - (Earth and Space Science): an understanding of Earth's history.

E - (Science and Technology): understandings about science and technology.

G - (History and Nature of Science): science as a human endeavor, the nature of science and the history of science.

9-12: As a result of activities in grades 9-12, all students should develop,

A - (Science Inquiry): abilities necessary to do scientific inquiry and understandings about scientific inquiry.

C - (Life Science): an understanding of biological evolution.

D - (Earth and Space Science): an understanding of the origin and evolution of the earth system.

E - (Science and Technology): abilities of technological design and understanding about science and technology.

G - (History and Nature of Science): an understanding of science as a human endeavor, nature of scientific knowledge and historical perspectives.

Wisconsin State Science Standards:

A4.2

<http://www.dpi.state.wi.us/standards/scia4.html>

When faced with a science-related problem decide what evidence, models, or explanations previously studied can be used to better understand what is happening now.

C4.2

<http://www.dpi.state.wi.us/standards/scic4.html>

Use the science content being learned to ask questions, plan investigations, make observations, make predictions, and of explanations

C4.4

<http://www.dpi.state.wi.us/standards/scic4.html>

Use simple science equipment (including rulers, and computers) safely and effectively to collect data relevant to questions and investigations.

C4.5

<http://www.dpi.state.wi.us/standards/scic4.html>

Use data they have collected to develop explanations and answer questions generated by investigations.

C4.6

<http://www.dpi.state.wi.us/standards/scic4.html>

Communicate results of their investigations in ways their audiences will understand by using charts, graphs, drawings, written descriptions, and various other means.

Wisconsin Math Standards:

A.4.3

<http://www.dpi.state.wi.us/standards/matha4.html>

Connect mathematical learning with other subjects, personal experiences, current events, and personal interests: use math in a way to understand the other areas of the curriculum (e.g., measurement in science, map skills in social studies).

D.4.5

<http://www.dpi.state.wi.us/standards/mathd4.html>

Determine measurements by using basic relationships (such as perimeter and area) and approximate measurements by using estimation techniques

Simulating Fusion

“What surprised me most about this activity is how positive the kids were about this being the way to show the process. They all said they wouldn’t have understood this concept without the activity. I’ve never had such a unanimous response before from a particular activity.”

Eileen Bendixsen, Beers Street Middle School, Hazlet, NJ

Teacher Background

Is everything we see around us—rocks, gold, plants, humans—made up of fundamentally different material? Or are all these things composed of similar building blocks, differently arranged? And if so, what might those basic units be? Some 2,400 years ago, Greek philosophers wondered what would happen if something was divided into smaller and smaller pieces until you got to the ultimate limit where it could not be divided any more. They called this basic unit of matter an *atom* which means indivisible. We now know that atoms are not, in fact, the ultimate unit: atoms are made of protons, neutrons and electrons. And modern physics further breaks down protons and neutrons into “quarks” and other subatomic particles of many different kinds. This Activity focuses on perhaps the most fundamental process in our entire solar system, without which no other physical, chemical or biological process would exist—the fusion of hydrogen into helium which makes the Sun shine and our own existence possible.

The fourth state of matter and the most common throughout the Universe (though not on Earth) is plasma. Plasma is a gas-like mixture of positively charged particles (ions) and negatively charged particles (electrons). Most matter is electrically neutral, with its positively charged protons balanced out by negatively charged electrons. As particles of matter are heated, they move faster and as they move faster they collide with one another with greater force. When matter is heated to extremely high temperatures, as in the Sun’s plasma, the particles collide so violently that they break up into the smaller particles of which they are composed. These particles are electrically charged.

Fusion is the process that powers the Sun and the stars. In a fusion reaction the nuclei of hydrogen atoms fuse (come together) in a series of reactions to form a nucleus of the helium atom. The nucleus of the hydrogen atom is a single proton and two of these positively charged particles normally repel each other. But in a fusion reaction these nuclei come together with sufficient force to overcome this repulsion and fuse. During this process some of the mass is converted to energy, as shown in Einstein’s famous $E = mc^2$, (energy = mass x the speed of light, squared.) In order for a fusion reaction to occur, the particles must be hot enough so that they approach one another fast enough to overcome repulsive forces. There must be a large enough supply of particles, and they must be well contained, all of which conditions apply in the dense interior of the Sun.

In addition to giving students a model of the process which powers the Sun, this Activity also allows teachers a chance to outline how theories of matter have changed over time (a component of many state curricula).

Note: teachers may want to work this Activity through for themselves in advance, not only as a chance for a chocolate snack and an opportunity to census M&M colors, but also to ensure they feel comfortable with terms and procedures, in order to support students on a topic that may, at first, seem challenging.

Objectives

- Students will model the fusion reactions which power the Sun
- Students will show how particles in the Sun are transformed into other particles, releasing matter and energy

Vocabulary

proton, electron, neutron, nucleus, fusion, fission, chain reaction, isotope, gamma radiation, neutrino, erg

Materials

For each student, or student team, 4 containers:

- one “plasma soup” bowl
- two plastic cups (one to hold candy representing particles emerging from the transformation of other particles, and the other to hold radiation output from the reactions)
- a flat plate or saucer to “contain” or hold the fusion reactions.
- a small package of multi-colored candy: here we suggest the 47.9g Plain M&M’s and the color choices available in late 1998. (We’ve debated whether blue or green are the “rarest” M&M and therefore which color should represent neutrinos. Ah, the complexities of high energy physics.) You and your students can opt for different brands of candy, for example, Skittles, (“Smarties”, if in the U.K.) as long as your packages have at least 6 colors.

In this description, we have arbitrarily assigned colors to particles and radiation as follows:

- proton=red, neutron=brown, electron=yellow, gamma ray=green, positron=orange, neutrino=blue
- Only 2 gamma rays, or greens, and 2 neutrinos (blue) are required!

Engage

Each student (or team—depends on how many M&M’s you want your students to consume!) should have one “plasma soup bowl” (holding the red protons and the yellow electrons), a flat plate or saucer to provide a place for the fusion reactions to take place, a cup to hold radiation emitted by the reactions, and a cup to hold the M&M’s that represent the particles created by the transformation of the original hydrogen nuclei into new particles and energy. Put all the M&M’s apart from red and yellow in the “emergent” cup. (In this demonstration, for pedagogical purposes only, of course, some particles do get eaten up, but you should tell students that in the real Universe, there are no cosmic snackers chomping down candy: “energy is neither created nor destroyed.”) Discuss the difference between nuclear fission (the breaking apart of atomic nuclei) and nuclear fusion (the coming together of atomic nuclei.) On the chalkboard board make a diagram of each step of the fusion process (see below for step-by-step notation.) Make sure that students understand that there is energy (radiation and particles) produced at each step of the process, which is represented by the variously colored candies, but that what comes out to balance what goes in often looks very different.

Teacher Tip

“You will need to go through this reaction several times with your students. I first explained the reaction on the board. Then I talked them through one complete sequence of reactions several times. At this point I found that enough students understood the process and they began showing the students who did not understand—an intellectual chain reaction!” Eileen Bendixsen

Explore/Explain

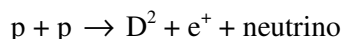
The following counterpoints actual processes in the Sun and “Candy Fusion” (not confusion, we hope!) Decide whether you want to talk students through the process, or have them work by themselves in groups—which will probably result in a certain amount of peer counseling as they coach each other through a pretty complex chain of reactions. But with a few repetitions (even if you run out of neutrinos and gamma rays!) they should have grasped the essence of perhaps the most fundamental concept without which life on Earth would not exist.

Setting up CANDY FUSION: Separate your atomic particles (all the M&M's) into 2 cups, one containing all the “input” bouncing around in the Sun's plasma soup (red protons and yellow electrons) and the other holding the “emergent particles” which will be created by the transformation of the protons and electrons: neutrons (brown), gamma rays (green), positrons (orange) and neutrinos (blue).

IN THE SUN: When two hydrogen nuclei (i.e. protons [p]) fuse, they form a deuteron (D^2), the nucleus of an isotope of hydrogen (deuterium) which has one proton and one neutron.

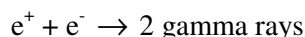
CANDY FUSION: Take 2 red protons from the input jar and place them on the plate. One red M&M is replaced by a brown neutron. For now, put the extra proton into the “radiation” cup.

IN THE SUN: When a positively charged proton changes into a neutron, to balance the energy equation (matter is neither created nor destroyed), one of the protons emits a positive particle, a positron (e^+), and a low-energy neutrino.



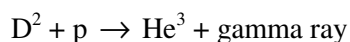
CANDY FUSION: Take the *former* proton in the radiation jar: since part of it has been transformed into the neutron, it's no longer really a proton but instead an orange positron and a blue neutrino. Substitute an orange and a blue M&M for the red one. (We guess that sometimes, in the interest of clarity in science education, matter *is* consumed. Eat the red M&M, but ensure students realize eating the red M&M is only a model!)

IN THE SUN: The positively charged positron collides with a negatively charged electron and they annihilate each other in a matter-antimatter reaction to become pure energy at gamma ray wavelengths.



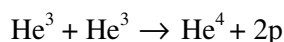
CANDY FUSION: Take a yellow electron from the input jar, and put it into the radiation cup. There it reacts with the orange positron and releases a gamma ray. Place 2 green M&M in the radiation jar. They are going to remain in the Sun for quite a while! But you might as well eat the yellow and orange M&M's—they're gone. And since neutrinos escape from the Sun at nearly the speed of light, and transform themselves into other particles, you might as well eat the blue M&M neutrino as well!

IN THE SUN: Meanwhile the deuteron (the proton and neutron combo) bumps into another proton and becomes a nucleus of light helium (H^3), 2 protons and one neutron. And this reaction also releases another gamma ray.



CANDY FUSION: Place one more red proton onto the plate and another green gamma ray into the radiation jar.

IN THE SUN: Next two light helium nuclei (each containing 2 protons and 1 neutron) meet and fuse to become a nucleus of regular helium He^4 with 2 protons and 2 neutrons, leaving 2 protons left over to continue the series of reactions amid the roiling sea of unattached protons and electrons.



CANDY FUSION: Take two more red protons from the plasma soup bowl, and one brown neutron, and move them onto the fusion reaction plate. Remove two of the red protons and place them back into the plasma soup bowl, leaving behind a nucleus of helium, and two more protons to continue the series of reactions. In reality so many protons bouncing around, you might as well eat the ones you're moving, though you know it's not completely realistic to do so!

Since this is the sweetest physics lesson you'll ever have, you're probably ready to walk through the real reactions in the Sun. And since there are so many particles in the Sun.

The Physics of Sunshine

“The Sun shines by a sequence of nuclear reactions called the proton-proton chain, in which four protons are fused together to form a helium nucleus that contains two protons and two neutrons. Each nuclear transformation releases 0.00004 erg of energy. This results from the fact that the mass of the resulting helium nucleus is slightly less (a mere 0.007 or 0.7 percent) than the mass of the four protons that formed it, and the missing mass appears as energy... that energy is multiplied by the huge number of reactions that occur inside the Sun every second. Roughly 100 trillion trillion trillion, or 10 to the thirty-eight (10^{38}) helium nuclei are created every second, resulting in a total mass loss of 5 million tons per second, which is enough to keep the Sun shining with its present, brilliant luminous output of 4 million, billion, billion, billion, or 4 times ten to the thirty-three ergs per second.”

Kenneth Lang, “Sun, Earth and Sky”, page 25

Expand/Adapt/Connect

In these kinds of fusion reactions, particles overcome the repulsive forces which normally keep them apart. A demonstration of this might involve blocks of wood, 1 or 2 weak springs and velcro. Two blocks of wood have a few strips of the two “polarities” of velcro placed on them, represent the attractive nuclear force. Two weak springs stretching between them represent the electromagnetic repulsive force. If the blocks are pushed towards each other gently, the springs will force them apart. If propelled together with a lot more energy, they will stick.

Use a periodic table to compare the mass of one helium atom to the mass of four hydrogen atoms. Discuss what happens to the difference in mass. The particle that is produced in the first step of the reaction is called a positron. Have students compare the positron to an electron. Both have almost no mass and a single unit charge, but a positron has a positive charge and an electron has a negative charge. Have students draw a model of the fusion reaction.

Have students research one of the scientists who contributed to our current model of the atom, or to the periodic table, and present their research to the class. Have students make 3D models of Rutherford's, Bohr's and our current model of the atom. Incorporate key discoveries in atomic theory and the idea of fusion in a timeline.

Suggested URL's

<http://fusedweb.pppl.gov/>

Princeton Plasma Physics Laboratory site features eight ways to learn about fusion energy.

<http://FusionEd.gat.com/>

General Atomics Fusion Group: a fusion slide show and teacher resources on the electromagnetic spectrum.

<http://www.chem4kids.com/chem4kids/index.html>

A great site for students to learn about the periodic table, atoms, and chemical reactions.

<http://www.chemicalelements.com/>

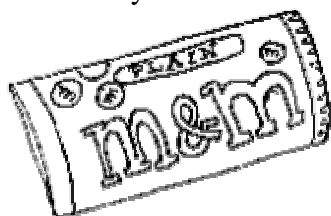
Good site for middle school students. Includes periodic tables with atomic mass, atomic number, and electron configuration, and pictures of the atomic structure of each of the elements.

© PASSPORT TO KNOWLEDGE

M&M Science: Chromatography

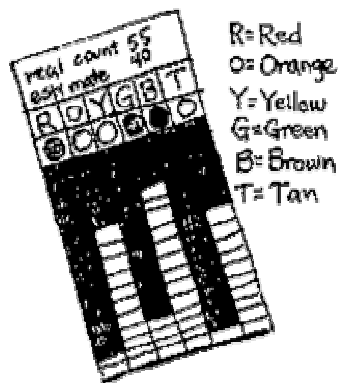
by Nancy Blakey

Nancy Blakey: This is science at its best - hands-on, interesting and full of concepts that become deliciously clear.



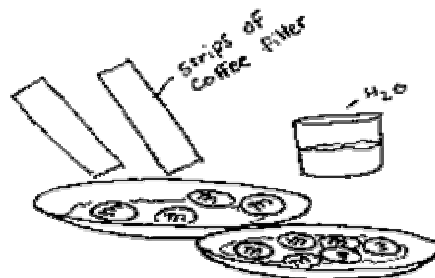
What You Will Need:

1 package plain M&Ms per child
1 glass of water
white coffee filter
paper and colored marking pens



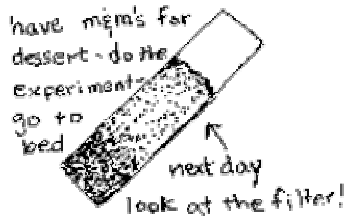
Your child should first feel the package of M&Ms before it is opened and make an estimate of how many candies are in the bag. Write down the estimate. Open the package and count the number of M&Ms. Write down the actual number. Now, you are going to make a graph. Across the top of the paper, write down the different colors of candies and draw lines down the paper separating each column. Find colored marking pens that match the colors of candies. With each candy counted in the color categories, make a mark with the pen. Don't eat them yet!

When the graph is finished, it is time to move on to the science of chromatography. Cut the coffee filter into two long sections. Next take two yellow, two green and two light-brown M&Ms and place them on a small saucer. Take two red and two dark-brown candies and place them on another saucer. Add one teaspoon of water to each saucer and stir the candies around in it until all the color is washed off. Now you can eat the wet ones! Take a strip of filter and place a third of its length onto the colored water of one saucer; repeat with the other strip of filter. Leave overnight or for several hours.



What happens? The dyes in the candies are absorbed by the filter at different rates, causing them to separate again on the filter (they will not separate into exactly the same colors of your M&Ms, however). This process is called "chromatography." Even though the colors were mixed together

physically, the atoms and molecules actually remain separate in the water. Chromatography is the process that demonstrates this concept.



Source: [More Mudpies: 101 Alternatives to Television](#). Copyright © 1994 by Nancy Blakey. All rights reserved. This activity was reprinted with permission from Tricycle Press and may not be reproduced in any manner, including electronic, without prior written approval from the publisher.

Chromatography of Foods

Chromatography is a separation technique for mixtures. It is based upon the relative attraction of the components of the mixture for the mobile phase (water) and the stationary phase (paper).

Separating a mixture of FD&C dyes will allow students to practice this technique.

Materials Substitutions

filter paper—about 15 cm. in diameter coffee filters

toothpicks

jar lid – about 4 cm in diameter

petri dishes

food coloring sets-4 vials

Orange Kool Aid

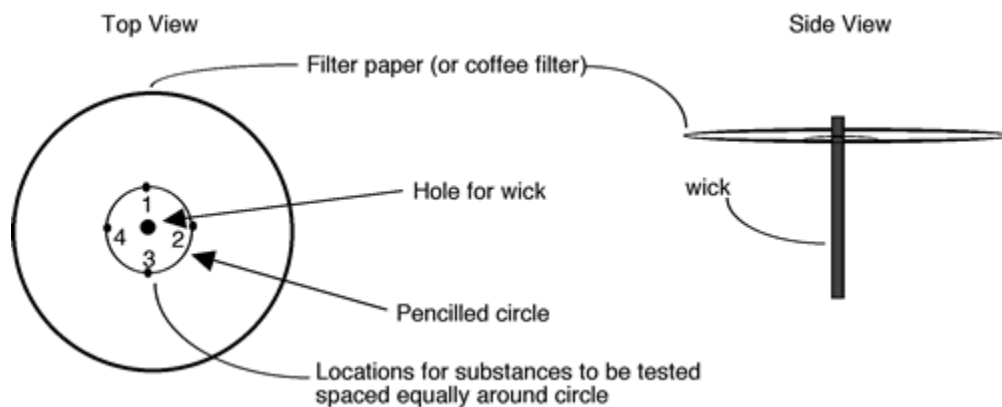
1 lb. bag of M &M's

black transparency pens (optional)

pencil with graphite-based “lead”

Procedure

Obtain a piece of filter paper (or a coffee filter) and use a pencil to trace a circle approximately 4 cm. in diameter with the jar lid.



Use a pencil to number the areas on the filter paper for each of the substances to be tested. Your teacher will tell you how many positions you will need. Spread the numbers out so that they are equal distances apart.

Record the substances to be tested by their appropriate number in the data section below.

For each of the substances to be tested, place a small dot on the penciled line by dipping a toothpick into the colored liquid to be tested and touching the paper. Allow the spot to dry, and re-spot it in the same position. (To test the solids, use the directions found in the Teacher's Notes to prepare the samples).

Use the pencil to punch a hole in the center of the filter paper or coffee filter. Insert a folded piece of coffee filter into the hole as a wick.

Add water to the petri dish so that it is approximately one-third full. Set the wick into the water with the filter paper resting on top of the disk. Allow the chromatogram to develop. The filter paper itself must NOT touch the water in the petri dish.

For best separation of components, remove the chromatogram BEFORE the water reaches the edge of the filter paper (chromatograph). Record the colors in the data table. What trends do you note? (i.e. Are there primary colors in more than one sample?)

Data and Observations

Substance	Center	Middle	Edge

Tape your chromatogram to the back of your lab handout.

Questions

What kind of change took place? Was it chemical or physical? How can you tell if the change was chemical or physical? What could you do to test this hypothesis?

Why do we use chromatography?

How might a chemist use a similar process to analyze a sample containing mixed, colored substances?

What do the words heterogeneous and homogeneous mean? How do they apply to the substances in this lab?

What are two other mixtures that can be separated by ordinary, physical means?

Teacher's Notes

Directions for mixing food coloring and other substances

CHARTREUSE - 12 drops yellow food coloring & 1 drop green food coloring. Mix and apply to the chromatogram with a toothpick.

TURQUOISE - 5 drops blue food coloring & 1 drop green food coloring. Mix and apply to the chromatogram with a toothpick.

M & M's™ - Place one drop of water on one M & M™, and use the toothpick to apply the coloring from that drop of water. Use either a brown or tan M & M™. Then repeat the process for a green M & M™.

ORANGE KOOL-AID™ - Mix an entire pack of unsweetened Orange Kool-Aid with a few drops of water to make a thick paste. Apply to the chromatogram with a toothpick.

Recommended pens to use for this lab are:

Vis-à-Vis™ transparency pens (black, blue, red, green) and Flair™ black pens.

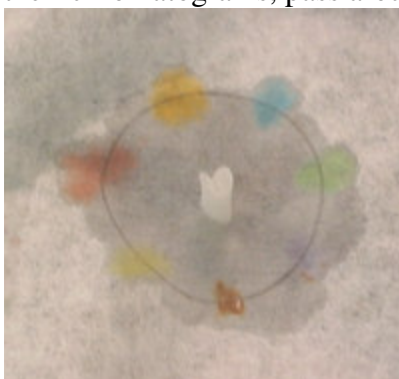
Results of Chromatographs:

Coloring	Center	Middle	Edge
CHARTREUSE	blue	yellow	
BROWN M&M	yellow		red
GREEN M&M	blue		yellow
ORANGE KOOL AID	yellow		red

After every one is through setting up their chromatograms, pass around the M & M's and enjoy!



A sample set up. You can use a cup instead of a dish as well.



After a few seconds the water reaches the dyes. All of the dyes in these photos are from M&M's. Clockwise from the top: orange, blue, green, purple, brown, yellow, red.



After about 5 minutes...



After about 15 minutes...

Answers to questions

Chromatography is a physical change. Any of the separated colors could simply be re-mixed in water. Physical changes are reversible.

Chromatography is a method of separation for pigments or dyes that shows the different rates of evaporation for the component substances.

Chemists can use more complex forms of this method to analyze a sample to determine its contents.

Homogeneous matter is the same throughout and exists in only one phase of matter.

Heterogeneous matter is composed of a mixture of substances that can usually be seen with the naked eye. Heterogeneous matter can be separated by physical changes.

Dissolving the salt in water and filtering the sand from the solution can separate Sand and salt.

Evaporation of the water would recover the salt. Colored M & M's™ can be separated by moving the differently colored pieces into separate piles. Student answers will vary.

Safety Precautions

You should monitor the eating of the M & M's™ to be sure that the students are not consuming the ones used for the experiment or ones that have been handled. You might divide the candies by pouring some into a small, paper cup and pass them out to the students.

Disposal

All liquid materials may be poured down the sink. All solid materials should be placed in a solid-waste container.

Colorful Candy



Colourful Candy

This project idea comes to you from [Science Discovery](#) in Kingston, Ontario. 

PURPOSE:

To use chromatography to compare different colour coatings on candies.

THEORY:

Chromatography is the scientific study of colours. In this experiment, you will use paper chromatography to analyze the different colour coatings of M&M's, Skittles, Smarties, and Reese's Pieces candies.

Paper chromatography is a method of identifying the components of a mixture by treating them with a solvent and observing how they "travel" different distances on absorbent paper.

A **solvent** is a liquid that can dissolve other substances. The substance that is dissolved in the solvent is called the solute. The solvent must be chosen according to the nature of the mixture's components. This lab project uses only water-soluble mixtures.

The solvent moves through the filter paper because of **capillary action**. Capillary action is a force that pushes liquid through small tubes, such as blood vessels. Each dye (solute) travels different distances according to the attraction it has for the paper or the solvent.

In other words, when you put dye on the paper and dip it in the salt solution, the liquid will spread; the solvent will travel farther than the dye, and you will see a dark area and a lighter area. If you divide the distance traveled by the dye by the total distance traveled by the solvent, you get a ratio, called the **R_f** or **Retardation factor**. This value is different for different compounds, which means you can identify a compound by the value of its Retardation factor.

In this activity the solutes are the various dyes and the solvent is water.



Materials

- 4 different colours of M&M's
- 4 different colours of Smarties
- 4 different colours of Skittles
- 4 different colours of Reese's Pieces
- 0.1% table salt solution
- 4 sheets of filter paper
- 16 plastic cups
- 4 large beakers (600 ml)
- toothpicks
- stirring rods
- mm ruler
- scissors
- pencils



PROCEDURE:

A. Extract the colour from the M&M's candies

1. Label each of the 4 cups with one colour of the candy.
2. Place one sample in each cup.
3. Put as few drops of water as possible (around 5) in each cup.
4. Stir carefully with the toothpick to extract as much colour as possible without disturbing the white coating or the centre of the candy.
5. Remove the sample as soon as the white coating appears.
6. Add each sample in turn to its appropriate cup until as much colour has been extracted as possible.

Note: Repeat the steps for each kind of candy. Be sure to include the colour and kind of candy on your label. Also, the colour takes longer to remove from Reese's Pieces.

B. Label the filter paper

1. Label your filter paper with a pencil. Do not use ink for labeling the paper since it may dissolve in the salt solution and interfere with your results.
2. Fold the filter paper in half, and in half again. Unfold it; now you can see exactly where the centre is.
3. Draw a circle around the centre of each piece of filter paper (one for each colour). The circles should be approximately 2 cm across. When you add the solvent, make sure the level stays below the circles you have drawn.

C. Paper Chromatography

1. Place a spot (using a stirring rod or toothpick) of each coloured solution in its labelled circle. Repeat this several times, to the same spot, to concentrate the dye on each spot. Allow drying time between each application.
2. Put the salt solution into a clear plastic cup. Keep the level of salt water below 0.5 cm. (You may want to use a marker to mark the outside of the cup to make it easier.)
3. Fold the filter paper, and stand it up in the cup. Only the tip of the paper must be immersed in the salt solution; the solution must not touch the circles you drew in pencil.
4. Watch as the salt solution (solvent) moves up the paper, pulling along the components of the dye. This should take 10 minutes. If the room is very

dry or warm, it might be necessary to put plastic wrap over the top of the cup to slow down the evaporation of the salt solution.

5. Remove the wet filter paper from the cup when the advancing solution reaches about 1 cm from the top edge.
6. Mark the place on the filter paper where the solvent finally stopped moving.
7. Each sheet of filter paper is a **chromatogram**. Allow your chromatograms to dry.

D. Compute the Rf values

1. Measure the distance from the middle of the filter paper to the edge of the salt solution marked in step 6 of part C. This gives the total distance travelled.
2. Measure the distance from the centre of the filter paper to the final location of each band of colour in your chromatogram. This gives the distance travelled by the dye (solute).
3. Calculate the retardation factor for the different colours of each candy by dividing the total distance by the distance travelled by the dye. You may wish to set up a table to display your results.

CONCLUSIONS:

For each type of candy, which colour travelled the farthest? From your table, you can also compare the retardation factors for the same colour between the different types of candy, for example, red M&M's vs. red Smarties.

A scientist using sophisticated equipment can tell many things from chromatograms. A scientist can find out exactly what substances each dye is composed of, and how much of each is present. This technique is used in *forensic science*: detectives can have a sample of paint analysed to find out information about the car it came from. Not only can they trace the model of car, but they can also pinpoint the year it was made!

Candy Chromatography

PURPOSE

The purpose of this experiment is to separate and identify the FD&C dyes from M&M's or Skittles using paper chromatography.

DESCRIPTION

This experiment is appropriate for general, first-year college prep, or AP classes and could be adapted for use with middle school physical science classes. Wool yarn is used to separate the FD&C dyes present in the coatings of M&M's and/or Skittles from other components of the coatings. The resulting dyes are then separated using paper chromatography. If commercial food colors are used as standards, the separated dyes can be identified.

TIME REQUIRED

One and one-half to two lab periods.

MATERIALS

Chemicals:

- M&M's and/or Skittles
- white household vinegar
- clear, colorless household ammonia solution
- food colors
- red litmus paper

Equipment:

- Bunsen burner
- ringstand, ring and wire gauze or hot plate
- 600-mL beakers 25-cm × 150-cm test tubes
- 10-mL graduated cylinder
- stirring rod
- evaporating dish
- test tube holder
- beaker tongs
- crucible tongs
- wool yarn
- chromatography paper (Whatman #1)
- tooth picks
- stapler
- scissors
- aluminum foil boiling chips
- ruler

HAZARDS

Care should be exercised when using boiling water baths.

PROCEDURE

1. Place a test tube containing a 10-15 cm length of white woolen yarn and 10-15 mL of household vinegar in a boiling water bath and heat for 4-5 minutes to remove any fluorescent dyes which could interfere with the separation of the FD&C dyes. After cooling, remove the yarn from the vinegar and let it drain.
2. Place 5 or 6 M&M's or Skittles in a test tube with enough household vinegar to cover the candies. Heat the tube in a boiling water bath until the colored coating dissolves. Avoid dissolving the interior of the candies.
3. Carefully decant the solution which now contains the FD&C dyes, some sugar, etc. into another test tube. Avoid transferring the sediment.
4. To extract the dyes, add the prepared length of woolen yarn and 3 mL of vinegar to the test tube containing the dye solution. Heat this tube in the boiling water bath for about 5 minutes with occasional stirring. Remove the yarn and rinse it with a little tap water.
5. To release the extracted dyes, place the yarn and about 5 mL of clear household ammonia solution in a clean test tube. Mix with a stirring rod and then test the resulting solution with red litmus paper to make sure that it is basic. If not, add a bit more ammonia solution.
6. Heat the tube containing the yarn and ammonia in a boiling water bath for about 5 minutes with occasional stirring to release the dyes. Remove the yarn and pour the solution containing the dyes into an evaporating dish. Heat the evaporating dish gently to concentrate the solution. Stop just short of dryness. If all the liquid evaporates, add a drop or two of distilled water and stir.
7. Cut two 10-cm × 20-cm pieces of chromatography paper. Draw a pencil line 1 cm from one long edge of each piece of paper. Mark six or seven equally spaced positions along the pencil line. Use toothpicks to place as small a drop of the concentrated dye solution as possible on two of the positions on the pencil line on each piece of paper. Allow the spots to dry and spot them again in exactly the same positions to increase the amount of sample. Spot a third time and a fourth time if the color is not very intense. Use toothpicks to place one small drop of each food color sample on the remaining positions on each piece of paper.
8. Add 5 mL of vinegar to a 600-mL beaker. Carefully staple one piece of chromatography paper into a cylinder and place the paper in the beaker with the spots at the bottom of the cylinder. Be careful that the paper does not touch the sides of the beaker. Cover the beaker with aluminum foil and allow the chromatogram to develop until the developing solution has climbed to about 1 cm from the top of the paper. Remove the paper from the beaker, open it out and allow the paper to dry on a piece of paper towel.
9. Repeat step 8 using the second piece of chromatography paper, but develop with 5 mL of clear ammonia solution.
10. Use the following information to identify the specific dyes present in the candy coatings.

