APPENDIX K – Connections to the Common Core State Standards for Mathematics

About Appendix K – Connections to the Common Core State Standards for Mathematics K-8. This document is not exhaustive and will continue to evolve as the NGSS move toward completion. The next iteration will include connections by DCI arrangement, high school, and middle school Earth Space Science connections.

Many thank to the contributions of Sue Pimentel and Jason Zimba in the development of this document.

Overall Alignment

Consistency with the Common Core State Standards for ELA/Literacy

Literacy skills are critical to building knowledge in science. To ensure the CCSS literacy standards work in tandem with the specific content demands outlined in the NGGS, the NGSS development team worked with the CCSS writing team to identify key literacy connections to the specific content demands outlined in the NGGS. Reading in science requires an appreciation of the norms and conventions of the discipline of science, such as understanding the nature of the kinds of evidence used, an attention to precision and detail, and the capacity to evaluate intricate arguments, synthesize complex information, and follow detailed descriptions of events and concepts. Students also need to be able to gain knowledge from elaborate diagrams and data that convey information and illustrate scientific concepts. Likewise, writing and presenting information orally are key means for students to assert and defend claims in science, demonstrate what they know about a concept, and convey what they have experienced, imagined, thought, and learned.

Every effort has been made to ensure consistency between the CCSS and the NGSS. As is the case with the mathematics standards, NGSS should always be interpreted and implemented in such a way that they do not outpace or misalign to the grade-by-grade standards in the CCSS for literacy (this includes the development of NGSS-aligned instructional materials and assessments).

Consistency with the Common Core State Standards for Mathematics

Science is a quantitative discipline, which means it is important for educators to ensure that students' learning in science coheres well with their learning in mathematics.[1] To achieve this alignment, the NGSS development team worked with the CCSSM writing team to ensure the NGSS do not outpace or otherwise misalign to the grade-by-grade standards in the CCSSM. Every effort has been made to ensure consistency. It is essential that the NGSS always be interpreted, and implemented, in such a way that they do not outpace or misalign to the grade-by-grade standards in the CCSSM (this includes the development of NGSS-aligned instructional materials and assessments).

[1] See page 16 of the *K-8 Publishers' Criteria for the Common Core State Standards for Mathematics*, available at www.corestandards.org.

For convenience, Table 1 shows CCSSM grade placements for key topics relevant to science. This table can help science educators ensure that students' work in science does not require them to meet the indicated CCSSM standards before the grade level in which they appear in CCSSM.

Another kind of consistency becomes especially important in middle school and high school. During these years, students develop a number of powerful quantitative tools, from rates and proportional relationships, to basic algebra and functions, to basic statistics and probability. Their applicability extends far beyond the mathematics classroom. Such tools can also become better understood, and more securely mastered, by applying them in a variety of contexts. The NRC *Framework* makes clear in its Science and Engineering Practices (Analyzing and Interpreting Data, Using Mathematics and Computational Thinking) that statistics and mathematics have a prominent role in science. NGSS also aims to give middle school and high school science educators a clear road map for how they can prepare their students for the quantitative demands of college and careers, where students need to apply quantitative tools in an applied or scientific context. For all these reasons, NGSS requires key tools from Grades 6-8 and High School Common Core to be integrated into middle school and high school science instructional materials and assessments. For additional detail, see Table 2 below, as well as the NGSS Condensed Practices (Appendix F), and the Common Core State Standards Connections boxes that appear throughout the NGSS.

Table 1. Some key topics relevant to science, and the grade at which they are first expected in CCSSM. See CCSSM for exact statements of expectations.

