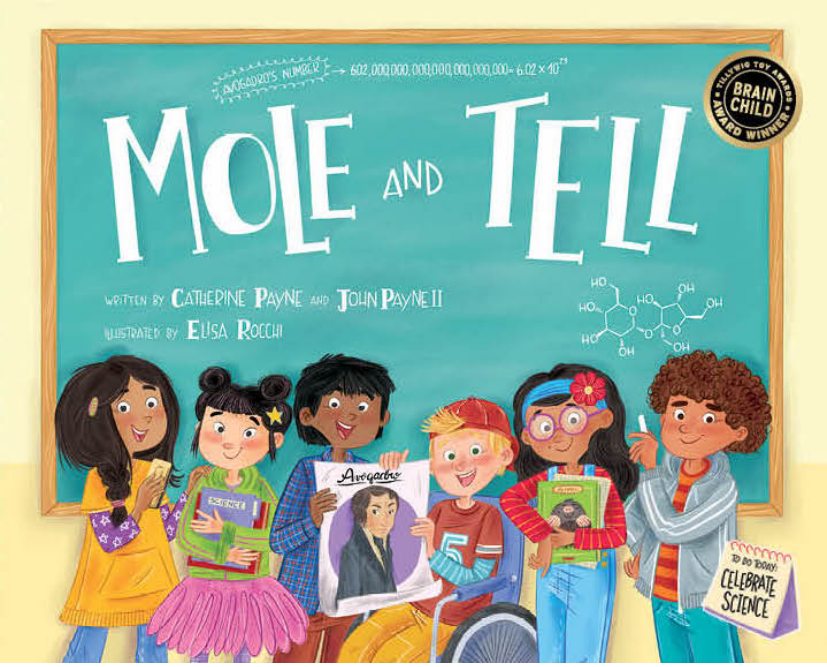
Mole and Tell
Teacher's Guide

Written and Designed by: Liliann Albelbaisi, Caitlin Burnham, Marlee Brooks, Hannah Thelen, and Charlotte Shao

To be used with
Mole and Tell
Written by Catherine Payne and John Payne II
Illustrations by Elisa Rocchi



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Introduction

Chemistry is all around us, woven into every aspect of the physical world. It's the reason why the leaves change colors, why fireworks explode, and why freshly baked cookies smell so delicious. Chemistry creates the foundation of all the other sciences, and is the key that connects each field of science to each other. From agriculture to medicine, from animals to space travel—chemistry is there. When you learn about chemistry, you don't just learn about chemicals and their reactions, but also how to problem solve and better understand the world around you.

In *Mole and Tell*, the students in Mr. Cantello's class learn about one of the standard units of measurement in chemistry: Avogadro's number, more commonly known as the mole. A mole is used to determine the amount of a substance, usually one of the elements or a chemical compound.

With this Teacher's Guide, we want to encourage and inspire the young chemists in your classroom to ask questions about the world around them and figure out why and how chemicals work. By the end, your students will be able to understand one of scientists' most fundamental units of measurement.

Resources

Websites

https://biochemistryliteracyforkids.com/lesson-10/
https://academickids.com/encyclopedia/index.php/Avogadro%27s_number
https://www.ck12.org/c/chemistry/avogadros-number/lesson/Avogadros-Number-CHEM/?referrer=concept_details
https://www.nist.gov/education/resources-parents-teachers-and-students

Books

Eeny, Meeny, Miney Mole by Jane Yolen
Really Big Numbers by Richard Schwartz
The Cartoon Guide to Chemistry by Larry Gonick and Craig Criddle

Youtube Videos

Avogadro's Number, the Mole and How to Use the Mole - Mr. Causey
Concept of Mole | Avogadro's Number | Atoms and Molecules | Don't Memorise - Infinity Learn Class 9&10
How big is a mole? (Not the animal, the other one.) - Daniel Dulek

About the Authors and Illustrator

Catherine Payne has been a storyteller all her life. She worked as a journalist after earning her master's degrees from Harvard University and Columbia University. Afterward, she returned to her native Guam, where she became an English instructor and tutor. Catherine especially loves mentoring young wordsmiths and writing books that transport children to happy places. She draws inspiration from Pacific cultures, which help her to appreciate the interconnectedness of all things. She can be reached at Catherine.Payne@ScienceNaturally.com.

When **John Payne II**, Catherine's brother, discovered superhero comic books, it sparked a lifelong love of reading that led to an interest in speech and language. After pursuing degrees at San Jose State University and the University of Hawai'i at Mānoa, John now works with kids as a speech clinician in Guam. He enjoys exercising, baking healthy desserts, playing guitar, and watching movies based on books. He can be reached at John.Payne@ScienceNaturally.com.