Product	Colors			
	Red	Yellow	Green	Blue
Crown Colony Kit	Blue #1 Red #3 Red #40	Yellow #5 Yellow #6	Blue #1 Yellow #5	Blue #1
Crown Colony Singles	Red #40	Yellow #5 Red #40	Blue #1	---
Durkee	Blue #1 Red #3 Red #40	Yellow #5	Blue #1 Yellow #5	Blue #1
McCormick	Red #3 Red #40	Yellow #5 Yellow #40	Blue#1 Yellow #5	Blue #1 Red #40

DISPOSAL

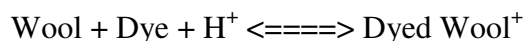
Remaining interiors of candies may be disposed of with solid waste. Solutions that remain may be flushed down the drain.

DISCUSSION

Paper chromatography is an important separation technique that depends upon differences in how strongly the dyes are adsorbed onto the paper (stationary phase) and how soluble the dyes are in the developing solvent (mobile phase). In paper chromatography, a small amount of the mixture to be separated is placed close to the edge of a piece of paper. The edge of the paper is then immersed in a developing solution. As the developing solution ascends up the paper by capillary action, the components of the sample are carried along at different rates. To prevent evaporation of the developing solution, this process is carried out in a closed container.

Each component of the mixture will move a definite distance on the paper in proportion to the distance that the solvent moves. This ratio, $H_f = \text{distance component moves} / \text{distance solution moves}$, can be calculated for each component to aid in identification. H_f values are dependent upon the paper, the developing solution, and the amount of sample used.

Candies, such as Mix's or Skittles, contain FD&C dyes, sugar, and other organic and Inorganic substances in their coatings. If the coating is dissolved in an acidic solution, the FD&C dyes can be adsorbed from the solution by wool. The dyes can be released from the wool in an alkaline environment. Thus the dyes can be separated from other substances in the coatings. This simplified equation represents the equilibrium involved:



A solution of ammonia can be used to supply sufficient OH^- to reduce the concentration of the H^+ and shift the equilibrium to the left releasing the dyes.

TIPS

1. The yarn used In this experiment must be 100% wool. To save time, the teacher can pretreat the wool to remove fluorescent dyes.
2. Two different developing solvents are used to illustrate the significant dependence of this technique on the solvent used and because the vinegar separates the yellow and blue dyes better while the ammonia separates the reds and yellows better.
3. Since it is difficult to apply comparable quantities of the extracted dyes and the food colors to the chromatogram, It is likely that the R_f values will not be very reproducible. The separations are sufficiently distinct that students can identify the components qualitatively.

REFERENCES

Jenkins, C., *Science and Children*, April 1986, p. 25. -- This article describes a chromatography experiment for young children using Kool-Aid and lists the FD&C dyes in various brands of food colorings.

McDuffie, T.E. Jr. and Anderson, J., *Chemistry Experiments from Daily Life*, J. Weston Walch, Publisher, 1980, p. 77. -- This work describes a similar experiment which uses non-consumer solutions for the extraction and for developing the chromatogram.

Food Dye Chromatography

Paper chromatography separates the different-coloured dyes in a mixture. It allows comparison of the forces between the particles of the dye and solvent, and the forces between the particles of the dye and paper.

In this activity, students separated the dyes used to colour M&M's, and the Queen food dyes sold in supermarkets.

AIM: To investigate the components of food dye mixtures using chromatography.

MATERIALS: large test tube
chromatography paper strip
peg
retort stand
bosshead and clamp
colour mixture
salt water
filter paper circle
M&M
plastic pasteur pipette

PROCEDURE: Separating the colours in a food dye mixture
Support the test tube in an upright position using the retort stand, bosshead and clamp
Introduce 1cm of salt water to the test tube
Place a small spot of colour mixture about 1 cm from the bottom of the chromatography paper strip
Lower the paper strip into the test tube until the bottom edge of the paper is just touching the salt water solution
Secure the paper strip with a peg and leave to develop
Draw a labelled diagram of the results of your chromatography test
Investigating the colours used to dye M&M's
Place the M&M in the middle of the filter paper circle
Using the pipette, wet the M&M with one drop of water and leave to develop
Draw a labeled diagram of the results of your chromatography test

QUESTIONS: Observe the chromatography paper strip. What colours were present in the food dye mixture?
Observe the filter paper circle. What colours were present in the dye used to colour the M&M?
Compare your filter paper circle with other groups. Are all the dyes used to colour M&M's mixtures?
What is the difference between a pure colour and a colour mixture?

Author: D Cook

Analyzing Data: An integrated math and science activity using M&M candies

Susan Deeds
August 2000

Introduction:

This is an activity that is used to compile and analyze data. Data will be collected and displayed in data tables and in graphs. It also has students analyze statistics and ratios of sets of data. The technology we used was Front page, excel and graphical analysis is. This is a great activity to review data tables and graphing.

Assignment

You will be given a package of M&M's. Tally the number of candies of each color. You will also need to take length and width measurements of the yellow M&M candies and write down those numbers. Compile the data to display and analyze. You will use the data from the whole class found in a group data table.

1. Students will need to create a data table on excel with the following categories:

Color	Group1	Group 2 to	Total number (add up group #'s)	percentage (Total of color candies/ total candies)	Factory Value(as found on M&M website)	percentage difference (Factory value-expt. value)/factory valueX 100
red						
green						
blue						
orange						
yellow						
brown						

2. After creating the data table, students should create a pie chart of data.
3. Analyze the difference between our experimental values and factory values. Explain the differences.
4. Using graphical analysis create a line graph of yellow M&M length vs. width. Be sure to label the axis. Is there a relationship between the Length and width?
5. Create a report on a web page to display your work.

Evaluation Rubric

Activity	4 Superior	3 Complete	2 Developing	1 Beginning
Collection and Display of Data	Collects all required data, displays as data table and graph, colors graph to match data, clearly labeled data	Collects all required data, displays as data table and graph	Collects some of the data and displays as data table and/or graph	Collects some data
Communicates understanding	Explains results, extrapolates from data, meaningful conclusions, infers correct relationships	Explains results, extrapolates from data, meaningful conclusions	Explains results	notices trends in data provided
Creates a report	completes introduction, background, process, data, graph, results and conclusion in complete full paragraphs	completes introduction, background, process, data, graph, results and conclusion in full paragraphs.	Completes most of the sections: completes introduction, background, process, data, graph, results and conclusion in full paragraphs.	Has identified introduction, background, process, data, graph, results and conclusion
mathematics	Calculates percentages and percentage differences for M&M color counts; Calculates average size, mean, and mode for length data. All done correctly.	Calculates percentages and percentage differences for M&M color counts; Calculates average size, mean, and mode for length data.	Calculates most of the following: percentages and percentage differences for M&M color count: average size, mean, and mode for length data.	Calculates a few of the following: percentages and percentage differences for M&M color count: average size, mean, and mode for length data.
The Web Page	Included banner, titles, text, graphs, tables, and links. Layout is complete and organized.	Included banner, titles, text, graphs, tables, and links. Layout is complete.	Included some of the parts: banner, titles, text, graphs, tables, and links.	Identified the parts: banner, titles, text, graphs, tables, and links.

Essential Learnings

The essential learning requirements for Washington State. The following benchmarks are met in this project. For further information contact the [Office of the Superintendent of Public Instruction](#).

Reading

1. The student understands and uses different skills and strategies to read.
2. The student understands the meaning of what is read.
3. The student reads different materials for a variety of purposes.

Writing

1. The student writes clearly and effectively.
2. The student writes in a variety of forms for different audiences and purposes.

Communication

1. The student uses listening and observation skills to gain understanding.
2. The student communicates ideas clearly and effectively.
3. The student uses communication strategies and skills to work effectively with others.

Mathematics

1. The student understands and applies the concepts and procedures of mathematics.
2. The student uses mathematics to define and solve problems
3. The student uses mathematical reasoning.
4. The student communicates knowledge and understanding in both everyday and mathematical language.
5. The student understands how mathematical ideas connect within mathematics, to other subject areas, and to real-life situations.

Science

1. The students knows and applies the skills and processes of science and technology.
2. The student understands the nature and contexts of science and technology.

Related links

[M&M's Web Site of color distribution](#)

Contact information

For more information contact Susan Deeds at sdeeds@steilacoom.k12.wa.us.

Student Project example: This is what a student might create from this project.

Color percentages of M&M candies

August 2000
Jane Student

Background Information:

We are currently students enrolled at Anonymous High School in Gig Harbor, WA. Our class has spent the last few days reviewing data tables and graphs. We also wanted to learn/review the computer programs: Excel, Graphical analysis, and Front page.

Procedure:

We received a package of M&M’s where we compiled the number of different colors of M&M’s.

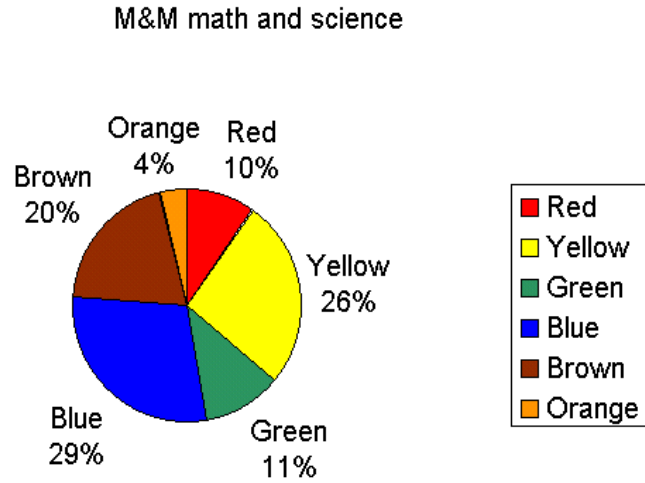
data:

This is the data table we produced to compile the color M&M data. The separate columns with initials are the color counts for each of the lab groups. The total column indicates the sum of all the groups data. The percentage column shows the number of color divided by the total amount of M&M’s. The factory values show the percentages the Mars company uses to produce M&M’s. The percent difference shows the difference between our experimental values and the factory values.

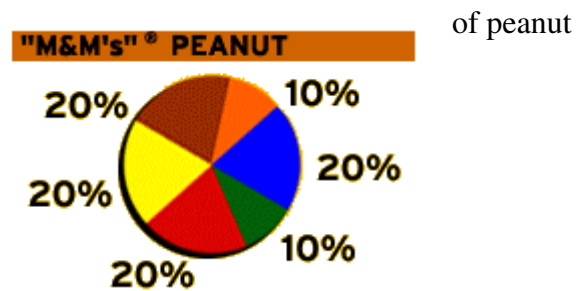
M&M math and science initials															
Color	CB	CC	BEJ	SD	JM	DN	BK	HK	RM	CLS	KLM	Total	Percentage	Factory Values	Percent difference
Red	3	0	6	4	1	1	1	1	3	1	2	23	9.6	20	-51.8828
Yellow	9	7	3	4	7	5	5	9	5	6	3	63	26.4	20	31.79916
Green	1	3	2	1	2	4	3	3	4	2	2	27	11.3	10	12.97071
Blue	8	5	7	7	8	7	8	5	2	4	8	69	28.9	20	44.35146
Brown	1	5	6	5	4	5	3	3	7	4	5	48	20.1	20	0.41841
Orange	0	2	0	1	0	0	1	0	1	2	2	9	3.8	10	-62.3431
Total	22	22	24	22	22	22	21	21	22	19	22	239	100.0	100	0

Graphs

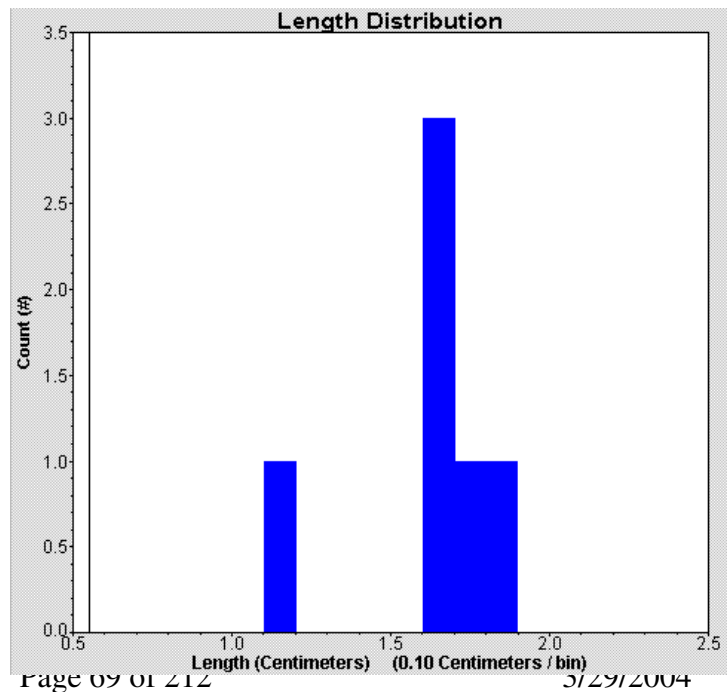
M&M Distribution: This first graph shows the percentages we found in our experimental group.



This next graph shows the factory values of M&M's.



Length of M&M's: This graph shows the different lengths of the peanut M&M's.



Results:

M&M Distribution: Our class data was different from the factory data. The percentage of red M&M's from our data was 10% and the factory value was 20%, which is a difference of -52%. The other values were: yellow (class data) 26%, yellow (factory value) 20%, percent difference 32%; green (class data) 11%, green (factory value) 10%, percent difference 13%; blue (class data) 29%, blue (factory value) 20%, percent difference 44%; brown (class data) 20%, brown (factory value) 20%, percent difference 0%; and orange (class data) 4%, orange (factory value) 10%, percent difference - 62% .

M&M Length: We recorded the lengths of 7 candies. We found the following statistics:

Sample Size 60

Average: 1.67

Minimum = 1.0

Maximum = 2.2

Median = 1.7

Mode = 1.7

Standard Deviation = 0.23

Conclusion:

We were really surprised that our distribution of M&M colors was very different from that of the company. This leads us to two possible conclusions, either our sample size is too small or their data is inaccurate. My guess is that our sample size was too small. It would be interesting to collect more data from other science classes and see if the larger sample size would bring us closer to the true factory values.

The other piece of data we gathered was that of M&M candy length. The lengths varied from 1.0 to 2.2cm. The average size was 1.7 cm. Since the standard deviation was only .23 most of the M&M candies were close to the average size. My guess is that the variation of peanut size is close to the spread we saw with the candies. It would be interesting to contact the Mars company and find out how they select peanuts to make their candies. I wonder if they buy a certain grade of peanut to keep the sizes fairly constant.

Using M&Ms to learn about statistics and measurement

Christopher D. Cunningham

8/8/2000

Introduction

This is an assignment in which students use M&Ms as a manipulative to help them learn about probability and statistics, and about preparing data tables and charts.

Assignment

In this lesson, students will record lengths of 5 M&Ms selected at random. To get a large data set, all students will share their measurements and generate a single class data set. Students can be assigned to bring in 1 bag of M&Ms, or they can be supplied by the teacher. The objects of the research may be appropriately disposed of AFTER ALL MEASUREMENTS ARE MADE.

Measurements:

We will begin by using the calipers to measure the length of each of these first 5 M&Ms to come out of the bag. We will share these values as a class, and each student will need to write down the whole list.

Next, make a table in which to write down the numbers of each of the six colors you have in your bag. Record the values, and then jot them in a class data table on the white board at the front of the class. You will then need to record the whole class table.

Analysis:

Using the graphical analysis program, enter the classes length measurements as x values. Be sure also to click on the 'x' at the top of the table to give this column of data an appropriate name.

Then use the program to generate a histogram of the data.

Finally, use the program to identify the mean, median, mode, max, min, standard deviation, and percentage of the standard deviation of the mean of the data. The final value is a coefficient similar to a correlation coefficient. It can be thought of as a measure of how well the mean truly represents the data set; and it should be in the neighborhood of 10% to 15%.

Next, open the Microsoft Excel program. In the first column, write your name in row 1, the date in row two, and the name of the assignment in row three.

Then prepare a table with the M&M colors as row headings, and the initials of each person as the column headings. Enter the data for each person in the class as recorded from the front white board. Include formulas to calculate totals for each bag at the bottom of each column, and totals of each color from all the bags combined at the end of each row. Finally, add a final column in which to calculate the percentages of each color in the total batch of M&Ms.

Next, use the data to generate a pie chart of the color distributions. The chart should refer to your spreadsheet for a title, chart headings, and data; and the legend should be appropriately color coded.

Assessment

Presentation of Project and brief quiz with most questions relating specifically to our research, and a few asking students to apply what they learned to a new but similar scenario.

Rubric

The following rubric will be used in a number of ways. First, it will help students evaluate their own work, second, it will be used in peer evaluation, and then finally, in a teacher assessment of the work.

Activity	4 Superior	3 Complete	2 Developing	1 Beginning
Collects and displays data	Complete data, displayed as table and graph with titles and labels, colors graph to match data.	Complete data, displayed as table and graph.	Collects some of the data, and displays in table and/or graph.	Collects some of the data.
Communicates understanding	Explains results, extrapolates meaningful conclusions from data, and infers correct relationships	Explains results, extrapolates meaningful conclusions from data	Explains results	Notices trends in data provided.
Creating the final Report	Completes Introduction, background, process, data and graphs, and conclusions with results, findings, error analysis, and suggestions for new research in complete full paragraphs	Completes at least 4 of the 5 sections in full paragraphs	Completes most of the sections in paragraph form.	Has identified most sections of the report with some relevant information in each
The mathematics	Communicates a clear understanding of the math principles involved so that they are clear to an uninformed audience.	Demonstrates understanding of the math principles involved with each set of data, with some communication to the uninformed audience.	Demonstrates understanding of most of the math principles involved with each set of data.	Demonstrates understanding of some part of the assignment.
The science	Student communicates clear ideas about limits of measurement methods and tools, and differences between class data and factory data. Suggests interesting ideas for new research	Student discusses ideas about limits of measurement methods and tools, and also ideas about differences between class data and factory data, and ideas for new research.	Student discusses ideas about limits of measurement methods or tools, and/or ideas about differences between class data and factory data.	Student identifies ideas about limits of measurement methods and tools, or ideas about differences between class data and factory data.
Web Page	Included banner, titles, text, graphs, tables and links to related information. Layout is complete and organized.	Included banner, titles, text, graphs, tables and links to related information. Layout is complete	Included most of the parts (banner, titles, text, graphs, tables and links to related information).	Identified most of the parts (banner, titles, text, graphs, tables and links to related information) with some relevant information.

Essential Academic Learning Requirements Met

This assignment meets the following of Washington State's essential learning requirements. For further information, contact the state's [Superintendent of Public Instruction](#).

Mathematics

- #1. The student understands and applies the concepts and procedures of mathematics.*
- #2. The student uses mathematics to define and solve problems.*
- #3. The student uses mathematical reasoning.*
- #4. The student communicates knowledge and understanding in both everyday and mathematical language.*
- #5. The student understands how mathematical ideas connect within mathematics, to other subject areas, and to real-life situations.*

Science

- #2. The students knows and applies the skills and processes of science and technology.*
- #3. The student understands the nature and contexts of science and technology.*

Communication

- #1. The student uses listening and observation skills to gain understanding.*
- #2. The student communicates ideas clearly and effectively.*
- #3. The student uses communication strategies and skills to work effectively with others.*
- #4. The student analyzes and evaluates the effectiveness of formal and informal communication.*

Writing

- 1. The student writes clearly and effectively.*
- 2. The student writes in a variety of forms for different audiences and purposes.*
- 3. The student understands and uses the steps of the writing process.*
- 4. The student analyzes and evaluates the effectiveness of written work.*

Student Project Example

This is a [sample template](#) students can use to write their own pages, and includes samples of how some of the tables and graphs should come out.

Title
Author
date

Introduction

In this assignment we will...

Background

The information we've studied that has lead up to our examination of statistics...

Procedure

We will follow the procedures listed below to measure and record data, and to present the data in graphical form.

1...

2...

Data and Graphs

Below are the tables and graphs students should generate for this assignment. Students must include a title and complete description of each table and graph. They should write these as though they are presenting it on a web page to an audience not familiar with their work.

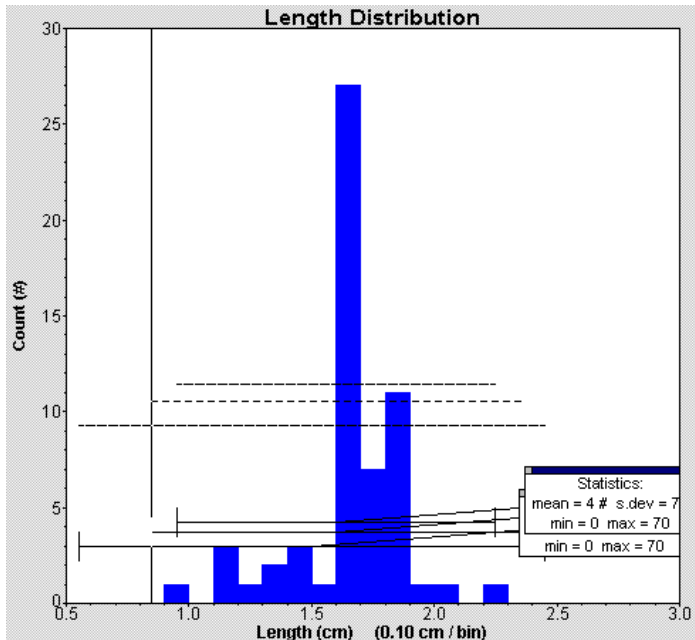
Table of M&M Lengths

(Graphical Analysis Program)

Below is a sample of the table students generate using the Graphical Analysis program.

Row Num	Data Set 1: Data		Data Set 1:
	Length (cm)	Y	Length (cm)
15	1.60000		1.8
16	1.60000		1.9
17	1.60000		2.0
18	1.60000		2.1
19	1.64000		2.2
20	1.65000		2.3
21	1.66000		2.4
22	1.66000		
23	1.70000		
24	1.70000		
25	1.70000		
26	1.70000		
27	1.70000		
28	1.70000		
Number	59		21
Mean	1.67932		1.450
Min	1.00000		0.4500
Max	2.20000		2.450
Std Dev	0.22459		0.6205

Histogram generated from M&M Lengths



Class Data Table of Peanut M&M Color Distributions

(Microsoft Excel)

Chris cunningham

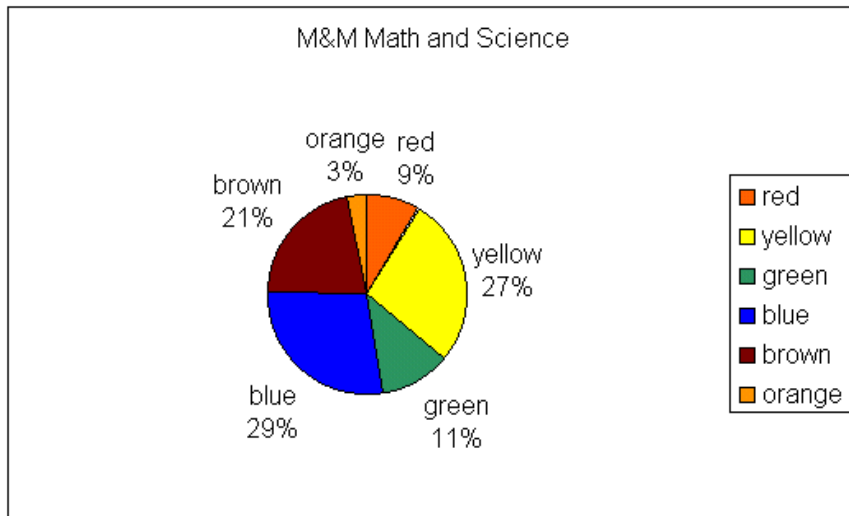
7-Aug-00

M&M Math and Science

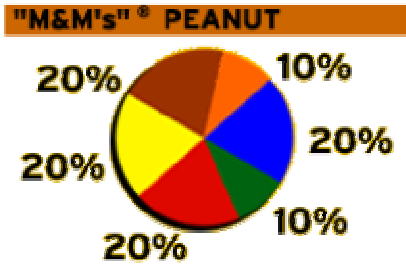
Initials	cb	cc	bej	rha	sd	jm	dn	bk	hk	rm	cls	klm	totals	percentage	Factory Percentages	
red	3	0	6	0	4	1	1	1	1	3	1	2	23	8.71	20	-56.4394
yellow	9	7	3	9	4	7	5	5	9	5	6	3	72	27.27	20	36.36364
green	1	3	2	3	1	2	4	3	3	4	2	2	30	11.36	10	13.63636
blue	8	5	7	5	7	8	7	8	5	2	4	8	74	28.03	20	40.15152
brown	1	5	6	8	5	4	5	3	3	7	4	5	56	21.21	20	6.060606
orange	0	2	0	0	1	0	0	1	0	1	2	2	9	3.41	10	-65.9091
total	22	22	24	25	22	22	22	21	21	22	19	22	264	100	100	

Pie Chart of Peanut M&M Color Distributions in Class Samples

(Microsoft Excel)



Pie Chart of M&Ms Factory Color Distributions



Conclusions

summary of results and "what we learned"
error analysis
new question to analyze or research suggestion

Related Links

[M&Ms web site for color percentages for each type of candy.](#)

[Washington's Essential Academic Learning Requirements](#)

Contact Information

Chris Cunningham

Science and Math Teacher

Capital High School

Olympia, Washington

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Analyzing Data: Math and Science

Created by Jennifer Manning
August 7, 2000

Introduction:

This is my sixth year teaching math and science to 7th grade students at Woodbrook Middle School in Lakewood, Washington. I am completing this web page as part of the Integrating Technology course at University of Washington, Tacoma. The course offerings were provided by a scholarship from Intel.

Assignment

Lesson Objectives:

- The students will use different types of M&M's to collect and compare data.
- The students will be able to draw conclusions from their data set on the mean, median, and mode so that a comparison can be made with the other varieties.
- The students will use various forms of technology to present their data. (Microsoft Excel Spreadsheet, Graphical Analysis)

Motivation:

How do the different varieties of M&M's compare to each other, with regards to the size, weight, color or number in each bag? Discuss this question and record some predictions.

Materials:

- Several packages of plain, peanut, crispy, peanut butter, and almond M&M's
- Microsoft Excel Computer Program
- Graphical Analysis Computer Program

Lesson Plan:

1. The students will get into groups of four or five and have several bags of one variety of M&M's.
2. They will collect data on the size, weight, color, or number in each bag.
3. This data can be recorded in Microsoft Excel Program in the spreadsheet.
4. They can enter in the equations to perform addition functions. For example, =Sum(B3;M3) Or enter in functions that will compute the percentage.
5. The students can create graphs out of their spreadsheet data by going to the chart function. They can create graphs out of each of the data sets and use them for comparison with the other groups.
6. The students should complete a lab write up using the following format:

- Introduction
- Background
- Process
- Data
- Graphs
- Results
- Conclusions

Assessment

I will be looking at their ability to collect the data and effectively present it in graph form. They will also be assessed on their ability to determine the mean, median, and mode. The students' conclusions about how the different varieties compare will be assessed as well.

Rubric

Activity	4-Superior	3-Complete	2-Developing	1-Beginning
Collection and Display of Data	Collects all required data, displays as data table and graph, colors graph to match data, labels provided..	Collects all required data, displays as data table and graph	Collects some data, displays as data table and/or graph,	Collects some data
Communicates Understanding	Explains results, extrapolates from data meaningful conclusions, infers correct relations.	Explains results, extrapolates from data meaningful conclusions.	Explains results.	Notices trends in data provided.
Creating a Report	Completes Introduction, Background, Process, Data, Graph, Results, and Conclusions in complete and full paragraphs.	Completes Introduction, Background, Process, Data, Graph, Results, and Conclusions in full paragraphs.	Completes most of the sections. Introduction, Background, Process, Data, Graph, Results, and Conclusions.	Has identified Introduction, background, process, data, graph, results, and conclusions.
The Mathematics	Computed the mean , median, and mode from the data that was collected correctly with evidence of the work. Measured the lengths of the items correctly with evidence of the work.	Computed the mean , median, and mode from the data that was collected correctly. Measured the lengths of the items correctly.	Computed the mean , median, and mode from the data that was collected with some accuracy. Measured the lengths of the items with some accuracy.	Has identified the mean, median, and mode from the data. Identifies with the process needed to find the lengths of items.
The Web Page	Included Banner, Titles, Text, Graphs, Tables, and Links. Layout is complete and organized.	Included Banner, Titles, Text, Graphs, Tables, and Links. Layout is complete.	Included some of the parts: Banner, Titles, Text, Graphs, Tables, and Links.	Included the parts: Banner, Titles, Text, Graphs, Tables, and Links.