Number and Operations	**Grade First Expected**
Multiplication and division of whole numbers	3
Concept of a fraction a/b	3
Arithmetic with fractions	4
The coordinate plane	5
Ratios, rates (e.g., speed), proportional relationships	6
Rational number system / signed numbers—concepts	6
Rational number system / signed numbers—arithmetic	7
Measurement	**Grade First Expected**
Standard length units (inch, centimeter, etc.)	2
Area	3
Convert from a larger unit to a smaller in the same system	4
Convert units within a given measurement system	5
Volume	5
Convert units across measurement systems (e.g., inches to cm)	6
Statistics and Probability	**Grade First Expected**
Statistical distributions (including center, variation, clumping, outliers, mean, median, mode, range, quartiles), and statistical association or trends (including two-way tables, bivariate measurement data, scatter plots, trend line, line of best fit, correlation).	6
Probability, including chance, likely outcomes, probability models	7

For additional information on representing and interpreting data in Grades K-5, see the Progression document at: http://commoncoretools.files.wordpress.com/2011/06/ccss_progression_md_k5_2011_06_20.pdf.

For additional information on measurement in Grades K-5, see the *Progressions* document at: http://commoncoretools.files.wordpress.com/2012/07/ccss_progression_gm_k5_2012_07_21.pdf.

Table 2. Middle and high school Science and Engineering Practices that require integrating CCSSM math/statistics tools into NGSS-aligned instructional materials and assessments.

Science and Engineering Practice	**6-8 Condensed Practices (subset requiring integration)**	**9-12 Condensed Practices (subset requiring integration)**
Analyzing and Intepreting Data	Apply concepts of statistics and probability from the CCSS (6-8.SP) to scientific and engineering questions and problems, using digital tools when feasible.	Apply concepts of statistics and probability from the High School CCSS (S) to scientific and engineering questions and problems, using digital tools when feasible.
Using Mathematics and Computational Thinking	Apply concepts of ratio, rate, percent, basic operations, and simple algebra to scientific and engineering questions and problems (see 6-7.RP, 6-8.NS, and 6-8.EE in the CCSS).	Apply techniques of algebra and functions to represent and solve scientific and engineering problems (see A and F in the CCSS).

Connection Boxes

In addition to the specific connections listed in each box, there are important general connections between the NGSS and the Standards for Mathematical Practice in CCSSM. Three of the CCSSM practice standards are most directly relevant to work in science:

MP.2. Reason abstractly and quantitatively.
MP.4. Model with mathematics.
MP.5. Use appropriate tools strategically.

Standards MP.2 and MP.4 are about using mathematics in context. The first standard, MP.2, centers on the interplay between manipulating symbols abstractly and attending to the meaning of those symbols. The second standard, MP.4, is also about applying mathematics, but with more of a focus on results, and less of a focus on the mental processes required to solve problems.

Standard MP.5 is about using tools of all kinds strategically—not just technological tools, but also well-known formulas and powerful representation schemes like the coordinate plane. These tools, and the skill and judgment to use them well, are important for quantitative science work also.

For more information on the Standards for Mathematical Practice, see CCSSM, pp. 6-8, and also pp. 72-73 for additional information on modeling in particular.

For the purposes of this public release of the NGSS, mathematics connections have been made to the topical arrangement of the standards. The document will be amended to reflect the Disciplinary Core Idea (DCI) arrangement. Finally, the document shows representative connections across K-8. The new arrangement, high school and middle school Earth Space Science connections will be in the final version of the NGSS.

K.IRE Interdependent Relationships in Ecosystems: Animals, Plants, and Their Environment

As part of this work, teachers should give students opportunities to **count and compare numbers** (see K.CC). *Science example: Count the number of trees in each of two photographs; in which photograph are there more trees? In which place might you find more squirrels?*

K.SPM Structure and Properties of Matter

As part of this work, teachers should give students opportunities to **use direct measurement**:

> K.MD.1. Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. *Science example: Describe a beaker of water as being heavy and cold.*
>
> K.MD.2. Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. *For example, directly compare the heights of two children and describe one child as taller/shorter. Science example: Directly compare two objects and describe one object as warmer/cooler.*

K.WC Weather and Climate

As part of this work, teachers should give students opportunities to use **numbers**, **counting**, **direct measurement**, and **classification**.