Elisa Rocchi grew up in the countryside of northern Italy, alongside her unique mate and pet cat, Minù. She has always loved drawing and writing, so much so that her mom said she was born holding a pencil! She now works as a children's book illustrator in Milan, surrounded by a laptop and many sheets of paper for the new stories she creates. Elisa currently lives in Italy with her husband and son. To see more of Elisa's work, visit elisarocchi.it.

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Pre-Reading: Numerical Names

Grades: 2-5

Materials: donuts/donut holes, Numerical Names Worksheet

Subject: Chemistry

NGSS: 5-PS1-1 Matter and Its Interactions

Skills: critical thinking, comprehension

Background: When it comes to describing things numerically, there are plenty of number names throughout the English language that can be used. *Mole and Tell* highlights one of those numbers: the mole, which is used to describe the amount of molecules in a substance. In this pre-reading assignment, your students will be introduced to a multitude of words that are used all the time to describe a quantity.

Activity:

1. Discuss how cookies, donuts, cupcakes, soda, etc. that you get from the grocery store usually contain a very specific amount that comes in each package.
2. Explain to the students that 12 items can be called a dozen, and that's why if you have six of something it's a half dozen. Two dozen would be 24, and so on. (ex. 13 is a Baker's dozen, due to the fact the medieval bakers would include a 13th loaf of bread to ensure they were not selling underweight bread.)
3. Hand out the Numerical Names pairing worksheet. Explain that the students will be matching the word with the quantity described.
4. Give your students an adequate amount of time to complete the worksheet and then rejoin to discuss the answers.

Discussion: What is the numerical equivalent of 'twice'? Which of these words surprised you the most? What are some other words that have a number associated with them? Why do you think it's important to have words like these to describe things rather than using just a number? What do you think a mole measures? Can anyone guess how big or small the number really is?

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Activity: How to Read the Periodic Table

Grades: 2-5

Subject: Chemistry

Materials: periodic table, How To Read the Periodic Table worksheet, *Mole and Tell*

NGSS: HS-PS1-1 Matter and Its Interactions

Skills: understanding and applying rules

Background: While it may not appear organized at first glance, the periodic table has a very specific order—and specific symbols and numbers for each element. In *Mole and Tell*, the students are taught what a mole is and then have to learn new things about this number and present them to the class (pages 32-35 show how two of the students learned about the periodic table). Understanding the molar mass of the elements is a great way to introduce your students to advanced chemistry topics like stoichiometry (the relationship between quantities of reactants and products before, during, and after a reaction) and converting molar mass into grams, which will be used in the next activities.

Activity:

1. Read *Mole and Tell* to your class. Point out pages 32-35 where they discuss the periodic table.
2. Display the periodic table or use the included handout. Explain what each part of the element's square represents (symbol, atomic number, atomic weight).
3. Then discuss how the periodic table is also organized by periods (the rows) and groups (columns). A period signifies the number of electron shells an element has. A group notes how many valence electrons are in an element. Teach them how to find a group and a period on the periodic table.
4. Hand out the Periodic Table Worksheet, which will send them on a scavenger hunt throughout the periodic table.
5. Once the students have completed their assignment, regroup as a class and discuss the correct answer.

Discussion: What did you notice about the groupings of the elements? Which elements did you find the most interesting? Does the organization of elements make sense to you? Was it difficult to answer these questions once you knew where to find the right information?

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Activity: How Big is a Mole?

Grades: 2-5

Materials: periodic table, How Big is a Mole? worksheet, a mole's worth of different items (beans, juice, salt, etc), *Mole and Tell*

Subject: Chemistry

NGSS: HS-PS1-7 Mathematical Representations

Skills: Mathematic equations, critical thinking, understanding and applying rules

Background: Moles measure the amount of a substance. They are used by scientists all over the world as a universal standard measurement to measure big quantities of small things, and are important in learning and understanding chemistry. One mole of a substance may have a higher mass than another due to the amount of molecules in one mole of that specific substance. In this assignment, you will teach your students how to calculate the molar mass of a chemical compound. This will help your students understand how molecule sizes vary among different substances.

Activity:

1. Read *Mole and Tell* to your class. Highlight the pages (24-29) that depict the difference between a mole of sugar and a mole of water.
2. Discuss why this occurs. This happens due to the fact that the molecules in different substances are bigger or smaller than others.
3. Then proceed to show students the mass of a mole of different items (beans, juice, salt, etc.) to demonstrate this concept further.
4. Print and pass out the How Big is a Mole? worksheet to each student. Explain to them that in order to calculate the molar mass of a substance, scientists take the atomic mass and multiply it by how many atoms there are in the substance. For single elements, this is pretty easy, but for compounds, they'll need to multiply the atomic mass by the subscript (the small number after an atomic symbol in a compound) and add all the elements' masses together.

