Chemistry, Physics, Earth, Biology, and Physical Science

DIALOGUES for the SCIENCE CLASSROOM

A How-To With Examples For Middle and Secondary Science Teacher Preparation and Professional Development

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Target Audience
The strategies, activities and professional development materials in this book are consistent with state and national education standards for learning and teaching. This book was written for, and therefore targets, pre-service teachers, in-service teacher professional development, and for teachers pursuing an advanced certification or national board certification, or a Masters degree in teaching.

Permissions - Read This!

Dialogues for the Science Classroom were created only after the many, many hours of dedicated, hard work by teachers, who are probably a lot like yourself. You know what it takes to produce a single lesson, so you can probably imagine what it took to fill this book with exceptionally creative and content-specific dialogues. Each of the Dialogues for the English Classroom books contain dialogues that will contribute 46-48 lessons to your course. We offer these books to you at a price so that you can incorporate a powerful teaching strategy into your classroom at a very low cost per lesson.

Since using dialogues in the classroom is a relatively new and innovative teaching strategy, we have created this book (*Dialogues for the Science Classroom : A How-To With Examples For Middle and Secondary English Teacher Preparation and Professional Development*) so that you may become familar with how to use dialogues in the classroom, and to see examples of dialogues that will excite and engage your students. After reading about the strategy, and seeing the *Table of Contents* and *Abstracts* of the 57-67 dialogues (per book), you will excited try them out and to incorporate many of the dialogues into your units of study.

Note that we are giving this book away for free so future and current English teachers learn about using dialogues in the classroom. Share this book with fellow students in teacher preparation programs, cooperating teachers, and with colleagues - doing so will help spread the word about using dialogues in the classroom. We encourage you to present this strategy at district workshops, or professional conferences. For such purposes the presenter may copy and use the dialogues within this book, or send attendees to *www.moosemosspress.com* to download this book or purchase any of the science dialogues books.

We encourage you to purchase the *Dialogues for the Science Classroom (Biology, Physical Science, Physics, Chemistry and Earth Science)* - those who do so may photocopy pages for use in their classroom. Thank you for your integrity and please enjoy the creative work of your fellow teachers.

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Authors

Dialogues for the Science Classroom - Craig Berg

Craig Berg taught middle and high school science before pursuing an M.S. and Ph.D. in Science Education from the University of Iowa. His daily adventures now include directing the science teacher preparation program at the University of Wisconsin-Milwaukee, working with undergraduates, post-baccaulaureates, and M.S. students in pursuit of exemplary science teaching. His twenty-four years of work in Milwaukee resulted in the 2011 University of Wisconsin-System Regents Excellence in Teaching Award. Until his battery runs out he plans on continuing to work at something he truly loves doing on a daily basis - pursuing excellence in science education. He is feels exceptionally blessed by being able to work with many of the exemplary teachers in the Milwaukee area on a variety of grants and projects such as this one. The colleagues below who authored dialogue books are some of the finest science teachers in the country.

Biology I - Greg Bisbee, Kathleen Westrich and Craig Berg

Greg Bisbee, a high school science and biology teacher since 1988, is an enthusiastic teacher and learner of science and is especially excited about biological conservation and ecological restoration. He has published numerous articles and is a frequent presenter at science education conferences.

Kathleen Westrich has been teaching high school biology and human anatomy since 1997. She is a National Board Certified Teacher and has a Master's degree in molecular genetics. Kathleen is passionate about teaching in a challenging urban setting, and absolutely loves creating new ways to engage and excite her students about science.

Biology II - Greg Bisbee, Craig Berg and Michael Mullen

Michael Mullen has spent the majority of his life around science and education. He began his science career roaming the forest of many western states working for the US Forest Service. Following a brief stint in business, Mike went on to earn a Masters in science education from the University of Iowa. A passion for science became a 18 year career teaching Biology and Anatomy/Physiology. Mike is currently an Associate Principal at Ben Franklin Elementary and can occasionally be found teaching a little science to elementary students.

Chemistry I - Greg Zimmer, Christina Cattey, Andi Winkle, Raymond Scolavino, Nancy Smith and Craig Berg

Greg Zimmer - Greg Zimmer is from West Bend, Wisconsin and has taught science in Wisconsin since 1993. Greg switched careers to education at age 27 when he attended UW-Milwaukee to earn a teaching license in Broadfield Science, Biology and Chemistry. Greg is an active member of the Wisconsin Society of Science teachers and has taught and participated in the Science Futures professional development program. Greg enjoys fishing and has been a licensed fishing guide on local lakes in Southeastern Wisconsin. In addition Greg has a family tradition of making maple syrup from sugar maple trees in his backyard. Greg's family includes his wife, two sons and a daughter. He is very excited to share some of the stories he has told his chemistry students over the years when helping them learn chemistry in a memorable way.

Christina Cattey - Christina Cattey started her career as a production chemist, manufacturing large scale batches of nucleotides. She returned to school to pursue her dream of teaching and is now a high school chemistry teacher, where she gets to put her real world chemistry experience to good use. In her spare time, Christina loves to race sailboats, do math problems, and cheer for her alma mater, the University of Michigan.

Andi Winkle - Andi Winkle earned her undergraduate degree from the University of Wisconsin at Madison and a post-baccalaureate teaching certificate as well as a Masters degree in Curriculum and Instruction from the University of Wisconsin at Milwaukee. She has been teaching Chemistry since 1998 in the Milwaukee area and has a passion for creating lessons that help students not only understand but also like Chemistry. She was awarded a Wisconsin 2012 Kohl Fellowship and works on occasion with the UWM teacher education program. She enjoys hiking, teenagers and finding chemical formulas while looking at license plates.

Raymond Scolavino - Ray Scolavino is currently a Senior Lecturer at the University of Wisconsin Milwaukee working with the MACSTEP program for science teacher education. Prior to UWM he taught secondary level Chemistry, Biology, Environmental Science, Physical Science, Physics, and Anatomy and Physiology. Besides writing dialogues for fun he enjoys ultra-running, beer and wine making, and helping students become the best science teachers they can be.

Nancy Smith - Nancy Smith has been a chemistry and forensic science teacher at Waterford Union High School for the last 20 years. In addition to teaching at Waterford, she is the coordinator of the Mentor Teacher Program which helps and guides teachers new to the district and a member of the staff development and academic standards committees. She has presented numerous times on a variety of chemistry and forensic topics both at the state and national level and is the board of directors for the National Mole Day Foundation. She is also a Milken Foundation National Educator and Herb Kohl Educational Foundation Fellow.

Physics I - Marian Schraufnagel, Matt Heer, Todd Everson, Michele Fuller, Michell Sackerson and Craig Berg

Marian Schraufnagel taught physics and chemistry for 31 years in suburban Milwaukee, Wisconsin schools. She also taught the science teaching methods course for Carroll University for over 10 years. She has a B.S. degree from UW-Madison and a M.Ed. degree from UW-Whitewater. Marian has also earned National Board Certification in high school physics. Marian has been active in developing science education in Wisconsin by participating in professional organizations and teaching many workshops for other teachers. She hopes to encourage teachers to use innovative strategies that promote active learning in students.

Matt Heer is a graduate of UW Platteville in Math and Physics, and has been teaching high school physics for many years. He spends his summers working in Lake Geneva at a summer camp showing kids how to sail and wakeboard. His hobbies include sailing, wind surfing, wakeboarding, snowboarding, woodworking, and coaching track / cross country. His inspiration was Stuart Harper, who was his high school physics teacher with all the wonderful toys and demonstrations he would do, and for seeing the physicist within him.

Todd Everson was raised on a dairy farm in western Wisconsin (so much physics) and obtained a mathematics degree from UW – La Crosse, then moved to Milwaukee where he worked odd jobs, and attended UW Milwaukee to earn teaching licenses in Broad Field science, physics and eventually chemistry. He teaches physics and physical science at Milwaukee School of Languages where his “language” is mathematics (the language of science). He was recently recognized as an Outstanding Urban Educator after being nominated by a former student. He is still trying to figure out what he wants to do when he grows up.

Michele Fuller is a science teacher at Madison Memorial High School in Madison, WI. Michele has taught Memorial’s physics, chemistry and integrated science courses since earning her B.S. in Physical Science from Michigan State in 2009. In her free time, Michele enjoys coaching gymnastics and watching Michigan State Basketball.

Michelle Sackerson currently teaches in the Franklin, WI school district, teaching AP Physics-B, Advanced Physics, and Advanced Chemistry. In 2006 she was awarded the Kohl Fellowship in teaching. She graduated Phi Beta Kappa with a BS in Chemistry, followed by working in industry for 10 years. Then she became certified to teach 6-12 in chemistry and physics, and now has a Masters in Curriculum and Instruction. With 13 years of teaching she finds that she is still learning many new ideas to help prepare students for success in the 21st century!

Physical Science - Michael Felske and Craig Berg

Michael Felske has been and always will be a teacher at heart. During a 33 year career in a suburb of Milwaukee, he taught middle school and high school science, taught perspective teachers at the University of Wisconsin-Milwaukee, presented science education programs at local, state, and national conventions and was a member of the executive board of the Wisconsin Society of Science Teachers. For his work, Mike received several awards for distinguished science teaching. Since retiring from public education, Mike has expanded his job titles to include Science Ed Consultant for a local Montessori school, Flight Instructor and Vagabond Pilot/Ski Instructor. When not in a classroom, he can be found flying his 1949 Piper Clipper around the skies of Wisconsin or ski instructing at a local ski resort. He lives on a small lake in East Troy, Wisconsin with his wife, Claudia (2011 Wisconsin High School Teacher of the Year) and son, Eliot.

Earth Science - Amy Schiebel, Mary Ruth Kotelnicki, Sandra Rutherford. Erin Parker and Craig Berg

Amy Schiebel taught middle school science in Iowa for 11 years after receiving her M.A.T, M.S. and Ph.D. from the University of Iowa. She now directs the K-16 Science Program and the Office of Science Outreach at Edgewood College in Madison Wisconsin. Her work is focused on science teacher pre- and in-service instruction, field science courses for undergraduates, and helping Latino families to increase their understanding of science and engineering.

Mary Ruth Kotelnicki is a geobiologist who teaches undergraduate courses in geoscience and natural science. She has a graduate degree in Geoscience and undergraduate degrees in Biological Aspects of Conservation, Geology & Geophysics, and Physical Anthropology from the University of Wisconsin-Madison. Her passion for all things science is only rivaled by her fondness for trilobites. In addition to teaching in the classroom, she facilitates professional development workshops in science for K-12 teachers and works with organizations, school groups, and outreach programs to enhance science education. Simply put, teaching & learning about science makes her smile, and she has the same goal for her students as she does for herself: know more about the universe today than was known yesterday.

Sandra Rutherford is a former grade 8 Earth Science teacher with a Ph.D. in geology. She is currently an associate scientist at the University of Wisconsin and an adjunct professor at Edgewood College. She has published many papers in the area of Earth Science curriculum with fun titles like *Rock and Rap CD* cover and *Bromothymol Blue the Demo We All Do!* She is also the PI for numerous grants, including National Science Foundation sponsored projects, and an NOAA environmental literacy grant that developed the *Ducks in the Flow* module, a story book and three activities for grades 3-5. Her daughter Georgina is hoping to become an art teacher and she did the drawings of the clown fish and coral.

Erin Parker has been a high school earth and environmental sciences teacher since 2009. Along with teaching a variety of courses, she has continued her own education with interests in environmental education and science literacy. She is particularly excited to get outside with students, and provide real-world connections to classroom studies.

Introduction

In my thirty plus years as a science teacher and science-teacher educator, I find that the great ideas for teaching science stem from researchers studying teaching and learning, and from teachers who have persevered to find ways to reach more children in order to maximize learning in their classroom. Many of these creative and highly effective teaching ideas arise from teachers who are embedded in the most challenging situations, and, as such, are motivated to explore, find, or develop new strategies or materials to use with their students so as to have a greater impact on their learning.