> K.CC.A. Know number names and the count sequence. *Science example: Students write the number of sunny or rainy days in the previous month.*
>
> K.MD.1. Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. *Science example: Describe a beaker of water as being heavy and cold.*

K.MD.2. Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. *For example, directly compare the heights of two children and describe one child as taller/shorter. Science example: Directly compare two objects and describe one object as warmer/cooler.*

K.MD.3. Classify objects into given categories; count the number of objects in each category and sort the categories by count. *Science example: Build up a tally chart showing the number of rainy or sunny days as the month progresses. Count the number of sunny or rainy days in the previous month (see K.CC.B). Were there more rainy days or sunny days (see K.CC.C)?*

Alignment notes: (1) Picture graphs and bar graphs are not expected until Grade 2. (2) Standard length units such as centimeters or inches are not expected until Grade 2.

1.SFIP Structure, Function, and Information Processing

As part of this work, teachers should give students opportunities to **measure with non-standard units** and **use indirect measurement**:

1.MD.1. Order three objects by length; compare the lengths of two objects indirectly by using a third object. *Science example: Every sunflower is taller than the pencil…every daisy is shorter than the pencil…so without measuring directly we know that every sunflower is taller than every daisy.*

1.MD.2. Express the length of an object as a whole number of length units, by layering multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps. Limit to contexts where the object being measured is spanned by a whole number of length units with no gaps or overlaps. *Science example: The sunflower is 11 erasers tall.*

Alignment notes: (1) Standard length units such as centimeters or inches are not expected until grade 2. (2) Picture graphs and bar graphs are not expected until grade 2.

1.W Waves: Light and Sound

As part of this work, teachers should give students opportunities to **measure with non-standard units**:

1.MD.1. Order three objects by length; compare the lengths of two objects indirectly by using a third object. *Science example: The class makes string phones. Maria's string is longer than Sue's…Sue's string is longer than Tia's…so without measuring directly we know that Maria's string is longer than Tia's.*

1.MD.2. Express the length of an object as a whole number of length units, by layering multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps. Limit to contexts where the object being measured is spanned by a whole number of length units with no gaps or overlaps. *Science example: Using a shoe as the length unit, the string for Sue's string phone is 11 units long.*

Alignment notes: Standard length units such as centimeters or inches are not expected until Grade 2.

1.SS Space systems: Patterns and cycles

As part of this work, teachers should give students opportunities to **practice addition and subtraction**:

1.OA.1. Use addition and subtraction within 20 to solve word problems involving situations of adding to, taking from, putting together, taking apart, and comparing, with unknowns in all positions, e.g., by using objects, drawings, and equations to represent the problem.

1.OA.2. Solve word problems that call for addition of three whole numbers whose sum is less than or equal to 20, e.g., by using objects, drawings, and equations to represent the problem.

Alignment notes: Students in this grade are expected to be fluent in adding and subtracting within 10.

2.ESP Earth's Surface Processes

As part of this work, teachers should give students opportunities to **work with numbers to 1000**, **use standard units for length**, and **relate addition and subtraction to length**:

2.NBT.3. Read and write numbers to 1000 using base-ten numerals, number names, and expanded form. *Science example: Students write about a sand dune that is 550 feet high.*

2.MD.3. Estimate lengths using units of inches, feet, centimeters, and meters. *Science example: Students estimate the depth of sediment from a photograph.*

2.MD.4. Measure to determine how much longer one object is than another, expressing the length difference in terms of a standard length unit. *Science example: Students measure the heights of two aquarium plants, one in a shallow aquarium and another in a deeper aquarium. What is the length difference, in inches? Why is one plant taller than another?*

2.MD.5. Use addition and subtraction within 100 to solve word problems involving lengths that are given in the same units, e.g., by using drawings (such as drawings of rulers) and equations with a symbol for the unknown number to represent the problem. *Science example: A gulley is 17 inches deep before a rainstorm and 42 inches deep after a rainstorm. How much deeper did it get during the rainstorm?*

Alignment notes: Students in this grade are expected to be fluent in mentally adding and subtracting within 20, knowing single-digit sums from memory by end of Grade 2; also to be fluent in adding and subtracting within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtraction.