Discussion: Why did some of these objects/substances look like they have more or less than others? What do you think a mole describes? Did you notice a relationship between the atomic mass and the mass of the mole?

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Discussion: Scientific Collaboration

Grades: 2-5

Materials: *Mole and Tell*

Subject: Chemistry

NGSS: Practices: Obtaining, Evaluating, and Communicating Information

Skills: collaboration, communication, and critical thinking

Background: When it comes to scientific discovery and experimentation, all great minds in science collaborate and work together to bring theories, hypotheses, and ideas to fruition! It starts and ends with one person, but the entirety of the scientific community comes together to solve and understand the world a little bit better.

Discussion: Looking back at *Mole and Tell*, there is a section where Mr. Cantello's class discusses that Avogadro did not actually come up with the number, but set the integral framework that helped other scientists reach that discovery. Discuss how collaboration is important in the scientific community. If you like, you can encourage students to share other scientific discoveries they know of that involved multiple scientists working together to solve it. Also consider asking students to partner up and research a scientific discovery using the Internet. Have them record how many scientists were involved in the finding, and what part they played. Come together as a class and discuss what your students have learned. Which pair found the largest collaboration, and what did that group of scientists discover? Ask the students why they think there were so many scientists involved.

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Activity: A Chemist's Classified Cookie Recipe

Grades: 3-5

Materials: *Mole and Tell,* calculator, recipe sheet, cookie recipe worksheet, chocolate chip cookies (premade dough, from scratch, or prepackaged), answer key.

Subject: Chemistry, Food Science

NGSS: 5-PS1-2 Matter and Its Interactions

Skills: Problem solving, critical thinking, working with equations

Background: *Mole and Tell* discusses how chemists measure the mass of the elements and other substances. Chemists and other scientists all use moles as their measurement for mass, so this chemist's chocolate chip cookie recipe is a little hard to decipher! With your students, you will need to learn how to convert a recipe that uses moles as the measurement to figure out how to make chocolate chip cookies with measurements that are more familiar!

Activity:

1. You have a few options on how to incorporate cookies into this lesson:
    - Bake chocolate chip cookies before class, and give them to your students after the assignment is completed.
    - Buy premade chocolate chip cookies to hand to your students after class.
    - Bake the cookies as a class, as you are solving for the measurements.
2. Read *Mole and Tell* out loud to the class. Once you are finished, hand out the Chemist's Classified Cookie Recipe worksheet and the Cookie Recipe sheet. Discuss the equation used to find the grams of a substance that is measured in moles with your students.
3. You have three steps to convert mole values to grams.
    - Find how many moles there are of the substance.
    - Find the molar mass (atomic weight) of the substance.
    - Multiply both the values together.

        Grams = # of Moles x Molar Mass
4. Use an ingredient from the recipe as an example to teach the student's on how to do the equation.
5. Set the students in groups, pairs, or independently, so they can solve each part of the recipe in a timely manner.

6. After the students finish the conversion of each ingredient, you can bake the cookies as a class or start handing out the cookies to the students.
7. While the students (and you) are finishing the cookies, have a discussion about what they learned about Avogadro's number.

Discussion: What did you learn about the measurement of moles compared to grams? Do you think that using moles as a unit of measurement for cooking is a good thing or a bad thing?

Name:_____ Date:_____

Numerical Names Worksheet

Match each measurement word to the number it describes.

Couple	20
Hat-trick	1,000
Dozen	2
Score	12
Grand	10,000
Myriad	3

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Name:_____ Date:_____

How to Read a Periodic Table Worksheet

Use the periodic table to answer these questions.

1. What is the atomic weight of Argon?

2. What is the atomic weight of Plutonium?

3. What is the symbol for Iron?

4. What is the symbol for Zirconium?

5. What is the atomic number for Cobalt?

6. What is the atomic number for Potassium?

7. What group does Radium belong to? How many electrons does it have?

8. What group does Bismuth belong to? How many electrons does it have?

9. What period does Carbon belong to? How many electron shells does it have?

10. What period does Arsenic belong to? How many electron shells does it have?

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Name:_____ Date:_____

How Big is a Mole? Worksheet

Calculate the molar mass (g/mol) of different elements and compounds.
Refer to a periodic table to find the atomic mass of an element.