Teachers who embrace these challenges of teaching and learning accumulate a substantial set of teaching tools, combined with a clear framework and rationale for teaching (see section I), are able to utilize *the appropriate tool for the moment at hand.* Dialogues are another teaching tool; a teaching strategy that will help teachers reach children in ways that other strategies might not. Dialogues involve students in speaking and listening, acting and reacting, tapping into emotional and kinesthetic parts of the brain. State and *National Standards for English Language Arts and Literacy in Subject Areas* are very clear in that "students must learn to read, write, speak, listen, and use language effectively in a variety of content areas." The Next Generation Science Standards are also very clear in that we must engage our students in learning using strategies that maximize engagement in all aspects of the process. In short, dialogues maximize student's engagement in the learning process; all students are involved as active participants when dialogues are in play.

Dialogues have been tested from elementary to college levels and in urban, suburban and rural classrooms. You might decide to use them as is, or might modify them and add your own spin or local context to them. You might also craft some from scratch, or have students write dialogues; we have included some suggestions and tips for writing dialogues.

Dialogues engage learners at high levels, so try them! Your students will enjoy the activity, learn something about the content you are trying to teach them, and learn something about themselves. You will witness the power of using dialogues when students ask "When are we going to do another dialogue."

Editor - Dr. Craig Berg

Using This Book

There are three major sections to this book:

Section I - Science Dialogues and Teacher Decision-Making: This unit provides the reader with an overview of how dialogues fit into the big picture of classroom instruction, and how using dialogues connects to, and supports, the goals for students in science classrooms. While this unit is important, the typical reader will probably be more interested in the what and how to, and therefore read Section I last. However, read Section I to better understand how teacher decision-making is so critically important to success in the classroom, and how dialogues is one of the teaching tools that helps teachers accomplish the difficult task of helping students to develop a better understanding of science. Use this section to help frame one's thoughts about teaching, in preparation for talking with administrators (or parents, or sometimes colleagues) who could benefit from a better understanding about what it takes to effectively teach science.

Section II - Using Dialogues in the Classroom: This section details the key aspects of using dialogues in the classroom - the what, when, and how to, of using and writing dialogues. This section provides examples of how dialogues can target content goals, be used in conjunction with a lab activity, help teach about historical aspects of the subject, and help students grapple with current issues or science-based ethical dilemmas.
In addition, there are numerous suggestions and tips for implementing dialogues in the classroom, and the benefits thereof, with guidelines on how to write your own dialogues, and how to have students create their own dialogues as a measure of what they learned.

Section III - Table of Contents, Abstracts and Sample Dialogues: This section provides the reader with a Table of Contents and the Abstracts from each of the dialogue volumes. The abstracts provides a quick overview of each dialogue and the science concepts or terms embedded within. Scanning the abstracts helps the reader determine which dialogue might be suitable for the upcoming lesson. In addition, there are a few example dialogues from that particular volume for the reader to choose from, and try out with children in classrooms. In order, they include:

Dialogues for the Biology Classroom- Volume 1: The section contains the TOC and Abstracts for the fifty-seven dialogues that cover eleven units in Biology, along with eight sample biology dialogues.

Dialogues for the Chemistry Classroom - Volume 1: This section contains the TOC and Abstracts for the sixty-three dialogues that cover twenty different units in chemistry, along with seven sample chemistry dialogues.

Dialogues for the Physics Classroom - Volume 1: This section contains the TOC and Abstracts for the sixty-seven dialogues that cover twenty-one different units in physics, along with six sample dialogues.

Dialogues for the Earth Science Classroom - Volume 1: This section contains the TOC and Abstracts for the fifty-eight dialogues that cover ten different units in earth science, along with seven sample dialogues.

Dialogues for the Physical Science Classroom - Volume 1: This section contains the TOC and Abstracts for the fifty-eight dialogues that cover eleven different units in physical science, along with six sample dialogues.

Dialogues for the Biology Classroom- Volume 2: The section contains the TOC and Abstracts for the dialogues that cover many units in Biology, along with some sample biology dialogues.

Section I - Dialogues & Teacher Decision-Making

Introduction

The science dialogue modules are part of a set of professional development modules (prepared or under development) from the *Framework for Teacher Decision-Making in Science Series,* which focuses on having a research-based and standards-based justification for teaching science; some refer to this as "a rationale for teaching science." The science *Dialogues* includes volumes on: biology, biological issues and ethical dilemmas, chemistry, physics, earth and space, environmental sciences, middle school science, as well as volumes for elementary science.

Additional strategies modules include *The Learning Cycle*, *The Five E's*, *Structured Controversy*, and *Issues Analysis*. Another *Framework module* titled *Interactions* targets improving teacher-to-student interactions, exploring how to ask questions to get and keep students thinking, and how to analyze your questioning-responding behaviors to determine patterns and tendencies. You will also learn how to determine if your patterns of interaction are compatible with the strategy you are using and whether your interactions with students support your goals for teaching students, or undermine your efforts. Tables of Contents, sample *Dialogues,* and a listing of other *Framework modules*, can be found at www.moosemosspress.com.

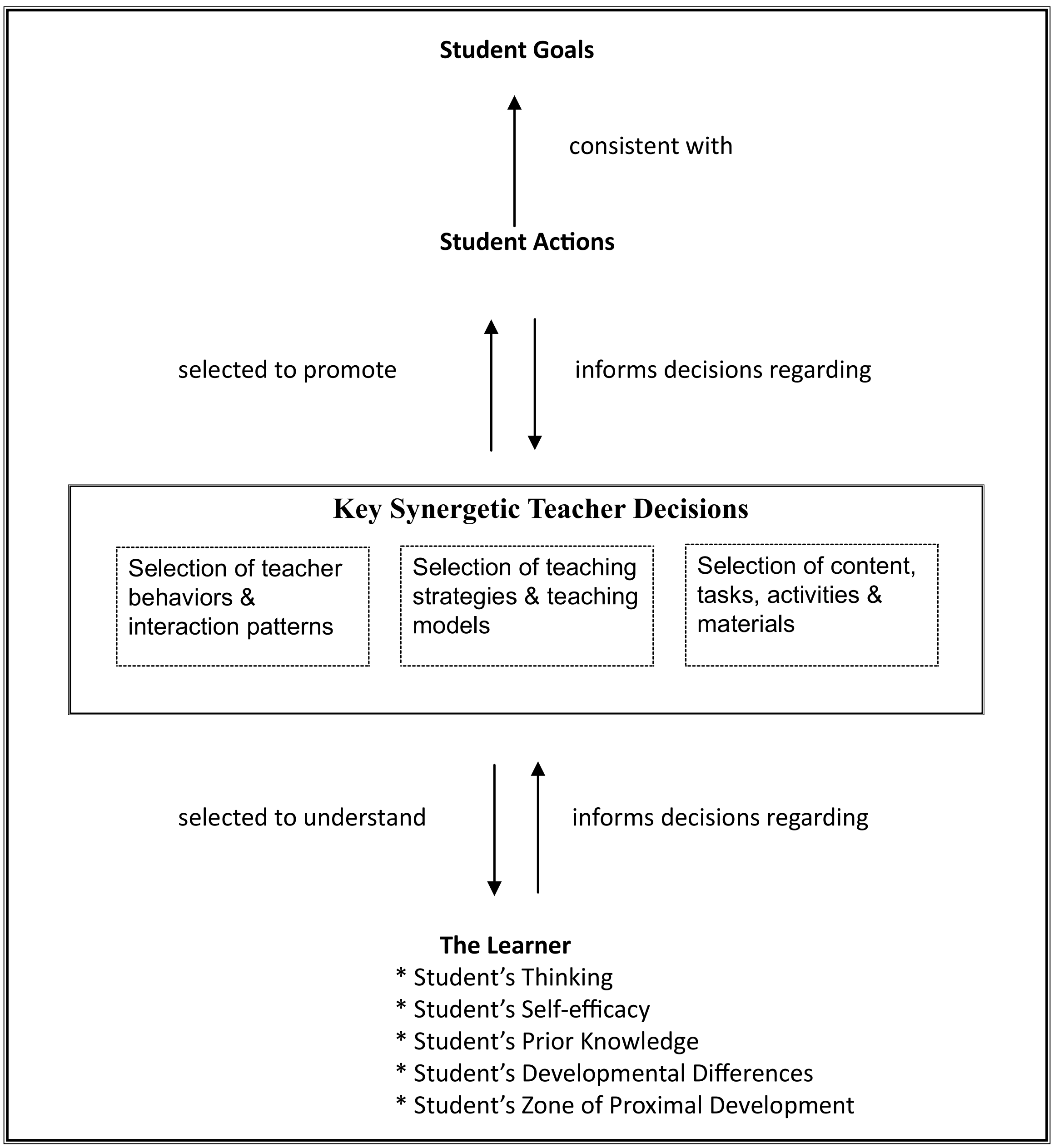
Whether you are just beginning to teach, or are an experienced teacher, or if you are working on a teaching certification, professional development plans, a Masters degree, or advanced or national certification(s), the *Framework series* will aid in your efforts to become an exemplary teacher. The modules are designed not only to get your teaching engine started, but also to fine tune your teaching. The modules provide an expansive set of tools and strategies for teaching science and are essential reading for every teacher.

How the Framework Modules Are Crafted

The *Framework* modules are crafted around a visual organizer (see Figure 1) that was designed as a tool to plan for teaching, teaching with purpose and a rationale, and reflecting on teaching in a manner that relates to the coordinated whole. This visual organizer provides an overarching visual representation to help pre-service and in-service science teachers conceptualize their decision-making, and understand the importance and interactions of these decisions. First generated by Clough and Berg in 1988, the Decision-Making Framework has since undergone several iterations (Berg & Clough, 1991; Clough, 1992; Clough & Berg, 1995; Clough & Kauffman, 1999; Clough, 2003; Clough & Berg, 2006) leading to the current draft presented in Clough, Berg & Olson, 2009 and shown as Figure 1. The current version of the *Teacher Decision-Making Framework* is complex enough to stimulate and foster continued growth in teaching, yet also pragmatic enough for daily use. The *Framework* depicts the components of, and the relationships between key components of: planning for teaching, teaching, and reflecting on teaching.

To gain a better understanding of this *Framework* and how it is designed and used in order to help teachers secure a solid teaching foundation, as well as enter a pathway toward exemplary teaching, first scan the *Framework* on the next page, then read the explanation and discussion of the various components. Finally, read to understand how we have applied this *Framework* to the strategy of using *Dialogues* and how this strategy connects to the whole of teaching science for maximum impact on the learner.

Figure 1. Framework Illustrating Teacher Decisions and Their Interactions



Components of the Framework

It is important for effective teachers to understand the particular components that make up the *Framework Illustrating Teacher Decisions and Their Interactions*. The major components are:

1. Goals - All instruction begins with thinking about the desired endpoint - your short term and long term targets - what you are attempting to accomplish during the act of teaching science. What are your goals for the school year, the unit, the lesson for the day? It is an interesting phenomenon that when various groups of teachers are asked to brainstorm and list their goals, two things happen. First, content goals are mentioned; there is a plethora of content, so groups of teachers quickly compile the content goals into a statement that indicates content should be learned robustly versus superficially - goal #1. The second thing that occurs is teachers quickly list another 10-12 goals for their students, and the list almost always contains the following pieces.

T*able 1. Common Science Education Goals for Students (Bonstetter, Penick and Yager, 1984; Berg & Clough, 1999)*

Students will:

1. Demonstrate deep, robust understanding of fundamental science concepts rather than covering many insignificant/isolated facts.
2. Use critical thinking skills.
3. Convey an accurate understanding of the nature(s) of science.
4. Identify and solve problems effectively.
5. Use communication and cooperative skills effectively.
6. Actively participate in working towards solutions to local, national, and global problems.
7. Be creative and curious.
8. Set goals, make decisions, and self-evaluate.
9. Express a positive attitude about science.
10. Access, retrieve, and use the existing body of scientific knowledge in the process of investigating phenomena.
11. Express self-confidence and a positive self-image.
12. Demonstrate an awareness of the importance of science in many careers.

An examination of the National Science Education Standards, AAAS's Project 2061, the Next Generation Science Education Standards, or various state and local standards, would show that the goals listed above depict in a condensed sense, the very targets contained in these documents and reform efforts. However, the list above is one that busy practitioners can wrap their teaching heads around, and therefore, keep it foremost in their minds while fully engrossed in the daily rigors of teaching.

2. The Learner - It is impossible to envision "teaching" occurring without students present and indeed learning. But, if no student is learning, or there is no evidence gathered to indicate which, if any, students are learning, then claims of "teaching" are hard to support. Without evidence or indicators of learning, the teacher might as well be teaching to an empty classroom, as they know as much about what the desks learned as they do regarding what students learned.