2.SPM Structure and Properties of Matter

As part of this work, teachers should give students opportunities to **represent and interpret categorical data**:

2.MD.10. Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems[2] using information presented in a bar graph. *Science examples: (1) Make a bar graph with a single-unit scale showing how many samples in a mineral collection are red, green, purple, or various other colors. How many samples are represented on the graph? (2) Make a picture graph with a single-unit scale showing how many tools in a toolbox are made of metal, wood, rubber/plastic, or a combination. How many tools are represented on the graph?*

Alignment notes: (1) Scaled bar graphs are not expected until Grade 3. (2) Multiplication and division of whole numbers are not expected until Grade 3.

2.IRE Interdependent Relationships in Ecosystems

As part of this work, teachers should give students opportunities to **represent and interpret data**:

2.MD.10. Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems[3] using information presented in a bar graph. *Science examples: (1) Make a picture graph with single-unit scale showing the number of plant, vertebrate-animal, and invertebrate-animal species observed during a field trip or in a nature photograph; how many more plant species were observed than animal species? (2) Make a bar graph with single-unit scale showing the number of seeds dispersed by two or three different design solutions for seed dispersal.*

[2] See CCSSM, Glossary, Table 1.
[3] See CCSSM, Glossary, Table 1.

Alignment notes: (1) Scaled bar graphs are not expected until Grade 3. (2) Multiplication and division of whole numbers are not expected until Grade 3.

2.FM Forces and Motion: Pushes and Pulls

As part of this work, teachers should give students opportunities to **measure and estimate lengths in standard units**:

2.MD.1. Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.

2.MD.2. Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.

2.MD.3. Estimate lengths using units of inches, feet, centimeters, and meters.

2.MD.4. Measure to determine how much longer one object is than another, expressing the length difference in terms of a standard length unit.

Science examples: Students build a track to study collisions between objects. How long do we want the track to be? Measure it out on the floor first. Is the track at the front of the room longer than the one at the back of the room? Measure and tell how much longer.

3.WC Weather and Climate

As part of this work, teachers should give students opportunities to **work with continuous quantities** and **represent and interpret data**:

3.MD.2. Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l).[4] Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.[5] *Science examples: (1) Estimate the mass of a large hailstone that damaged a car on a used-car lot. (2) Measure the volume of water in liters collected during a rainstorm.*

3.MD.3. Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in bar graphs. *Science example: Make a picture graph or bar graph to show the number of days with high temperature below freezing in December, January, February, and March. How many days were below freezing this winter?*

[4] Excludes compound units such as cm^3 and finding the geometric volume of a container.

[5] Excludes multiplicative comparison problems (problems involving notions of "times as much"; see Glossary, Table 2).

Alignment notes: Graphing in the coordinate plane is not expected until Grade 5.

3.IRE Interdependent Relationships in Ecosystems: Environmental Impacts on Organisms

As part of this work, teachers should give students opportunities to **represent and interpret data**:

> 3.MD.4. Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters. *Science example: Make a line plot to show the length of each fossil that is visible in a piece of shale. Do any of the fossils resemble modern organisms except for their size?*

3.IVT Inheritance and Variation of Traits: Life Cycles and Traits

As part of this work, teachers should give students opportunities to **represent and interpret data**:

> 3.MD.3. Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in bar graphs. *Science example: Make a scaled bar graph to show the number of surviving individuals with and without an advantageous trait. How many more of the individuals with the advantageous trait survived?*

3.FI Forces and Interactions

As part of this work, teachers should give students opportunities to **work with continuous quantities**:

> 3.MD.2. Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l).[6] Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.[7]
>
> *Science examples: (1) Estimate, then measure, the masses of two objects being used in an investigation of the effect of forces; observe that the change of motion is larger for the smaller mass (students need not explain or quantify this observation in terms of Newton's laws of motion). (2) When the reservoir of a model dam is filled to capacity, measure the volume of water in liters that flows over the dam when a known volume of water in liters is poured into the reservoir. Observe that the two volume measures are equal and that the water level is the same afterwards as it was before. Model this with a subtraction sentence such as $V + 2 - 2 = V$ (adding 2 liters and subtracting 2 liters did not change the volume of water in the reservoir).*

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[6] Excludes compound units such as cm^3 and finding the geometric volume of a container.
[7] Excludes multiplicative comparison problems (problems involving notions of "times as much"; see Glossary, Table 2).