Ne (neon):

CO_2 (carbon dioxide):

Zn (Zinc):

NaCl (table salt):

Mg (magnesium):

H_2O (water):

H (hydrogen):

$NaHCO_3$ (sodium bicarbonate):

B (boron):

$C_6H_{12}O_6$ (glucose):

Hg (mercury):

H_3PO_4 (phosphoric acid):

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Periodic Table of the Elements

1 IA 1A	2 IIA 2A	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 H Hydrogen [1.00784;1.00811]																	2 He Helium 4.002602(2)
3 Li Lithium [6.938;6.997]	4 Be Beryllium 9.0121831(5)											5 B Boron [10.806;10.821]	6 C Carbon [12.0096;12.0116]	7 N Nitrogen [14.00643;14.00728]	8 O Oxygen [15.99903;15.99977]	9 F Fluorine 18.998403163(6)	10 Ne Neon 20.1797(6)
11 Na Sodium 22.98976928(2)	12 Mg Magnesium [24.304,24.307]											13 Al Aluminum 26.9815386(8)	14 Si Silicon [28.084;28.086]	15 P Phosphorus 30.973761998(5)	16 S Sulfur [32.059;32.076]	17 Cl Chlorine [35.446;35.457]	18 Ar Argon 39.948(1)
19 K Potassium 39.0983(1)	20 Ca Calcium 40.078(4)	21 Sc Scandium 44.955908(5)	22 Ti Titanium 47.867(1)	23 V Vanadium 50.9415(1)	24 Cr Chromium 51.9961(6)	25 Mn Manganese 54.938045(5)	26 Fe Iron 55.845(2)	27 Co Cobalt 58.933194(4)	28 Ni Nickel 58.6934(4)	29 Cu Copper 63.546(3)	30 Zn Zinc 65.38(2)	31 Ga Gallium 69.723(1)	32 Ge Germanium 72.630(8)	33 As Arsenic 74.921595(6)	34 Se Selenium 78.971(8)	35 Br Bromine [79.901,79.907]	36 Kr Krypton 83.798(2)
37 Rb Rubidium 85.4678(3)	38 Sr Strontium 87.62(1)	39 Y Yttrium 88.90584(2)	40 Zr Zirconium 91.224(2)	41 Nb Niobium 92.90637(2)	42 Mo Molybdenum 95.95(1)	43 Tc Technetium <98>	44 Ru Ruthenium 101.07(2)	45 Rh Rhodium 102.90550(2)	46 Pd Palladium 106.42(1)	47 Ag Silver 107.8682(2)	48 Cd Cadmium 112.414(4)	49 In Indium 114.818(1)	50 Sn Tin 118.710(7)	51 Sb Antimony 121.760(1)	52 Te Tellurium 127.60(3)	53 I Iodine 126.90447(3)	54 Xe Xenon 131.293(6)
55 Cs Cesium 132.90545196(6)	56 Ba Barium 137.327(7)	57-71	72 Hf Hafnium 178.49(2)	73 Ta Tantalum 180.94788(2)	74 W Tungsten 183.84(1)	75 Re Rhenium 186.207(1)	76 Os Osmium 190.23(3)	77 Ir Iridium 192.217(3)	78 Pt Platinum 195.084(9)	79 Au Gold 196.966569(5)	80 Hg Mercury 200.592(3)	81 Tl Thallium [204.382;204.385]	82 Pb Lead 207.2(1)	83 Bi Bismuth 208.98040(1)	84 Po Polonium <209>	85 At Astatine <210>	86 Rn Radon <222>
87 Fr Francium <223>	88 Ra Radium <226>	89-103	104 Rf Rutherfordium <267>	105 Db Dubnium <268>	106 Sg Seaborgium <271>	107 Bh Bohrium <272>	108 Hs Hassium <270>	109 Mt Meitnerium <276>	110 Ds Darmstadtium <281>	111 Rg Roentgenium <280>	112 Cn Copernicium <285>	113 Uut Ununtrium unknown	114 Fl Flerovium <289>	115 Uup Ununpentium unknown	116 Lv Livermorium <293>	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown

Atomic mass values reflect the IUPAC accepted values as of 09/2013.

Masses expressed in [a,b] format show the lower and upper limit of atomic mass depending on the physical and chemical history of the element.

Masses expressed in < > format are the mass numbers of the longest-lived isotope for elements with no stable nucleus.