As such, the learner is a key and critical starting point for planning for instruction, teaching, and assessing the success of the lesson. Students are unique individuals, with different experiences, backgrounds, ideas, developmental growth, and differing beliefs about themselves in terms of whether they can learn science. The learner brings different knowledge, experiences and attitudes to the table. Instruction begins and proceeds based upon the current and changing state of the leaner.

** Students' Thinking* - their thoughts about science content and how science works, their creative or critical thinking or problem solving abilities. What are students' ideas as the lesson progresses?

** Students' Self-efficacy* - their beliefs about their ability to learn science, to understand science. Do they possess some level of confidence that they can in fact learn science, or are they like many children who have come to believe that science and math are beyond their reach?

** Students' Prior Knowledge* - children have experiences at home, on the playground, or in any aspect of life that might give them notions of how things work, behave, or will respond, and these initial ideas affect them greatly when learning in science classes. What ideas about the lesson and content do students have prior to beginning the lesson?

** Students' Developmental Differences* - brought to light, mainly by Piaget, students are developmentally different from one to another, and this directly affects how they construct concepts, wrestle with ideas and content presented in science classes, analyze and identify patterns within data.

** Students' Zone of Proximal Development* - Vygotsky, a social constructivist, put forward the notion of this zone being the difference between what a learner can do with help and what he or she can do without help from peer or adult. Students may or may not be at an opportune moment for learning the material and for understanding the content.

All these factors aggregate to make up an individual learner, who might need different starting points, unique lesson adaptations, and varying levels of assistance. With the **goals** being the target, the **individual learner** is the starting point. What we know about the individual learner and a collective group of students provides teachers with the knowledge of where to begin instruction. This can vary from class to class, and from individual to individual. What we know about the learner informs us about difficulties and hurdles we have to overcome, and their level of foundational knowledge. This information about the learner is vital to successfully building the learner's content knowledge and thinking skills.

3. Key Synergetic Teacher Decisions - The teacher as a decision-maker is critical when it comes to the lesson having the desired effect on students. Let's face it, the best curriculum can be destroyed by poor choices regarding any of the three factors listed below, or a mediocre lesson can be elevated to outstanding by wise choices regarding these three factors. A good decision in two areas can be swiftly negated by an incongruent choice for the third area. Teachers make hundreds of decisions each day that affect the students and their learning in a variety of ways: questioning, responding, use of wait-time, whether to apply direct instruction or to choose an inquiry strategy that challenges children to grapple with scientific concepts. We have separated these teacher-decisions into three categories.

** Selection of Teacher Behaviors* - how teachers interact with students; the manner of asking questions and responding to students greatly affects learning and the learning environment. Teachers have a variety of choices depending upon the particular goals being targeted.

** Selection of Teaching Strategies and Teaching Models* - the particular strategy(s) employed, that set the learning environment and target the goals you are working towards; a variety of choices that might include the 5 E's, Learning Cycle, Generative Learning Model, Structured Controversy, Dialogues, Direct Instruction, SSCS, The Three P's, Issues Analysis, Futures Wheel, and the list goes on. Each model has a particular strength with regard to targeting goals for instruction, for the day's lesson, and the accumulative effects for the school year. Each of the models mentioned above involves students as central figures in the lesson, not passive participants.

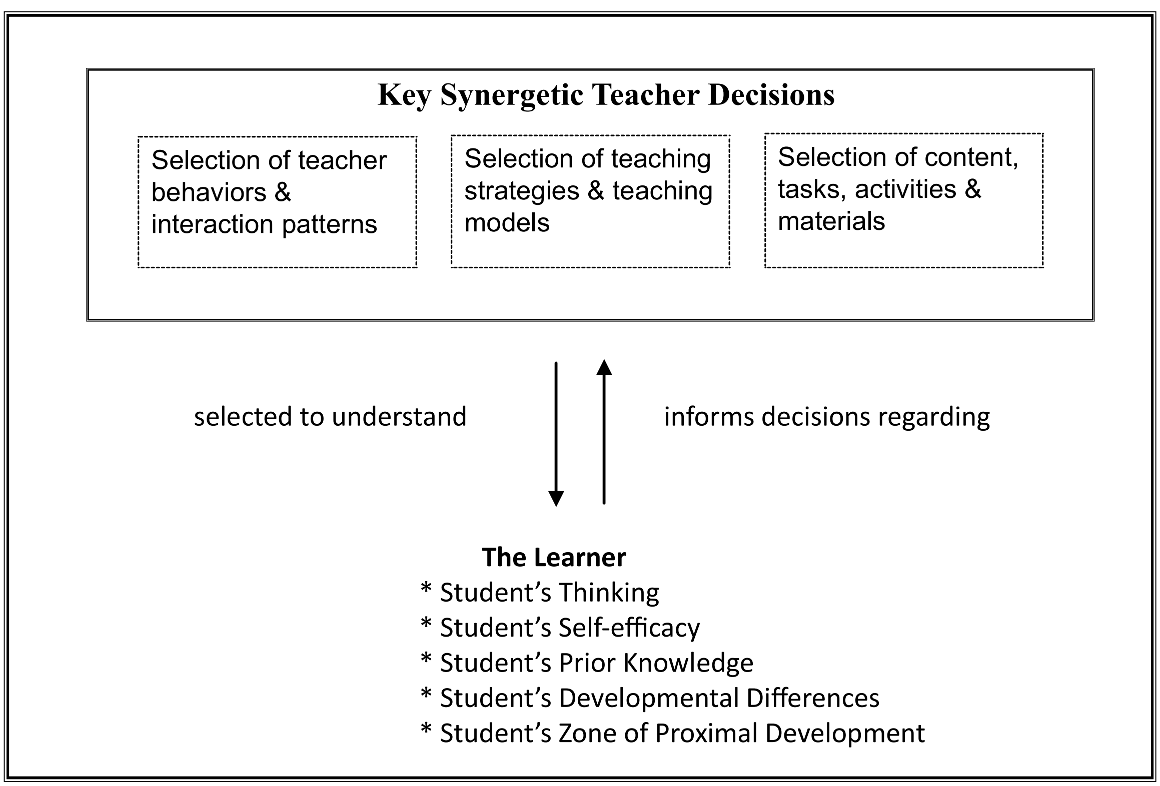
** Selection of Content, Tasks, Activities and Materials* - again, choices made depending upon goals for, and knowledge of, the learner. Is the content defensible in terms of standards-based instruction, and are the tasks and activities chosen at a level that will challenge, but not defeat or present overwhelming odds against success, with regard to the intellectual development, nature and curiosity of the students? Are materials present that allow for exploration, investigation, inquiry, and with investigative options and choices so that variation in exploration can occur when learners have different notions of how to proceed.

4. Student Actions - This is what you should hear or see regarding students' actions that provide evidence that students are moving toward the goals. Continuous formative assessment, monitored from beginning to end, these are the indicators and evidence that instruction is having the desired effect on students. Indicators such as engagement level, questions asked by students, student responses to teacher-posed questions, and interactions between students, provides guidance for teacher decisions. Student actions are the key indicator and feedback to teachers that indicate what to do next and whether our choices for instruction were on target, or need to be modified to have some impact, or a greater impact, on students.

The Arrows, Connections, and Relationships Between Components

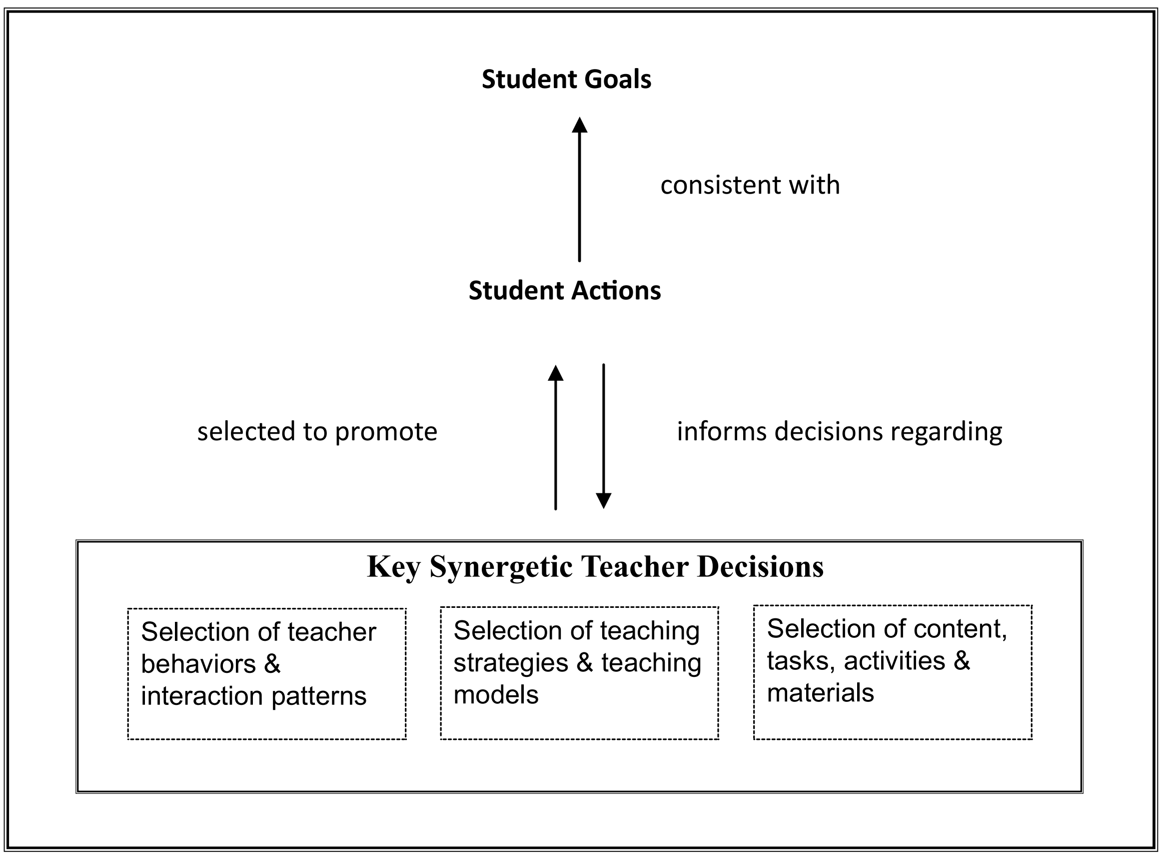
Looking at the bottom two-thirds of the *Framework* (see figure 2), you will find phrases that connect the various components. For example, "selected to understand" and "informs decisions regarding" connect **The Learner** to **Key Synergetic Teacher Decisions**. The learner is not a static entity. The learner has a starting point in terms of what he/she thinks, believes or knows, and the starting point may not change, or may change slowly, or may change rapidly at various points of the lesson. Teachers make the **Key Synergetic Decisions** based upon what they know about the learner, or what they want to know about the learner, and those decisions set in motion a process that continues to inform the teacher about the learner and the evolving learner, by way of his/her actions and spoken thoughts.

Figure 2.



Teachers initially select content to teach based on targeted content goals, on grade level expectations, and on knowledge of the learner based on past interactions with students. "Selected to understand" **the learner** means a calculated and purposeful choice for an **activity**, and choosing a particular **strategy** with the corresponding **teacher behaviors;** a synergistic package that provides optimal information to help us understand the learner. These are key teacher decisions because wise and proper choice(s) initiates activity among the learners, while promoting students saying or doing things that help us understand them as **the learner**, providing us with indicators of the **learner's** thinking, beliefs, misconceptions, or roadblocks to their thinking, which then "inform our decisions" regarding what to do next that is optimal for the learner. As we improve our understanding of the current state of the learner, we then make or alter decisions regarding **teacher behavior and interaction patterns**, the **strategies and models** we select, and the **content, materials and activitie**s we choose, in reaction to our improved understanding of the learner. In short, the learner is a moving target and teaching must be dynamic based upon the current state of the learner.

Figure 3.