Alignment notes: (1) Rate quantities (e.g., the speed of a moving object, the volume flow rate of a liquid) are not expected until Grade 6. (2) Fraction arithmetic is not expected at Grade 3.

4.ESP Earth's Surface Processes

As part of this work, teachers should give students opportunities to **solve problems involving measurement** and **represent and interpret data**:

> 4.MD.1. Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. *For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36).*
>
> 4.MD.2. Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.
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> *Science example: 0.2 kg of topsoil was lost from a square meter of farmland due to erosion over the course of a year. If 60 g of topsoil was deposited during that year, what was the net gain or loss in grams? What will happen if this pattern continues each year?*
>
> 4.MD.4. Make a line plot to display a data set of measurements in fractions of a unit (1/2, 1/4, 1/8). Solve problems involving addition and subtraction of fractions by using information presented in line plots. *For example, from a line plot find and interpret the difference in length between the longest and shortest specimens in an insect collection. Science example: Use paired line plots to show the mass of soil displaced by flowing water with and without vegetation, using several trials in each condition (measurements would likely be in whole numbers of grams or ounces).*
>
> 4.MD.5. Measure angles in whole-number degrees using a protractor. Sketch angles of specified measure. *Science example: Measure the angle of incline in an investigation of erosion by flowing water; make an accurate sketch showing several different angles of incline.*

Alignment notes: (1) Graphing in the coordinate plane is not expected until Grade 5. (2) Rate quantities, such as the annual rate of erosion, cost of erosion, rate of deposition, etc., are not expected until Grade 6.

4.E Energy

As part of this work, teachers should give students opportunities to **use the four operations with whole numbers to solve problems**:

> 4.OA.3. Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding. *Science example: The class has 144 rubber bands with which to make rubber-band cars. If each car uses 6 rubber bands, how many cars can be made? If there are 28 students, at most how many rubber bands can each car have (if every car has the same number of rubber bands)?*

Alignment notes: Grade 4 students are expected to fluently add and subtract multi-digit whole numbers; multiply a number of up to four digits by a one-digit whole number; multiply two two-digit numbers; and find whole-number quotients and remainders with up to four-digit dividends and one-digit divisors.

4.W Waves

As part of this work, teachers should give students opportunities to **draw and identify lines and angles**:

> 4.G.1. Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. *Science example: Identify rays and angles in drawings of wave propagation.*

5.MEOE Matter and Energy in Organisms and Ecosystems

As part of this work, teachers should give students opportunities to **convert measurement units**:

> 5.MD.1. Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems. *Science example: If one kind of animal in an ecosystem consumes about 0.75 kg of food in a day, and another kind of animal consumes about 600 g of food in a day, which kind of animal consumes more in a day? How much more, in kilograms?*

Alignment notes: (1) Converting between measurement systems (e.g., centimeters to inches) is not expected until Grade 6. (2) Rate quantities, such as annual rates of ecosystem production, etc., are not expected until Grade 6. (3) Grade 5 students are expected to read, write, and compare decimals to thousandths, and perform decimal arithmetic to hundredths.

5.ESP Earth Surface Processes

As part of this work, teachers should give students opportunities to **use the coordinate plane**:

> 5.G.2. Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. *Science example: Plot monthly data for high and low temperatures in two locations, one coastal and one inland (e.g., San Francisco County vs. Sacramento). What patterns do you see? How can the influence of the ocean be seen in the observed patterns?*

Alignment notes: (1) Trends in scatterplots and patterns of association in two-way tables are not expected until Grade 8.