Essential Academic Learning Requirements

The following essential learnings were targeted for the activity I have described. For more information on the Essential Academic Learning Requirements [Click Here](#).

Mathematics

1. The student understands and applies the concepts and procedures of mathematics.
2. The student uses mathematics to define and solve problems.
3. The student uses mathematical reasoning.
4. The student communicates knowledge and understanding in both everyday and mathematical language.
5. The student understands how mathematical ideas connect within mathematics, to other subject areas, and to real-life situations.

Science

- 1.1 use properties to identify, describe, and categorize substances, materials, and objects, and use characteristics to categorize living things.
- 2. The students knows and applies the skills and processes of science and technology.
- 3.2 know that science and technology are human endeavors, interrelated to each other, to society, and to the workplace

Student Project Example

Title: M&M's

Introduction:

This is my sixth year teaching math and science to 7th grade students at Woodbrook Middle School in Lakewood, Washington. I am completing this web page as part of the Integrating Technology course at University of Washington, Tacoma. The course offerings were provided by a scholarship from Intel.

Background:

The only background knowledge I had coming into this activity is the knowledge of the different colors and the knowledge of the different varieties.

Process:

1. The first thing that we did in this investigation, is count the number of each type of color in our own M&M bag.
2. This information was recorded on the white board for all to see.
3. This data was entered into a spreadsheet program and we entered in different functions to perform the different calculations quickly. (adding the values, determining the percentages, finding the difference in percentages)
4. We then went to the chart function and created a pie graph out of the data. This was useful in comparing our percentages to the actual found on the M&M website.
5. We used calipers to determine the length of five of our M&M's.
6. This information was shared with the group to create the second chart and graph you see below. This was all created on the Graphic Analysis Program.
7. These charts and graphs were saved to the disc and brought over through the cut and paste functions.

Data

The chart that you see below was first put together on the white board in the front of the room. Our instructor gave each of us a bag of M&M's. With that bag, we collected the number of each type of color. We shared our data with the class to get a larger sample size. We were able to make several conclusions. It should be noted that we only used peanut M&M's.

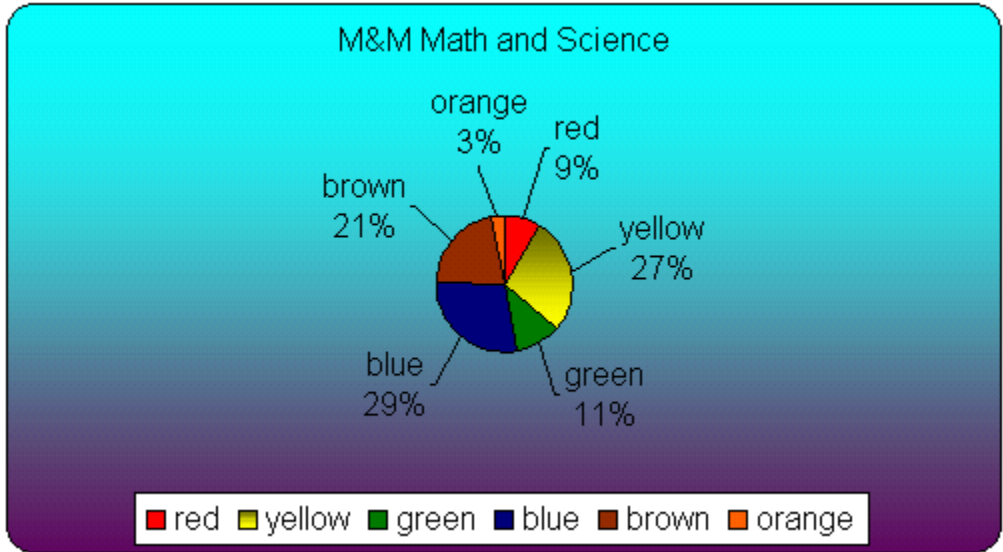
Initials	CB	cc	bej	rha	sd	jm	dn	bk	hk	rm	cis	klm	total	Percentage	Factory values	Percentage Difference
red	3	0	6	0	4	1	1	1	1	3	1	2	23	9	20	-56.43939394
yellow	9	7	3	9	4	7	5	5	9	5	6	3	72	27	20	36.36363636
green	1	3	2	3	1	2	4	3	3	4	2	2	30	11	10	13.63636364
blue	8	5	7	5	7	8	7	8	5	2	4	8	74	28.0	20	40.15151515
brown	1	5	6	8	5	4	5	3	3	7	4	5	56	21	20	6.060606061
orange	0	2	0	0	1	0	0	1	0	1	2	2	9	3	10	-65.90909091
total	22	22	24	25	22	22	22	21	21	22	19	22	264	100	100	0

The following statistics gives us a summary of the length data we collected in centimeters for the peanut M&M's.

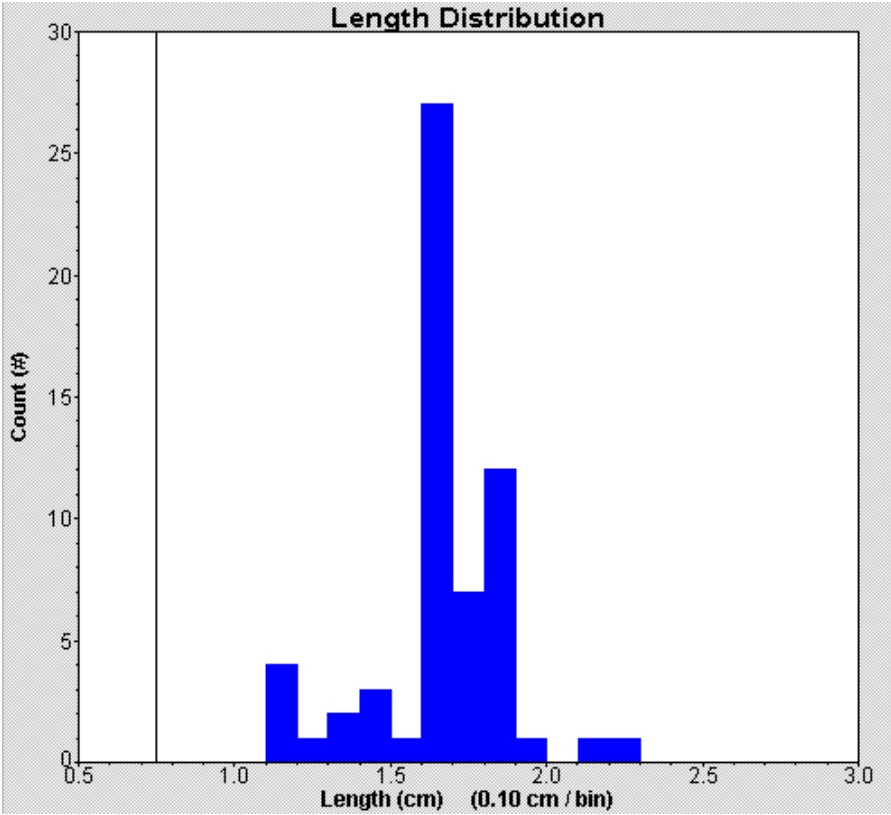
Average=1.67
Minimum=1.1
Maximum=2.2
Median=1.7
Mode=1.7
Standard Deviation=.23
E.C.=13.77%

Graphs

This graph was constructed from our results within the spreadsheet above. We went to the create a chart function and selected a pie graph. I was able to modify the colors of the sections within the graph and modify the background color. The spreadsheet above shows the differences between our results and what we should actually find in a bag of peanut M&M's. As you can see, our results were much different. This indicated to us that we may need to look at a larger sample size to get more accurate results.



To produce the following graph, our class went into Graphical Analysis, a type of computer software, and we each contributed five lengths for our set of M&M's. Our instructor went around the classroom and collected the information from each of us. We entered the data into the computer at the same time. We modified the graph so that there were only x values to create a histogram. Within the program you can determine all of the statistics-mean, minimum, maximum, etc. By sorting the data you can determine the median. By looking at the graph you can determine the mode. This graph is presenting information on peanut M&M's only.



Results:

Through our results we were able to see that most of our M&M's were about 1.7cm in length and the most common color was brown with yellow close behind.

Conclusions:

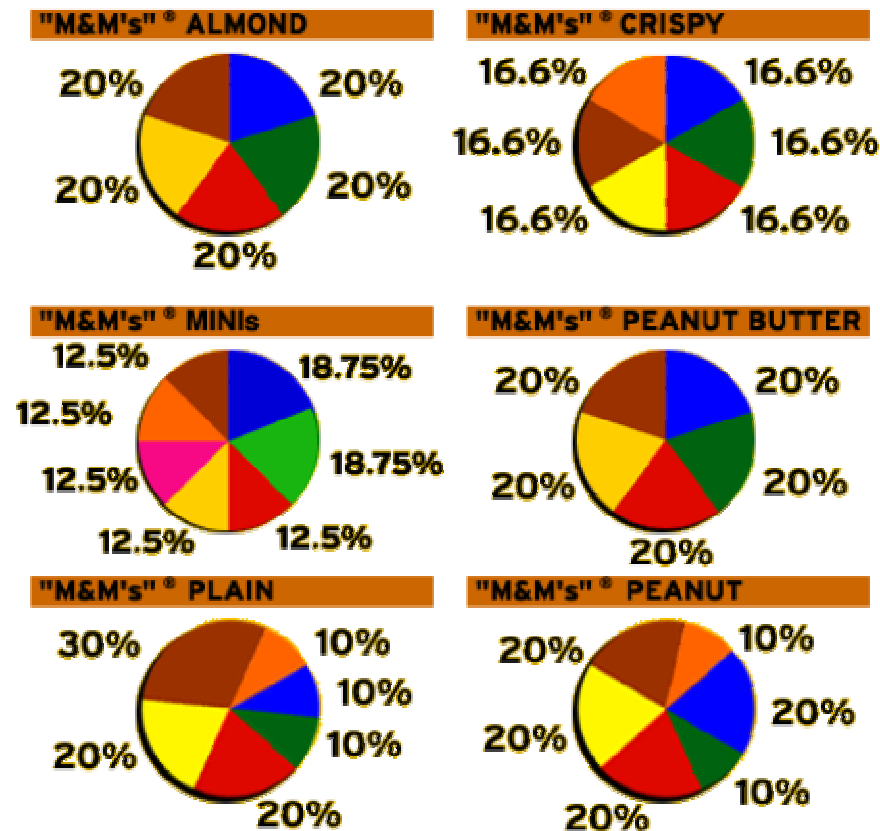
Our color results did not match up with what the M&M Company says will be in each bag. This made us wonder if our sample size was not large enough. I would want to do further investigations with a larger sample size to see if the length data is correct.

Related Links

[M&M's Web Site of Color Distribution](#)

Actual Color Distribution Comparison

Use these graphs with a lesson on sample size. How did the students' results compare to the actual?



Contact Information

To contact me, call Woodbrook Middle School in Lakewood, Washington at 253-589-7682.



M&M Math and Science

Kenton L. Morrison
August 7th, 2000

Introduction

We have been working with gathering and charting data. Using percentages, charts and graphs, we are working to learn to compare data gathered with data gathered by others.

Assignment:

Needed Resources:

- M&M's
- Computers
- Microsoft Excel (Software)
- Internet Connection
- Front Page

The Activity:

- Open a bag of M&M's
- Count and record the number of each color that you have.
- Input the count for each color on an excel spreadsheet
- Input the numbers counted by the other students in the class
- Find the total number of each color found by the class
- Find the percentage that each color represents

Create a chart showing the percentage of each color that the class found

- Go to the M&M web site and find their data on percentage of each color each bag should contain on the average.
- Compare your class data to the M&M data
- Explain why your data may differ.

Assessment:

The Product: Create a web page using FrontPage

- Include a chart
- Include a Data Table.
- Include Images.
- Explain why your data may be different than the data found at the M&M site.

Rubric:

Activity	4 Superior	3 Complete	2 Developing	1 Beginning
Collects and display of data	Collects all required data, displays as data table and graph, colors graph and provides labels to match data.	Collects all required data, displays as data table and graph.	Collects some of the required data, displays as data table and or graph.	Collects some of the required data.
Communicates understanding	Explains results, extrapolates from data meaningful conclusions, infers correct relationships.	Explains results, extrapolates from data meaningful conclusions.	Explains results.	Notices trends in data provided.
Creating A Report	Completes Introduction, Background, Process, Data, Graph, Results, and Conclusions in complete sentences and paragraphs.	Completes Introduction, Background, Process, Data, Graph, Results, and Conclusions in sentences and paragraphs.	Completes most of the Introduction, Background, Process, Data, Graph, Results, and Conclusions.	Has identified Introduction, Background, Process, Data, Graph, Results, and Conclusions.
Mathematical Usage	Creates Percentages to compare data gathered on colors and sizes with Web Resources	Creates Percentages to compare data gathered on colors or sizes with Web Resources	Creates Percentages to compare data gathered on colors or sizes	Identifies Percentages to compare data gathered on colors or sizes
The Web Page	Included Banner, Titles, Text, Graphs, Tables, Links, and Images. Layout is complete and organized	Included Banner, Titles, Text, Graphs, Tables, Links, and Images. Layout is complete.	Included some of the Banner, Titles, Text, Graphs, Tables, Links, and Images.	Identified the Banner, Titles, Text, Graphs, Tables, Links, and Images.

Essential Academic Learning Requirements:

The Essential Academic Learning requirements for Washington State. The following benchmarks are met in this project. For further information contact the [Superintendent of Public Instruction](#).

Essential Academic Learning Requirements in Reading

1. The student understands and uses different skills and strategies to read.
2. The student understands the meaning of what is read.
3. The student reads different materials for a variety of purposes.

Essential Academic Learning Requirements in Writing

1. The student writes clearly and effectively.
2. The student writes in a variety of forms for different audiences and purposes.
3. The student understands and uses the steps of the writing process.
4. The student analyzes and evaluates the effectiveness of written work.

The Essential Academic Learning Requirements in Mathematics

1. The student understands and applies the concepts and procedures of mathematics.
2. The student uses mathematics to define and solve problems.
3. The student uses mathematical reasoning.
4. The student communicates knowledge and understanding in both everyday and mathematical language.
5. The student understands how mathematical ideas connect within mathematics, to other subject areas, and to real-life situations.

The Essential Academic Learning Requirements in Communication

1. The student uses listening and observation skills to gain understanding.
2. The student communicates ideas clearly and effectively.
3. The student uses communication strategies and skills to work effectively with others.
4. The student analyzes and evaluates the effectiveness of formal and informal communication.

The Essential Academic Learning Requirements in Science

1. The student understands and uses scientific concepts and principles.
2. The student knows and applies the skills and processes of science and technology.
3. The student understands the nature and contexts of science and technology.

Student Project Sample



Comparison of M & M Length

Kenton L. Morrison

August 8, 2000

Introduction:

Background:

Materials:

- Calipers
- One bag of M&M's per person in the study
- Microsoft FrontPage Software
- Graphic Analysis Software
- Computer
- Digital Camera

Procedure:

- Use the Caliper to measure the length of several M&M's
- Input the data into Graphic Analysis Software
- Create a Histogram using data.
- Create a FrontPage Document to share data gathered, charts created, and conclusions.

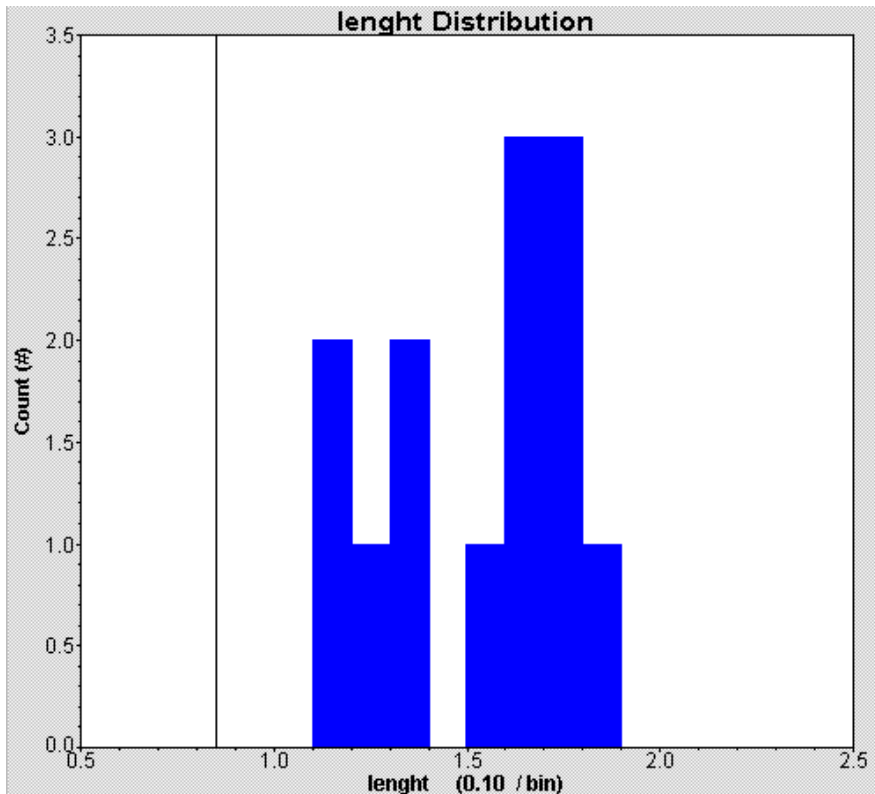
The Data:

This chart represents the length of 13 different peanut M&M's in centimeters.

Row Num	Data Set 1: Data	
	length (cm)	Y
1	1.10000	
2	1.20000	
3	1.30000	
4	1.40000	
5	1.40000	
6	1.60000	
7	1.70000	
8	1.70000	
9	1.70000	
10	1.80000	
11	1.80000	
12	1.80000	
13	1.90000	
14		
Number	13	
Mean	1.56923	
Min	1.10000	
Max	1.90000	
Std Dev	0.25944	

The Graph:

This Histogram reflects the length of the M&M's studied.



Results:

We found that M&M's vary slightly in length.

Conclusion:

The variance in length is caused by the size of the peanut inside the M&M.





Comparison of M & M Colors Per Bag

Kenton L. Morrison

August 8, 2000

Introduction:

We have been studying the gathering of data and the creation of charts and graphs based on data gathered. We are now studying using percentages to analyze and compare the data gathered and draw conclusions based on our comparisons.

Background:

Materials Used:

- Internet Computer
- Microsoft Excel
- Microsoft FrontPage
- One bag of Peanut M & M's per student participating in the study
- Computer
- Digital Camera

Process:

- Each participant in the study should count and record the number of each color of M&M in a bag.
- The entire group Data should be recorded in Microsoft Excel
- Charts are created based on the data gathered.
- Data is compared to data from the M&M web site

Data:

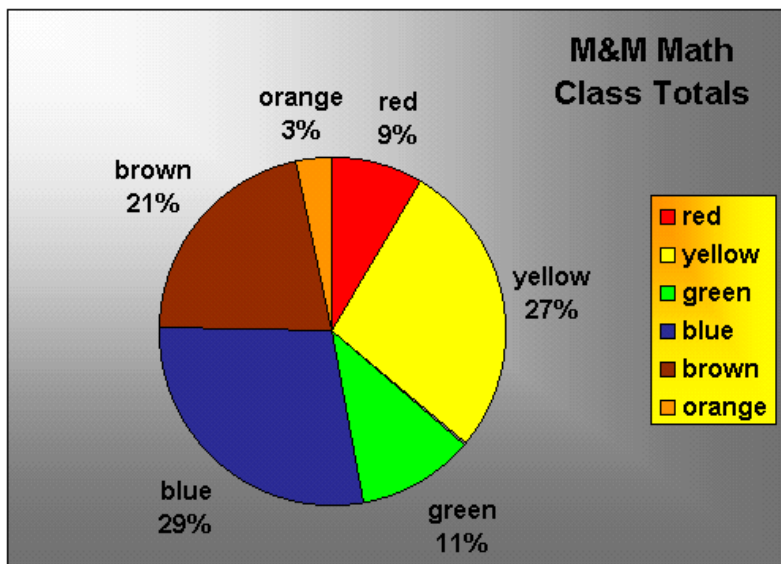
- The initials row represents the initials of the students who participated in the study.
- The Colors represent the number of each color that each participant found in their bag.
- The Total column represents the total of each color found.
- The percentage column represents the percentage of the total counted each color represents.
- The Factory value shows the average percentage that the M & M web site said should be found in a sampling of bags.
- The Percentage Difference Column represents the percentage that our findings differed from the M & M Site.

Initials	cb	cc	bej	rha	sd	jm	dn	bk	hk	rm	cls	klm	TOTAL	Percentage	Factory Values	Percent Difference
red	3	0	6	0	4	1	1	1	1	3	1	2	23	8.71	20	-56.44
yellow	9	7	3	9	4	7	5	5	9	5	6	3	72	27.27	20	36.36
green	1	3	2	3	1	2	4	3	3	4	2	2	30	11.36	10	13.64
blue	8	5	7	5	7	8	7	8	5	2	4	8	74	28.03	20	40.15
brown	1	5	6	8	5	4	5	3	3	7	4	5	56	21.21	20	6.06
orange	0	2	0	0	1	0	0	1	0	1	2	2	9	3.41	10	-65.91
TOTAL	22	22	24	25	22	22	22	21	21	22	19	22	264			

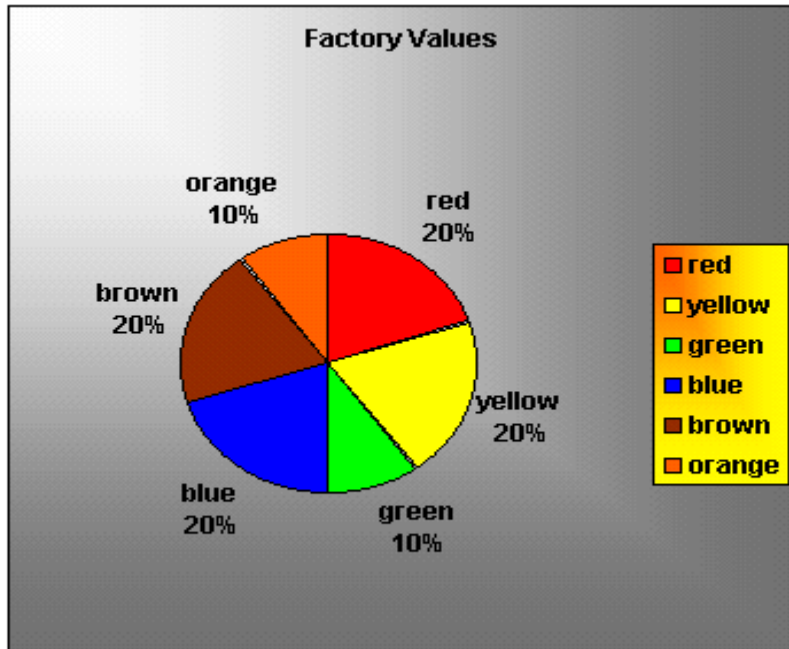
Charts:

These charts reflect the data that our class gathered.

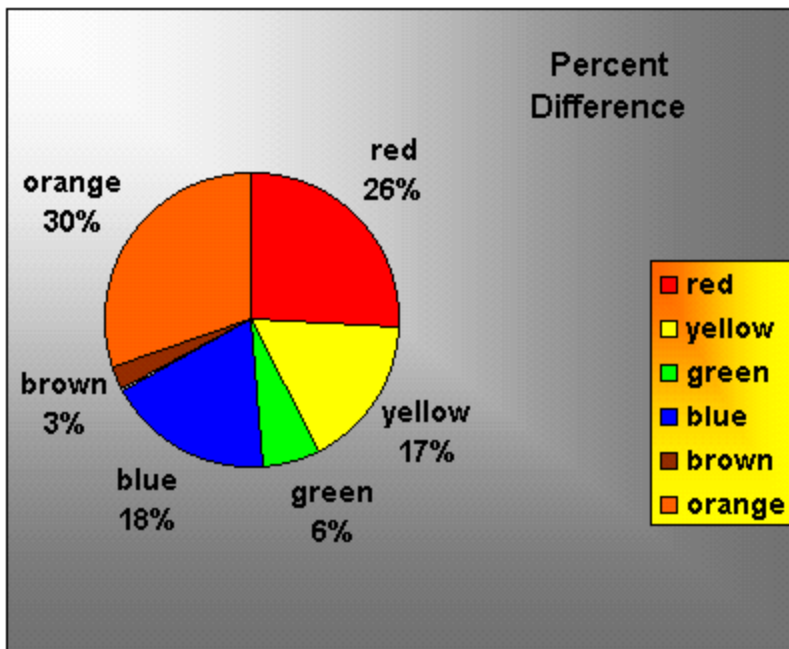
This shows the percentage of the total studied each color represents.



This chart shows the factory values from the M & M Web Site



This chart represents the difference between the classes data and the factory values.



Results:

Our class findings were different than the expected outcome. The M & M site stated that color distribution on the average should be 20% red, 20% yellow, 10% green, 20% blue, 20% brown, 10% orange in each bag. However, we found that we had a larger percentage of blue, brown, green, and yellow. We had a lower than expected percentage of orange and red.

Conclusion:

We concluded that we did not take a large enough sample. We only gathered a limited amount of data. If we had opened and counted more M&M's we would probably have gotten closer to the factory data.



Related Links

M&M Data Website:

<http://www.m-ms.com/factory/history/faq1.html>

Office of the Superintendent of Public Instruction

State of Washington - Essential Academic Learning Requirements:

<http://www.k12.wa.us/reform/EALR/default.asp>

Contact Information

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M&M Graphing and Probability

An AskERIC Lesson Plan

AUTHOR: Karen Stewart, Harmony Elementary, Cushing, OK

Date: 1994

Grade Level(s): 1, 2, 3, 4, 5

SUBJECT: Mathematics/Probability

OVERVIEW:

Charts and graphs are not only valuable instruments for communicating data quickly and simply, they can be tools for stimulating discussion, and aids in promoting mathematical thinking. Graphing activities for elementary students should include more than fixed displays of information. A hands-on, relevant lesson can be a successful way of teaching concepts which students are more likely to retain. M&M Graphing And Probability can be as simple as making a pictograph (1st and 2nd grades), or as involved as predicting and determining probability (3rd-5th grades).

PURPOSE:

To provide students with a hands-on and cooperative learning experience in the process of collecting, analyzing, and interpreting data, and to improve decision making skills through the use of probability.

OBJECTIVES:

Students will be able to:

1. Count, sort, and classify M&M's by color.
2. Record data on a chart.
3. Use data from a chart to create a pictograph.
4. Use data from a chart to create a bar graph.
5. Use data from a chart to create a circle graph.
6. Analyze and interpret data.
7. Use data to figure ratios.
8. Use data to determine probability.

Curriculum

- Mathematics/Problem Solving and Reasoning/General Problem Solving and Reasoning
- Mathematics/Problem Solving and Reasoning/Understanding Problems
- Mathematics/Problem Solving and Reasoning/Logical Reasoning
- Mathematics/Problem Solving and Reasoning/Generalize
- Mathematics/Whole Numbers and Numeration/Number Properties/Fractions Decimals Ratio Percent
- Mathematics/Statistics and Probability/Statistics/General Statistics
- Mathematics/Statistics and Probability/Statistics/Data Collection-Organization
- Mathematics/Statistics and Probability/Statistics/Construct and Read Tables

- Mathematics/Statistics and Probability/Statistics/Construct and Interpret Graphs
- Mathematics/Statistics and Probability/Probability/General Probability

Process Skills

- Natural Science Process/Gather Data/Observe
- Natural Science Process/Gather Data/Measure
- Natural Science Process/Gather Data/Record
- Natural Science Process/Analysis Synthesis Evaluation/Infer
- Natural Science Process/Analysis Synthesis Evaluation/Investigate
- Natural Science Process/Analysis Synthesis Evaluation/Interpret
- Natural Science Process/Analysis Synthesis Evaluation/Hypothesize
- Natural Science Process/Analysis Synthesis Evaluation/Problem Solve and Conclusions
- Natural Science Process/Communicate Ideas/Define Ideas
- Natural Science Process/Communicate Ideas/Describe
- Natural Science Process/Communicate Ideas/Graphs Tables Maps
- Natural Science Process/Communicate Ideas/Oral and Written Expression

RESOURCES/MATERIALS:

- small bags of M&M's
- pencils
- paper
- rulers
- crayons or markers

ACTIVITIES AND PROCEDURES:

1. Give each student (or pair of students) one small bag of M&M's.
2. Ask students to open the bag, sort, and classify the M&M's according to color.
3. Ask students to record the information from step 2 on a chart.
4. After illustrating various pictographs, ask students to use their data to create their own pictograph.
5. Compare graphs. Have students discuss the differences and the similarities of the graphs.
6. Have class form small groups of 4-6. (possibly by rows in the classroom) Ask the groups to combine their data and make a new chart illustrating the results.
7. After discussing bar graphs, ask the groups to create and color a bar graph using the new figures. Compare this graph to the individual pictographs. Are the ratios the same.
8. Ask the groups to combining all of the data to include on a class chart. Round the numbers to the nearest tens for ease in creating a circle graph. You may want to do this together on the board or an overhead projector.
9. Ask students to determine the ratio of each color of M&M to the entire bag. With this information, the students can predict the probability of selecting one color at random from a large bag. How many of each color would be likely to be found in a handful of 10, of 20? Try it. Discuss the results. Then enjoy the M&M's.