Looking at top two-thirds of the Teacher Decision-Making Framework (Figure 3 - above), you will again find phrases "selected to promote" and "informs decisions regarding" that connects **Student Actions** to **Key Synergetic Teacher Decisions**. A particular **strategy** or **model of instruction** along with synergistic (non-contradictory) **teacher behaviors and interaction patterns** and **appropriate content, task, activities and materials** are "selected to promote" **Student Actions** consistent with the **Goals** targeted in the lesson. **Student Actions** observed during the lesson (and over a longer period of time) are the rich feedback that "informs decisions regarding" the teacher's choice of **interactions, strategies and content** and tells us whether instruction is having the desired impact, or not. Are we seeing or hearing indications that students are growing and developing toward the goals of instruction for the lesson, unit, and year? With adequate knowledge of our students and reflective planning, the strategy, content, activity and teacher interaction behaviors selected should facilitate student actions that indicate the learner is engaged in an activity that is profitable in terms of working towards the targeted goals.

If the **Student Actions** are not consistent with those expected regarding student growth toward the targeted goals, the feedback loop indicates a new choice(s) is called for regarding one or all three of the components listed under **Key Synergistic Teacher Decisions.** The choice of **strategy** and **teacher interaction behaviors** are especially key decisions. If the **content** is too hard or too easy, the strategy you are using and how you interact with students will quickly uncover evidence of such. A strategy that does little to engage students or provides little information in terms of students' thinking may waste a whole period or more without moving forward as the feedback from students is missing that would have indicated confusion, a lack of understanding, or a need for change to the activity. Thus, the **Student Actions** indicate what to do next. A pre-planned activity may last a few minutes before the feedback indicates little movement toward the targeted goal for students. As such, the teacher might:

* <u>stay the course</u> - students who have been conditioned in prior classes to expect to be told what to do and how to do it, need teachers who send a different message during instruction, and students can sometimes overcome the challenge by putting a bit of mental effort into the activity.

* <u>ask different, or better questions</u> - students need to think about what they are doing and talk about what they know and think, in order for the teacher to ascertain the level of knowledge and any misconceptions, and for students to begin to get mentally engaged in the activity to make progress toward the end goal(s).

* <u>make a quick modification to the activity</u> - adjust it so that students can wrestle with the activity on a level that is within their thinking zone; something less complex to help build foundations and a bridge from their current thinking to the targeted outcome(s) or goal of the activity.

* <u>use an analogy or metaphor</u> - relating the familiar to the unfamiliar also helps bridge the mental gap.

Key Synergistic Teacher Decisions are purposeful decisions, guided by educational research, and are either proactive or reactive, based on what teachers know about their students prior to instruction, or from feedback gathered through observations and interactions with students in their classroom. Analysis may result in a teacher decision and action designed to increase desired student actions, or decrease undesired actions. Alternatively, it may be decided that the most effective choice is to take no action at all with a particular student, or groups of students. Experience in the classroom, internalizing educational research, and an accumulated knowledge of the learner develops and hones a teacher's skills at being able to predict the effects of classroom activities on the learner. Teachers can also continue to improve their effectiveness, IF the strategies and activities they use, and the manner in which they interact with students, are ones that provide rich and timely feedback indicating their level of success with students.

While effective teaching requires planning and decision-making prior to teaching lessons, effective teaching is also responsive and requires "thinking on your feet" with regard to the **Key Synergistic Teacher Decisions**. Thinking on your feet entails a consideration of the systematic whole and utilizing a "mind-set through which a practitioner could observe, interpret, and judge unfolding classroom events (Clough, Olson & Berg, 2009). Decision-making in response to unfolding classroom events involves consideration of the synergistic relationships that exist between various factors when choosing which action(s) to take. For example, a popular and effective way in which to structure a science activity, called the Learning Cycle, can quickly be reduced to an ineffective model, by poor decisions regarding teacher questioning and responding during implementation of the Learning Cycle. One manner of interacting with students will predictably foster student inquiry, while another will predictably diminish inquiry. Inquiry models such as the Learning Cycle or 5 E's need teacher-student interaction behaviors and patterns that work in concert with inquiry models, that synergistically foster and increase the potential for maximum student engagement, thinking and learning. Thinking on your feet entails: a consideration of the learner, the goals for the lesson, and knowledge regarding effectiveness of the lesson gleaned through observations and interactions with students. Each of these critical components guide a teacher when making **Key Synergistic Teacher Decisions**.

The Framework and Educational Research

Components of the *Teacher Decision-Making Framework* are guided by educational research. For example, Berliner (1987) and others, state that "engaged time, or time-on-task, or attending time, is a positive predictor of achievement." Yet, for many years teachers have been criticized for operating classrooms in which the learner is a passive, non-engaged participant. From Goodlad (1984) to Cintorino (1993) to Ruddell (2005), the various studies expose the overwhelming predominant use of strategies in which the learner is minimally engaged, or not engaged at all in the lesson. Berg (2011) describes this low level of engagement and interaction between teachers and students as "the typical classroom questioning scenario." An example of this occurs when teachers lecture and students take notes, then a question is thrown into the mix, and one or two students respond while other students listen. In this example, there is evidence that one or two students are engaged and have thought about an answer, but what about the other twenty to thirty students in the class? Research indicates (Berg, 2011) that about one-third of the students aren't even thinking about an answer to the question. Teachers see the evidence of this when students are called upon and they blurt out "*I don't know"* to cover their lack of thinking and to escape further pursuit. In review sessions, the same process repeats itself - the teacher poses a question, one student answers, the teacher asks another question, another one or two students respond. The result is minimal levels of student engagement and an extremely passive classroom - a condition that could easily be altered by the teacher, using educational research to guide lesson planning-decisions, and teaching-decisions, associated with the components of the *Teacher Decision-Making Framework.*

There is a research-based foundation for a significant portion of decision-making associated with exemplary science teaching and pedagogical decisions made by teachers. Consider the extensive work on students' developmental differences (Piaget, 1964; Bybee and Sund, 1990; Phillips, 1994; Phillips, 1996; Phillips, 1999) with a related premise that all students enter the classroom with prior knowledge and misconceptions and that students must give up and let go of deeply held beliefs in order to develop more sound notions of science concepts (Driver, 1986 and 1997; Osbourne and Witrrock, 1985). Numerous researchers including Karplus (1977), Erickson (1979), Novic and Nussbaum (1981), Renner (1982), Rowell and Dawson (1983) have developed a substantial evidenced-based understanding of student thinking and misconceptions; research that more than justifies the critical need for, and use of, strategies such as the Learning Cycle (Karplus and Thier, 1967), the Generative Learning Model (Osbourne and Freyberg, 1985) or the 5 E's Model (Bybee, et. al., 2006).

There are a number of strategies that put the learner in the center of the activity. In science, exemplary teachers pull various strategies out of their teaching toolbox, including the Learning Cycle, The 5 E's, Structured Controversy, Futures Wheel, Issues Analysis, Search-Solve-Create-Share, Science-Technology-Society and many others including Dialogues. The specific strategy chosen depends on the goal(s) of the lesson. The aforementioned teaching strategies facilitate student actions consistent with the desired endpoint, by setting up a learning environment in which students are constantly thinking about their ideas and teachers are listening to student ideas and watching student actions. Teachers look for indicators of the effectiveness of the lesson, and guideposts for informing their future decisions. The commonality to all of the strategies listed above is highly engaged students versus passive participants in the classroom.

Many teacher decisions have predictable outcomes, and therefore teaching should be strategic, purposeful and guided by educational research. Like other powerful teaching strategies, using Dialogues with students has predictable outcomes that are in congruence with exemplary teaching and standards-based instruction. In the following section, the *Framework* is used to describe the rationale behind using Dialogues in a science classroom.

Framework Applied to Dialogues

This section focuses on how the *Framework for Illustrating Teacher Decision-Making and Their Interactions* is specifically applied to using Dialogues in the classroom.

1. Goals - goals for students facilitated by using dialogues within the classroom can include one or many of the following, but often include the goals that are boldfaced:

1. **Demonstrate deep robust understanding of fundamental science concepts rather than covering many insignificant/isolated facts.**
2. **Use critical thinking skills.**
3. **Convey an accurate understanding of the nature(s) of science.**
4. Identify and solve problems effectively.
5. **Use communication and cooperative skills effectively.**
6. Actively participate in working towards solutions to local, national, and global problems.
7. **Be creative and curious.**
8. Set goals, make decisions, and self-evaluate.
9. **Express a positive attitude about science.**
10. **Access, retrieve, and use the existing body of scientific knowledge in the process of investigating phenomena.**
11. **Express self-confidence and a positive self-image.**
12. **Demonstrate an awareness of the importance of science in many careers.**

Dialogues can be tailored to target particular goals. All dialogues are designed to facilitate the development of *goal #1 - demonstrate deep robust understanding*, *goal #5 - communication and cooperative skills* , and *goal #9 - positive attitude*. It's a powerful lesson if students are learning, becoming better communicators, and leave class with a more positive attitude about science. When students are writing the dialogue, there is even more emphasis on goal #1 as they have to build the conversation using accurate notions of the science concepts. A student-written dialogue can reveal their misconceptions and level of knowledge on a topic.

2. The Learner - In order to optimize the learning environment we know that learners need to be actively involved both mentally and physically in order to develop a robust understanding of concepts. We know that simply sitting passively and listening to a teacher does little for most students. We know that getting students verbally and kinesthetically involved in the activity improves students' chances for success. Dialogues involve every single student in reading, listening, thinking, and communicating the concepts embedded in the dialogue; ALL students are engaged in the lesson. Dialogues can also involve hands-on activities and even data collection, graphing and/or calculations. Dialogues improve vocabulary skills - when a student doesn't know how to pronounce a word, or is unclear about the meaning of a word or phrase, their dialogue partner is there to provide instant support.

3. Key Synergetic Teacher Decisions - The teacher makes many complex decisions about how to structure the lesson, how to interact with students, what expectations to set in terms of student engagement and behaviors, and how to deal with misbehaviors so as to minimize the disruptions and maximize learning. All teacher decisions potentially increase or decrease synergy, and therefore affect success of the lesson.

Choosing the Dialogues strategy is a primary step toward the desired goals for a particular lesson, and for the year. Teachers can set the stage for appropriate classroom behaviors and expectations for participation prior to doing a dialogue. One of the goals of doing dialogues is to move the passive and seated students into an engaged and lively character role; this can be a challenging shift for some students, while others may welcome the change and opportunity to thrive under a speaking and acting role. When teachers model the role-playing with enthusiasm it provides encouragement for students to play their character to the hilt and helps reduce student's self-imposed expectations for remaining passive and subdued. Once started, dialogues run with almost no intervention. Post-dialogue discussion with well structured, open-ended questions on material embedded in the dialogue, serves to further identify and emphasize key points and helps to determine students' level of learning.

4. Student Actions - The effectiveness of Dialogues can be seen by the types of student actions seen during the activity. It is obvious that while doing the dialogues student engagement is maximized, while conversely the teacher's role is altered. The structure of the dialogue activity gives the teacher much more time to monitor and assess student activity and interactions. During student-to-student interchanges the teacher is free to observe who is communicating, holding back, exhibiting good listening skills, or who is asking for clarification. Any effective lesson includes accountability for being involved and learning the material. Accountability can be assessed via observations of students at work during the dialogue and using measures that assess individual gains post dialogue.

Summary

The *Framework for Illustrating Teacher Decision-Making and Their Interactions* helps organize thoughts and guide actions when planning for teaching, teaching the lesson, and reflecting on the lesson. It provides an organizer and a mechanism for merging the research on teaching with the skills and tools of the trade, focusing on the learner and the targeted goals for instruction, while bridging the learner and target goals with the key synergistic decisions that teachers need to make to create an optimal learning environment for individuals and classrooms full of students.

Section II - Using Dialogues in the Classroom

Introduction

Section II details the key aspects of using dialogues in the classroom - the what, when, and how to, of using and writing dialogues. This section provides examples of how dialogues can target content goals, be used in conjunction with a lab activity, help teach about historical aspects of the subject, help clarify the nature of science, and help students grapple with current issues or science-based ethical dilemmas. In addition, there are numerous suggestions and tips for implementing dialogues in the classroom and the benefits thereof, with guidelines on how to write your own dialogues, and how to have students create their own dialogues as a measure of what they learned.

What Are Dialogues?

Dialogues are conversations between two or more characters regarding a topic being studied in class. Built into the conversation is science content, concepts, information and ideas that students should know, understand and think about. For example, in this short excerpt from *6.2 Whiz and Bang Marvel at Moles,* the characters are discussing the dreaded concept of the "mole."