5.SS Space Systems: Stars and the Solar System

As part of this work, teachers should give students opportunities to **use the coordinate plane**:

> 5.G.2. Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. *Science examples: (1) Over the course of a year, students compile data for the length of the day over the course of the year. What pattern is observed when the data are graphed on a coordinate plane, and how can a model of the sun and Earth explain the pattern? (2) Students are given (x,y) coordinates for the Earth at six equally spaced times during its orbit around the sun (with the sun at the origin). Students graph the points to show snapshots of Earth's motion through space.*

MS.SMP Structure and Properties of Matter

As part of this work, teachers should give students opportunities to **use ratios and proportional relationships, write and solve equations**, and **use order of magnitude thinking**:

> Ratios and Proportional Relationships (6-7.RP). *Science examples: (1) A pile of salt has mass 100 mg. How much chlorine is in it? Answer in milligrams. What would the answer be for a 500 mg pile of salt? (2) Twice as much water is twice as heavy. Explain why twice as much water isn't twice as dense. (3) Based on a model of a water molecule, recognize that any sample of water has a 2:1 ratio of hydrogen atoms to oxygen atoms. (4) Measure the mass and volume of a sample of reactant and compute its density. (5) Compare a measured/computed density to a nominal/textbook value, converting units as necessary. Determine the percent difference between the two.*

> Expressions and Equations (6-8.EE). *Science examples: (1) For Grade 8: With substantial scaffolding, use algebra and quantitative thinking to determine the interatomic spacing in a salt crystal. (2) For Grade 8: Use scientific notation for atomic masses, large numbers of*

atoms, and other quantities much less than or much greater than 1. Also use convenient units such as unified atomic mass units.

MS.CR Chemical Reactions

As part of this work, teachers should give students opportunities to **work with ratios and proportional relationships**, **signed numbers,** and **basic statistics**:

> The Number System (6-8.NS). *Science examples: (1) Use positive and negative quantities to represent temperature changes in a chemical reaction (signs of energy released or absorbed). (2) For Grade 7 or 8: Solve a simple equation for an unknown signed number, (e.g., A solution was initially at room temperature. After the first reaction, the temperature change was* -8^oC*. After the second reaction, the temperature was* 3^oC *below room temperature. Find the temperature change during the second reaction. Was energy released or absorbed in the second reaction? Show all of the given information on a number line/thermometer scale. Also represent the problem by an equation.)*
>
> Statistics and Probability (6-8.SP). *Science example: Compile all the boiling point measurements from the class into a line plot and discuss the distribution in terms of clustering and outliers. Why weren't all the measured values equal? How close is the average value to the nominal/textbook value? Show the average value and the nominal value on the line plot.*

MS.E Energy

As part of this work, teachers should give students opportunities to **work with ratios and proportional relationships** and **basic statistics**:

> Ratios and Proportional Relationships (6-7.RP) and Functions (8.F). *Science examples: (1) Analyze an idealized set of bivariate measurement data for kinetic energy vs. mass (holding speed constant). Decide whether the two quantities are in a proportional relationship, e.g., by testing for equivalent ratios or graphing on a coordinate plane and observing whether the graph is a straight line through the origin. (2) Do the same for an idealized set of data for kinetic energy vs. speed (holding mass constant). (For Grade 8: Recognize from the data that the relationship is not proportional; that kinetic energy is a nonlinear function of speed. Draw conclusions such as that doubling the speed more than doubles the kinetic energy. What are some possible implications for driving safety?)*

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Statistics and Probability (6-8.SP). *Science example: As part of carrying out a designed experiment, make a scatterplot showing the temperature change of a sample of water vs. the mass of ice added. (For Grade 8: If the data suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line. Just for fun, compute the slope of the line; what are the units of the answer?)*

MS.WER Waves and Electromagnetic Radiation

As part of this work, teachers should give students opportunities to use **ratios and proportional relationships** and **functions**.

Ratios and Proportional Relationships (6-7.RP) and Functions (8.F). *Science examples: (1) Analyze an idealized set of bivariate measurement data for wave energy vs. wave amplitude. Decide whether the two quantities are in a proportional relationship, (e.g., by testing for equivalent ratios or graphing on a coordinate plane and observing whether the graph is a straight line through the origin). (For Grade 8: Recognize that wave energy is a nonlinear function of amplitude, and draw conclusions such as that doubling the amplitude more than doubles the energy. Discuss possible implications for the safety of wading in the ocean during a storm.) (2) Interpret an idealized set of bivariate measurement data for wave energy vs. wave speed.*

MS.SFIP Structure, Function, and Information Processing

As part of this work, teachers should give students opportunities to use **order of magnitude thinking**:

Expressions and Equations (6-8.EE). *Science examples: (1) Quantify the sizes of cells and parts of cells, using convenient units such as microns as well as* (in Grade 8) *scientific notation. (2) Appreciate the orders of magnitude that span the difference in size between cells, molecules, and atoms.*

MS.GDRO Growth, Development, and Reproduction of Organisms

As part of this work, teachers should give students opportunities to **work with basic statistics**:

> Statistics and Probability (6-8.SP). *Science examples: (1) Analyze and interpret scatterplot data showing the mass of a plant at different times over its lifespan to support a conclusion that plants may continue to grow throughout their life. (For Grade 8: Is the association linear? If so, what is the slope of a model fit and what quantity does the slope represent?) (2) For Grade 8: Use data in a two-way table as evidence to support an explanation of how environmental and genetic factors affect the growth of organisms. (3) For Grade 7 or 8: Use probability concepts and language to describe and quantify the effects that characteristic animal behaviors have on the likelihood of successful reproduction.*

MS.MEOE Matter and Energy in Organisms and Ecosystems

As part of this work, teachers should give students opportunities to **write and solve equations**:

> Expressions and Equations (6-8.EE). *Science examples: (1) Write a number sentence that expresses the conservation of total matter or energy in a system as matter or energy flows into, out of, and within it. Assign values to the arrows in a diagram to show flows quantitatively. (2) Infer an unknown matter or energy flow in a system by using the concept of conservation to write and solve an equation with a variable.*

MS.IRE Interdependent Relationships in Ecosystems

As part of this work, teachers should give students opportunities to **work with ratios and proportional relationships** and **basic statistics**:

> Ratios and Proportional Relationships (6-7.RP). *Science example: Use ratios and unit rates as inputs for evaluating plans for maintaining biodiversity and ecosystem services (e.g., consider the net cost or net value of developing a wetland, using inputs such as the value of various wetland services in dollars per acre per year; in analyzing urban biodiversity, rank world cities by the amount of green space as a fraction of total land area; in analyzing social factors, determine the amount of green space per capita (m^2 per person)).*

> Statistics and Probability (6-8.SP). *Science example: For Grade 8: Use data in a two-way table as evidence to support an explanation of the effect of resource availability on organisms and populations of organisms in an ecosystem.*

MS.NSA Natural Selection and Adaptations

As part of this work, teachers should give students opportunities to use **basic statistics and probability** and **order of magnitude thinking**:

Statistics and Probability (6-8.SP). *Science examples: (1) Use scaled histograms to summarize the results of a simulation of natural selection over many generations. (2) For Grade 7 or 8: Use probability language and concepts when explaining how variation in traits among a population leads to an increase in some traits in the population and a decrease in others.*

Expressions and Equations (6-8.EE). *Science examples: (1) Quantify durations of time in interpreting the fossil record. (2) For Grade 8*: *Use scientific notation for long intervals of time or for dates in the distant past; also use convenient units (e.g., Myr, Gyr, Ma, Ga). (3) Appreciate the spans of time involved in natural selection.*

Sources consulted:

http://www.agiweb.org/nacsn/40890_articles_article_file_1641.pdf

http://en.wikipedia.org/wiki/Atomic_mass_unit

http://www.nyc.gov/html/dot/html/about/knowthespeedlimit.shtml

http://learn.genetics.utah.edu/content/begin/cells/scale/

http://learningcenter.nsta.org
http://www.fws.gov/economics/Discussion%20Papers/USFWS_Ecosystem%20Services_Phase%20I%20Report_04-25-2012.pdf

http://www.teebweb.org/local-and-regional-policy-makers-report/

Richard T. Woodward , Yong-Suhk Wui, The economic value of wetland services: a meta-analysis. *Ecological Economics* **37** (2001) 257–270.

http://www.rssweather.com/climate/California/San%20Francisco%20County/

http://www.rssweather.com/climate/California/Sacramento/

http://www.ewg.org/losingground/report/erosion-adds-up.html

http://soils.usda.gov/technical/manual/

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/?cid=stelprdb1041887

http://en.wikipedia.org/wiki/Topsoil