TYING IT ALL TOGETHER:

Probability is an important decision-making tool. Teaching students to successfully use data from charts or graphs to predict probability will improve their decision-making skills. A hands-on approach will help students apply the concepts of graphing, and probability to other problem solving and risk-taking situations.

ADDITIONAL ACTIVITIES:

1. Get the students thinking in another direction. Ask them why they think the makers of M&M's make more brown ones than green. Write a creative essay about it.
2. Have students research to find out why there was a period of years that no red M&M's were made. When did they start including red M&M's in the packages again?

May 1994

These lesson plans are the result of the work of the teachers who have attended the Columbia Education Center's Summer Workshop. CEC is a consortium of teacher from 14 western states dedicated to improving the quality of education in the rural, western, United States, and particularly the quality of math and science Education. CEC uses Big Sky Telegraph as the hub of their telecommunications network that allows the participating teachers to stay in contact with their trainers and peers that they have met at the Workshops.

M and M Project

(This lesson will soon be updated to include the blue M & M's)

DO NOT OPEN YOUR PACKAGE YET !

1. Guess how many M & M's are in your package. _____
2. How many different colors are there in your package? _____
3. What are the colors?

4. What color do you think occurs most often? _____
5. What color do you think occurs least often? _____
6. Look at your package and one other package in your group. Do you think that all of our packages weigh the same?

What would be the easiest way to find out ?

7. How many M & M's of each color do you think you have in your package? **MAKE SURE YOUR ESTIMATE EQUALS YOUR GUESS IN NUMBER 1.**

COLOR	ESTIMATE

8. **If a large box of M & M's cost \$15.00, and there are 48 bags in each box, how much would one bag cost? _____ SHOW YOUR WORK BELOW.**

DO NOT EAT THEM (yet)

9. Complete the chart. Copy your estimates from the first page. Then count for the actual amounts.

COLOR	ESTIMATE	ACTUAL
Red		
Yellow		
Orange		
Green		
Tan		
Brown		
Blue		

10. As a group, share actual amounts and fill in the chart. Then, you need to **TOTAL** the columns, and **AVERAGE** the amounts. Remember, you cannot have remainders, so **ROUND UP!**

Your Color	Amount	#1	#2	#3	TOTAL	AVG.
Red						
Yellow						
Orange						
Green						
Tan						
Brown						
Blue						
TOTAL						

11. Why do you think that everyone didn't have the same amount of M & M's in their bag as everyone else?(Really think about this one--there is one correct answer !)

12. Pick out the following 30 of your M& M's: 5 Red, 7 Yellow, 5 Orange, 3 Green, 2 Tan, and 8

Brown If you don't have these amounts...see your teacher. Place the 30 in your bag. COUNT CAREFULLY (or you will have major problems tomorrow!)

OPEN YOUR BAG...DON'T EAT YET!

13. Complete the chart based on the M & M's in your bag now.

COLOR	AMOUNT
Red	
Yellow	
Orange	
Green	
Tan	
Brown	
Blue	

14. Does one of your colors equal exactly...

of your M&M's? _____ Which one? _____

of your M&M's? _____ Which one? _____

of your M&M's? _____ Which one? _____

(End of Page 3)

15. Write the fraction for each color and then REDUCE to lowest terms if possible.

RED = _____ GREEN = _____

YELLOW = _____ TAN = _____

ORANGE = _____ BROWN = _____

16. Using the lowest terms fraction from #15, compare the fractions of the following colors, using >, <, or = signs between the fractions. EXAMPLE:

G:R _____ Y:B _____

O:G _____ Y:R _____

17. If you eat 2 of your brown M&M's (go ahead....do it) what fraction now shows the brown ones? BE CAREFUL! _____

Now...the time you've been waiting for....

YOU MAY EAT THE REST OF YOUR M&M'S WHILE YOU FINISH THIS PAGE.

18. Complete the chart with all the calculations. Fractions need to be in lowest terms and decimals need to be rounded to the nearest hundredth.

COLOR	FRACTION	DECIMAL
Red		
Yellow		
Orange		
Green		
Tan		
Brown		
Blue		

GRAPH TIME

19. Make a **DOUBLE BAR GRAPH**. Use the information that you gathered on page 2 number 9 comparing your estimated amounts for each color to the actual amounts.

- Title the graph - **MAKE SURE IT TELLS WHAT THE GRAPH IS ABOUT**
- Use a key to tell what the colors mean (one color for actual and one for estimated)
- Label the x axis and the y axis with "COLOR" and "NUMBER OF M&M's"
- Make sure that it is neatly done and well organized!

20. Make a **PICTOGRAPH** for the average amount of each color of M&M's using the amounts from question #10.

- Title the graph - **MAKE SURE IT TELLS WHAT THE GRAPH IS ABOUT**
- Use the key: one picture of an M&M = 2 M&M's.
- Make it neat and legible!

After you make the graphs, answer the questions. Your answers will be graded so answer them completely!

Note: **DOUBLE BAR GRAPH** and **PICTOGRAPH** will be pages 6 and 7

21. What can you say about your estimated amounts compared to your actual?

22. Make a statement about something that your pictograph tells.

24. What was your overall feeling about this M&M project?

25. Besides the eating of the M&M's, what parts did you like?

26. What parts did you dislike doing?

27. On a scale from 1 to 10 where 10 is the highest, how would you rate the following:

_____ The Project

_____ The quality of your work

_____ The amount of time spent at home on the project

_____ Your effort to do well

28. SHOW THIS WHOLE PACKET TO YOUR PARENTS.

Parents: Please sign this packet indicating that you have looked over your child's work and everything seems to be completed. Please feel free to comment. Thanks!

Parent Signature _____

Data's M&M's spreadsheet

Table of Contents

This lesson is designed to help students understand how data can be represented by spreadsheet and by bar graph. Students will take information and arrange by category in the spread sheet. They will then use the spreadsheet to create either a line or a circle graph using their information. Since this lesson is for ESL students, we should concentrate on the language skills rather than the technical skills. Students should be encouraged to discuss their findings and compare their graphs with other students.

1. Lesson Description

2. Classroom and Time Management

3. Materials Needed and Teacher Preparation

4. Teacher Instructions

5. Assessment

6. Examples of Student Work

Lesson Description

Period of time required for lesson:

4-5 days, 1-2 periods per day

Overall goal of the lesson:

Students will learn how to create a spreadsheet and a simple bar graph that will correspond to data that they received in a scientific experiment involving numbers of M&M's in a bag.

Rationale for the lesson:

As part of the middle school curriculum in science, the students will have to write about their findings. Part of this writing will be to display and interpret data found in their experiments. This program will allow them to compare their hand done work with that done by the machine.

Student academic outcome objectives:

1. Students will be able to represent data using a spreadsheet.
2. Students will be able to create a bar graph using part of the spreadsheet program.
3. Students will be able to discuss their findings with each other and interpret their data using the graphs.

Student social outcome objectives:

1. Students will be able to work in groups at the computers.
2. Students will be able to share information and create a product (graph).

Student technical skills outcome objectives:

1. Students will be able to increase their ability to use the computer.
2. Students will be introduced to the ClarisWorks program.
3. Students will be able to create a simple spreadsheet.
4. Students will be able to create a simple bar graph using the spreadsheet program.

Prerequisite academic skills required:

1. Students must already be able to read simple bar graphs.
2. Students must already have completed the experiment and recorded their data.
3. Students must be able to understand what a spreadsheet is.

Prerequisite social skills required:

1. Students must be able to work as teams.
2. Students must already have experience working on the computer as part of a team.
3. Students must be able to stay on task for over 15 minutes at a time.

Prerequisite technical skills required:

1. Students must be able to use a keyboard to input information.
2. Students should be able to save to a disk.
3. Students should be able to use a basic word processing program.
4. Students should know simple computer commands such as open, close, exit, save, and print.

Grouping and use of technology in the classroom:

Students will come to the computers in pairs to input information that they have previously gained through their science experiment. They will have already had practice in rotating through the computers, but with only 2 computers, they might not have had enough time to complete the rotations of the last lesson.

Group Management

Students should be grouped in pairs for this lesson, with the pairs rotating through the computers. It will take a full period for each pair to input the information to their satisfaction.



Time Management

All teams will rotate through the computers. Each team will have a full class period at the computer. Pairs of teams will use computers each day. Students will input their information into a ClarisWorks document. It will go faster if a template of the spreadsheet is made and installed first. The teams will continue to go to the machine doing this until all teams have had a turn at the computer.



Materials needed and Teacher Preparation

Plan, Review and Do:

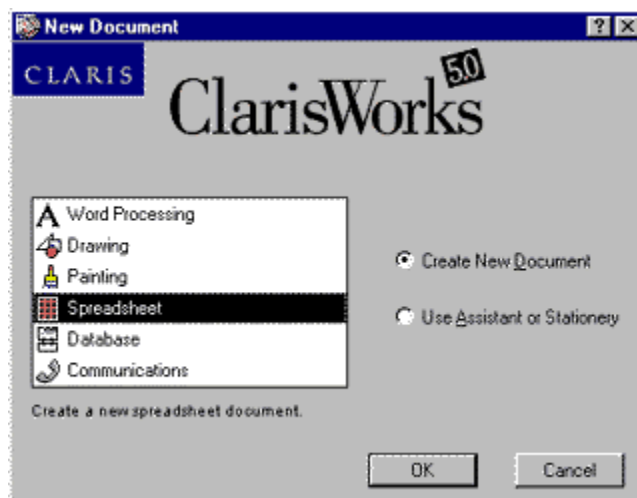
1. Students should have had their science lesson completed and data recorded.
2. Students need to have finished their paper graph.
3. Students should have finished their writing in Bilingual Writing Center about their findings during the experiment.
4. Students should have their information down on paper and a student list of instructions or a chart posted.

Materials Needed:

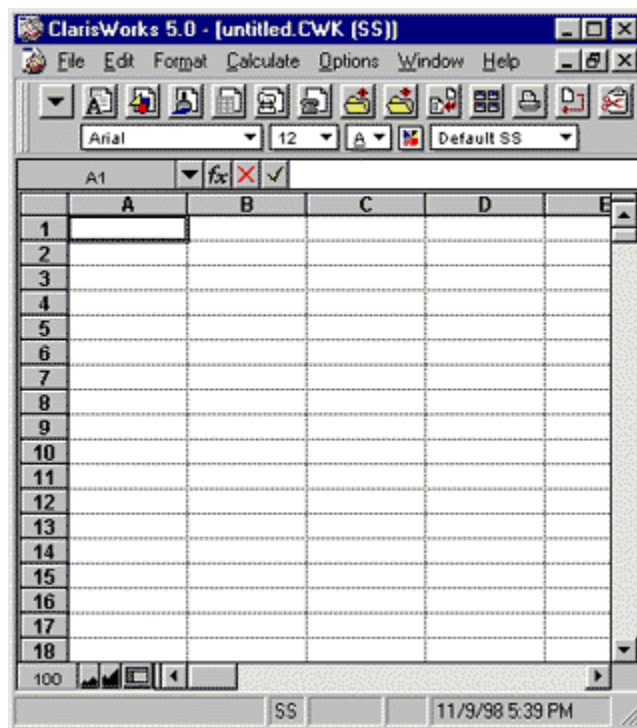
two computers

Teacher Instructions

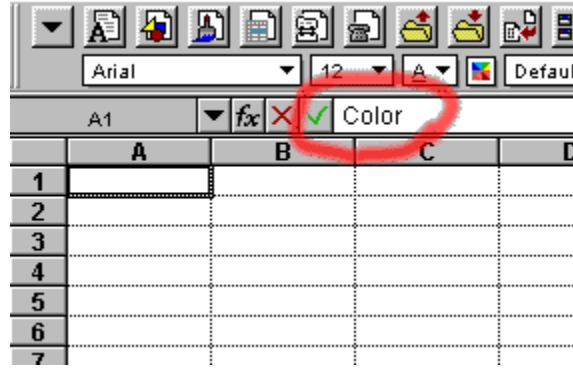
1. Open ClarisWorks and Start a new Spreadsheet document: Click "Spreadsheet" and then the "OK" button.



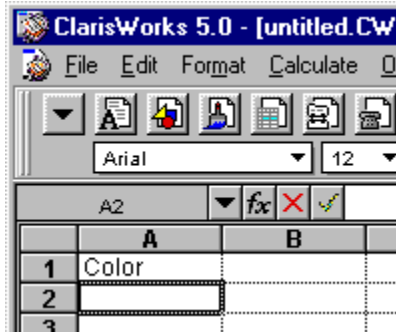
2. You will see a blank spreadsheet in front of you. Begin typing in your information.



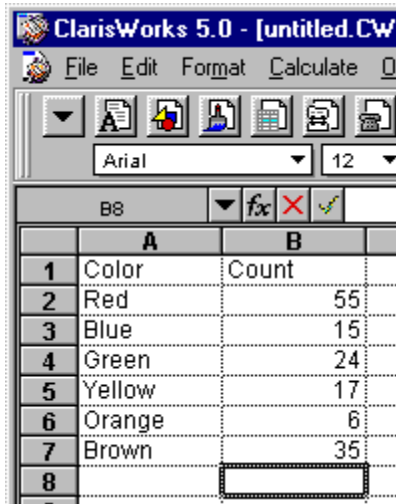
3. Notice that as you type, the word you are typing appears above the spreadsheet cells:



4. When you have finished entering information for a cell, press the "Return" key on your keyboard. Now, the cell just below the one you typed information in will be selected, and the information you typed will appear in the cell that was previously highlighted.



5. Keep typing in your information. In the first column, enter in the colors of your M&M's.

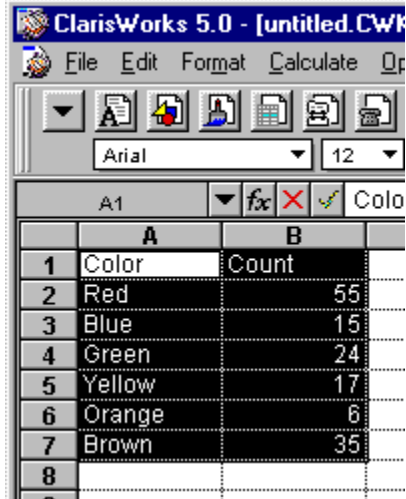


6. When you have entered all of the colors in, use the mouse to click on the cell to the right of the one labeled "color." Label this column "count." Now, go down the column, entering your count for each color.

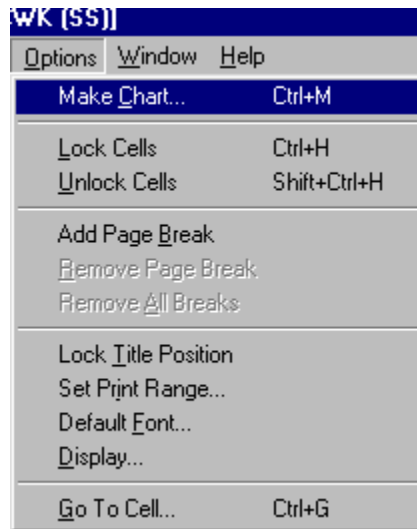
7. Now, you are ready to make a graph. Select all of the cells in this way:

- (a) first, click in the cell labeled "color"
- (b) hold the mouse button down and click and drag to select all of the cells.

If your screen does not look like this, with the first cell white and all the other cells black, then try again until it does:

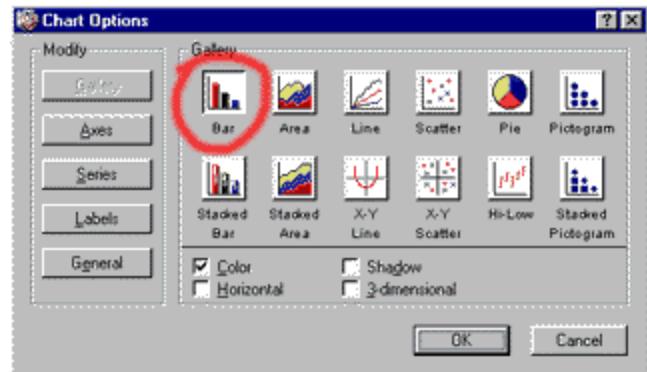


8. Now, from the menu bar choose Options, Make Chart...

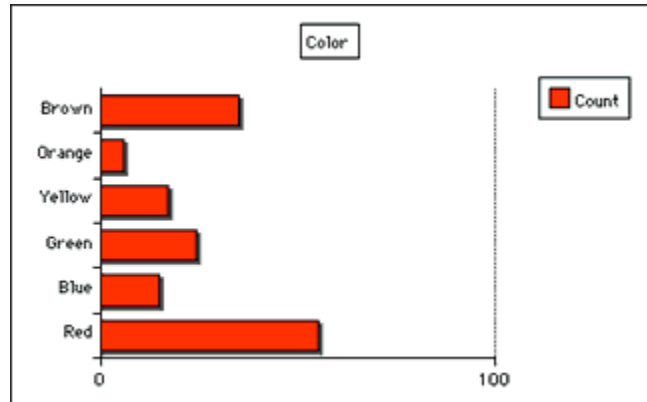


9. It will be easier for groups to compare charts if we all make them the same. Click on the icon for "Bar" charts:

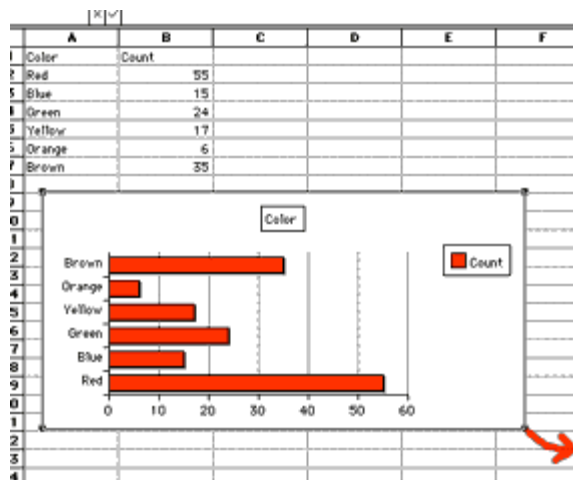
10. Below the chart types are options for the chart. In this example, "Color" is selected (see how it has a check mark?) Click on "Horizontal" to make the bars go left and right instead of up and down. Click on "Shadow" to create a shadow behind the bars. Click on "3-dimensional" to make the bars look like they are solid shapes.



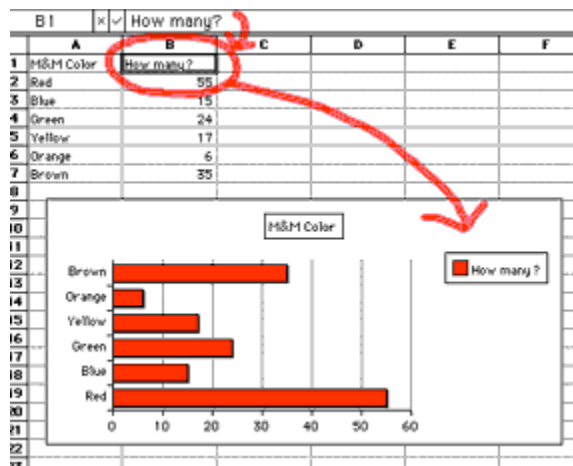
11. Click on the "OK" button to create the chart:



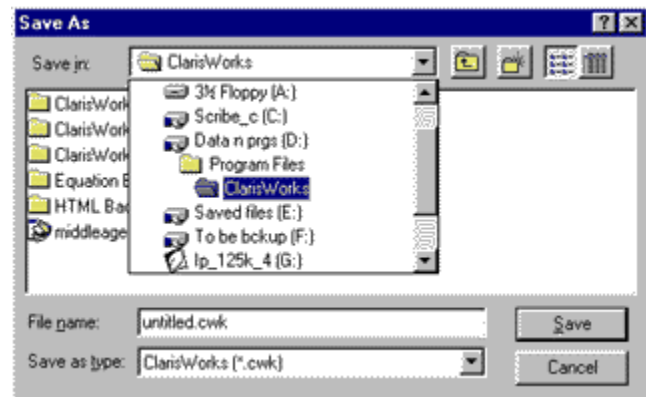
12. If you want to change the size of your chart, click and drag the corner of the chart:



13. If you want to change the value in any cell (for example, the labels on the chart, or a number that you typed wrong) just click in the cell, change it in the field above the cells, press the "Return" button on the keyboard, and you will see it change in the spreadsheet and the chart:



14. Now, save your work. Choose *file*, *Save* from the menu bar. In the box at the bottom, replace the word "untitled" by typing in a name for your file. Click the "Save" button.



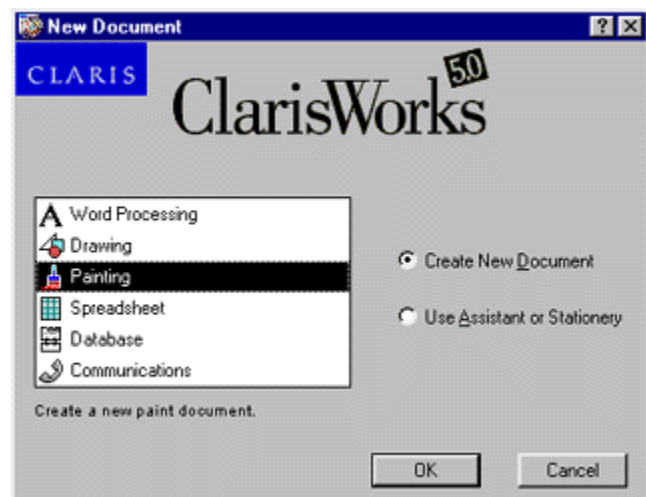
15. Now, print your work. Choose *file*, *print* from the menu bar, then click the "OK" button.

Advanced Options

If your group has finished with plenty of time, you may want to add some more color to your chart.

1. Click on the chart and press Ctrl-C on the keyboard to copy the chart to the clipboard.
2. From the menu bar, choose *File*, *New*.

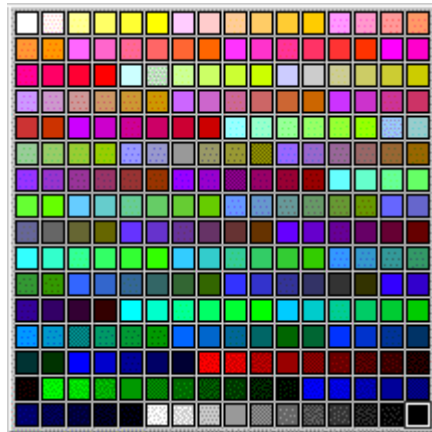
3. Choose "Painting."





4. Press Ctrl-V to paste your chart into the painting area.

5. Click on the color button below the paint can and select the color you want.

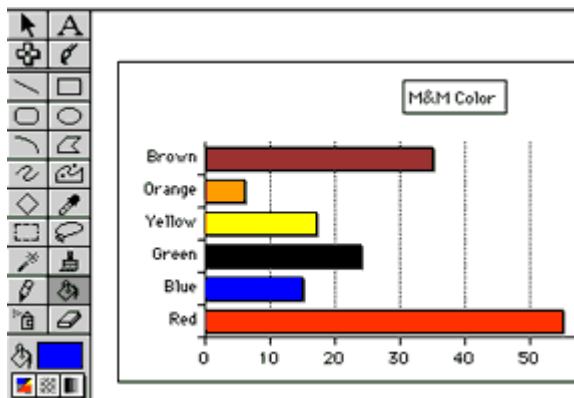


6. Click on the paint can icon in the tool palette:



7. Click the tip of the paint can into the bar you want to color.

If you make a mistake, press Ctrl-Z on your keyboard (undo.)



8. Save and print your work (see steps 14 and 15.)

Student Assessment

Academic assessment

Groups will be assessed based on whether or not they complete the spreadsheets and graphs.

Social assessment

Teacher observation should be used to evaluate social interaction.

M&M Science

You might think you are just playing with chocolates but you will actually be learning and practicing the key scientific skills of estimating, hypothesizing, observing, measuring, classifying and graphing!

WARNING: We only have one packet of M&Ms per group. You can eat the M&Ms BUT ONLY AT THE END!

Part One: Estimating

When you make an estimate about something you are making a guess about it.

Q. Without opening them, how many M&Ms do you think are in your packet?

I think there are _____ M&Ms in my packet.

Q. How many different colours do you think are in your packet?

I think there are _____ different colours in my packet.

Q. What colours do you think you have in your packet?

I think that the colours of my M&Ms are:

Q. Which colour do you think will be the most common one in your packet?

I think that _____ will be the most common colour in my packet.

Part Two: Checking Estimates and Classifying

Action: Carefully pour your M&Ms out on to your worksheet and count them.

Q. How many M&Ms were in your packet?

I have _____ M&Ms in my packet.

How close were you to your estimate in Part 1?

Action: Sort the M&Ms into groups of each colour. This is known as classifying – you are dividing up your M&Ms into groups of all the same thing.

Action: Record your results in the box: Colour Number

Action: Put a star next to the most common colour in your packet.

Was your estimate of the most common colour correct?

Action: Talk to some other groups.

Was the most common colour in their packet the same as yours? _____ If not, what colour was it? _____.

Part Three: Graphing

An easy way to show the results from an experiment is to draw a graph.

Action: On a sheet of graph paper draw a bar graph that shows how many M&Ms of each colour you had in your packet. *Please ask for help if you need it.*

The leader of the session will now collect information from everybody about the number of M&Ms of each colour that they had in their packet.

Action: Draw another bar graph that shows the whole group data on how many M&Ms of each colour were in all the packets.

Is there still one colour that is more common than the others and is it the same colour that was the most common one in your packet?

Part Four: Hypothesizing

When you make a hypothesis you are using something that you already know to make a guess about something else.

In my packet of M&Ms, there was _____ M&Ms, so all of the other people here will probably have a packet of M&Ms with _____ M&Ms in them.

Action: Check with other people doing this activity. Does everyone have the same number of M&Ms in their packets, and all the same colours?

Q: What is the weight of a packet of M&Ms? A packet of M&Ms weighs _____.

Q: If each packet weighs the same, can you think of why there may be different numbers of M&Ms inside them?

Part Five: Calculating

Action: Use what you know about your packet of M&Ms to calculate the weight of one M&M. The weight of one M&M is _____ grams.

Q: How could a more accurate calculation of the weight of one M&M be made using the results from everyone in the group?

Q: If a packet of M&Ms costs 40 pence, how much does one M&M in your packet cost?

One M&M in my packet costs _____ pence.

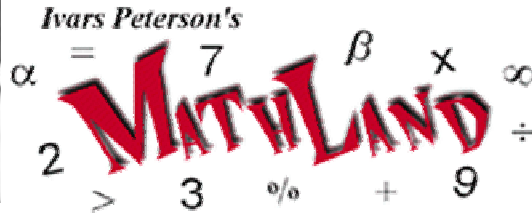
Q: How could a more accurate calculation of the cost of one M&M be made using the results from everyone in the group?

Part Six: Tasting

Action: Do a comparative taste test. Eat only one M&M of each colour, one at a time.

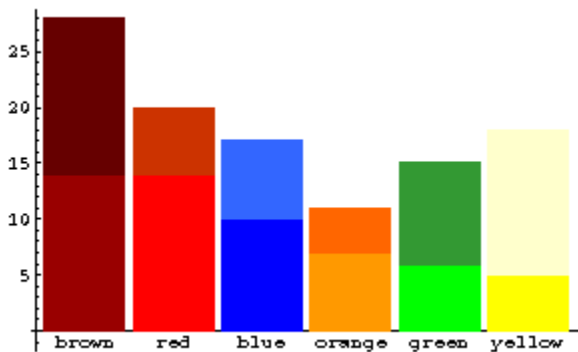
Q: Can you notice any difference in the way that the M&Ms taste?

Now you can eat the rest of the M&Ms!



***** March 8, 1997 *****

A Taste for M&M's



The package of M&M's chocolate candies (plain) I had just opened contained 56 colorful little oblate spheroids. It was obvious from a quick glance that certain colors were more common than others in this sample. I counted up each color and confirmed my suspicion.

Then I opened another packet to see if I would get comparable results. There were some interesting similarities and differences in the data, including the fact that the second package had three fewer M&M's!

	First Package	Second Package	Combined	Official
Brown	14 - 25.0%	14 - 26.4%	25.7%	30%
Red	14 - 25.0%	6 - 11.3%	18.3%	20%
Blue	10 - 17.9%	7 - 13.2%	15.6%	10%
Orange	7 - 12.5%	4 - 7.5%	10.0%	10%
Green	6 - 10.7%	9 - 17.0%	13.8%	10%
Yellow	5 - 8.9%	13 - 24.5%	16.6%	20%

Number of each color in two packages of M&M's plain chocolate candies.