Taking a break in the school cafeteria, Whiz and Bang are discussing the mole concept.

Whiz: Hello, Bang! You look depressed, did someone take your cookie or something?

Bang: No, I am completely confused in chemistry right now. We are learning this mole stuff and it is like the teacher is talking in a different language.

Whiz: If you would like, I can help you. I am a little bit of a "whiz" in chemistry. Get it Bang? I am a "whiz" in chemistry. *(sitting down next to Bang and nudging him on the shoulder)*

Bang: Ha, ha, I get it. I am so perplexed, my brain is tired, and I have a quiz 8th hour.

Whiz: Let's use some analogies. Sometimes using real everyday objects and ideas helps us understand what is happening on the submicroscopic level a little easier.

Bang: Now you are talking in a different language. If I wanted a foreign language I would have taken Spanish like my mom wanted me to.

Whiz: Díos mío! *(oh my goodness)* It isn't that difficult. Chemists talk about the submicroscopic because all the chemistry magic in reactions and with elements and compounds happens at a level so small that you can't even see it with high powered microscopes. The submicroscopic. What do you remember about the mole Bang?

Bang: I know that it is some sort of number that has an exponent in it and somehow is related to the periodic table or something.

(continued on the next page)

Whiz: Good, we are halfway there. A mole is a counting number like a dozen equals 12. A mole is equal to 6.02 x 10^{23rd}. That is 602 with 21 zeroes after it, the reason it is in exponential notation is because it is so big. Chemists need a number so big because atoms and molecules are so small. In order to measure atoms out on our lab equipment we need to work with a large quantity of them.

Bang: So, how big of a number is that. I can't picture it; I know what a dozen cookies taste like.

Whiz: A mole of marshmallows (6.02 x 10^{23rd} marshmallows) would cover the United States to a depth of 6500 miles (105,000 km) with marshmallows. Astronomers estimate that there is approximately a mole of stars in the universe. If you counted 1 mole of sheep as you were trying to fall asleep, it would take you 19 billion years, and that is counting by a million sheep per second and never falling asleep.

Bang: Wait a minute, hold up. If a mole is that large of a number, how the heck can we use our lab equipment in class to measure it?

Whiz: That's the thing Bang, it is an analogy. I can fit a mole a of carbon atoms in the palm of my hand yet a mole of marshmallows covers the United States in a gooey mess. So what is the difference in size between a marshmallow and a carbon atom?

Bang: I got it Whiz; atoms are really, really small compared to marshmallows. Even if you have a lot of them they still don't take up much space. But what does this have to do with the periodic table?

Whiz: This is where things get really cool. Do you remember the unit label for the mass numbers on the periodic table?

Bang: Yeah, it was a.m.u. or atomic mass unit or something, but those units didn't make any sense because none of our scales measure in a.m.u.'s.

Whiz: Exactly, the a.m.u. was the unit label for just one atom of an element. We just learned that in order to work with atoms you need a lot of them, how about using a mole of atoms? So if I had a mole of carbon atoms, how many atoms would that be?

(continued on page 83 in Dialogues for the Chemistry Classroom)

Note that Whiz and Bang are having a conversation based on information stemming from a topic covered in chemistry class. This dialogue continues on until our two characters have worked out the misunderstanding and confusion about the mole concept. During the conversation, important and pertinent information is uncovered and discussed. Often in a dialogue, one character knows a bit more about the subject matter and helps the other character come to a better understanding through statements, questions and responses, and robust conversation.

One way to use dialogues in class is to have students in class pair up; each person takes on the role of one of the characters by reading that part of the conversation. Picture thirty students in class, with fifteen pairs of students who are reading/acting the Whiz and Bang parts of the dialogue. The goal of using dialogues is to engage all students in the class in an activity that uses multiple senses, such as seeing, speaking and listening, but at the same time taps into parts of the brain that connect to kinesthetic and emotion, in an interchange centered around learning the content or material designated as important for that particular lesson or unit. Students read and act out the dialogue, and in the process are engaged in a conversation that addresses key aspects of the concept and common stumbling points to understanding the concept.

Using Dialogues in the Classroom - What For?

Dialogues can be used to address a variety of goals, such as learning content, learning content in conjunction with a lab activity, learning about the historical context of subject matter, understanding the nature of science, studying current issues, or grappling with science-based ethical dilemmas, or used as a writing and assessment exercise designed to find out what students know about the topic.

1. Dialogues can be **used for learning content** - For example, take this excerpt from Biology I, *5.8 Wei and Noé Discuss Meiosis (pronounced "way" and "no way")*, a discussion focused on a common difficulty students have when differentiating between mitosis and meiosis. This particular dialogue was written due to students often having difficulties differentiating between mitosis and meiosis. As such, this dialogue addresses those key differences in a manner that would place emphasis on the subtle points that students have difficulty understanding.

Noé: I know…well, that's life! It's a complicated business, being alive. So…do you understand the meiotic process?

Wei: Well enough, I think. It's pretty much the same as mitosis—just twice! So that makes it a little easier to remember.

Noé: What I think is interesting is how the cell divides twice rather than once, but the DNA still only replicates once during the cell cycle—like for mitosis. The result is something quite different than what we find in mitosis.

Wei: How so, Noé?

Noé: Well…the DNA replicates once, right? But then in Mitosis the chromosomes and the cell only divide once. So we double the DNA and one half goes to one cell and the other half goes to the second cell ... we end up with the same thing we started with…but two cells. In a human—the result is two cells, each with 46 chromosomes…identical (genetically) to the original.

Wei: OK…but with meiosis, the cell divides twice even though the DNA replication occurrs only once. So, instead of making two cells, we end up with four cells. By the end of this process, each one of the four cells only has one-half the DNA of the original cell. Right?

(continued on the next page)

Noé: Exactly! So for humans, a cell going through meiosis produces 4 daughter cells, each with only 23 chromosomes.

Wei: Right!!! To make it even more interesting, all four of those daughter cells are different genetic mixes of information—they are all genetically different!

Noé: No way!

Wei: Way!

Noé: But how does that happen, Wei? The process does not seem that different from mitosis…and those cells end up being genetically the same.

Wei: Great question my curious friend! This happens because of synapsis!

Noé: Synapsis???! What's that?

Wei: Synapsis is the step at the beginning of meiosis in which homologous chromosomes pair up.

Noé: "Homologous chromosomes"…I know I should know what those are. What are they?

Wei: You know that we have 46 chromosomes. But they occur in pairs! That's because we each have one of each chromosome from each parent. Our largest chromosome is called the #1 chromosome (yeah, I know…really innovative naming system). You have two #1 chromosomes—one from your mom and one from your dad—those two #1 chromosomes are homologous. During synapsis, all of your homologous chromosomes line up.

Noé: *[excited]* Now I remember! And during synapsis, the homologous chromo somes swap chunks of DNA…kind of like shuffling a deck of cards. This mixes up the DNA and adds diversity. By the time the chromosomes separate, the cells are all genetically different.

Wei: But that brings up a question, Noé. Why would we—or any critter—WANT a cell with only one-half the normal amount of DNA? I mean, it seems that having less than the normal DNA would be a problem for the cell.

Noé: Good thinking, Wei! And, normally, you would be right. A cell with too little or too much DNA is in for trouble!! But meiosis results in a special type of cell—one with a very specific purpose.

(continued on page 124 in Dialogues for the Biology Classroom)

Sometimes teachers will construct and attached post-dialogue questions so that after reading the dialogue the pair of students goes back into the dialogue to answer the questions designed to get them to focus on specific aspects of the dialogue. See *My Oh Meiosis* on page in the Biology II sample dialogues pages.

For an example from Chemistry, take this excerpt from *10.2 Ying and Yang Fill Their Orbitals*, a discussion focused on learning about electron configuration.

Ying:	Holy moley Yang! I am up to my ears with these electrons! How many rules and principles and whatEVER else can there be about where the electrons are?!?! This is ridiculous!
Yang:	What?!? I actually like this electron configuration thing! What's your deal?
Ying:	With all these weird dudes' names and rules and stuff, I just can't keep it all straight. I finally understand the orbitals and the different energy levels, shapes, orientation on the axes, and even the spin of the electrons, but I can't figure out how to fill those orbitals!
Yang:	Well I think you've got the hard part down! There's just three things you've gotta follow to fill the orbitals.
Ying:	Three doesn't sound too bad in theory, but yikes, I am struggling here!
Yang:	Ok, let's go piece by piece. Number one is the Aufbau principle. This one says that you fill the lower energy levels first.
Ying:	So I have to build from the bottom up? I guess that makes sense. If I was going to build a tower of cards, I would have to start from the bottom, not the middle or the top!
Yang:	Exactly. Aufbau actually means "building up" in German! On to number two…the Hund rule.
Ying:	I remember this was something about sharing or repelling or something, right?
Yang:	For sure. The Hund rule says that electrons will not share an orbital if they don't have to. Electrons repel each other because they have the same charge, so they won't choose to share if they have a choice.

(continued on page 108)

Well-written dialogues have science terms or concepts embedded in the dialogue. For example, in the (full) dialogue excerpted above, concepts include electrons, electron configuration, energy levels, orbitals, Aufbau Principle, sharing electrons, repelling electrons, charges, and the Hund Rule, the Pauli Exclusion Principle, spin and quantum number.

During the dialogue the characters develop a better understanding of the concept through a conversation, much like real students might have when attempting to understand a topic. Teachers, who wrote the dialogues, utilized years of past experiences with student's thinking to craft dialogues that represent difficulties students have with various concepts and topics. As such, many of the dialogues address common misconceptions (or preconceptions) targeting areas where students commonly have difficulties in learning the material.

For an earth science example, in the excerpt below from 5.2 *Pate Tectonics: Magnets in the Rocks*, the two characters Rocky and Plato discuss magnetic fields, magnetic reversals, and the nature of scientific thought. Science terms or concepts included in this particular dialogue are the following: Alfred Wegener, continental drift, Glossopterus, plate tectonics, evidence, magnetic reversals, Earth's magnetic field, crystals, magnetite, magma, basalt, oceanic rifts, scientific theory, experiments, observations, and data.

Rocky: Well then! There are fossils of land animals that are all from the same rock layer that are now separated by oceans. There were plants too, but you didn't say much about them. How did I do?

Plato: Very well. The plants are called Glossopterus. Look it up on the internet when you have a chance.

Rocky: You promised to tell me about more evidence for plate tectonics, because frankly I am still a bit skeptical.

Plato: OK. Let's see what you think of today's evidence.

Rocky: So, let's get started. What do you have for me?

Plato: I think that today we will talk about magnetic reversals.

Rocky: I have magnets. And I can turn them around. So what is the big deal?

Plato: This is magnetic reversal on a grand scale. Right now we are surrounded by Earth's magnetic field. You know that when you hold a compass, the needle will point to magnetic north.

Rocky: The North Pole.

Plato: Actually, there are two north poles. One is geographic north, which is what most people call the North Pole, and the other is magnetic north, which is where your compass points. When there is a magnetic reversal your compass would point to what we now call the South Pole.

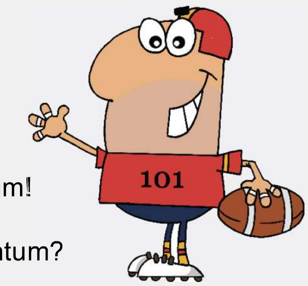
Rocky: That is a big reversal. But what possible evidence could there be of that happening? It is not like there have been compasses around for that long; certainly not for millions of years.

Plato: Actually there have been compasses around for almost as long as there have been rocks. Only these compasses are crystals of a mineral called magnetite. When these crystals form, by cooling from a magma, they orient themselves in line with the existing magnetic field, just like the needle in your compass. When the rocks these minerals are in cool and harden these little magnetic needles are locked in place. This records the position of magnetic north at the time the rocks cooled.

Rocky: How is this related to plate tectonics?

(continued on page 91 in Dialogues for the Earth Science Classroom)

For a physics example, in this excerpt from *7.1 Hip 'n Hop Get Impulsive*, Hip and Hop are at a football game and are discussing differences between momentum and impulse.



Hip: *(surprised)* Holy Cow! Look at how big that lineman is!

Hop: Oh of course! Linemen need a lot of mass.

Hip: *(sighing)* Of course you would bring physics into this…

Hop: Well duh! Football is a game that involves a lot of momentum!