Atomic Number
Symbol
Name
Atomic Mass

Lanthanide Series	57 La Lanthanum 138.90547(7)	58 Ce Cerium 140.116(1)	59 Pr Praseodymium 140.90766(2)	60 Nd Neodymium 144.242(3)	61 Pm Promethium <145>	62 Sm Samarium 150.36(2)	63 Eu Europium 151.964(1)	64 Gd Gadolinium 157.25(3)	65 Tb Terbium 158.92535(2)	66 Dy Dysprosium 162.500(1)	67 Ho Holmium 164.93033(2)	68 Er Erbium 167.259(3)	69 Tm Thulium 168.93422(2)	70 Yb Ytterbium 173.054(5)	71 Lu Lutetium 174.9668(1)
Actinide Series	89 Ac Actinium <227>	90 Th Thorium 232.0377(4)	91 Pa Protactinium 231.03588(2)	92 U Uranium 238.02891(3)	93 Np Neptunium <237>	94 Pu Plutonium <244>	95 Am Americium <243>	96 Cm Curium <247>	97 Bk Berkelium <247>	98 Cf Californium <251>	99 Es Einsteinium <252>	100 Fm Fermium <257>	101 Md Mendelevium <258>	102 No Nobelium <259>	103 Lr Lawrencium <262>

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Name:_____ Date:_____

A Chemist's Classified Cookie Recipe Worksheet

Convert the recipe ingredients from moles to grams using the molar masses listed below. Multiply the molar mass of a substance by the corresponding number of moles listed on the recipe handout.

Molar Mass of ____

butter: 503.847 g/mol
brown sugar: 342.2965 g/mol
sugar: 342.3 g/mol
all-purpose flour: 108.068403 g/mol
baking soda: 84.007 g/mol
salt: 58.44 g/mol
vanilla extract: 152.149 g/mol
chocolate chips: 120.1039 g/mol
eggs: 160.1711 g/mol

Unsalted butter

Fine salt

Brown sugar

Vanilla extract

Sugar

Chocolate chips

All-purpose flour

Large eggs

Baking soda

Cookie Recipe

Yield: 30 cookies

Ingredients

0.2243 mol unsalted butter
0.4820 mol brown sugar
0.4382 mol sugar
2.6002 mol all-purpose flour
0.0304 baking soda
0.1013 mol fine salt
0.0276 mol vanilla extract
0.2360 mol chocolate chips
0.3122 mol large eggs

Instructions

1) Preheat the oven to 375 F. Line two baking sheets with parchment paper or silicone baking sheets.

2) Melt the butter, either by microwaving on medium in a covered heat-safe bowl, or in a saucepan on the stove. Whisk butter, eggs, sugar, brown sugar, and vanilla in a large bowl until smooth.

3) Whisk the flour, salt, and baking powder together in a separate bowl. Then stir the dry ingredients into the wet ingredients, making sure to not over-mix. Stir in the chocolate chips.

4) Scoop large tablespoons of dough onto the baking sheets. Wet your hands and roll the dough into balls, and place them about two inches apart from each other.

5) Bake until golden brown, about 12 to 16 minutes. Adjust time depending on how chewy or crispy you like your cookies. Transfer cookies to a cooling rack with a spatula and let cool.

6) Serve. Cookies can also be stored in a tightly sealed container for up to five days.

Recipe adapted from Food Network

Answer Key

Numerical Names Worksheet Answers

Couple - 2
Hat-trick - 3
Dozen - 12
Score - 20
Grand - 1,000
Myriad - 10,000

How to Read a Periodic Table Worksheet Answers

1. 39.948 amu
2. 244 amu
3. Fe
4. Zr
5. 27
6. 19
7. group 2 (alkaline earth metal), 2 electrons
8. group 15/5A (post-transition metal), 5 electrons
9. period 2, 2 shells
10. period 4, 4 shells

How Big is a Mole? Worksheet Answers

Ne: 20.180 g/mol
Zn: 65.380 g/mol
Mg: 24.305 g/mol
H: 1.0078 g/mol
B: 10.811 g/mol
Hg: 200.57 g/mol
CO_2: 44.009 g/mol
NaCl: 58.443 g/mol
H_2O: 18.01528 g/mol
$NaHCO_3$: 84.007 g/mol
$C_6H_{12}O_6$: 180.156 g/mol
H_3PO_4: 97.994 g/mol

A Chemist's Classified Worksheet Answers

113 g butter (1/2 cup)
165 g brown sugar (3/4 cup)
150 g sugar (3/4 cup)
281 g flour (2 1/4 cup)
2.55 g baking soda (3/4 tsp)
5.92 g salt (1 tsp)
4.2 g vanilla extract (1 tsp)
28.3495 g chocolate chips (12 oz)
50 g eggs (2 large eggs)

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