I was tempted to open a third package to investigate further. Luckily for both my diet and my pocketbook, however, Ronald D. Fricker Jr., a statistician with TRW and a graduate student at Yale University, had already gone through a similar experience, which he described in a recent issue of Chance.

Soon after the official introduction of blue M&M's in September 1995, Fricker was grading homework assignments with a bowl of the candies at his side. He noticed that there seemed to be far fewer of the new blue variety than of the other colors.

"This led me to think about how estimating the proportions would make an interesting class experiment," he says. "Ever on the lookout for an excuse to avoid grading papers . . . I decided to conduct my own experiment right then and there."

However, given that he had eaten most of the data, he first had to go shopping to replenish his supply. With the aim of getting samples from different manufacturing lots, he bought three pounds of candy in bags of various sizes from two different stores.

Counting 1,527 M&M's by color, Fricker found that brown M&M's were the most numerous, followed by yellow and red, then orange, green, and blue. Intrigued by the uneven distribution, he investigated further by conducting a NEXIS search. He found a July 1, 1995, newspaper article in the Austin American Statesman that purported to report the true distribution of colors.

When he compared his data to the "true" distribution, four of the colors matched up fairly well, but the brown and blue percentages were significantly off. It was particularly striking that the under representation of blue nearly matched the overrepresentation of brown.

"I could come to only one of two conclusions," Fricker remarks. "Either I had uncovered a large corporate conspiracy designed to dupe an unsuspecting public out of blue M&M's, or the newspaper was wrong."

Checking with Mars, the manufacturer of M&M's, Fricker determined that the official distribution of colors fits the observed data better than the distribution reported by the newspaper. Even then, there were small discrepancies. "We can rationalize the observed differences from the distribution reported by M&M/MARS by recognizing that true randomness must be at least slightly violated in the candy manufacturing and bagging process," Fricker notes.

Many classroom teachers have gone through similar exercises with their students. Indeed, Mrs. Lieber's third-grade class at the Santa Fe Christian School in Solana Beach, Calif., sampled a total of 3,512 candies for a virtual science and math fair project and obtained roughly the same results as Fricker. M&M/MARS Consumer Affairs in Hackettstown, N.J., also publishes a leaflet on suggested math tasks using the candies and a brochure on the percentage of each color in various M&M's products, including details of how the colors are chosen.

"Several insights resulted from this study," Fricker concludes. "The first is that you can have your data and eat it too. . . . Second, skepticism is healthy when reading facts and statistics in the popular media."

My data are now gone, and I'm starting to wonder about animal crackers. Barnum's Animals Crackers, made by Nabisco, contain a mixture of animals, some considered predators and the others prey. Are the prey more likely to be found broken than the predators?

This may call for some serious sampling.

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References:

Fricker, R.D., Jr. 1996. The mysterious case of the blue M&M's. *Chance* 9(No. 4):19.

Johnson, R.W. 1993. Testing colour proportions of 'M&M's.' *Teaching Statistics* 15:2.

Check out the official M&Ms Web site at <http://www.m-ms.com/>.

The electronic publication CHANCE News featured the Austin American Statesman data on the distribution of M&M colors and comments on the predator-prey relationship in Barnum's Animals Crackers. Check issues 4.12, 4.13, and 6.01 at:

http://www.geom.umn.edu/docs/education/chance/chance_news/news.html.

Mrs. Lieber's third-grade class describes its M&Ms project at

http://www.vpds.wsu.edu/fair_95/gym/em010.html.

Various math assignments involving M&Ms are available at

<http://www.teachnet.org/blueplate/M-M/m-mprobs.htm>.

The MathSoft math puzzle page for January has a problem on candy probabilities:

<http://www.mathsoft.com/puzzle.html>.

For the history of Barnum's Animals Crackers and the current list of animals, check

<http://www.nabisco.com/museum/barnums.html>.

Ronald Fricker can be reached at fricker@stat.yale.edu.

Bar chart created using Mathematica 3.0 (<http://www.wolfram.com>).

"M&M's" is a registered trademark of Mars, Inc., Hackettstown, N.J. 07840-1503, and

"Barnum's Animals" is a registered trademark of Nabisco Brands.

Comments are welcome. Please send messages to Ivars Peterson at ip@scisvc.org.

M&M Math

Grade Levels: K - 5

Objectives

- Students will represent data in a bar graph.
- Students will learn to extrapolate data from a bar graph.
- Students will use comparison math terms.
- Students will average numbers.

Materials

- A large bag of M&M's or anything else that can be divided so that every child has an assortment of about 20 items that can be sorted by different attributes (color, size, shape). There are a number of cereals that work well for these lessons as do colored tiles.
- Graph Paper
- Crayons
- Spreadsheet software (optional)

Procedures

1. Give each child a piece of 1/2 inch graph paper, crayons, and about 20 M&M' s.
2. Demonstrate how to make the X and Y axis, to assign number values, and attributes to them.
3. The children sort the M&M's by color, counting each color grouping as well as the total M&M's.
4. Have students arrange the M&M's by color from the most to the least on the graph paper.
5. Direct the students to convert this data into bar graphs.
6. Tell the students to write number sentences and less than/greater than statements about their findings.
7. Have students find the average number of each color for the whole class.
8. Students can take all of this information, put it into a spreadsheet, and generate graphs on computers.

Mining for MMM-Good Minerals

A Lesson Plan from The Education Center, Inc.

Enjoyed by Grade 5 Students in the Pattie Elementary Science Lab

Here was a great chocolate chip cookie activity done by our students in the school Science Lab.

Purpose

To learn about the process of mining and how it affects the earth, and how real mining companies face constraints on their mining processes which. Laws exist to protect the environment, and mining companies must conform to these laws or risk losing significant profit. The students were instructed how to "mine" for the minerals (chocolate chips) so that the environment (the rest of the cookie) was impacted as little as possible.

How we implemented this lesson

Our science lab was equipped with cookies, toothpicks and a digital camera to record the "mining efforts. Students learned about the problems associated with mining, and how the earth can be harmed. As the lesson shows, students were "fined" for poor mining habits, and "rewarded" with profit when they were successful at good mining habits.

Here is the complete lesson activity, From the June/July 1998 Intermediate edition of The Mailbox® and reprinted by permission of [The Education Center, Inc.](#) It is to be given out to the student "mining teams" to use during their lab activity. Our students had to keep their data complete all through out the process, and it was turned in for a grade at the end of lab.

"Mining for MMM-Good Minerals

Some rocks contain large amounts of minerals. These rocks are called mineral deposits. A mineral deposit that can be mined for profit is called an ore. Silver, gold, and asbestos are examples of ores. However, there can be problems with the mining of ores. A mine may cover a very large area and may reach deep into the earth's surface. This digging up of very large areas of land can cause environmental problems.

Complete the following activity to help you understand the difficulty in reaching ores. You will also discover how land is lost during mining.

Materials needed for each student: 1 chocolate-chip cookie, toothpick, plastic drinking cup, paper towel, scale, clock. [NOTE: At Pattie, we used a brand of hard, crunchy cookies.]

Mining Rules

1. Your mine will earn \$1,000 for every _____ chocolate pieces. [NOTE: at Pattie, we put "weighed gram of" in this blank.]
2. The value of your chip mine goes down \$100 just for mining it.
3. You will be charged \$100 for every five minutes it takes to mine the chocolate.
4. You will be fined \$100 for each cookie piece that breaks off. The more damage you cause, the more money you lose.

Part I: Mining & Processing

1. Examine the chocolate-chip cookie mine (your cookie). How many "minerals" (chocolate chips) can you see on the surface? _____
2. Record your starting time: _____
3. Use the toothpick to carefully dig out the minerals. You may look at the bottom of the cookie, but you may only mine it from the top.
4. To process your minerals, separate the crumbs from the chocolate you have mined.
5. Record your ending time: _____
6. Record your total mining and processing time: _____ minutes.
7. Total Mining & Processing Fee (\$100 per every five minutes): \$ _____

Part II: Land Damage

1. Chip Mine fee: \$100
2. Land Damage: Count the cookie pieces that broke off as you worked: _____
of cookie pieces X \$100 = \$ _____
3. Total Land Damage + Chip Mine Fee: \$ _____

Part III: Measure Minerals

1. Pick up the mined chocolate pieces, put in cup.
2. Weigh the amount of chocolate in the cup: # grams _____ [Pattie students were told to round up.]
3. Record the value of your minerals (\$1,000 for every gram in the cup): \$ _____

Part IV: Compute Profit

Total Mining & Processing Fee: _____

+

Total Land Damage Fee \$ _____ -

=

Total cost \$ _____

Value of Minerals \$ _____

-

Total Cost \$ _____

=

Total Profit \$ _____

Part V: Conclusions

1. How is your chip mine like a real one?
2. How is it different?
3. What happened to the land while you were mining?
4. How could you repair the land?"

M&M lab: Percent Fractions

Grade Level: 5th - 7th

Objectives

1. Students will practice computing percentages.
2. Students will compare percentages.
3. Students will practice computing fractions.

Materials

Students will work in pairs for the M&M lab and each pair of students will need:

- M&M lab materials, worksheets
- a bag of M&M's
- a calculator
- markers or crayons - brown, yellow, orange, red, green, blue

Lesson

Time: This activity is designed to take approximately one class period, 45 minutes. It can be lengthened or shortened depending on the amount of class discussion

Anticipatory Set

1. Divide students into cooperative learning groups, such as each table, group of desks, etc.
2. Have students pair up, so that each student has a lab partner.
3. Each pair of students will need to make sure that they have the following materials:
 - lab worksheets a bag of M&M's a calculator markers or crayons
4. Prepare students for activity by discussing fractions and percents. Pose questions to the students such as:
 - What is a fraction? Possible explanations include part to a whole, etc.
 - How do we find a fraction?
 - What is a percent?
 - How do we calculate percents?
 - How are fractions and percents related, i.e. how can we use fractions to calculate percents?
5. Give directions. Explain the lab and the different activities involved in the lab.
6. Demonstrate the tasks required in the lab, such as computing percents.
7. Ask the students if they have questions over the lab before they begin.

Concept Development / Activity

1. Sort M&M's according to color.
2. Calculate the number of each color of M&M's and record the data on the first lab sheet, according to the corresponding space for each color.
3. Graph the number of each color of M&M's on the graph by using crayons or markers to color in the amount of M&M's
4. After students have graphed the number of each color of M&M's calculate the total number of M&M's.

5. Discuss with students the information that the Mars Company provides, and have students solve problems using this information. Record this data on the appropriate lab sheet.
6. Have students compute fractions for each color of M&M's in their bag. Record this data on the lab sheet.
7. Have students compute the percent of each color of M&M's in their bag. Record this data on the lab sheet.
8. Have the students share their group's information.
9. Record this information on the chalk board so that all students can see it, and have students record this information on the appropriate lab sheet.
10. Have students use each individual group's data to compute class results. Record these results on the appropriate lab sheet.

Discussion Questions

These are questions that can be used throughout the activity.

1. What kind of answers did you compute?
2. How do you think your results will compare to other students' results?
3. Given your results for one color of M&M's can you make predictions or estimates related to the fractions / percents for other colors of M&M's
4. What kind of results did you expect to get?
5. Why do you think you got these results?

Extensions

1. Use the data students computed and compare the results of individual colors by using greater than, less than or equal to problems. (problem examples on lab sheets)
2. Use data collected for each individual color and solve mathematical problems such as the number of blue M&M's plus the number of brown M&M's. (problem examples on lab sheets)
3. Have students create their own problems using the data collected from their M&M lab and share those problems with the class.

Closure

1. Have students discuss class data and results.
2. Have students discuss their findings from the lab, and compare that data to data provided by the Mars Company. How true are the percentages that Mars provides?
3. Review the math concepts practiced in the lab - - fractions, percents.
4. Ask students to discuss the relationship between fractions and percents
5. Have a student / group discussion about the overall lab, i.e. which tasks were difficult, which concepts were unclear, what areas need to be reviewed so that students have a better understanding.

Evaluation

A formal evaluation can be used by checking each student's lab sheets. A more informal evaluation that can be used for this activity is one of the extensions suggested. Have students use data and concepts learned from the lab to create their own M&M problem. Have the students share these problems with the class and explain their problem. Through the explanation students should demonstrate their understanding of the lesson.

M&M's And The Scientific Method

Science, level: Middle

Posted by Kim George.

East Cobb Middle School, Marietta, GA

Materials Required: M&M's

Activity Time: 30-40 minutes

Concepts Taught: Applying the scientific method to a problem.

1. Have each student bring in a bag of M&M's.
2. Give each student a copy of the scientific method.
3. First students will need to come up a problem.
4. Tell students that the school is conducting a study on the colors of M&M's.
5. The problem is that you want to know the most dominant color of M&M.
6. Next have students make a prediction. What color M&M is the most dominant?
7. Allow students to group their M&M's according to color and write down this information.

Use this information to devise a T table and then analyze the data by having students graph their results.

Make sure they give their graph a title and label the X & Y axis.

Last...come to a conclusion. They either accept or reject their hypothesis.

Now it's time to eat!!

Scientific Method/ M&M Lab

- Authors:** Celeste Steinman
- Subject:** 6th Science/Science 1
- Grades:** 6th grade
- Overview:** To use spreadsheet; collect data using scientific method using M&M bags; average; make graphs and share data
- Objectives:** To use spreadsheet; collect data; design graph from data; share data and draw conclusions
- Materials:**
- 1) spreadsheet
 - 2) computer
 - 3) M&M bags
- Procedures:**
- 1) to use spreadsheet
 - 2) count number of M&M's in each bag/each color
 - 3) share data; collect data
 - 4) design graph and share data
 - 5) draw conclusions
- Assessment:**
- 1) observe data
 - 2) observe graph
- Enrichment:**
- 1) compare with other classes
 - 2) predict what the next M&M bag will contain

Technology Tools for Teaching Integrated Mathematics and Science

[National Education Technology Standards](#) and the [Illinois Learning Standards](#) guide us towards helping students use tools that help analyze data and support the problem solving process. Spreadsheets are a critical tool to help meet this goal.

Scenario: Teams have analyzed their bags of M&Ms recording how many of each color there were in the bags.

Questions to answer:

- How could technology help us with analyzing M & Ms?
- If we graphed the data, what would the viewer be able to learn from the graph?
- If we created a spreadsheet what would be our column and row headings for the spreadsheet?
- What variables would we be trying to track and analyze?
- What types of analysis could we perform on the data?

columns

	A	B	C	D	E
1	Title of Spreadsheet Analysis				
2					
3	Variable	Variable X-1	Variable X-2	Variable X-3	Total
4	Variable Y-1				Total Y-1
5	Variable Y-2				Total Y-2
6	Variable Y-3				Total Y-3
7	Variable Y-4				Total Y-4
8	Total	Total X-1	Total X-2	Total X-3	Total All

rows

For Example: If we were conducting the M&M grab activity would it be interesting to look at the bag contents with the following analysis?

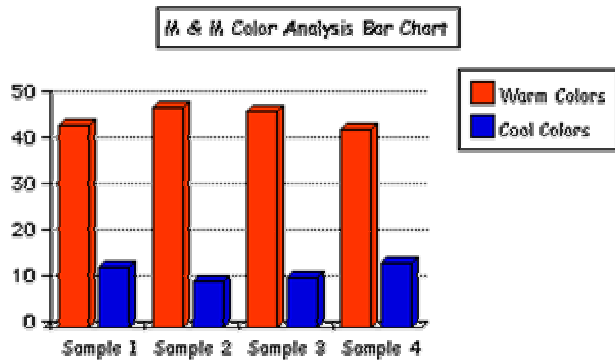
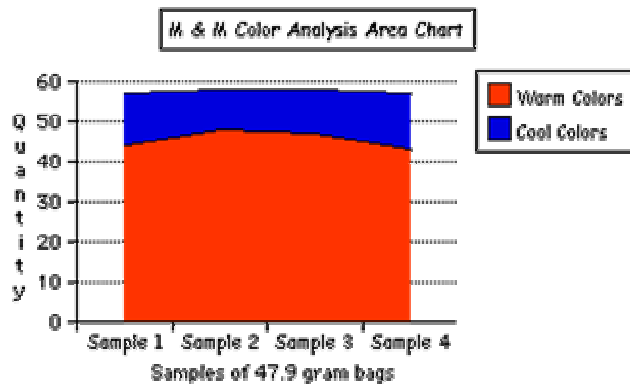
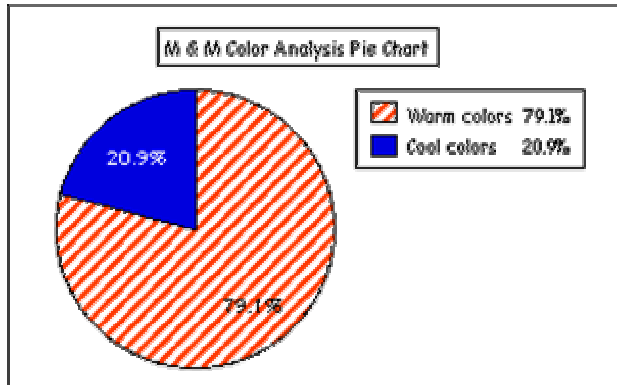
What formulas would be needed for these answers?

	A	B	C	D
1	M & M Color Analysis			
2	Weight of sample in grams:		47.9	
3	Bag Sample	Warm Colors	Cool Colors	Total
4	Sample 1	44	13	57
5	Sample 2	48	10	58
6	Sample 3	47	11	58
7	Sample 4	43	14	57
8	Total	182	48	230
9				
10	Average	45.5	12	57.5
11	Maximum	48	14	58
12	Minimum	43	10	57
13	% of Total	79.13%	20.87%	100.00%
14	Per 100 grams of M & Ms	94.99	25.05	120.04

Plan your M&M color analysis on the following template:

	A	B	C	D	E	F	G	H
1								
2								
3								
4								
5								
6								
7								
8								
9								
0								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

What type of graph(s) would best depict your data? What other options could be used to display the data via a graph?



Assignment: Create a table and graph(s) depicting your data. Include the answers to the following or similar questions: How many M&Ms are in a pound, and what is the color breakdown in that pound?

Homework: Explore the M&M web site at: <http://www.m-ms.com> There are the exact proportions posted on section of the web site titled: Industrial Candy and Magic or <http://www.m-ms.com/factory> of each color of M&Ms within each product type (plain, peanut, crispy, etc.). Compare your team findings with the web page answers and share with an e-mail with class members and/or your instructor.

Extension: What if you were going on a long voyage and you had to calculate your rations to last the whole trip? If you had a budget of \$20 for M&Ms, and you were going to be gone for three months, how many M&Ms could you eat per day. When you bought your \$20 worth, predict how many there would be of each color.

M&M Estimation



Math Process Skills

- Problem Solving
- Reasoning
- Communication
- Number/Operations/Computation



Materials (per group)

- small bag of M & M's (or other container of small multiple colored candies or objects) for each team of students
- paper
- pencil
- crayons
- graph paper



Doing the Activity

1. Find 2 or 3 people to be your partners.
2. Answer these questions:
 - How many M & M's are in the bag?
 - How many different colors of M & M's are in the bag?
 - Which color M & M has the most?
 - Which color M & M has the fewest?
3. Each team should go get one bag of M & M's and open it but do not eat the candy yet.
4. Answer each of the questions asked previously but use the M & M's from bag for data.
5. Put the data you have found on graph paper using a bar graph. Use the color of the M & M to represent it on the graph.



Reflecting

- What factors did your team consider when making your estimate of total M & M's?
- Did all teams have the same number of different colors of candy? If so, why? If not, why not?

- Do you think all teams will have the same color with the most and least M & M's? Why or why not?
- Did the results of this activity turn out like you thought it would?



Applying

Combine data from all groups and compute average number M & M's in each bag.

Also colors of M & M's and which color had the most and least.

- How can you apply what you learned in this activity to another situation?
- How can you use what your team learned in the future?
- What other things can you do with the information from this activity?



What's Happening

The amount of M & M's placed in a bag is determined by weight not number. Teams will find that the number of M & M's varies by bag but will be approximately the same.



More Challenges

- Why are there more of certain colors than others?
- Contact the company to determine if there is a reason for certain colors.
- Compute ratios for each color of M & M's.
- Try a large bag of M & M's to see if color ratios are the same as smaller bags.

Internet Sites for students

- [Mars Candy](#)
- [M & M's](#)

Internet Sites for leaders

- [Mathematic Activities](#)
- [Probability Activities](#)
- [Math Activities, games, and more](#)

Statistics With M&M Peanuts

Judy Allard

Is there a difference in mass between M&M peanuts of different colors? In this exercise, you are going to use statistical methods to answer this extremely important question!

Each student will measure the mass of 10 M & M Peanuts (which have been dipped in milk chocolate and covered with a thin candy shell) to the nearest tenth of a gram. Do not use any defective peanuts. Express the results in chart form. Calculate the mean, median, mode, variance, standard deviation (1s and 2s) and standard error for your sample.

Get the mean and variance from the samples of three other students in the class. These students must have used different colors of M & M Peanuts than the ones in your sample. Apply the t-test to compare each of the samples to your own. Be sure to include all the elements of the t-test, including the null hypothesis and the conclusion.

Write your sample mean on the table on the chalkboard. Express the means of the class in a frequency distribution table and a frequency distribution graph.

Write up the lab in proper lab report form.

HINT: Your experimental hypothesis should be written in terms of the difference in mass of M & M Peanuts of different colors. The statistical analysis of your data should be part of your "Results" section. Your experimental conclusion should be written after the discussion portion of your lab report in which you discuss your results and the class results and speculate as to explanations. You can also discuss further areas of research in the discussion section..

REFERENCE:

Biological Science: Interaction of Experiments and Ideas (BSCS Second Level), 3rd edition, Chapter 5



ZERO-G CANDY

Chocolate in orbit: Design an M&M dispenser that would work on the Space Shuttle.

module: Astronauts

objective

Students use critical thinking skills to solve a compelling problem - how to get enough candy in space - and gain an awareness of both zero G and 1 G (Earth) environments.

lesson components

- teacher page
- student article
- activity
- data sheet

Find more lessons, and cool online and offline activities, at: www.space.com/teachspace.
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ZERO-G CANDY

module: Astronauts

overview

Students invent and draw an M&M dispenser that would work without gravity.

objective

Students use critical thinking skills to solve a compelling problem — how to get enough candy in space — and give students an awareness of both zero G and 1 G (Earth) environments.

curriculum topics

- science - technology, gravity
- art - drawing
- language arts - write a description
- math - problem-solving skills

materials

- one per student or group of these handouts: the student article, activity sheet and data sheet
- scrap paper
- optional: M&Ms for inspiration

estimated time required

1 hour

background

Astronauts on orbiting space stations experience microgravity — gravity so low it's effectively zero. Earth's gravity is 1 G; gravity on other planets or moons is measured in terms of Earth's.

The demand for efficiency and zero-gravity functionality in space keeps aerospace engineers busy. Many everyday products require gravity. Toilets, desks, chairs, breast pockets and even shopping bags use gravity to hold things in place. Pinball machines depend on the ball rolling downward, washing machines require water and soap to flow down, grandfather clocks need the pull of gravity to tug the pendulum into motion. In space, everything from drinking straws (siphons don't work in space) to bookshelves must be modified to function in a zero-gravity environment. Simple modifications, like Velcro on everything, go a long way.

Engineers must keep other limitations in mind as well when designing space equipment. For instance, it costs about \$5,000 per pound (0.45 kilogram) of payload to launch the shuttle into space, so every tool has to be as light as possible. Power, water and space are limited in spacecraft — and there's no place to throw away the garbage.

What kinds of NASA inventions have gotten around these limitations? Cordless tools such as drills, dust-busters and saws come with their own battery power. Strong, lightweight metals, such as the wires used in dental braces, help cut down on payload cost. Travel wipes cut down on water use. Efficient packaging keeps waste to a minimum.

This activity is a good chance for students to use their imaginations. You don't have to worry about procuring supplies or cleaning up — students can make wild designs as long as they meet the basic criteria of not relying on gravity to hold down or deliver the candy. However, if you would like to give students the opportunity to actually build their designs, then encourage them to stick to readily available materials.

prep

Copy one for each student or group: student article, activity sheet and data sheet. Bring in M&Ms if you decide to do so.

tips

If students get stuck, discuss the materials on the list we gave and gather suggestions for how they could use each one.

procedure

1. Divide the class into pairs or groups if you wish to do so.
2. Distribute the student article.
3. Have students read the article.
4. Ask: Would a gumball machine work in an orbiting spacecraft? Why or why not? (Answer: No, because gumball machines rely on gravity to pull the gum down. Nothing has any weight in orbit.) How could a gumball machine be modified to work in space? (Something would need to catch the gumball and propel it out the shoot into your hand — a spring could push it or suction could pull it or...?)
5. Distribute the activity and data sheet.
6. Ask students to name materials that they might use to make an M&M dispenser that would work in orbit.
7. You might want to go over the questions in step one of the procedure on the activity.
8. You may want to discuss the steps and brainstorm materials as a class, particularly for younger children.
9. After students complete the activity, collect the data sheets and drawings to assess or have students present their designs to the class.

answers

Check designs to make sure that nothing falls (is pulled down by gravity). Accept all ideas that work without gravity — from the simple to the outlandish.

When Penny tested this activity, her students came up with ideas that included: a lever, a suction cup, a spring, an inclined plane, a sliding-door mechanism, a screw and a piston. Several mentioned a Pez-dispenser-type contraption.

extensions

science/technology — Challenge students to choose an Earth tool (anything from a shelf to a complex machine) that relies on gravity and adapt it so it would work in space.

inventions/technology — Invent more zero-G contraptions with the Space Day design challenges here:

<http://www.spaceday.com/design2000/teachers/dc/index.html>

standards

This unit supports these National Science and Education Standards grades k through 4:

- abilities necessary to do scientific inquiry
- position and motion of objects
- abilities of technological design
- understanding about science and technology grades 5 through 8:
- abilities necessary to do scientific inquiry
- motions and forces
- abilities of technological design
- understanding about science and technology

links

Let your inventors get a look at how Frisbees, yo-yo's, Chia pets (and much more) came into being.

<http://inventors.about.com/science/inventors/library/inventors/bltoy.htm>

Check the Space Day website for more space design challenges.

<http://www.spaceday.com/design2000/teachers/dc/index.html>

For the inventors who really get carried away, show them how far Rube Goldberg went with his contraptions.

<http://www.rube-goldberg.com/index.html>

<http://www.anl.gov/OPA/rube/>

ZERO-G CANDY: SNACKING IN SPACE

module: Astronauts

It takes a lot of imagination to design everyday tools for astronauts. Just like you, astronauts need equipment that helps them eat, sleep, wash and work every day. But they do it all without gravity. And that changes everything.

Earth toilets, for instance, rely on gravity to flush. Space toilets use suction (think of a vacuum cleaner). Ballpoint pens must be pressurized, like a spray can, for use in space. Beds? Nope, straps. In space you sleep on air, tethered to a wall so you don't accidentally bump into the control panel. No mattress or box spring needed. Velcro is used all over the interiors of spacecraft to hold things down. Take a look at your desk. What's holding your pens, papers and books down? Gravity.

Instead of cups, astronauts drink out of fluid-filled bags. They use pressure — they squeeze the bag — to move the liquid through a straw-like tube into their mouths.

But what about eating small candies, like M&Ms? If you open a bag of M&Ms in space, you can't dump them into your hand. If you tear the bag apart, they'll go everywhere. And how long can you go without M&Ms? Certainly not for months — the length of some space missions.

What's the answer? A zero-G candy dispenser. Where do you get one? Use our activity to design your own!

ZERO-G CANDY: MAKE A MACHINE

Take our Challenge: Design an M&M dispenser that would work without gravity
module: Astronauts

think about this

How would an M&M dispenser that worked in space be different from a model that worked on Earth?

materials

- pencil and paper
- data sheet

procedure

1. To make a design that works, start by thinking about these questions:
 - A. What will hold down the candies until you want one?
 - B. What will keep the whole dispenser from floating away?
 - C. Will the dispenser hold candy until you need it, or deliver it to your hand or mouth?
 - D. If your invention delivers candy, what will get the candy moving? Will it rely on pressure — like a space pen? Will it use suction — like a space toilet, or propulsion — like a slingshot? Will it use a lever? Or reach your hand or your mouth? Will the candy float through a straw, be squeezed from a tube, be flung through the air or something else...?
2. What kinds of materials will you use? On your data sheet, make a list of materials you might try. For example, you might want to use a:

plastic soda bottle	tape	hinge
piece of a garden hose	fan	spandex
straw	vacuum cleaner	pulley
paper cup	motor	lever
rubber band	slingshot	bicycle wheel
film canister	plastic wrap	slinky or spring
paper	tin foil	other stuff...
3. Find a combination of materials from your list that would work together to make a candy dispenser. If you can't, think of more materials to satisfy the missing requirements. List your materials on your data sheet.
4. Draw a sketch of your work on scrap paper.
5. Check your sketch for design flaws, or parts that don't work. (Hint: Would your invention work upside down on Earth?) Make changes to solve those flaws. Warning: You may have to think of new ideas and materials!
6. Draw your invention on your data sheet. Label the parts. Write a paragraph describing how it works.
7. Get a patent, sell your invention to NASA and get rich!