Hip: I know I am going to regret asking this… but what is momentum?

Hop: *(excitedly)* Momentum is mass in motion. All objects have mass, so if they are moving, then they have momentum!

Hip: So all of the different football players have mass, so when the play begins, they are all moving and therefore they all have momentum?

Hop: *(nodding)* Right! An object can have a large amount of momentum by either having a large amount of mass, or a high speed, or both!

Hip: So a semi-truck would have a large amount of momentum even when it is moving very slowly because of its large mass. But it would be possible for a small car to have an equal amount of momentum because it is moving really fast?

Hop: Exactly! Can you think of a situation in which all objects have the same momentum?

Hip: Ummm… Since all objects have mass, it must have something to do with the speed… *(shouting excitedly)* I GOT IT! It has to be when their speed is zero!

Hop: Yep! Momentum is pretty easy to understand. But about as easy as and even more interesting than just plain momentum is the change in momentum, or impulse.

Hip: *(hesitantly)* Wait… I think I know something about this… momentum is always conserved, right?

Hop: Yes it is. When we focus on a system, we can account for all of the momentum and where it is transferred between different objects.

Hip: *(questioning)* So if momentum is always conserved, then how can we look at impulse, or a change in momentum? Shouldn't it always be the same?

(continued on page 88 in Dialogues for the Physics Classroom)

2. Dialogues can be **used in conjunction with a lab activity, or to prepare students for a lab activity** - On the next page is an an example from Chemistry, *15.5 Riff and Raff Get Titrated,* where Riff tries to help clear up Raff's confusion about a titration lab.

Riff: Hey Raff, what's shakin'?

Raff: Uh, not too much Riff, just trying to wrap my head around this titration stuff.

Riff: Dude, I'm lovin' titrations…I think they are pretty basic…maybe I can help!

Raff: Well, you can certainly try.

Riff: Alright, where you at?

Raff: Ok, so we did that titration lab the other day.

Riff: Yep, A-MAAAZZZIIINNNGGGG!

Raff: Um, right, so anyways…I basically got through the lab by following the directions, but that's about it. I put the base in the beret…er…buret, and I put the acid in the Erlenmeyer flask and I added that indicator thing, and then I dripped in the base until the stuff changed color, but I don't even know what was actually happening!

Riff: Yikes…okay, let's slow this down. So first you got all your glassware set up and then you put the base in the buret *(yes, a buret, not a beret, we aren't wearing French hats)*. What do you know about that base?

Raff: Well, I knew WHAT base it was and I knew the concentration of that base. It was sodium hydroxide, and I think it was 0.1M.

Riff: Ok cool, so you also mentioned an acid…what did you know about that acid?

Raff: I knew what acid it was too…it was hydrochloric acid…but I didn't know the concentration.

Riff: So Raff, you also mentioned an indicator…what do you know about that?

Raff: Hmph. All I know about that is that it was called some crazy name, feel-no-thang-ie, and that I added three drops!

Riff: Feel-no-thang-ie??? Wow. I think you mean phenolphthalein.

Raff: Sure, that, whatever you say. I still don't know what it is.

Riff: For titrations, indicators are the peanut butter to a peanut butter and jelly sandwich, they're the paper to a notebook, they're the trees to a forest! You can't do titrations without an indicator!! *(Or I guess you could use a pH meter instead, but that would be WAY less colorful.)*

Raff: You are ridiculous. Just tell me what I did in my lab!!! Sheesh!!

Riff: Ok, ok, chill! First off, what are you trying to figure out in the lab?

Raff: The concentration of the HCl…since that one is unknown.

Riff: Exactly. You know the concentration of the base, but you don't know the concentration of the acid. So, the indicator is SUPER important, but I guess I already hinted at that. The indicator will tell you when the number of moles of base is equal to the number of moles of acid.

Raff: Hmmm…ok, but why?

Riff: Well, you already know that your strong acid, HCl, will dissociate into H+ and Cl-, and your strong base, NaOH, will dissociate into Na+ and OH-. So, in your Erlenmeyer flask you have a bunch of H+ floating around, which makes your pH super low. Now, what did you say about the drips??

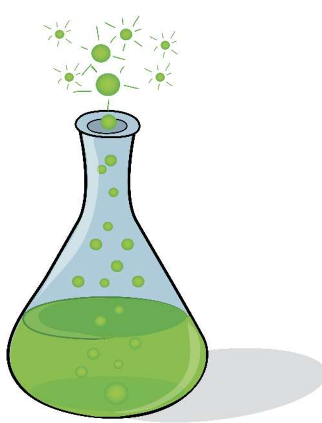
Raff: Yeah, I wrote down the volume of base in the buret, and then I started dripping it in slowly and swirling the Erlenmeyer flask while I dripped it. After awhile, the drips started turning the liquid pink, but it kept going away. So I kept dripping it in and dripping it in and then suddenly, the whole thing turned pink and didn't change back to clear! But I still don't really get what happened.

Riff: Don't worry, we're close! Ok, so we had all those H+ ions floating around and then you started adding the base, which has a bunch of OH- ions. Every time you added more base, each OH- was snatched up by an H+ and made a water molecule.

Raff: Well that makes sense. So when I kept adding more base, I kept making more water molecules, which was actually getting rid of those hydrogen ions.

Riff: For sure! So what do you think was happening to the pH?

(continued on page 155 in Dialogues for the Chemistry Classroom)



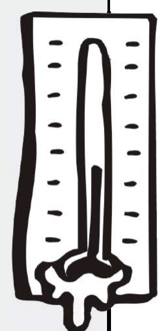
As another example of connecting labs to dialogues, in *3.2 Water Ya Know* from *Dialogues for the Biology Classroom: Volume 1,* students discuss their ideas about water, then actually collect some data, followed by more discussion.

Zap: I once saw a performer who boiled water in a paper cup! The water very efficiently carried away all the heat so that the paper never reached its burning point!

Zip: Not only that, but evaporating water absorbs an enormous amount of heat, which makes it a good method of cooling for temperature regulation.

Zap: I know a good way to test this, Zip. Take one of those pieces of cloth and dunk it in the water. Squeeze the excess water out of it, then wrap it around the end of a thermometer. I will wrap the dry cloth around the end of the other thermometer. *(Zip and Zap do this)*.

Zip: I get it…the thermometer will measure the cooling effect of the evaporation. This will show us why animals sweat and will also show one of the benefits of transpiration in plants. The evaporating water cools down the critter! Let's give the thermometers a couple minutes before we check the temperatures…



Zip: There are many more interesting characteristics related to water, Zap. Take some of the ice in that cup and put it in your glass of water. *(Zap puts ice into the water)* What do you see?

(continued on page 65 in Dialogues for the Biology Classroom)

The full *3.2 Water Ya Know* dialogue includes many key science terms or concepts such as properties of water, melting point, boiling point, Celsius scale, phases, specific heat, evaporation, temperature regulation, thermometer, transpiration, density, hydrogen bonding, polar molecule, crystalline structure, surface tension, and cohesion.

Another lab-connected example from Chemistry is dialogue *2.4 Gases Has Masses,* in which Sis and Sas are using fishing line and balloons to create a mobile to explore how air in a balloon contributes to its mass. The dialogue and activity address the common student misconception that air does not have any mass.

An example from a physics lab-connected dialogue, in *17.2 Hockel and Ockel Repel and Attract*, the two characters are in physics class using magnets and paper clips to examine magnetic fields. Students reading the dialogue can also use magnets and paper clips to do what the characters are doing. Concepts and terms included are magnets, atomic level, electrons, spin, current, and domain.

In the earth science dialogues, some of examples where the characters do an experiment or label diagrams related to the dialogue include *7.1 A Salty Solution, 7.9 Ocean Temperatures*, and *7.10 Only One Ocean.*

For another example from physics, in dialogue *3.8 Hockel and Ocket Figure Out Newton's 3rd Law,* the two characters are in their physics class about to examine Newton's Third Law using spring scales and ropes. As the dialogue progresses, Hockel and Ockel continue to explore the key concepts involved including: 1) Forces act in pairs, 2) The forces are equal in magnitude (number) but opposite in direction, and 3) The forces act on *different* objects, so the *effect* on each looks different.

Ockel: *(rolling his eyes)* I don't know why we are doing this. I've known this since I was in grade school.

Hockel: Well, there is always more to learn. Tell me what you know about Newton's 3rd Law of Motion.

Ockel: Easy. For every action there is an equal and opposite reaction.

Hockel: *(rolling his eyes)* Sooo… what does that mean?

Ockel: I'm a little fuzzy on that part.

Hockel: You are not alone. Lots of people don't really understand what it means.

Ockel: *(picking up the rope and a spring scale)* Bet we are going to use these to figure it out.

Hockel: *(smiling and nodding)* You are so correct. Remember what we learned from 1st Law? Objects continue as they are unless a net, unbalanced force is exerted.

Ockel: *That* I understood.

Hockel: To demonstrate 3rd Law, neither of us can exert a force that causes the other to move.

Ockel: *(flexing)* Oh so you want me to go easy on you.

Hockel: *(annoyed)* Alright. I know you're stronger than me. Make a prediction. When we each pull so that the string is tight, who is pulling with the greater force, you or me?

Ockel: Haa! Me of course. We already established that I am stronger than you. Let's go.

Both attach one end of their rope to the spring scale and hold on to the other end. They pull the rope taut without making each move.

Hockel: So what is the reading on the scale?

Ockel: 10 Newtons

(continued on page 62 in Dialogues for the Physics Classroom)

3. Dialogues can be **used to learn about the historical aspects of the subject and the nature of science -** The history of science is a very important aspect of understanding the context of our current state of knowledge, and also how "science" occurs or advances. For example, in the excerpt on the following page, taken from *3.1 Skip and Chip are Professional Atom Talkers* and in the follow-up dialogue *3.2 Skip and Chip Try Some Modeling*, Chip is tutoring Skip on the various models used throughout history to describe the atom.

Chip: Hey Skip, I'm starting to really get into this whole atomic model of the atom.

Skip: How so? Are you into quantum mechanics or something?

Chip: No, not quite that deep Skip, I'm just enjoying how our understanding of the atom has evolved and changed over the years.

Skip: Well, I saw a kid wearing one of those "element" shirts that said: "Wind, Water, Fire and Earth." It reminds me of the Air, Earth, Fire, Water element that ancients believed to be true.

Chip: Certainly they were wrong about that! I mean air is a mixture, water is a molecule and Earth is made up of many different types of atoms, although the crust is mostly silicon and oxygen. And Fire? Wow, that's not even a substance, it's energy release from the combustion of several types of atoms in the presence of oxygen.

Skip: Slow down buddy, you are getting ahead of where I'm at. So how did it all start out?

Chip: Science did not really get into the "atom" act until several hundred years ago, but an old Greek philosopher named Democritus is credited with first thinking and talking about matter in terms of atoms and "the void" which is that area we now know as the vacuum of space.

Skip: I thought we are talking about chemistry, now you have to go into some philosophical rant about some old, dead Greek guy, what gives?

Chip: It's just that after Democritus first thought in terms of atoms, it took years of discovery, mostly after the 1500s A.D. to come up with an atomic theory. Many different people hypothesized about matter, charges, and the air.

Skip: So when does this all come together Chip?

Chip: An English school teacher named John Dalton put together the philosophy of Democritus, the electric charge of Ben Franklin, some reactions done by alchemists and conservation of matter. He determined that all matter was made of unique, indivisible atoms that could combine, separate, or be rearranged in patterns to make reactions.

Skip: But Dalton does not have his name on any of the four accepted models of the atom? It only seems fair that he should have a model named after him doesn't it?

(continued on the next page)

Chip: Well, Dalton got the ball rolling and once the cat was out of the bag, so to speak, others started to find ways to observe this tiny thing called an atom.

Skip: So did they look at it with a microscope and then observe all the stuff we now know?

Chip: No, all of the observations were indirect. J.J. Thomson was able to determine there was a negative charge that could be removed from atoms, so he determined that atoms were not indivisible. He even got credit for the discovery of the electron in 1897.

Skip: So if atoms are neutral and they have a negative part called an electron, then there must be something positive inside an atom as well.