ZERO-G CANDY: DESIGN DATA

Design a Space Candy Machine

module: Astronauts

Data Sheet

Name: _____

1. List of possible materials:

2. Combination of materials that would make a dispenser:

3. Draw your invention on the back of this sheet. Label the parts. Write a paragraph describing how it works.

M&M Math - Investigation

Subject: Math / ELA

Grade: Second

Essential Question: *If you were in charge of packaging M&M's, would you have each package be the same or different? Explain your answer.*

<p>Learning Standards What standard is being addressed through the activity/activities?</p>	<p>Instructional Activities What learning activities will the student be involved in to acquire knowledge and skills to achieve the standard?</p>	<p>Assessment What will each student do to demonstrate achievement of the standard?</p>	<p>Resources What materials will support the student during the activities?</p>
<p>ELA #1: Language for information and understanding.</p> <p>ELA #2: Language for literary response and expression.</p> <p>ELA #3: Language for critical analysis and evaluation.</p> <p>ELA #4: Language for social interaction.</p> <p>MST #1: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seeks answers, and develop solutions.</p> <p>MST #2: Students will access, generate, process, and transfer information using appropriate technologies.</p> <p>MST #7: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.</p>	<p>1. Present the problem to the class. (see student activity sheet)</p> <p>2. Examine packages of M&M's, make comparisons with other students, count and sort by color, count number of each color.</p> <p>3. Using the ClarisWorks for Kids pie graph template, enter the number for each color found in the package. Print the graph for comparison.</p> <p><u>Optional activities:</u></p> <p>Journal writing: thoughts on the essential question presented to the class. At the conclusion of the project, write one thing you learned by doing this project.</p> <p>Class discussion: make a simple graph to show the number of students who think that each package should be the same, different or are not sure. Analyze the results. Have students explain why they voted the way they did.</p> <p>Write a letter to the Mars Candy Co. telling about the project and giving feedback based on the research.</p> <p>Notes: pie graphs will show percentages - you may need to discuss what this means with your students.</p>	<p>Show an accurate count of the M&M's. Have all information entered on the activity sheet.</p> <p>Enter data appropriately at the computer.</p> <p>Writing reflects an understanding of the research.</p> <p>Verbal response accurately address the questions asked during class discussion.</p>	<p>Teacher made activity sheet for students.</p> <p>Chart paper, chalkboard or white board to record student responses.</p> <p>ClarisWorks for Kids pie graph template set up in advance for this activity.</p>

Name _____

Date _____

The Mars Candy Company has appointed you to be in charge of packaging M&M's. Your job is to determine how many M&M's of each color should be placed in packages. Should all packages be the same? Should all packages be different? You'll need to do some research to help you decide.

Tasks:

Begin by examining your package of M&M's.

How many M&M's are in your package all together? _____

Does your package contain the same number as other students sitting near you?

Yes _____ No _____

How many of each color M&M do you have in your package?

Blue _____ Green _____ Red _____

Yellow _____ Orange _____ Brown _____

At the computer, make a pie graph to show the number of M&M's in your package. When all students have made a graph, the results will be compared.

1. Based on your research:
 1. How many M&M's do you think should be placed in each package?
 2. Should all packages be the same? Why or why not?
 3. Should all packages be different? Why or why not?

M&M Duels

Whenever I get a package of plain M&Ms, I make it my duty to continue the strength and robustness of the candy as a species. To this end, I hold M&M duels.

Taking two candies between my thumb and forefinger, I apply pressure, squeezing them together until one of them cracks and splinters. That is the "loser," and I eat the inferior one immediately. The winner gets to go another round.

I have found that, in general, the brown and red M&Ms are tougher, and the newer blue ones are genetically inferior. I have hypothesized that the blue M&Ms as a race cannot survive long in the intense theatre of competition that is the modern candy and snack-food world.

Occasionally I will get a mutation, a candy that is misshapen, or pointier, or flatter than the rest. Almost invariably this proves to be a weakness, but on very rare occasions it gives the candy extra strength. In this way, the species continues to adapt to its environment.

When I reach the end of the pack, I am left with one M&M, the strongest of the herd. Since it would make no sense to eat this one as well, I pack it neatly in an envelope and send it to M&M Mars, A Division of Mars, Inc., Hackettstown, NJ 17840-1503 U.S.A., along with a 3x5 card reading, "Please use this M&M for breeding purposes."

This week they wrote back to thank me, and sent me a coupon for a free ½ pound bag of plain M&Ms. I consider this "grant money." I have set aside the weekend for a grand tournament. From a field of hundreds, we will discover the True Champion.

Science Hoaxes


Lesson Introduction

Science is a process of asking questions, then through research and experimentation, proposing answers to those questions. These "answers" are tested over time by other scientists. If new answers are found, they replace the old. During this process, there have been many times that scientists have been fooled by hoaxes. Hoaxes are deliberately fabricated "answers." Scientists or people who create a hoax know they are lying. The Piltdown Man, once believed to be an ancestor to humans, was this kind of hoax. Sometimes, scientists think something is just too strange or off-the-wall to be real. These real theories or discoveries can be branded a hoax. When the first platypus was discovered and a specimen brought to scientists, it looked so strange the scientists were sure it was a hoax. Eventually, the platypus (an Australian marsupial) was accepted as real.

In this lesson, students will learn about the half-life of radio-active isotopes. This concept is used by scientists to date objects (and detect hoaxes) using the half-life of carbon atoms. This process is called radio-carbon dating.

Age Appropriateness:

In order to make Total CAoS! relevant to as many grades (K-8) as possible, activities have been written at a middle grade level. Teachers in very early elementary or middle school classrooms may need to adapt portions of the Total CAoS! lesson to meet the needs of their grade level.

Look for the  symbol for the math connection in this lesson.

Illinois State Goal	Standard	Learning Benchmark
11	A	1f. compare observations of individual and group results. 2c. construct charts and visualizations to display data.
13	B	3b. analyze historical and contemporary cases in which the work of science has been affected by both valid and biased scientific practices.

Time Allotment

one 45-minute session

Materials

Per Group:

- a small cardboard box with lid
- 100 M&M candies or any other object with a "marked" side or two distinct sides (i.e. skittles, coins, etc.)
- graph paper

Per Person

- Journals
- Pencils

Per Classroom

- Large class chart for recording data
- markers
- chalk
- an animal bone

Advanced Preparation

gather materials
arrange students in cooperative groups of 4-6

Lesson Assessment

Try making a student-designed rubric. Before the lesson, tell your students that they are going to evaluate their own group for this lesson. Have a class discussion about what they should be evaluated on in their groups (for example; did they cooperate well, did they stay on task, did they finish the activity). Have the class vote on the top three or four items to be evaluated and write them in their journals.

Next, decide on a numbering system with criteria for each. It would be best to use a three point scale and have the class decide on the criteria for each number. The following is an example of three possible criteria for the area of "cooperation":

- 1= the group did not cooperate well, which made it difficult to complete the task.
- 2= group had some trouble cooperating, but problems were quickly resolved.
- 3= group cooperated well making it easy to work on task.

After deciding on three criteria for each of the three or four questions, decide how it should be graded (such as: 8 or 9 points = A; 5, 6, 7 points = B; 3 or 4 points = C-what do they think is fair?).

Procedure

Tap Prior Knowledge

Place the bone on a table and have the students gather around it. An alternative might be to have a few bones and pass them around. Tell the students to imagine they are a type of scientist called an archaeologist. Archaeologists study the past. Someone has turned in this bone and said it was from a human ancestor called Cro-Magnon Man. As a scientist, it is your job to see if the person is correct.

Ask the students how they might prove or disprove what the person said. Tell them they should not limit their ideas to what they can do in the classroom. They can pretend they have a whole laboratory to work in. Write their ideas on the board. If they are having trouble thinking of possibilities, guide them with the following questions: Are the bones too big/small to be human? What questions could you ask the person about where he/she found the bones? Are the bones the right shape? If they still have trouble generating ideas, write down their questions.

Engage Students in a Hands-On Activity


Pass out a box and 100 M&M's to each group. Each group should place the M&M's in the bottom of the box such that all candies are "m" side down.

Inform the students that these candies exist in two distinct "states:" "m" side up and "m" side down. As good scientists, they must keep track of which is which. Have each student draw a data table in their journals to record their results. The table should look like this:


Trial #	# of candies "m" side down
0	100
1	
2	
3	
4	
5	
6	
7	
8	
9	

Once the candies are placed, each group should close their box and shake it gently up and down 3 times.

Open the box and remove all the candies that have changed and are now "m" side up.

 Students should count and record on their data sheets the candies that remain in the box. Or they can subtract from 100 the number of candies that have been removed to get the same result (the number of candies that have not changed (still "m" side down).

Repeat steps 5, 6, and 7 until all the candies have "changed" and been removed.

 Take the information from the data sheet and graph it. (If students cannot set up their own graph, a sample graph has been included at the end of the lesson)

Record their group's data on a class data chart (on chart paper or the chalkboard).

 If age appropriate, calculate the average of all groups.

Introduce Scientific Principle

Atoms make-up all of the matter in our world. Matter can be in the form of a solid, liquid or a gas. Look around you, everything you see and the air that surrounds it are made-up of matter! So, why do the things around us look different and have different properties if they are all made-up of atoms? Because, the atoms that make-up everything can be arranged in different ways. Elements differ according to the number, weight and

arrangement of the atoms that make them up. There are about 90 naturally occurring elements in the world (gold, iron, and uranium are three types).

Most elements are stable. This means that in a natural setting, they do not spontaneously (all at once) break down. However, some elements are radioactive. This means that they slowly emit some form of radiation (energy) as they break down to form a new stable element.

Everything that is radio-active breaks down at a specific rate. This rate has two important characteristics: it is even and it is continuous. That means it happens at the same rate and is happening all the time. The radioactive atoms are unstable and disintegrate releasing particles and radiation. Once it has decayed, a new element is formed.

The rate of decay (how fast or slow it occurs) is called a half-life. A half-life is the time it takes for half the atoms of the radioactive element to change into atoms of another element. For example, radium-226 (a radioactive element) has a half life of 1,622 years. That means if you have 10 grams of radium-226 today, 1,622 years from now you will have only 5 grams of radium-226 remaining and 5 grams will have changed into new elements.

Another element that is radioactive is Carbon-14 (C-14). This isotope occurs in small percentages of carbon dioxide in the air because the air is bombarded by cosmic rays. As a result all living things contain a small amount of Carbon 14. When the living thing dies, it no longer absorbs the radioactive Carbon 14 and what is already there begins to decay. Because radioactive materials decay at an exact and even rate (in this case C-14 has a half-life of 5,730 years), we can date an object comparing the amount of C-14 in it to the amount in a living thing. Radiocarbon dating, or C-14 dating, is used to determine the amount of time that has passed since the living thing died. The bones from the beginning of class could be dated in this manner to determine they are less than a year old (assuming it was store-bought meat bones used).

In this experiment, the M&M candies represented radioactive atoms. When the candies turned "m" side up, that meant they decayed and became a new element. So we removed them. This is just like scientists would only count the amount of the original radioactive element that was left.

Relate Activity and Concept

If each trial represented one hundred years, how long did it take for half the candies (your radioactive atoms) to "decay"? Record this in your journals.

What is the half life of your candy atoms? How did this compare to other members of the class. Compare their results to the average or class data. Record observations in journals.

If the model was perfect (a good representation of the outside world), how many candies (atoms) would be left after 500 years (5 trials).

What would happen to the graph if you increased the number of candies (atoms) in the box?

Connect to Other Everyday Examples

Archaeologists and other scientists are like detectives. They use science to establish facts and build evidence that supports a conclusion (or answer). What other careers try to use evidence to prove or disprove an idea or conclusion? (i.e. doctors use symptoms to determine what is making someone sick.)

Language Arts Connection

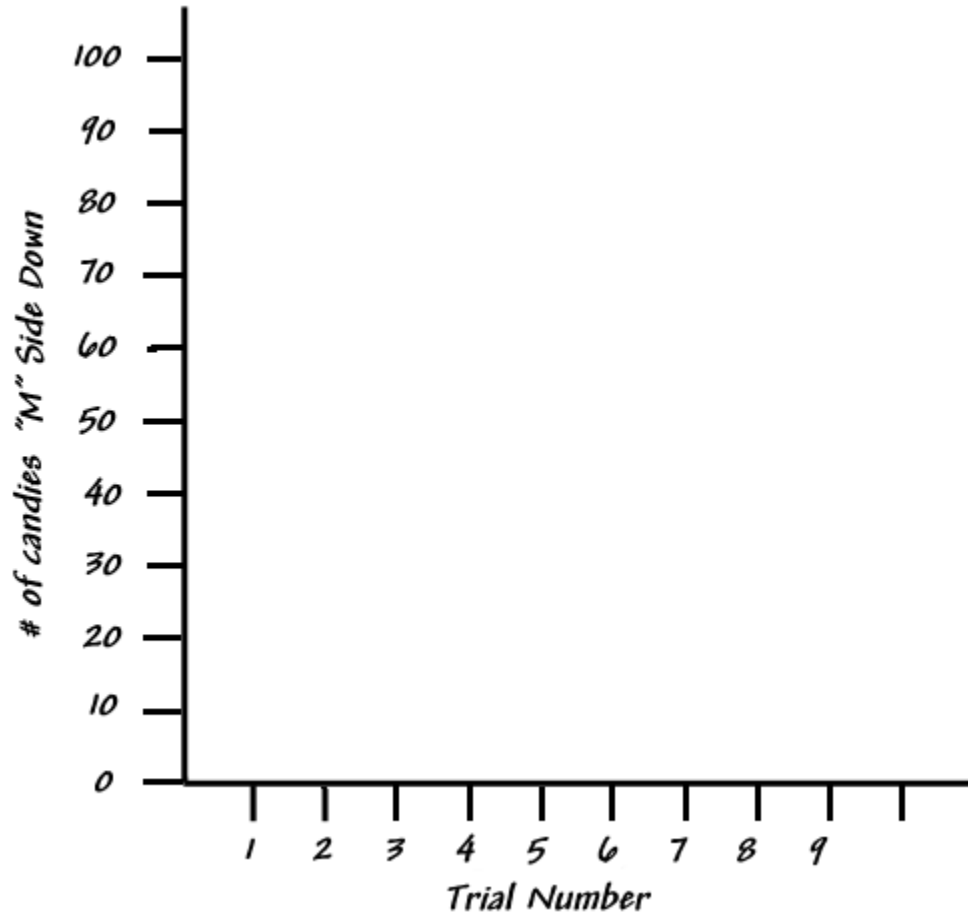
In 1938, Orson Wells did a radio broadcast of the H.G. Wells' science fiction classic the *War of the Worlds*. This broadcast was so realistic, it created panic and mass hysteria when the listening public actually believed the U.S. was under attack from Martians! Could this hoax happen again? Have your students answer this question in an essay. Focus on structuring an essay with a single main idea, with at least three paragraphs of arguments that supporting their answer as well as three or more facts that "prove" the validity of each argument. When the essays are complete, have a discussion of the issue.

Background Information

Few hoaxes in science have received as much attention and debate as the controversy surrounding Piltdown Man. This story begins in the early 1900's. Scientists were trying to find evidence of a human-like creature that would connect Neanderthal Man and Apes in the fossil record. Competition to find such a specimen, with features of both apes and man, was growing intense and in 1912 a man name Charles Dawson found something that seemed to be the answer. It was a skull with a head similar to man and a jaw that was similar to apes.

While there were some doubts about the skull fragments before 1953, many scientists believed the bones were real. This may have been because they were seeing only what they wanted to see. Scientists wanted to find bones that would fit what they thought happened. This is called a bias. They paid more attention to what fit their thinking and less attention to anything (such as doubts) that might suggest something different. But eventually, as doubts built up, scientists began to pay more attention to the possibility that the bones might not be real. These doubts came from the discovery of additional humanoid bones and new analysis techniques unavailable to Dawson's contemporaries.

The scientific community believed in Dawson's discovery until 1953 when a new analysis brought the hoax to light, stunning scientists worldwide. Scientists used the then-new technology of flourine testing to discover the jawbone was "new" and the skull only a 600 hundred years old. Both pieces had been "aged" using bleach and other substances to look old and have some of the chemicals found in older bones. Where parts, such as teeth, might give the fraud away, they were filed down. From this evidence, the hoax was deliberate. There is still a lot of argument about who actually was responsible for a deception that lasted 40 years.



Groups Members Names _____

M & M Math

Objectives: collect and tally data, find probabilities, find percentages, use proportions to make predictions, and create various graphs using the computer

Open and empty the bag of candy. Record colors and amounts in the chart below.

Find the experimental probability of pulling each color from the bag.

Find the percentage of each color. (Round to the nearest tenth.)

Your teacher has a large bag that contains 630 M&M's. Use your data and proportions to predict how many of each color will be in your teacher's bag. Show all work.

HAVE WORK APPROVED BEFORE GOING TO STEP #5

Eat the candy ---SHARE!

You will now create a bar graph and a circle graph using EXCEL on the computer.

Color	Amount	Probability	Percent

Use the following space to show how you found each percent. Label work for each color.

Use the following space to show proportions and make predictions. Label work for each color.

Predictions:

Create a Graph Using Excel

Open Excel.

In column A type your colors.

In column B type the corresponding amounts.

Save your data to the "My Documents" folder.

Create your graph by highlighting your data and clicking on the chart wizard button. It looks like a miniature graph.

Choose the type of graph you want.

Be sure to give your graph a title.

Experiment to see if you can change the colors, font, axis, and legend. Get your graph to show the percents.

Print your graphs.

Name _____

M & M Activity Rubric

Each of the following is ranked 0 -10 with 10 being the highest.

1. Experimental probabilities _____
 2. Percentages _____
 3. Predictions _____
 4. Graph _____
 5. Cooperative Group Score* _____
- TOTAL (out of 50) _____

*This score was the student's average score as given by group members.
Cooperative group rubrics will be attached.

M & M Participation Rubric

Complete a rubric for each member of your group including yourself.

0 = never

1 = sometimes

2 = always

Member's Name _____ Total _____

- 0 1 2 group member stayed on task
- 0 1 2 group member assisted in doing all calculations
- 0 1 2 group member assisted in computer work
- 0 1 2 group member was respectful of other group members
- 0 1 2 group member was cooperative

Member's Name _____ Total _____

- 0 1 2 group member stayed on task
- 0 1 2 group member assisted in doing all calculations
- 0 1 2 group member assisted in computer work
- 0 1 2 group member was respectful of other group members
- 0 1 2 group member was cooperative

Member's Name _____ Total _____

- 0 1 2 group member stayed on task
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- 0 1 2 group member was cooperative

Member's Name _____ Total _____

- 0 1 2 group member stayed on task
- 0 1 2 group member assisted in doing all calculations
- 0 1 2 group member assisted in computer work
- 0 1 2 group member was respectful of other group members
- 0 1 2 group member was cooperative

Name: _____

Date: _____

Graphing M&M'S

Dear Parent or Guardian,

We are learning to construct, read, and interpret graphs. This activity will help build science skills in collecting, recording, and graphing data. I hope you enjoy this activity with me. This assignment is due _____.

Sincerely,

Materials

pen or pencil ruler

small bag of plain M&M candy or other multicolored product

Procedure

1. Find a flat surface on which to work and separate the M&Ms according to color.
2. Complete your data table.

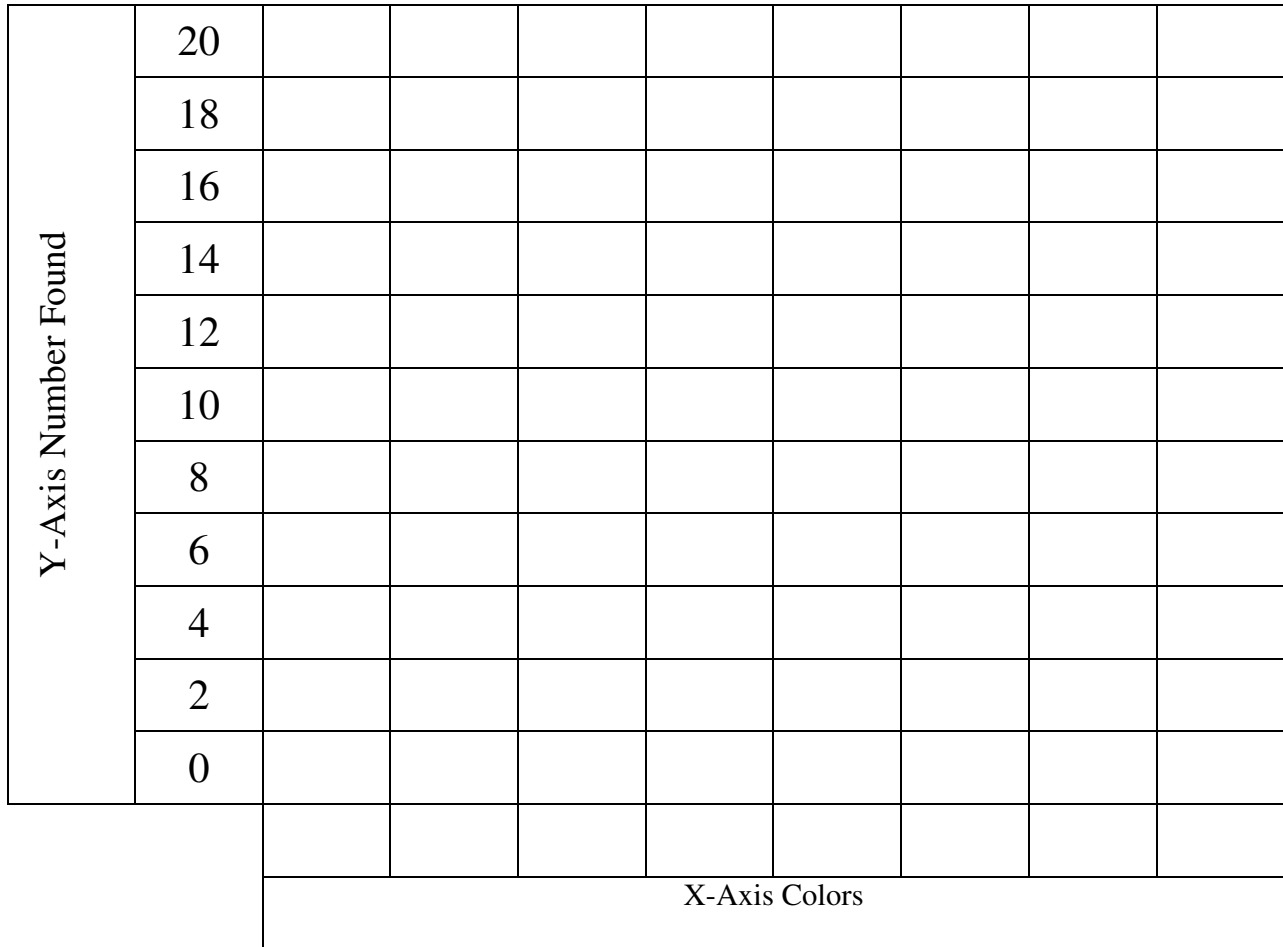
Data Table

What Colors ?	How Many?

3. On the X-axis of the graph, label the colors you found.
4. Using your data table, plot the numbers of each color and draw a line graph. Fill in a title for your graph.

Line Graph

Title:



5. Share the M&Ms with your family partner.

Conclusion: Look over the graph with your family partner and answer these questions. Who is working with you? _____

1. Which color had the highest point on the graph? Why?

2. Which color had the lowest point? Why?

4. Suppose you had 3 red M&Ms. Describe in a complete sentence where you would plot that point on the graph.

Now Try This NOW TRY THIS

1. If you used M&Ms, fill in the number of different colored candies in your bag in the **first column** of the data table, or leave it blank.

How Many M&M's?

Color	Your Bag	Bag 2	Bag 3	Bag 4
RED		15	11	
YELLOW		13	15	
GREEN		1	4	
ORANGE		4	5	
BLUE		5	8	
BROWN		18	14	

2. We bought two more bags and filled in the numbers of M&Ms in Bag 2 and Bag 3. Along with your bag, was there any color which was consistently low or high in all three bags? Name these colors.

LOW: _____ **HIGH:** _____

3. **Suppose you bought a 4th bag.** What would you expect to find in the bag? Complete the last column of the data table and explain. Write a sentence to explain why you expected what you did.

Home to School Communication

Dear Parent,

Please give me your reactions to your child's work on this activity.

Write YES or NO for each statement.

- _____ 1. My child understood the homework and was able to discuss it.
_____ 2. My child and I enjoyed the activity.
_____ 3. This assignment helped me know what my child is learning in science.

Any other comments:

Parent Signature:

Mining a Chocolate Chip Cookie

(10 minutes)

Equipment needed: 1 cookie and 1 toothpick (on a paper plate) per child. If the family group consists of only 1 adult and 1 child the adult may wish to do the activity also. This is a good 'warm-up' activity. Ask people to 'mine' the chocolate chips from a cookie using only a toothpick. They can use their hands to hold the cookie in place but otherwise should only use the toothpick. There are no other rules – they can do it how they like. After 5-10 minutes, when you can see the different approaches that have been used you can stop the group and discuss what they've done. Anyone who has left behind a pile of cookie crumb debris on their plates as well as a pile of extracted chocolate chips has demonstrated the 'open cast mining' approach. Ask them why they chose to do it this way.

(It's quicker, easier to get out the chocolate chips etc.). In the real world these reasons relate directly to why open cast mining is sometimes used. Ask them what the disadvantages are of this approach. (It's environmentally destructive).

Anyone who has used the toothpick to carefully pick out the chocolate chips, leaving behind a more intact biscuit has adopted the 'hardrock mining' approach, where more specific tunnels and shafts are created. This is slower and more expensive but less environmentally destructive. This type of mining is more likely where rich high quality 'seams' are available.

If repeating the activity then use a new cookie each time, but some recycling of the paper plates and toothpicks is possible. If using the cheapest chocolate chip cookies people are more likely to use an 'open cast mining' approach because the chips are small. Could be interesting to use some cheap biscuits and some more expensive ones to see if people are more likely to try 'hardrock mining' if the chocolate chips are bigger.

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The Chocolate Biscuit Model of Plate Tectonics

(25 minutes)

Give out one set of equipment (on a paper plate) to each family group (about 4 or 5 people – depending on resources may need to make any adult/child pairs join together). The tubs of chocolate icing used were fairly expensive (could make up your own but this is more time consuming and we found it hard to get the right consistency) so these can be shared. In all the experiments the wafers/biscuits represent the Earth's crust and the icing represents the molten magma of the Earth's mantle. The layers of icing used need only be 2-3 mm thick (note: families with access to fairly full tubs of icing will tend to spread thicker layers!). Although each family had a copy of the worksheet, this activity was guided by the session leader – with each part being introduced first and everyone doing it together. After each part the biscuits or wafers used can be eaten/discarded and the icing renewed and smoothed down again.

Part One: Divergent Plate Boundaries

What you are looking for here is a tiny ridge of icing being pushed up in the middle of the gap between the two biscuits. This represents the formation of new crust from the magma in the mantle (e.g. the Mid-Atlantic Ridge). Not everyone may successfully observe this, but about half of the groups should manage it.

Part Two: Convergent Plate Boundaries – Subduction

What you are looking for here is for the wafer (the less dense layer - continental plate) to ride up over the biscuit (the more dense layer - oceanic plate). This will happen for some groups but not all. People may need to push harder to get one to ride up over the other if nothing happens. Because the biscuit is actually a little thicker than the wafer some groups may find that the biscuit rides up over the wafer rather than the other way around. If people report seeing their wafer or biscuit crack then this is fine – it represents earthquake activity, which often happens at plate boundaries of all kinds.

Part Three: Convergent Plate Boundaries – Continental

What you are looking for here is for the damp ends of the two biscuits to crumple up as you push them, forming a ridge in the middle. All groups should manage to see this happening. The water is really just to make the experiment more successful – it doesn't represent anything. Biscuits are used in this experiment rather than wafers because they work better.

Part Four: Transform Plate Boundaries

What you are looking for here is the wafers cracking – representing earthquake activity. Most groups should be able to see this happening. The key thing is for people to ensure that they are pushing the wafers together and pushing them past each other at the same time. Wafers are used here rather than biscuits because they work better.

Useful website for further information

The online edition of 'The Dynamic Earth' (by USGS – the United States Geological Survey) can be found at: <http://pubs.usgs.gov/publications/text/dynamic.html>

Click on the 'Understanding Plate Motions' chapter for useful background information.

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M&M Science

(25 minutes)

Briefly introduce the activity and give each family group a packet of M&Ms and a copy of the worksheet, a pen and two sheets of graph paper. They can then work through this activity on their own, though some families may need a little bit of extra help. Different groups will work at different speeds. In 25 minutes most families will reach the graphing section and those that don't finish are usually happy to complete the activity at home. Buying the M&M's in bulk from a cash and carry (e.g. Bookers on Osney Mead) is cheaper.

Estimating

People commonly underestimate the number of M&Ms in their packet.
Colours are: red, green, blue, yellow, orange and brown

Classifying

Once families have recorded the number of each colour in their packet the leader needs to collect the results from each family and add up the totals for each colour to see if in general some colours are more popular than others. Although the number of each colour can vary quite a lot between individual packets, overall there are always fewer orange and brown M&M's (could these colours involve more dyes and therefore be slightly more expensive to make?).

Graphing

We used a central box of coloured pencils/felt tips for families to use to draw their graphs. The session leader needs to read out the results for the whole group on how many M&Ms of each colour there are before families can draw the second graph.

Hypothesizing

There is some variety in the number of M&Ms in each packet.
The weight of the packet is printed on the back of the bag.
The weight is an average – so some packets are slightly over and some are slightly under.

Calculating

In order to make the more accurate calculations, families will need the session leader to tell them the total number of packets that were handed out. They already know the total number of M&Ms for the whole group (by adding up the totals for each colour that were gathered earlier).

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Chocolate Bar Geology

(30 minutes)

This activity works very well, but needs the most preparation. It is more challenging than you might think, with some families finding it easier than others (depending on how much chocolate they eat!). It can be organized in a variety of ways – the notes below explain how we chose to run it.

We used two sets of chocolate bars:

SET ONE: A-E

A – Bounty

B – Lion Bar

C – Mars Bar

D – Toffee Crisp

E - Topic

SET TWO: a-e

a – Boost

b – Double Decker

c – Milky Way

d – Picnic

e - Snickers

Five groups had set A-E and five had set a-e (small family groups were merged so as to give only ten groups in total – just to limit resources needed). This meant that we only needed to buy ten chocolate bars to resource the activity as, with care, each chocolate bar was big enough to yield five core samples and five cross sections.

Five core samples (labelled A–E or a–e) were placed on each table in advance, along with a worksheet for each family group. After an introduction from the session leader about the activity each family examined their core samples and recorded their guesses. Then the labeled cross sections (A-E or a-e) were handed out and they guessed again.

The descriptions were handed out in a random order (i.e. the order 1-5 did not match the order A-E or a–e) and this needed emphasising. The descriptions used were taken from the chocolate bar wrappers. Finally each family got to see their five chocolate bar wrappers (also in random order).

Making Core Samples

We used very small glass tubes with push in lids to make these. We pushed the tube through the chocolate bar, then took it out and popped the lid on.

Making Cross Sections

Cut with a sharp knife – each cross section was about 0.5-1cm thick (depending on size of chocolate bar). For protection each cross section was wrapped up in cling film and stuck down with clear sellotape so the package did not unravel.

A few of our samples did go missing – essentially because a couple of children (I think) did not realise that the core samples and cross sections were to be used again in future sessions and thought they could eat them! So this may be something worth emphasising.

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The Science of M&Ms

Goal : to provide an introduction to the concept of 'process variation' related to quality.

1. Divide into work groups.
2. Each group gets one bag of plain M&Ms. Open the bag and count by color – do not eat. Results will be tabulated in the table below.

Color	1	2	3	4	5	6	7	8	M&M Norms
Brown									
Red									
Yellow									
Orange									
Green									
Blue									
Total									

3. At one time, the M&M Mars web site listed the following ‘norms’ for color percentages are listed – Brown 30%, Yellow 20%, Red 20%, Green 10%, Blue 10%, Orange 10%.
4. In your group, discuss and speculate on the following questions and summarize your conclusions for class discussion.
 - a. Why the total number of M&Ms in each bag varies.
 - b. Why the color percentages are different in each bag and are not the same as the norms.
 - c. Speculate on the manufacturing process, layout, material flow that might be used.
 - d. To reduce or eliminate variation in the color counts, what process changes would you recommend.
 - e. What other quality attributes could be used to characterize this product.
 - f. Rank the quality attributes you have listed from most to least important.
 - g. Who is the target customers for this product.
 - h. What quality and product satisfaction criteria might they have.
5. Class discussion of questions above – ok, now eat.

Assignment : (Due next class period, Week 2)

Summarize the results of this exercise in a short written report.

- List the question above and your answer/discussion.
- Include an Excel bar chart of the data above.
- Visit the M&M Mars web site (www.m-ms.com) to investigate what manufacturing process is used. How does this information help explain the results above.

M&M's and Length Measurements

The goal of this lesson is review the concept of length, and how to use a fundamental unit to measure different lengths.

Performance Objectives - At the end of this lesson the student will be able to:

1. Explain what a fundamental unit is.
2. Explain the origin of the metric system.
3. Define the term "length".
4. Using a class defined fundamental unit of length, measure the diameter and circumference of a circle.
5. Calculate the value of π using the measured values of diameter and circumference.
6. Organize the class results of π using a line plot.
7. Determine the median value of the class results of π .
8. Determine the relative error for their values of π .
9. Explain what a natural number is and carry out the arithmetic operations of addition, subtraction, multiplication and division using natural numbers.
10. Explain what an integer is and carry out the arithmetic operations of addition, subtraction, multiplication and division using integers.

Vocabulary

fundamental unit	metric system	length
mass	time	temperature
line plot	median value	relative error
natural number	integer	

Instructional Activities -

1. Review the metric system and the fundamental units of length, mass, time and temperature.
2. Review the concept of Length.¹ -Science is based on measurement. We learn about science by measuring quantities such as length, mass, time, temperature, and pressure. We measure each physical quantity in its own units, by comparison with a standard. The unit is a unique name we assign to measures of that quantity -for example, meter (or m) for the quantity length. The standard corresponds to exactly one unit of the quantity.

In physics one is concerned with the motion of objects which involves the change in position in space of the object. This involves the concepts of displacement and of distance. Both of them requires the measurement of length. Paraphrasing Einstein, we can say that - ***Length is something we measure with a length measurer, or ruler.***

We can define a unit and its standard in any way we care to. However, the important thing is to do so in such a way that scientists around the world will agree that our definitions are both sensible and practical. If we define the length standard as the distance

between one's nose and the index finger on an outstretched arm, we certainly have an accessible standard-but it will, of course, vary from person to person. The demand for precision in science and engineering pushes us to aim first for invariability. We then exert great effort to make duplicates of the base standards that are accessible to those who need them.

In 1792, the newborn Republic of France established a new system of weights and measures. Its cornerstone was the meter, defined to be one ten-millionth of the distance from the north pole to the equator. Later, for practical reasons, this Earth standard was abandoned and the meter came to be defined as the distance between two fine lines engraved near the ends of a platinum-iridium bar, the standard meter bar, which was kept at the International Bureau of Weights and Measures near Paris. Accurate copies of the bar were sent to standardizing laboratories throughout the world. These secondary standards were used to produce other, still more accessible standards so that ultimately every measuring device derived its authority from the standard meter bar through a complicated chain of comparisons.

Eventually, modern science and technology required a more precise standard than the distance between two fine scratches on a metal bar. In 1960, a new standard for the meter, based on the wavelength of light, was adopted. Specifically, the standard for the meter was redefined to be 1 650 763.73 wavelengths of a particular orange-red light emitted by atoms of krypton-86 (a particular isotope, or type, of krypton) in a gas discharge tube. This awkward number of wavelengths was chosen so that the new standard would be close to the old meter-bar standard.

2. **Review the Unit 1 Project with the class.**

UNIT 1 PROJECT

LENGTH: PI and M&M's

Length Measurements - The goal of this project is to use M&M's as a fundamental unit of length to measure the diameter and circumference of a circle and, then using these measurements to calculate the value of π .

Materials - For this experiment the student will need:

- A ruler.
- A compass.
- Several dozen M&M's.

Step 1- Draw a straight line in the middle of a blank piece of paper. Then line up the assigned number of M&M's on the straight line, and mark off the beginning and end of the line of M&M's. This will establish the diameter of your circle using an M&M as our fundamental unit of length. (Figure 1.)



Figure 1 - Diameter of an M&M Circle

Diameter (**D**) = 6 M&M's.

Step 2- Using your compass and ruler construct the perpendicular bisector of the diameter to find the center for the circle. Draw the circle using your compass.

Step 3- Line up M&M's on the circle until the circumference is filled in. If necessary, split an M&M in half to complete the circumference. (Figure 2.)

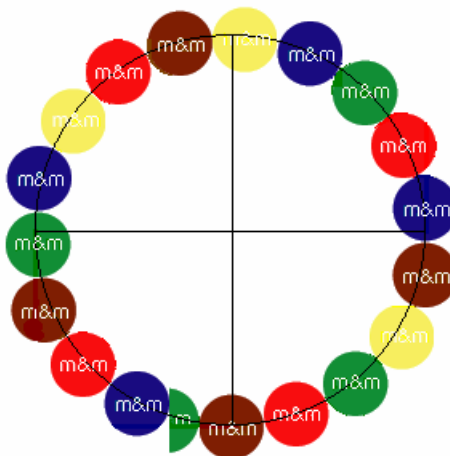


Figure 2 - Circumference of an M&M Circle.

Step 4 - Record the number of M&M's required to complete the circumference.

$$\text{Circumference (C)} = 18.5 \text{ M\&M's.}$$

Step 5 - Calculate π to two decimal places, by dividing the number of M&M's required to complete the circumference by the number of M&M's on the straight line.

$$\pi = C/D$$

$$\pi = 18.5/6.00$$

$$\pi = 3.08$$

Step 6 - Calculate the relative error of π using the students experimental value.

$$e_r = |\pi_{\text{acc}} - \pi_{\text{exp}}| / \pi_{\text{acc}} * 100 \%$$

$$e_r = |3.14 - 3.08| / 3.14 * 100 \%$$

$$e_r = 1.9 \%$$

3. Handout the Project One Worksheet.

- Assign number of M&M's each student should use for his or her diameter.
- Have students make their measurements.
- Have students calculate π using their measured values.
- Have students calculate the relative error for their value of π .

4. **Review Line plots.**

1. Have the students record all the values of π in a table.
 2. Line plot the class values of π .
 3. Using the line plot show students how to determine the median value.
 4. Explain why the median value is a good representation of the middle value in a set of numbers.
 5. Have students calculate the relative error for the class median value of π .
5. Lab Report - Each student will write a report about The Metric System with particular emphasis on the concept of length. The report will include the following sections. (A rough draft will be done first and included in their notebook.)
1. Purpose
 2. Introduction. (*A 300 to 400 word report about The Metric System with particular emphasis on the concept of length.*)
 3. Equipment and Procedure.
 4. Table of Data and Results.
 5. Analysis.
 6. Discussion.
 7. Conclusions.
 8. References.

6. Handout MATH ASSIGNMENT ONE - **Natural Numbers**

7. Handout MATH ASSIGNMENT TWO - **Integers**
8. **Problem Solving.** Extend the concept of length to area and volume. Consider the following geometric figures: a) rectangle and rectangular box, b) square and cube, and c) circle and sphere.

Assessment -

Each student will have the following items in his or her notebook. (*One to five extra credit points.*)

1. General notes about the Metric System and measurements.
2. Complete set of data of the measurements of the length of the table.
3. Line plot of these measurements.
4. Complete set of measurements for the Unit 1 project.
5. Line plots of the measurements for Bedroom 1 and one other room.
6. MATH ASSIGNMENTS ONE and TWO.
7. A rough draft of their project report.

Each student will submit a complete Science Lab report. (50%)

Each student will take the Unit 1 test. (50 %)

Enrichment Activities - A student's I.E.P. will be followed.

Special Needs Activities - A student's I.E.P. will be followed.

Materials -

1. Activity materials:

- A ruler.
- A compass.
- Several dozen M&M's.

2. Handouts:

- Project One Worksheet
- MATH ASSIGNMENT ONE - Natural Numbers
- MATH ASSIGNMENT TWO - Integers

Homework -

1. Complete the Project One Worksheet.
2. Complete the Exploratory Data Analysis.
3. Complete MATH ASSIGNMENTS ONE and TWO.
4. Complete the Length Lab report.

References:

1. Fundamentals of Physics 5th Ed. Part 1 by Halliday, Resnick & Walker; John Wiley & Sons, Inc., New York (1997), p. 4.

PROJECT ONE WORKSHEET

LENGTH: PI and M&M's

Name _____ Date _____

Length Measurements - The goal of this project is to use M&M's as a fundamental unit of length to measure the diameter and circumference of a circle and, then using these measurements to calculate the value of π .

Materials - For this experiment the student will need:

1. A ruler.
2. A compass.
3. Several dozen M&M's.

Step 1 - Line up the assigned number of M&M's on the straight line, and mark off the beginning and end of the line of M&M's. This will establish the diameter of your circle using an M&M as our fundamental unit of length.

Diameter (**D**) = _____ M&M's.

M&M Math

1. Guess how many M&M's are in the bag. _____
2. Open your bag. Count the M&M's. How many M&M's are in the bag?

3. How far off was your guess? _____
4. Sort your M&M's by color.
G = green _____ R = red _____
O = orange _____ Y = yellow _____
B = blue _____ LB = light brown _____
DB = dark brown _____
5. Which color had the most candies? _____
6. Which color had the fewest candies? _____
7. Were there more blue or yellow? _____
8. Were there more light brown or dark brown? _____
9. Were there more red or orange? _____
10. Do all the candy bags contain the same number of candies and colors? How can you explain this? _____
11. M&M's have between _____ and _____ candies in a bag.
12. The least common color is _____.
13. The most common color is _____.
14. Why were more dark brown candies in the bag? _____
15. What combination of two colors equals the greatest amount of candies? _____ and _____
16. How does the number of dark brown candies compare with the number of all the other candies together?

Candy Math: Sorting, Classifying and Graphing

Author: Marc Sheehan

Grade Level: Second

Subject: Math

Time: 40-45 minutes

Idea Suggested By: Frances Fleischmann and Sue Nygard, Lister Elementary (Tacoma, WA)

Materials: Small bags of multi-colored candies (e.g. M&Ms, Skittles, jellybeans), graph/sorting sheets, question sheets, pencils

Objectives: The students will sort candies by color. They will also complete various addition problems using candy pieces and complete a graph using those candies. The students will also compare and contrast selected amounts of candies.

Introduction: Each student will receive a small bag of candy, a graphing worksheet, and question/sorting sheet before the lesson begins. Then I will explain what they will do first: they will open the bags of candy and sort the candies by color. They will be able to eat the candies later, but they must wait until told to do so. (I have found that allowing the students to eat one piece first helps to stave off their eating of all of the pieces.) Students are to be told they should not trade their candies with classmates until after the assignments are completed.

Procedure: I will run through an example for the students, showing them what they will do before the candies are handed out. The students will open the bags, sort the candies in preparation for a graphing assignment. The students will make a graph of all the different-colored pieces they have. Once the graphs are done, the students will answer the questions (addition or subtraction) on their question-and-answer worksheets. Samples: how many more blue candies than red candies do you have? How many red candies and yellow candies do you have?

Closure: Once the assignment is completed, the students will be able to eat (and trade) their candies. They are allowed to compare their graphs to those completed by classmates in order to see how the graphs differ.

Assessment: (Relate to Objectives) The worksheets will be collected to see if the graphs are correct and if the questions have been answered correctly. Each question sheet will be a bit different, as the amount of candy pieces will vary by bag.

Candy Math Question/Sorting Worksheet

Name: _____

Date: _____

Instructions: Open your bag of candy and remove the candies. You may eat one (1) piece now. Sort the rest out by color. When you have sorted the candies, answer the questions below. Remember not to trade with or copy from a neighbor! All of your work and candy amounts will be different.

How many blue candies do you have? _____

How many red candies do you have? _____

How many yellow candies do you have? _____

How many green candies do you have? _____

How many orange candies do you have? _____

How many candies of other colors do you have? _____

How many candies do you have altogether? _____

How many more blue candies do you have than red candies? _____

How many green candies and orange candies do you have? _____

How many blue candies and yellow candies do you have? _____

How many red, green, and yellow candies do you have altogether? _____

Do you have more blue candies or green candies? _____

What color of candy do you have the most of? _____

What color of candy do you have the least of? _____

Candy Math Graphing Worksheet

Name:

Date:

Instructions: You are going to make a graph of how many candies you have. Remember not to eat them yet! Each color group of candies will have a separate bar. Fill in one square for each candy you have in that section. For example, if you have 5 blue candies, fill in 5 blue squares. When you finish the graph and the question sheet, you may eat your candies.

Blue	Red	Yellow	Orange	Green	Other
Blue	Red	Yellow	Orange	Green	Other
Blue	Red	Yellow	Orange	Green	Other
Blue	Red	Yellow	Orange	Green	Other
Blue	Red	Yellow	Orange	Green	Other
Blue	Red	Yellow	Orange	Green	Other
Blue	Red	Yellow	Orange	Green	Other
Blue	Red	Yellow	Orange	Green	Other
Blue	Red	Yellow	Orange	Green	Other
Blue	Red	Yellow	Orange	Green	Other
Blue	Red	Yellow	Orange	Green	Other

"M&M's"® Candies, Line Plots, and Graphing

By: [Deanna Lehar](#)
Lakeside Elem.
Hanford, CA.

Introduction: Everyone loves "M&M's"® Candies! A fun activity where the kids can eat their math! Activities include estimating, sorting, counting, graphing, plotting, fractions, percentage, and calculating mean, median, mode.

Objective: Using small individual bags of "M&M's"® Candies, students will do activities to review their understanding of estimating, sorting, graphing, mean, median, mode, fractions, percentage, and averaging.

Prior Knowledge: Students need prior knowledge of the terms [mean](#) [median](#) and [mode](#). Students also need prior experience in calculating averages.

Grade Level: 4-7

Resources: MATERIALS (All supplies are per student):

- *one small bag of "M&M's"® Candies
- *1 copy of Worksheet 1
- *3 copies of Worksheet 2
- *1 copy of Worksheet 3
- *pencils
- *colored pencils or crayons
- *Post-It Notes
- *calculators
- *overhead projector(optional)
- *overhead transparency of worksheets(optional).
- *overhead calculator(optional)

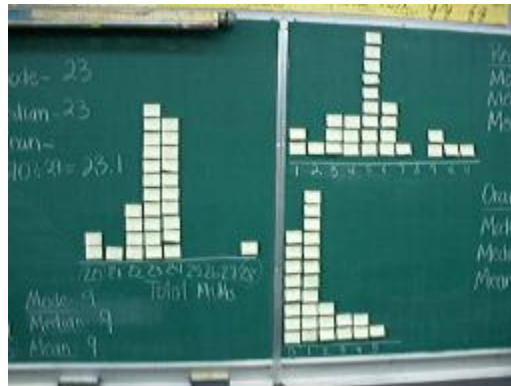
Process:

Worksheet 1: Hand out worksheet 1 to each student. Distribute small bags of "M&M's"® Candies to each student in class. Do not allow the students to touch or open the bags! (Some students will try to feel how many "M&M's"® Candies are inside.) Have the students estimate how many "M&M's"® Candies are in their bags and write their estimate on the top of their paper.

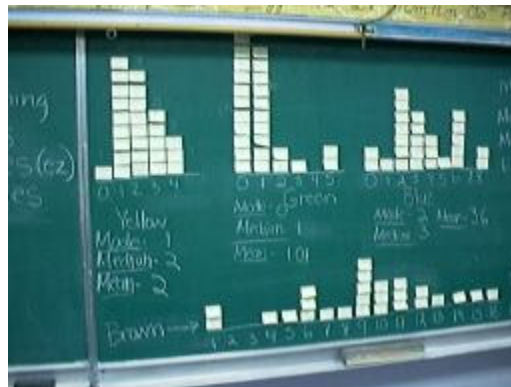
Next, have the students predict how many of each color they will get in their bag and write their prediction down. Make sure their total prediction for all colors matches their estimate count of "M&M's"® Candies in their bag. (For example, a student predicts there are 10 "M&M's"® Candies in their bag. They predict there are 3 red, 1 orange, 2 yellow, 1 green, and 3 brown. When these are added together they should total 10.)

Finally, let the students open their bags (They are not allowed to eat any until this part of the activity is over!) Have the students record their actual total and actual total of colors on worksheet 1.

Have each student write their total of "M&M's"® Candies in their bag on a sticky note and post it on a line plot on the chalk board. As a whole class, find the mean, median, and mode. (This should be review.) Find the average of "M&M's"® Candies in each bag. Compare this with the mean.



Worksheet 2: Have the students plot class results for each color on Worksheet 2. (Three copies are needed- one for red and orange, one for yellow and green, and the third for blue and brown.) As a whole class begin with one color, using sticky notes, the students record how many they had of each color on the chalkboard line plot. Plot how many red each person had on the chalkboard. As a class, find the mean, median, and mode for red. Ask each person for total number of each remaining color (orange, yellow, green, blue, and brown) and write amounts on their sticky note to post on chalkboard. (Do one color at a time). Individually or in small groups, using the information on the chalkboard, students will make line plots for each individual color. Find the mean, median, and mode for each color. Compare class results of mean, median, and mode for each color.



Worksheet 3: Using the information gathered from Worksheet 1, have the students color in the bar graph using the same color for the "M&M's"® Candies they are graphing. Turn this information into fractions and percentages. Calculators may be needed for the percentage part for some.

Learning Advice:

On worksheet 1, make sure top total and bottom total agree for estimate and actual amounts.

On worksheet 2, it is better to let the students eat the colors one at a time as you plot the data on the chalkboard.

Worksheet 3 is good to use as a filler for advanced or quicker students while waiting for the class to complete Worksheet 1 and 2.

Evaluation: Students will be evaluated by their group work produced. The class is using the same data, therefore the results should be the same or very similar.

Links:

- ["M&M's"® Candies Studios](#)

Name _____

Date _____

"M&Ms"® Candies Worksheet 1

Without opening or touching your bag of "M&Ms"® Candies, estimate how many are inside and record below. Predict how many of each color you will have. (If your estimated total is 10 "M&Ms"® Candies in your bag then your total prediction of "M&Ms"® Candies colors should also add to 10.) Then open your bag and find your actual total and how many you have of each color. Record your results below.

Estimated total= _____

Actual total= _____

Colors:	Prediction:	Actual Amount:
Red		
Orange		
Yellow		
Green		
Blue		
Dark Brown		
Total=		

Number of:

Red =	Orange =	Yellow =	Green =	Blue =	Brown =
-------	----------	----------	---------	--------	---------

Total number of "M&M's"® Candies = _____

Using the information above, convert each color into a fraction.

Red =	Orange =	Yellow =
Green =	Blue =	Brown =

Using the information above, convert each color into a percentage.

Red =	Orange =	Yellow =
Green =	Blue =	Brown =

M&M Cookie Math

AUTHOR: Martha Adams, Jefferson Elem., Everett, WA

GRADE LEVEL: 1-6

OVERVIEW AND PURPOSE: This is a fun math activity using M&M cookies that are prepared ahead by the teacher or that the students plan for and make the day before. Students munch their way through the cookie keeping a tally of how many M&M's are found in each color. Then a teacher designed math worksheet is completed that reviews any math concepts desired. I enjoy this activity around Halloween calling the cookies M&M Monster Cookies.

OBJECTIVES: The students will:

1. Plan and make the M&M cookies.
2. Tally M&M's by color while eating cookie.
3. Complete worksheet using math skills.

RESOURCES:

M&M Cookies (recipe below); teacher designed worksheet

M&M Monster Cookies*

- 1 c. butter 1 1/2 t. vanilla
- 2 1/4 c. peanut butter 3 t. soda
- 2 c. sugar 9 c. uncooked rolled oats
- 2 1/4 c. packed brown sugar 4 c. M&M candies
- 6 eggs
- 1 1/2 t. light corn syrup

Cream butter, peanut butter and sugars until light and fluffy. Add eggs; beat well. Stir in corn syrup, vanilla, and soda. Add rolled oats and M&M candies; mix thoroughly. Drop by tablespoonfuls onto ungreased cookie sheet. Bake at 350 degrees for about 12 minutes.

YIELD: about 10 dozen **NOTE:** The recipe requires no flour.

* For a class of 30, I use 1/2 this recipe and make each cookie about TWO TABLESPOONFULS in size yielding just under 3 dozen cookies. The baking time will need to be slightly longer for the larger size cookie. Adding more M&M candies before baking increases the fun of the math activity.

ACTIVITIES:

1. Plan with students for cookie making. Ingredients, utensils, and cooking source need to be planned for.
2. Make and bake cookies.

3. Give each student a cookie and a worksheet. The worksheet should be designed based on skill level of child. For young students, a tally and simple addition may be sufficient. Examples for older students:

$$\underline{\hspace{2cm}} \# \text{ red} \times 236 = \underline{\hspace{2cm}}$$

$$14,695 - 9,675 = \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \# \text{ brown} = \underline{\hspace{2cm}}$$

$$500 : \underline{\hspace{2cm}} \# \text{ yellow} = \underline{\hspace{2cm}}$$

$$432.1 \times \underline{\hspace{2cm}} \# \text{ green} = \underline{\hspace{2cm}}$$

4. The last activity on the worksheet is to add the answers to all problems to determine who has the "Most Valuable" cookie, the "Least Valuable" and for older students a class "Average Value" could be determined.

TYING IT ALL TOGETHER: This is a fun activity to review math skills. Math extensions are almost limitless and could include student made problems, story problems, etc. Other extensions include writing descriptive words or paragraphs about the cookie, writing cookie conversations, writing stories about the cookie, personification of the cookie, etc.

M&M Multiplication as Repeated Addition with Presentation Tools

Target Grade: 2 - 3

Target Curriculum: Mathematics

SOLs: [MAT.2.5](#) [MAT.3.9](#) [MAT.5.2](#) [MAT.5.4](#)

Time: 3 classes of 35 minutes each

Objective:

Using a presentation tool, the learner will create a stack of cards or slides, that correctly and clearly shows a given number of sets of a given amount (e.g. 5 sets of $5=25$) in a well-organized, attractive, and easy to read display. Mastery of this objective will occur when 4 out of 5 elements are consistently evident.

Purpose:

To practice multiplication as repeated addition

Materials:

An LCD display or an In Focus projector; a presentation program; an overhead projector, a clear plastic container filled with M&M's, 5 portion cups for display: a ziploc bag with 25 M&M's for each student; 5 portion cups per student; as well as a hundred chart for each student.

Procedure:

· Anticipatory Set: Students will look at container filled with M&M's and 5 portion cups filled with 5 M&M's each. Then I will share the story about a deep sea diver whose job it is to record the number of fish he sees. In this story the fish always travel in equal groups. The deep sea diver has a limited quantity of air in his tank. He can count each individual fish or he can count each equal set of fish. Count the 5 portion cups of M&M's in sets of 5. Then place them one at a time on a hundred chart. Which was faster? Show students how to use a presentation program to create a slide show or stack of cards. Open a new slide or card. Draw 5 ovals on the card or slide. Insert 5 similar clip art images or stamps in each of the 5 ovals. Add a text box with 5 sets of $5 = 25$ written in it. If a microphone is available show the students how to record their voice saying the math fact. Show students how to choose a transition and how to create a new slide or card showing another fact like 3 sets of $5 = 15$. · Guided Practice: Have students take turns creating a slide or card with stamps, transition and, if available a recorded voice naming the math fact with 5 as a factor. Independent Practice: Students should use their bag of M&M's and portion cups to create 2 sets of 5. Then have them count by 5 and place them on the hundreds chart one at a time. Have the students create a card or slide that shows 2 sets of $5=10$. · Closure: Discuss what they observed about the number sentences recorded and counting the M&M's out one at a time.

Observations:

Have students share their slide shows. Observe the finished products. A rubric will be used to evaluate the student's work. Mastery of this objective will occur when 4 out of 5 elements are always evident.

Conclusions:**Rubric:**

Elements to look for:	Always evident	Sometimes evident
1.Student used the same number of items per group on each card or slide.		
2.Student correctly recorded the math fact as text on each card or slide.		
3.Student had a transition between cards or slides.		
4.Student added voice or pre-recorded voice to each slide or card in stack.		
5.Student's cards or slides were well organized, attractive, and easy to read.		

For Your Information:

Preparing Ziploc bags with student names outside and filled with 25 M&Ms will save a lot of confusion and time. Test the font types for your program. The students will need to be able to record number sentences like 5 sets of 5 = 25. Sometimes certain fonts won't show = sign. The technology aspect of this lesson works really well with Kid Pix.

Extension:

High end learners can create a collection of cards or slides that other children can use to help them with their multiplication math facts. Remediation: Have students work with sets of 2 instead of 5.

Class Discussion Questions:

Which was a quicker way to get the answer for each problem - counting one at a time or counting by like sets?

Cautions and Concerns:

When children are creating cards or slides the sound made by placing circle shapes on the screen can become loud in a lab setting, but is easily fixed when students lower the volume.

Comments from Author:

The children loved all aspects of this plan from the M&M's to using stamps in Kid Pix.

Sweet Adventure

Course and Grade Level: Fifth Grade Science

Alabama Course of Study Objectives: Process skills---observing, predicting, classifying, communicating

SCANS Skills: Acquire, evaluate, interpret, and communicate information

Lesson Objectives:

1. Students will use their five senses to conduct a sweet adventure to observe, predict, classify, and communicate
2. Students will observe and classify M&M's according to similar properties--color, shape, size, texture
3. Students will predict the color, number, size, and shape of the M&M's inside the package before opening them
4. Students will communicate the results of the experiment verbally and in written form

Materials:

- Fun-size packages of M&M's or Skittles
- Sweet adventure worksheet which covers process skills
- PACE Learning Systems Critical Thinking Lesson 100 Science Literacy booklet, sections one and two

Procedure:

1. Pass out M&M's making sure students' eyes are closed and only telling students that they will be conducting a sweet adventure. Pass out process skills worksheet.
2. Have students open eyes and without touching the M&M's tell five things they already know about them. Instruct the students to record the information on their sheets.
3. Have students tell five things they learn by observing the package. (Yes, they may touch the package now). Read, smell, feel, listen to the package. Record the information.
4. Have students predict color, number, size, and shape of M&M's in package without opening them. Record results.
5. Ask students to explain how one could classify M&M's and to record these observations.
6. Allow students to open their packages to see if their predictions were correct and to record the correct number, color, size, and shape of the M&M's on their sheet.