(continued on page 66 in Dialogues for the Chemistry Classroom)

In dialogue 3.1 students learn about Democritus' first ideas of the atom, followed by Dalton, J.J. Thomson, Milikin, and Chadwick's contributions to the evolving notion of the atom and atomic models. The contributions of other historical figures in science are extended in dialogue *3.2 Skip and Chip Try Some Modeling* which takes the reader up to the present time in terms of our evolving atomic model. Dialogues can introduce students to an important concept related to the history and nature of science, shown in this example in terms of how models are used in science, and the representation of what was known about the subject at that particular time in history. Dialogues 3.1 and 3.2 take students through some of the scientists' perceived weaknesses of particular models that caused them to look for different explanations and come up with new models. Students need to understand that our present day understanding of science and concepts in science was often built over many hundreds or thousands of years.

Some historical dialogues are invented conversations between two scientists who have different or competing ideas about a concept, model or idea in science. Such dialogues place the mysterious nature of science into the human context, demonstrating the importance of differing viewpoints and how strongly held convictions about existing ideas can impede the objective scrutiny of new ideas. Imagine the exciting interactions among scientists, between scientists and the public, or between scientists and religious officials, when wrestling with conflicting notions of how the world works!

For a biology example, in the excerpt (on the following page) from *5.4 The Mysterious Case of Puerperal Fever*, Semmelweis, a physician, is speaking with Klein, his supervisor at the hospital, to discuss the data showing that more women were dying when delivering their babies at hospitals than were dying when having babies delivered by midwives. This dialogue places the physician and scientist Semmelweis into a context in which he wrestles with the patterns and data of illness and death rates while conversing with his supervisor who has a closed mind when discussing the possibilities of disease transmission. Semmelweis is attempting to convey an alternative viewpoint with regard to why so many women were dying when delivering babies in hospitals. This dialogue places the mysterious nature of science into the human context, demonstrating the importance of differing viewpoints and how strongly held convictions about existing ideas can impede the objective scrutiny of new ideas. Imagine the exciting interactions among scientists, between scientists and the public, or between scientists and religious officials, when wrestling with conflicting notions of how the world works! Dialogues can also be used to effectively model appropriate and professional discourse between people with conflicting views.

In this particular dialogue, students not only learn about the historical context of the evolving knowledge of disease transmission and the germ theory, but also included are the following science terms and concepts: theory, disease, epidemic, fever, autopsy, cadaver, blood, and infection.

5.4 The Mysterious Case of Puerperal Fever

Klein: *(walking up to Semmelweis)* So, there, Semmelweis…what are you examining so intently?

Semmelweis: Good afternoon, Dr. Klein. I'm re-examining this data on deaths due to puerperal fever. The comparison between the First Ward and Second Ward is striking!

Klein: Oh, good grief!!! Why are you wasting your time on that? You have far more important things to work on. Everyone knows that these deaths are due to bad air! They are an unavoidable part of childbirth.

Semmelweis: I have to respectfully disagree, Doctor. If you examine the data, you will see that the death rate in the Second Ward, run by midwives, is consistently less than 2%. In the First Ward, where doctors examine the patients, the death rate was 17% last year.

Klein: You are not suggesting that the doctors are causing this condition, are you, Semmelweis?

Semmelweis: Look at the data, Doctor! The First Ward averages 600 to 800 deaths to puerperal fever each year while the Second Ward averages 60 deaths.

Klein: To suggest that doctors play some part in the transmission of this disease is absurd! Disease and death are an inescapable part of medicine. Besides, puerperal fever is found in hospitals across Europe—this is not just a localized problem!

Semmelweis: Puerperal fever is common in many hospitals but there is no such epidemic in the cities and towns of Europe. Women who deliver their babies at home do not suffer this disease. Even the women who give birth in the streets and alleyways have a far lower chance of death than the women in our own hospital!!

(continued on the next page)

Klein: While I will reluctantly admit that these figures are correct, I do not believe that we have any part in spreading this disease. The miasma theory explains this unfortunate epidemic.

Semmelweis: But this disease does not follow the patterns of a typical epidemic. The death rate due to puerperal fever does not vary with the seasons or the weather and it does not seem to spread from person to person outside of hospitals.

Klein: There is clearly bad air in the First Ward. The Miasma Theory explains the difference in death rates…this conversation is pointless! If we scrub the floors, wash the bedding, and re-paint the walls, deaths will predictably decline.

Semmelweis: But we have tried that before. As you say, the deaths will decline, but only or a number of days. Then they rapidly increase to previous levels. Meanwhile, the rates in the Second Ward have never approached such high numbers of deaths. There must be some tangible reason for this difference!

(continued on page 109 in Dialogues for the Biology Classroom - Volume 1)

For a physics example, the excerpt below, from *5.1 What Goes Up Must Come Down*, is a invented conversation between Aristotle (384BC-322BC) and Galileo (1564-1642). Aristotle the great Greek philosopher, had many ideas that were so respected they were believed without question for almost two thousand years. Galileo, an Italian physicist, had the audacity to question the accepted ideas of the time. Imagine that Aristotle could travel in time to meet Galileo and discuss their ideas about the physics of falling objects while standing on the Leaning Tower of Pisa.

Aristotle: *(in a condescending manner)* All objects have a natural motion according to their composition of the four elements. For example, objects made mostly of the Earth element tend to drop straight down toward the ground.

Galileo: *(in a challenging manner)* Oh, yeah? Who decides what proportion an object has of the Earth, Air, Water, or Fire elements?

Aristotle: This is clear by just observing an object. Anyone can tell that a rock is made mostly of the Earth element.

Galileo: What about an animal, like a dog? Are dogs made of Earth and Water? What happens if I think animals contain some Air, too?

Aristotle: Any rational person will agree with my philosophy.

Galileo: When I drop two cannonballs of different weights from the Leaning Tower of Pisa, I say that they will fall at the same acceleration and hit the ground at the same time. They are both made of the Earth element, right?

(continued on the next page)

Aristotle:	*(confidently)* Oh, no! The heavier one will definitely hit the ground first because it contains more of the Earth element. Heavier objects always fall faster than lighter objects.
Galileo:	Let's do the test. We need evidence to support our ideas. We cannot believe a scientific idea just because someone says it.
Aristotle:	It is not necessary to test. We can just think about falling objects and come up with the correct answer.
Galileo:	Watch this! *(holding two cannonballs, about to drop them)* See the two cannon balls hit the ground at the same time!!!
Aristotle:	*(puzzled)* It does appear to be true. Could you do that again?
Galileo:	That's right. We need to repeat the test many times to see if we can get consistent results. Then an idea can be believed because it is based on scientific evidence.
Aristotle:	This seems to work for the two cannon balls, but what about a cannon ball and a feather? Surely, you agree that the cannon ball will fall faster than the feather.
Galileo:	Yes, you are right because air resistance slows the feather more than the cannon ball. But what would happen if there were no air resistance?
Aristotle:	It is impossible to not have air resistance. So your hypothesis is impossible to test.
Galileo:	I can slow down the falling process by rolling different weight balls down an inclined plane. Then I can time their trips using my pulse. If we use the same sized balls, then the air resistance will be the same for both balls.
	(continued on page 78 in Dialogues for the Physics Classroom)

This dialogue places the nature of science into the human context, demonstrating the importance of differing viewpoints and how strongly held convictions about existing ideas can impede the objective scrutiny of new ideas. In this particular dialogue, students not only learn about the historical context of the evolving knowledge of science, but also there is sometimes a competitive nature, or sometimes collaborative nature, with regard to science and scientists. It is important for science students to learn how science builds on previous ideas, or sometimes forges ahead by refuting prior ideas.

Other dialogues that target the historical aspects of physics include: *5.1 What Comes Up Must Come Down* and *5.2 The Gravity of the Situation* -gravitational force, *13.3 Wave Particle Duality of Light* - a conversation between Isaac Newton and Christian Huygens about the composition and behavior of light, *16.2 Battle of Currents* - where Nip and Tuck are discussing Edison, Westinghouse and Tesla's controversy about direct versus alternating current, *16.4 The Discovery of the Battery* - a conversation between Galvani and Volta and some of the early ideas about electricity and storage of electric charges, *18.1 History of the Atom* - a conversation between Democritus and Schrödinger about the changing model of the atom, and *19.1 Discovery of Radioactivity* -

a conversation between Henri Becquerel and his wife regarding Becquerel's findings that uranium was giving off energy rays - what we today call radioactivity.

In earth science, numerous dialogues incorporate concepts critical for developing an understading of the nature and history of science. In a *1.3 Scientific Upheaval*, the role of new data in changing hypotheses is explored. In *1.7 Studying the Rocks*, they learn that there is not only one scientific method, but many different methodologies that scientists use. In *5.1 "Marginal" Evidence for Plate Tectonics*, the characters briefly explore the problem that Wegener had in gaining acceptance for his ideas because he lacked a plausible explanation for the mechanism driving plate movement. In *5.4 Plate Tectonics and the Notion of a Scientific Theory*, Plato and Rocky talk about the nature of theories and the meaning of words to better understand plate tectonic theory. In *8.1 Evidence for Glaciers: A Mile of Ice Makes Gardening Difficult*, when discussing the formation of various basic glacial landforms, the role of evidence in creating scientific explanations is reinforced.

4. Dialogues can be **used when studying current issues or the science connections to our everyday life -** For example, in *11.3 Tiff and Tiff - Recycling Center and Dangers of Compressed Gases* (Chemistry), Tiff and Tuff discuss the dangers of bringing containers filled with compressed gases to the recycling center, and what might occur if the containers are suddenly breached, turning containers into mini-rockets. In *15.3 Acids in Our Body and Beyond*, the two characters discuss the significance of the pH of fluids in our body and in the atmosphere. In *18.2 That's Not Plastic, It's a Polymer*, the two characters talk about how scientific jargon can be used to try to impress consumers, and how knowing some chemistry can give one an advantage in some situations, or help consumers to make good choices regarding purchasing products. In the following excerpt from *Dialogues in the Physical Science Classroom*, *18.3 VOC's Take Over the Library*, volatile organic compounds are being emitted from the new carpet in the library, and the dialogue includes discussion about the danger to human health when breathing the VOC's.

It is the first day of school and Kyle and Sam head to the library to hang out between classes. As they enter the library their noses are hit with a strong odor.

Sam: What the heck is that smell? It's overpowering my sniffer!

Kyle: Oh – tell me about it. That is really strong!

Sam: What's causing it to stink in here?

Kyle: Look. New carpet. This sort of smells like it did when we had new carpet put into our house.

Sam: *(drops to the floor and takes a whiff)* Holy moly batman – that is it! Why does new carpet give off such a toxic smell?

Kyle: Don't know for sure, but when we got new carpet we actually opened all the windows and went to our cousins for a couple days until some of the smell left. When we returned, we could still smell it, but it wasn't so strong.

Sam: Let's stay here for bit, if we can stand it, and Google up new carpet and smell.

Kyle: Good idea.

Sam: So this website mentions that new carpet gives off volatile organic compounds.

Kyle: So organic is good right – like organic food. But volatile is not so good. Uncle Freddy K. seems like he is always angry and mom says he is a bit volatile.

Sam: OK. Let's start over and let me break this down for you. First, it says here that Volatile Organic Compounds or VOC's are given off as gases from some solids or liquids.

Kyle: So what we are smelling is a gas given off by the new carpet?

Sam: Right. Let's bump over to another web site and check out VOC's.

Kyle: Here it says that organic compounds are chemicals that have a high vapor pressure at ordinary, room temperature conditions and that the high vapor pressure results from a low boiling point. This causes large numbers of molecules to evaporate or sublimate from the liquid or solid form of the compound and go into the air. Sam - could you translate that into English for me?

Sam: Ok. I think there are some pieces in there that I understand. Something with a low boiling point. This means that the temperature doesn't need to be very hot in order for it to boil, and in this case they said evaporate or sublimate.

Kyle: What is the difference between evaporate and sublimate?

Sam: Remember in Physical Science when we talked about ice melting first into a puddle, then it going into the air by evaporation?

(continued on page 170 in Dialogues for the Chemistry Classroom)

For a biology or environmental science example, in this excerpt from *I'll Be Dammed - or Not?*, two students are discussing the removal of a dam on a river that runs through the center of a mid-western city; a controversial matter that has many people and groups concerned about the change and outcome. This short excerpt begins to highlight the various people, or groups, who have a stake in the decision and informs students of the controversy, politics, and consequences of science-related decision-making.

Zig: Holy cow - did you read the paper yesterday about the people who were out in their boats on the river with bullhorns and signs? Seems like they were all worked up!