Evaluation:

Follow up with class discussion. Share information and complete PACE Learning Systems Critical Thinking Sheet.

Plan submitted by Lisa Naugher.

Learning Fractions & Whole Numbers With M&M's

Greg Koelsch and Jason Jennings
11/11/98

Topics: *MATH*, product-fractions, process-communication, *SCIENCE*, product-animal, process-classifying

Student Level: 4th grade

Objective(s):

- The students will be able to determine the ability to classify colors of M&M's.
- The students will be able to determine the ability to construct their M&M's to form fractions.
- The students will be able to determine the ability to demonstrate effective cooperative learning within a group.
- The students will be able to determine the ability to classify colors of M&M's to colors in the environment.
- The students will be able to determine the ability to identify the numerator and denominator within a fraction.
- The students will be able to determine the ability to determine that the denominator in a fraction is the total number of equal parts within a fraction.

Materials: M&M's, plastic bowls, measuring cups, construction paper.

Prerequisite Skills: effective and comprehensive understanding of numerator and denominators within a fraction.

Time Required: 20-25 minutes

TEACHING PROCEDURES

Introduction:

- Have a big bowl of M&Ms sitting on the front table.
- Tell the students that they will get a cup full of M&Ms, but before they do this they must agree not to eat any of the M&Ms until they have completed their assignment. If they do eat any of the M&M's they will not be able to participate and will lose the points for the M&Ms assignment. The teacher will call two groups at a time to come up to get their M&Ms.
- The teacher will fill up the students' bowls and have them return to their seats.

At this time the teacher will ask the students to pour the M&Ms out of the bowl and examine the colors. Then ask the students to create on their construction paper an animal in the environment that resembles that color.

After the students have created an animal on construction paper place the colored M&Ms on the animal represented. (this makes the colors more identifiable)

At this time ask the students to write the number of each color of M&Ms beside each drawing. Each member in the group can have their own responsibility for picking a color of M&Ms to count.

Ask the students the fraction of green M&Ms to the entire group of M&Ms.

Repeat this step for each of the colors of M&Ms. Remind students to reduce whenever needed. Now have each group discuss their fractions.

Review: Ask the students to recall what we discussed about fractions the day before. The students should recall that the numerator is always on top, because the word numerator has a "u" in numerator this means up above the fraction line. The denominator has a "d" denominator this means down below the fraction line.

Strategies: The teacher will use a t chart in order to assess the students' effective cooperative group work.

Conclusion: The teacher will ask students to share with the rest of the class their fractions of each color of M&Ms. The students will also share their drawings of animals to represent the colors of the M&Ms.

Evaluation: The teacher will evaluate the students throughout the lesson to ensure cooperative group learning. The teacher will also use rubric to assess student's performance in this way. Correctly writing a fraction in longhand form reducing whenever needed. Effectively working within groups.

EXTENSION

An extension idea you could use as a teacher is to use M&Ms to produce similar outcomes with probability. You could ask the students to find the probability of finding a certain color of M&M within the group of M&Ms.

RESOURCES

Learning Fractions with M&Ms-An askERIC Lesson Plan

[Http://ericir.syr.edu/Virtual/Lessons/Mathematics/Arithmetic/ATH0023.html](http://ericir.syr.edu/Virtual/Lessons/Mathematics/Arithmetic/ATH0023.html)

M&M Graphs and Other Math Activities

To start off this unit, I have each child bring in 2 bags of M&M's...one plain and one peanut. I specify that I want the 1.69 oz size, and I even xerox the size bag that is needed. I do this the week before I start so I know I'll have enough M&M's to begin the unit. The candy comes in and the fun begins.

The first thing we do is pass around a sealed bag of peanut M&M's and then a plain bag. We compare and contrast the 2 bags. We make a list of everything we say about the bags. We look at colors, words, numbers, etc. Then we open the bags and pour out the candies onto 2 paper plates. We notice things that are the same and different.

Now I take the plain candies and we sort them into color groups. Then we do the same with the peanut candies. We notice that there are a lot more plain than peanut M&M's!

Then we do a few different graphs.

Graphs and Other Math Activities

I have the children sort the M&M's into color groups by putting them into cupcake tins or egg cartons. I have done this activity as a large group and in the Math Center.

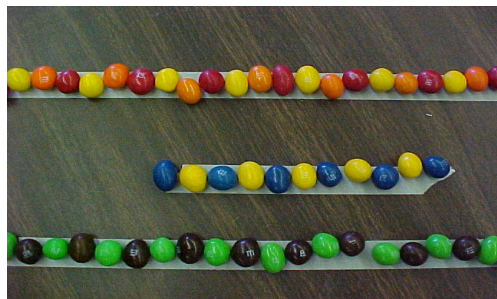
I put M&M's in the Guessing/Estimation jar.

I made graphs with the children such as:

- What is your favorite color M&M?
- Which flavor do you like best, plain, peanut or crispy?
- Would you let an M&M melt in your hand?

These are whole class graphs. I also give the kids individual packs of M&M's to graph by themselves at center time OR as homework.

We make patterns with the M&M's. (See pictures below for examples.) I put pieces of masking tape on the table in different lengths. The kids make a different pattern on each piece of tape. Plain M&M's work best. Peanut ones ROLL!



I cut out a bunch of construction paper circles and drew a small letter m on each one with fabric paint. The kids used these "M&M's" to measure ME, each other, desk tops, shelves etc. They also made patterns with them (Make sure you laminate these!)

I gave each child a recording paper that looked like this...

There was a picture of a hand, then a PLUS sign, then another hand, then an EQUALS sign, then a short line for recording the answer. (I hope that makes sense!) I made 4 of those on each paper. The child got a tub full of M&M's, dice, and a pencil. The child rolled the die, and put that many M&M's on the FIRST hand. Then the die was rolled again and that many M&M's were put on the SECOND hand. The child adds up the M&M's and records the answer on the short line. I also have them draw and color the M&M's on the hand with crayons or markers. I have also done this at a center with cut out construction paper hands (laminated) just to introduce the kids to adding.

We guess how many M&M's will fill up various containers, then we fill up the containers and count.

I also have different sizes of laminated , construction paper hands. The kids cover the hands with M&M's and count how many there are. We talk about how smaller hands have less M&M's, and larger hands have more.

I used the xerox machine and enlarged and shrunk an M&M bag. I cut those and laminated them and the kids measured the distance across the various sized bags.

It's fun to give each child one individual sized bag. Let each child open up their own bag and put the candy into color groups. It's amazing for them to see that the color groups are all different, and that each bag DOES NOT contain the same amount of candy.

Of course, we read The M&M's Counting Book by Barbara Barbieri McGrath, Charlesbridge Publishing. Of course, their favorite part is doing the subtraction pages, because they get to eat the M&M's.

A fun science activity for the kids to do is this...give each child an M&M and a small container of water. I have done this in class and as homework. Have the children put the M&M into the water. It will sink to the bottom. After a while, the m actually floats to the top of the water. It is really neat. Before we actually do the experiment, we predict what will happen to the piece of candy and write our predictions on a large piece of graphing paper. After the experiment, we see if we were correct! You can give each child a few M&M's...then they can see the color disappear too! They think that's cool!

Call **the Mars company** and tell them you are a teacher...ask for the packet of information. They will send you an envelope filled with all kinds of goodies for FREE!

The number is 1-800-222-0293.

Here are some language arts activities that I do with the kids.

In the chart I put the following sentences...

I like **orange** M&M's.

I like **brown** M&M's.

I like **yellow** M&M's.

I like **green** M&M's.

I like **red** M&M's.

I like **blue** M&M's.

As the kids learn the sentences, I take out the color words and put the words back in all black print. That shows me who is actually learning color words or not. I give the kids colored, construction paper M&M's to put on the correct color words.

I have done individual class books with these words...

PAGE 1 -- I like _____ M&M's.

PAGE 2 -- I like _____ M&M's.

PAGE 4 -- I like _____ M&M's.

PAGE 5 -- But, I do not like _____ M&M's.

Children print color words on the lines.

Another chant we do in the chart is this...

Red M&M's. YUM! YUM! YUM!

Red M&M's. YUM! YUM! YUM!

Red M&M's. YUM! YUM! YUM!

M&M's in my TUM TUM TUM!

Of course, we change the colors after every verse.

I cut out a bunch of M&M colored circles and put them into the writing center with white chalk. The kids loved printing lower case m's on the paper.

Problem Solving Using Percentages

Thelma A. Rex
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708-371-9575

Objectives:

The student will be able to recognize the three basic types of Percentage Problems.

The student will be able to:

1. Find what percent one number is of another.
2. Find a percentage of a number.
3. Find a number when the percent is known.

Materials Needed:

- 1-16 oz bag of plain M&M's; 19-4oz bags of M&M's; 19 plastic bags;
- 1 black marker and 19 pencils; 19 student folders with plain writing paper;
- M&M Math handouts
- Calculators
- Overhead projector.

Strategy:

All of the students are given a folder with a small plastic bag and one small bag of plain M&M's. The students are asked to guess how many M&M's are in the bag. They are asked to put their M&M's into sets by color and write the number of M&M's they have in each set. They are also asked to use $>$ or $<$ or $=$, to show the relationship between these sets. Students put 15 M&M's in front of them. Then they are asked various questions, for example, how many piles of fours can you make? What is left?

The teacher demonstrates three types of word problems on the board to find percents by using ratio and proportion. The overhead projector is used to illustrate the same problems, but in a different way. For example:

1. The student is given the following information;
 - the number of red M&M's in the small bag.
 - the total number of M&M's in the small bag.
 - the total number of M&M's in the big bag.The student is asked to find the number of red M&M's in the big bag.
2. A bicycle is on sale with a coupon for 25% off which is a \$15.00 savings. How much is the bicycle without the coupon?

3. A set of stereo speakers is priced at \$125.00. The sales tax is 8%. What will be the total price of the speakers?
4. In a photo, Carlos measures 8 centimeters. He is actually 56 inches tall. In the photo his brother, Juan, measures 7 centimeters. How tall is Juan?

Performance Assessment:

The students will be given a post-test. The students will be able to tell how many M&M's are in the big bag as compared to their small bag of M&M's. Students already know that there are 88 red M&M's in the big bag and that there are a total of 527 M&M's in the big bag.

Multicultural Aspects:

Percent comes from the Latin phrase per centum, which may be translated by the hundred, to the hundred, for each hundred. The symbol for percent is %. Thus, 85% means the ratio 85 to 100 or 85/100. Percent is used for mathematical calculations throughout the world in everyday living regardless of nationality.

References:

Math and Science, A Solution. 1987, Aims Education Foundation.

Scientific Method for Middle Schools

National Science Education Standards correlation: Science as Inquiry Content Standard A; Grades 5-8: “Recognize and Analyze Alternative Explanations and Predictions.”, “Communicate Scientific Procedures and Explanations.”, “Use Mathematics in All Aspects of Scientific Inquiry.”

Materials: M&M’s

Activity Time: One class period for activity and discussion of data.

Objective: Students will use knowledge of a scientific method to solve a teacher made scenario.

Procedure:

- Have each student bring in a bag of M&M’s.
- Give each student a copy of the scientific method.
- First students will need to come up a problem.
- Tell students that the school is conducting a study on the colors of M&M’s.
- The problem is that you want to know the most dominant color of M&M.
- Next have students make a prediction.
- What color M&M is the most dominant?
- Allow students to group their M&M’s according to color and write down this information.
- Use this information to devise a T table and then analyze the data by having students graph their results.
- Make sure they give their graph a title and label the X & Y axis.
- Last...come to a conclusion. They either accept or reject their hypothesis.

Follow-up questions:

1. Are scientific methods only used by scientists? Explain your answer.
2. As a scientist, why is it important to follow a scientific method?
3. Give three examples of how a scientific method is used in your daily events.
4. How is a hypothesis different from a random guess?
5. What criteria did you use to decide on a color prediction of m & m’s?

National Science Education Standards
National Academy Press,
National Research Council
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Spreadsheets and M&M's



This activity can be used with Microsoft Excel or ClarisWorks (or other spreadsheet programs) to teach students how to use spreadsheets. It provides data that can be used by the class and is fun!

Warm Up:

What is in a typical bag of M&Ms? How many different colors? What are the colors? Are there the same number of each color in a bag? Which color has the most? How many total M&Ms are in a typical bag? Record all responses.

Open a sample bag of M&Ms and demonstrate what the students will be doing with their bag. Place a transparency on the overhead., pour the candies on the sheet, and form a histogram with the candies. Ask students to count the numbers of each color and find the total number of M&Ms in the bag. Compare these numbers with the student guesses.

Data Collection:

Students estimate the numbers of each color and the total number in their own bags of M&Ms. Have students record their estimates on a record sheet. Don't let them eat the M&Ms without completing the data collection first!

1. Open the bag of M&Ms on a sheet of paper.
2. Move the M&Ms to form a candy histogram as in the warm up.
3. Count and record the actual number of each color of M&Ms.
4. Record the total number of M&Ms.
5. Using six 3 x 5 cards, record the number of each color on a separate card. Make the number large and dark. On the reverse side, record the corresponding color for that number.
6. Using one more 3 x 5 card, write the student name in large, dark letters.
7. Complete the record sheet by finding the difference between your guess and the actual number found in the bag. This difference might be negative.

Make a Floor Spreadsheet:

Place column (marked A, B, C, D, E, F, G, H, I) and row (1, 2, 3, 4, 5,...) identifiers (two more than the number of students in your class) made out of 3 x 5 cards on the floor marking out the area for the spreadsheet. Place labels for each of the columns that you will use, naming the cells as you store the information.

Have the students place their records of information in particular rows.
Then, have them find:

- the least number of green M&Ms.
- the most number of red M&Ms.
- the least number of orange M&Ms.

Consider the differences between *labels* and *values* . Cells D4, B5, and E3 have values in them whereas cells A2, A3, and A4 have labels. The spreadsheet cannot add, subtract, multiply or divide labels, but the spreadsheet can operate on values.

One value of the spreadsheet is that formulas may be entered into cells to have the computer compute other values.

	A	B	C	D	E	F	G	H
1	Name	Red	Yellow	Green	Orange	Tan	Brown	Total
2	Pat	8	5	3	9	14	19	
3	Karen	5	9	6	3	15	18	
4	Judy	6	4	1	11	9	23	
5	Sean	12	3	5	9	13	13	
6		Red	Yellow	Green	Orange	Tan	Brown	
7	Average	7.75	5.25	3.75	8	12.75	18.25	

One value of the spreadsheet is that formulas may be entered into cells to have the computer compute other values. Cell H1 has the label "Total". Ask the students how they would find the total, but instruct them to tell you by referring to the cell names. In the example, Pat's total is determined by "add the values in cells B2, C2, D2, E2, F2, and G2". As the formula is identified write the equivalent formula (B2+C2+D2+E2+F2+G2) for the spreadsheet on a 3 x 5 card and place the card in cell H2. Provide the students with the spreadsheet shortcut for this formula (for ClarisWorks it is: =SUM(B2...G2)

Have each student prepare a formula on a 3 x 5 card and place it in the appropriate cell in the spreadsheet. They should also act as the computer and prepare a card with the actual value, placing that card over the formula in the same cell.

Ask the students how they would compute the average for the first color. In ClarisWorks it is: =AVERAGE(B2..B5)

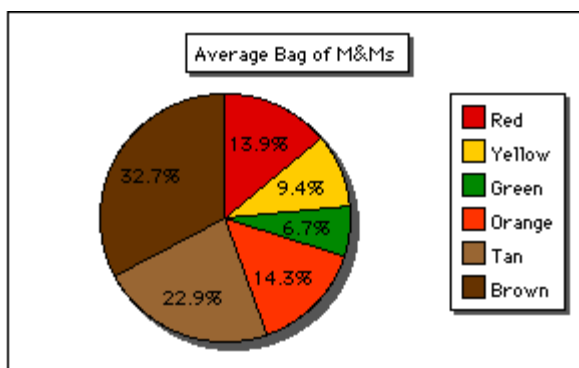


Assign students to place the appropriate formulas in the cells, and then have other students compute the value using the formula. Review the concepts of labels, values, and formulas referring to the specific information in the floor spreadsheets.

Make A Computer Spreadsheet:

Enter the data from the floor spreadsheet into a computer spreadsheet. Take away the values determined by the formulas (for total and average) so that students will have to do this on their computers.

Demonstrate the use of graphing tools to have the computer create a histogram of the average bag of M&Ms using the data in the spreadsheet Challenge the students to create a histogram that compares the average bag of M&Ms with their personal data.



Some extensions:

Have the students prepare a report using the word processor, copying the data and the graph into the report. For the report, students describe the experiment that was conducted and show the results, including the data and histograms. In the summary, they must respond to the following questions. From this sample of M&Ms:

- Which color(s) appear least?
- Which color(s) appear most?
- What is the ratio of red:yellow:green:orange:tan:brown M&Ms in an average beg?
- Based on this sample, if a bag of M&Ms contains 100 M&Ms, how many reds are expected?
- How many yellows? How many greens? How many oranges? How many tans? How many browns?

This activity adapted from "Mathematics and M&Ms" by Margaret L. Niess, *The Computing Teacher*, Aug/Sep 1992.

An excellent CD-ROM for teaching spreadsheets at the elementary level is:

[The Cruncher](#) by Davidson.

Also, visit the M&Ms page on the Internet:

<http://www.m-ms.com/>

M&M's & Percentages

Scott Reece

June 25, 2003

Brief Description:

Students will take a bag of M&M's and use them to learn about percentages. They will find percentages of each color of M&M found in the bag. They will use the calculator to find the percentages.

Technology Required: Calculators, spreadsheets, Internet

Grade Level: 5th – 7th

OCC's Addressed:

Solves practical problems using percents (e.g., sales tax, sale price and commission, and discounts).

Math Topic:

Percentages

What Color Are Your Skittles?

By - Ellyn Bewes

Primary Subject - Computers / Internet

Secondary Subjects - Math

Grade Level - 5-6

Discipline/ Focus: Computer Applications

State/Local Standard - Florida:

Create and manipulate spreadsheets and graphs

Overview/Summary: In this lesson the child will learn how to create spreadsheets, to chart the different colors in a package of Skittles. They will collect data, create appropriate charts and use percentages to describe quantities.

Lesson Time: 4 class periods

Guiding Question: Do all packages of Skittles have the same number and color combinations?

Learning Objectives: The student will learn how to create a spreadsheet to chart the different colors in a package of Skittles. They will collect data, create appropriate charts and use percentages to describe quantities.

Materials: 1 package of Skittles

Microsoft EXCEL

Internet Resources: www.skittles.com

Procedure

Open the package of Skittles and tally the amounts of the different colors of Skittles found in your packages (write the colors and numbers on the back of this sheet).

1. Open the program called Microsoft Excel. The first time we use this program we need to click on "Start" to begin.
2. Click the mouse in cell B1 and type "My Skittle Colors" in the entry bar.
3. Highlight "My Skittle Colors" in the entry bar and change the font size to 14 and BOLD.
4. Press the enter key to move the information from the entry bar to the active cell.
5. Click the mouse in cell B3 and type in "Green". Highlight the word Green and change the font to size 12 and make it BOLD.
6. Highlight cells B4 through B7, change font to size 12 and BOLD.
7. Enter the names of the different colors of the Skittles into cells, B4, B5, B6 and B7. Place your mouse in cell B4 and type in the next color. Continue until all the colors are entered.

8. After you have labeled all of your candy colors, you will need to enter the data recorded for each color. Click the mouse in cell C3 and enter the number of green Skittles found in your package. Repeat for all the colors, entering the data down column C.
9. Once the data is entered, click on cell B3 and drag the mouse to the end of where you entered information in Column C. From the Insert Menu on the Task Bar select Chart. Select Pie Chart. Click next and next again. In the Title Selection space type _____'s Skittles. (Put your name on the blank line.) Click on the Data Option tab and select percentages, and then Finish
10. Move the Pie chart off the spreadsheet table by clicking on the pie chart and dragging to the side. To increase the size of the pie chart, drag down on the bottom and side of the chart area, and the chart will grow in size.
11. Change the color of each piece of pie on the chart by double clicking on the color square in the legend, and selecting the appropriate color from the Pattern tab color chart. The legend and the piece of pie will change to this new color after you click OK.
12. When you have completed your pie chart, click on Print Preview to make sure that the chart and the spreadsheet will be printed. Save your work on your disk - call it Skittle Colors – and print 2 copies.

Outcome/Assessment: Children complete their spreadsheet and pie chart graphs. They compare their results to answer opening question and check the web site to see if their pie charts and percentages are the same as those advertised on the web.

Extensions: This activity can also be done with M&M's, or any other material with multi-colors (colors in fruit loops, etc.)

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Discovering the World of Graphs

Brief Overview:

These activities were developed to encourage creativity and discovery of concepts. In cooperative groups students will engage in a variety of hands-on activities to organize and interpret data displayed in a graph format. Math journals will be incorporated daily. Each day's lesson should be assessed through kid-watching, anecdotal records, and the child's overall performance.

Link to Standards:

- **Problem Solving** Students will demonstrate their ability to solve mathematical problems by interpreting and differentiated different types of graphs and their most effective uses.
- **Reasoning** Students will determine the most effective way to display collected data. They will make conjectures and give evidence to support their choices.
- **Number Relationships** Students will demonstrate their mastery of basic number concepts while they interpret their collected data.
- **Statistics** Students will be actively involved in the collection, organization, and display of data into various types of tables and graphs.

Grade/Level:

Grades 4-5

Duration/Length:

To accomplish the objectives of the unit will take approximately five days.

Prerequisite Knowledge:

Students should have working knowledge of the following skills:

- 3-digit addition and subtraction
- Multiples
- Sorting and classifying
- Tally marks
- Plotting coordinates
- Basic geometrical shapes

Objectives:

Students will:

- work cooperatively in groups.
- collect, analyze, and organize data.
- display data using a table, bar graph, line graph, and pictograph.
- determine appropriate scales for their graphs.

Materials:

- An individual bag of M&M's for the class
- Pencils/ crayons/ markers
- 1" graph paper (several sheets)
- Collection of geometrical shapes
- Copies of one week's lunch count
- The attendance for each student for one month
- Math journals
- Unifix cubes

Development/Procedures:

Day 1: Students will organize information using both a table and a pictograph.

- Discuss with students different ways data can be collected and displayed.
- Divide the class into cooperative groups of four.
- Give each group a bag of M&Ms.
- Direct students to sort and count the different colors of M&Ms. Allow students to organize this information and record in whatever way their group chooses.
- Have students share with the class how they chose to display their information. If students do not display a title, use questioning techniques to help them discover the importance of correct labeling.
- Have students put their recorded information in a table using tally marks.
- Have students then predict what a pictograph is. Share examples. Have students apply this information and as groups create a pictograph for their table.
- Have groups share their pictographs with the class. Have students eat M&Ms and enjoy!!!!
- Have students respond to the following in their math journals: Explain what a pictograph is. List situations when a pictograph would be useful or effective. Share responses.

Day 2: Students will apply skills learned previously to visually display both a pictograph and table. Students will begin to discover the elements necessary to create a bar graph.

- Pair students and give each pair one penny and two sheets of graph paper.
- Direct students to flip the penny 20 times and record their results as heads or tails on a table.
- Discuss gathered information. Then create a class table using data from each pair.
- Paired students should then use the class data to create a pictograph.
- Ask students to display this information another way on their graph paper.
- Have each pair explain what they did and why they chose this method.
- Using questioning techniques, as a summary, have students deduce that a scale is necessary for an effective display of data.
- Ask students to explain in their math journals why a scale would be necessary to display information effectively. Furthermore, why might it be necessary to use

different scales for data collected in your paired than from class data? Share responses.

Day 3: Students will make a bar graph incorporating all of the necessary elements.

- Put students in cooperative groups of four. Pass out bags of various geometric shapes. (At least 30 pieces and four different shapes for each group) 1"graph paper and crayons.
- Review the use of scales from the previous lesson.
- Direct each group to classify and count the different shapes in their bag. Have students record their data using a bar graph. The graph should include all necessary elements.
- Create a class table using the shape data from each group.
- Discuss ways to display the class information on a bar graph encouraging students to discover that with larger numbers, scales should be modified.
- Make a class display of the shape table data. Students should decide on a title, category labels and appropriate scale.
- In their math journals, have students give situations in which they might use a table, pictograph and bar graph. Share responses.

Day 4: Students will create a line graph using all necessary elements.

- For this activity make up a record of each day's lunch count for a week (who packed, bought, etc.). This data will be used to create a line graph.
- Display the lunch data in a table using tally marks.
- Pair students. Pass out unifix cubes.
- Have students use the lunch count data to create a bar graph using the cubes.
- Next, have students trace their bars onto a blank sheet of paper. Have students finish this by incorporating the other necessary elements.
- Discuss and review necessary elements in a bar graph.
- Have students apply previous knowledge to predict what a line graph is. Lead the class to discover the elements that would be necessary for an effective line graph.
- Have students transfer their bar graph data to a line graph.
- Share graphs and compare similarities and differences between line graphs and bar graphs.
- Have students write two or three questions in their math journals that the lunch count line graph will answer. Have students share their questions with the class and allow time for students to answer.

Performance Assessment:

Day 5: The final day will be an assessment of the week's activities.

- Develop a rubric appropriate for your class to measure the students' mastery of the unit objectives. Final assessment may be based on Activity 5, cooperative group activities, class performance, and the students ability to support their ideas.
- For today's activity make up a copy of the attendance for one month. Pair students and distribute crayons, large graph paper, and the attendance information.

- Explain to students that each pair should visually display the attendance data. Each pair will be responsible for an appropriately labeled graph and written explanation supporting their choice based on the week's activities.

Extension/Follow Up:

- Have students in groups create a board game. This game should require the players to interpret tables and graphs.

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URL's

<http://www.tacoma.washington.edu/education/intel/Projects/integrate.htm>

http://www.sciencenews.org/sn_arc97/3_8_97/mathland.htm

WEATHERED M&M'S®: USING CANDIES TO DEMONSTRATE GEOLOGIC CONCEPTS IN LECTURE-BASED INTRODUCTORY EARTH SCIENCE COURSES

http://gsa.confex.com/gsa/2002AM/finalprogram/abstract_44862.htm

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Students enrolling in introductory earth science courses at the St Louis Community College, Meramec, often have little or no science background. The course format is lecture-only with typically 25-30 students enrolled per section. Demonstrations to illustrate geologic concepts can be valuable teaching tools in such lecture-oriented earth science courses to facilitate student learning. Common brands of chocolate candies are good materials for classroom demonstrations because they are relatively inexpensive, easily obtainable, and familiar to the students. Additionally, learning is greatly enhanced when students are enjoying the taste of the lesson.

Concepts of physical and chemical weathering, erosion, transportation, deposition and lithification was illustrated using M&M's® containing peanuts. Several pieces of candy were used as examples of unaltered igneous rock, which were then crushed up (physical weathering). The crushed pieces were dropped in a beaker containing water. The outer colored sugar coating dissolves rapidly in water, but the chocolate and the peanut pieces remain undissolved, illustrating the concept that different minerals respond differently to chemical weathering. The undissolved peanut and chocolate pieces were then used to illustrate transportation and deposition by water. The demonstration was followed by visual examples of differential weathering in real rock samples.

<http://www.cyfernet.org/integrate/iowa/M&M.html>

<http://collections.ic.gc.ca/science/english/chem/projects/chromat.html>

<http://passporttoknowledge.com/scic/fusionandfission/educators/simulatingfusion.html>

<http://www.ac.wvu.edu/~pierced2/mathunit.pdf>

<http://www.caosclub.org/members/caosho30.html>

http://www.space.com/teachspace/module_astronaut_0900/candy_activity_0900.html

<http://teachers.net/lessons/posts/222.html>

<http://www.lessonplanspage.com/MathPercentFractions.htm>

http://www.tsbkm.com/cgi-bin/lessonlocator/view_activity_info/156

<http://www.atozteacherstuff.com/lessons/M-MCountingChart.shtml>

http://www.create.cett.msstate.edu/create/classroom/lplan_view.asp?articleID=98#handouts

<http://www.woodrow.org/teachers/chemistry/institutes/1986/exp3.html>

<http://www.woodrow.org/teachers/bi/1994/mmlab.html>

<http://www.science-house.org/learn/CountertopChem/exp4.html>

<http://www.askeric.org/Virtual/Lessons/Mathematics/Arithmetic/ATH0015.html>

<http://www.askeric.org/Virtual/Lessons/Mathematics/Probability/PRB0005.html>

<http://askeric.org/Virtual/Lessons/Mathematics/Arithmetic/ATH0023.html>

http://www.kent.k12.wa.us/curriculum/tech/lessons/4/m_and_ms.htm

<http://www.stcharles.k12.la.us/ci/intech/IntechLessonPlans/LessonsfortheWeb/MandMLesson.htm>

<http://www.mste.uiuc.edu/povich/mnm/>

<http://coe.west.asu.edu/students/eaxelrod/elecport/mandm.html>

http://www.esc20.net/etprojects/formats/webquests/summer99/northside/great_deserts/rubricspreadgraph.htm