Zag: Really? What's the big deal?

Zig: Well, seems that the Department of Natural Resources has decided to take out the dam and return the level of the water down to the river channel level.

Zag: So ... who cares?

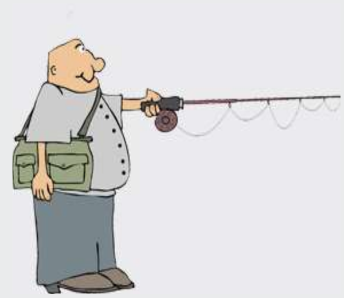
Zig: Well, to start with, the homeowners along the river who have boats are furious. Many bought their homes with the added advantage of having waterfront property so they could boat, or water ski, on the river.

Zag: Won't they still be able to do that?

Zig: No. The river will probably become a canoe-only waterway, since the level of the river will go way down, and during most of the year the rocks will be exposed, making boating a thing of the past.

Zag: So, why take out the dam?

Zig: Well, the newspaper said that there were many reasons. One reason being that once the dam is removed, the fish will be able to swim further upstream. My father is excited about being able to fish the stretch of the river, above the dam, where the walleyes and salmon can't swim to with the dam in place.



(continued)

This particular dialogue emphasizes how a current or past issue is governed by many different players or factions, and also how science concepts can be embedded into a current issues dilemma. Science-related issues abound, and when incorporated, make a science class relevant and connect learning to issues that are immediate and important to learners.

In another contemporary issues dialogue on the following page from physics, *19.2 Learn About Radioactivity*, Hip and Hop are discussing radiation, the nuclear reactor meltdown in Japan and the implications for human health.

Hip: *(turning towards Hop with fear in his eyes)* Have you heard about everything that is going on in Japan?

Hop: *(sigh)* Yes I have, Hip. It is very sad what the earthquake has done to their nuclear power plants.

Hip: *(very agitated)* Is that all you have to say about it?!! There is radiation going EVERYWHERE!!! I knew that movie was right… the one where the world ends soon… what is it called?

Hop: 2012?

Hip: *(panicked)* YES – the world is going to end!!! The radiation is going to spread from the nuclear power plant in Japan. We need to keep away from the radiation!

Hop: *(in a soothing voice)* Hip, you need to calm down. Not all radiation is bad!

Hip: How can you say that?! It causes cancer and mutations and…

Hop: *(tactfully cutting Hip off)* I learned it from my VERY smart Physics teacher in the last unit we covered! Radiation includes the entire electromagnetic spectrum – even the visible light that we see!

Hip: So light is a form of radiation?!

Hop: Duh! Where were you last unit?

Hip: *(hurriedly)* Well, it took spring break forever to get here, and I spent a lot of time texting on my phone and playing games on my calculator, so I wasn't really paying attention. Then I took a few extra days off when we came back and then BAM! The unit was over and I was taking a test!

Hop: *(somewhat annoyed)* Anyway… not all forms of radiation are harmful. The radiation you are thinking of is radiation from radioactive materials.

Hip: *(nodding)* Right! Like what makes superman super, or the incredible hulk incredible!

Hop: Maybe in Marvel Comics. But the truth is we all have mild exposure to radioactive materials everyday! Did you know that there is a small amount of radioactive material in smoke detectors?

Hip: *(shocked)* Get out of town!

Hop: Really! And X-rays are considered radiation, and when you fly in a plane you are exposed to radiation.

Hip: That makes sense – I knew planes couldn't just fly on their own! They have to have super powers…

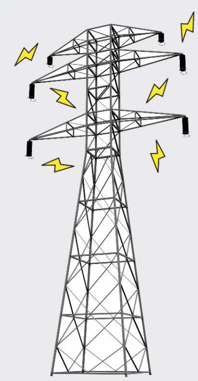
(continued on page 176 in Dialogues for the Physics Classroom)

Another current issues dialogues in physics includes *12.1 Wha'd You Say*, where Nip and Tuck are talking about the rock concert they attended and how their ears are ringing. This dialogue includes concepts and terms such as decibels, energy, hearing loss, amplification, log relationship, perception, ear buds, high frequency, and hair cells.

Dialogues are fruitful ground for examining issues and ethical dilemmas that have a strong science connection. In the following example with connections to physics, two students are discussing the issue of living near high voltage power lines; a controversial matter that has many people and groups concerned about the health effects. This dialogue aslo demonstrates how a current or past issue is governed by many different players or factions, and also how science concepts can be embedded into a current issues dilemma.

Zig: Holy cow - did you read the paper yesterday about the people who were out in the field next to the school with bullhorns and signs? Seems like they were all worked up!

Zag: Really? What's the big deal?



Zig: Well, seems that the some people are all upset about the new power line they are installing that transports electricity from the power plant to the city.

Zag: So ... who cares?

Zig: Well, to start with, the homeowners along the field are furious. Many bought their homes without ever dreaming there would be a power line 200 feet from their house.

Zag: So why is that a problem for them? Don't they like the way it looks?

Zig: No. They think it is an eyesore. But in addition, they are concerned about the potential negative health effects.

Zag: So plant some trees so they are screened off from the towers. And what health effects Zig? Are they going to get zapped by the power line?

Zig: Trees might help the esthetics, but they are upset because they have to fork over the money to have them planted - the city or powerline company won't contribute.

Zag: Ok. But what about the potential negative health effects? Wait - I suppose this is another cancer causing scare, because it seems like everything else is these days.

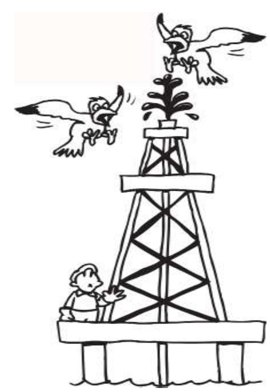
Zig: Well Zag. That is the main issue with the home owners. Some people are convinced power lines cause health problems, while the EPA report suggests there is no link between power lines and cancer.

(continued)

In another current issues dialogue for chemistry or environmental science, *19.3 Catching More Fish than Mercury*, Charlie and Sam are fishing and discussing mercury contamination in fish, and the potential dangers of ingesting too much mercury, sometimes from eating too much fish; a real dilemma in current times.

There are many science-based issues and ethical dilemmas connected to science. For example:

- the chemistry, economics and politics of ethanol production
- drilling for oil in ecologically-sensitive areas
- the chemistry utilized when fracking for oil
- overflow of sewage and untreated chemicals into lakes
- mining and the environmental impact of chemical drainage from mines
- gasoline additives, ozone levels and car emissions
- growth hormones in meat and dairy
- chemicals in ground water pollution
- Asian Carp invasion of the Great Lakes
- re-introduction of the wolf into new areas
- genetic testing and life decisions
- over-population of Whitetail Deer in urban areas
- to wear or not to wear a seatbelt
- cell phone use and cancer
- to wear a helmet while driving a motorcycle, or not
- the positives and negatives of using electric cars
- building code and the cost for structures that might be affected by earthquakes
- limiting levels of decibels concert attendees are exposed to because of hearing loss potential



Students need to mentally wrestle with issues like these, not only to understand the issues that face them now, but also to develop the skills necessary to improve how they deal with current issues, as well as their ability to resolve future issues. Dialogues can also be used to effectively model appropriate and professional discourse between people with conflicting views.

5. Dialogues can be **used for practicing communication skills, such as speaking, acting and listening -** Teachers know that in an ever competitive job market, communication skills are as important as any aspect with regard to securing and retaining a job. Outside of a job, communication skills are integral to many aspects of daily life. Therefore, an important goal of education is to develop and refine students' communication skills. Integral to the very strategy of using dialogues is communication skill development. As many students in school are masters in adopting a passive role and avoid engagement in the lesson (other than as an observer), it is critical to use strategies such as dialogues that will place them in an active role, a role that gives them an opportunity to develop their communication skills, and lessen their fear of communicating with others.

Dialogues place students into an active role and thus receive practice in speaking, listening, and acting. As all other students in class are in a similar position, taking part in the dialogue occurs in a low risk environment, so it is easier to join in, sheltered by the cacophony of voices in the room. Students who would never speak in front of the class will readily speak the character's lines in a dialogue.

6. Dialogues can be **used as an assessment tool to determine what students learned about the topic or unit -** students can develop and compose dialogues based on what they learned during a unit. Doing so exposes what they learned, and what they didn't learn, and misconceptions they may still embrace about the topic. There is much more information and tips on having students write dialogues in *Method 4* on pages 40 - 41.

How To Implement Dialogues in Your Classroom

As with most strategies, there are options for implementing dialogues, and they can be used in a variety of ways, depending on your goals for the lesson, including:

1. **Read and Act Out in Class** - students pair up, then each person takes on the role of one of the characters by reading that part of the conversation.
2. **Assign Reading As Homework** - the dialogue is assigned as homework reading so that students come to class with an introduction to the topic being studied in class.
3. **Assisting Language Learners or Poor Readers** - students listen to the audio version of the dialogue while reading along with the written copy.
4. **Assessing Learning** - students write their own dialogues to demonstrate what they know, don't know, or have learned from the lesson or unit of instruction.

Method 1 - Read and Act Out In Class

The teacher starts by asking the students to pair-up, and having each student take on the role of one of the characters by reading that part of the conversation. Let's imagine thirty students in class: picture fifteen pairs of students reading-acting the Pip and Pep parts of the dialogue. The goal of dialogues is to engage all students in the class in an activity that uses multiple senses, such as seeing, speaking and listening, but at the same time taps into parts of the brain that connect to kinesthetic and emotion, in an interchange centered around learning the content or material designated as important for that particular lesson or unit.

IMPORTANT! Modeling Expectations - When doing dialogues with students for the first time, the teacher should stress what to expect from students in terms of putting some energy into acting and reading the parts. As an example, the teacher might pair up with a student and read a few lines, using voice inflection, facial expressions, body motion, and gestures to bring life to the character. Student will then realize it is OK, and expected, to put some energy and fun into reading and acting out the character's role. Tell the students that they will get out of it what they put into it. Once they put some energy into being the character, they then realize it is so much more fun to portray the character and their actions, rather than simply reading the lines in a monotonous manner.

Using *dialogues* is actually quite simple. Here are the general steps:

1. Choose a dialogue that targets the content or process goals, and targets the objectives for learning. Does it meet the exact needs, or does it need to be modified to meet the needs and goals for the lesson?

2. Have students first read the dialogue silently. Note - If students are reading below their grade level, give them the dialogue the day before so they can practice reading the dialogue.

3. Put students in pairs, have them stand up, with space between groups.

4. Have students decide which character they will be first, and then act and speak their part of the dialogue.

5. [optional] Students should switch roles and act out the dialogue one more time. When it has been acted out twice, then students can return to their seats.

6. Students should then go through one more time on their own and underline or highlight all of the "facts" or key points about the chemistry topic.

Or

8. The teacher then might consider posing some questions that delve into the content embedded into the dialogue.

Or

9. The dialogue can then serve as a study or review sheet!

Summary of the above steps:

1. Students read the dialogue silently.
2. Students read the dialogue aloud with partner and act out the parts.
3. Then chose from options depending on the purpose of the lesson.

Method 2 - Assign Reading As Homework

The dialogue is assigned as homework reading so that students come to class with an introduction to the topic being studied in class. After students have read the dialogue, teachers have a number of options including: 1) pair up the students to help each other clarify the content within the dialogue, 2) have students underline key points in the dialogue to focus their attention what was important content, or 3) have students respond to teacher questions related to the dialogue in order to determine what students learned from reading the dialogue.

Method 3 - Assisting Language Learners or Poor Readers - Reading & Listening Along With mp3's

For students who are reading below their grade level, or for students who may be in bilingual or ESL classrooms, give students a copy of the dialogue, then play the audio version of the dialogue so the students can listen to the dialogue while reading along. Now teachers have a number of options that include: 1) pairing up the students and having them read the dialogue with a partner, without benefit of the audio support - doing so gives students more practice reading, 2) pair up the students to help each other clarify the content within the dialogue, 3) have students underline key points in the dialogue to focus their attention on what was important content, or 4) have students respond to teacher questions related to the dialogue in order to determine what students learned from reading the dialogue.

Method 4 - Assessing Learning By Having Students Write Dialogues

Having students write their own dialogues allows them to demonstrate their understanding of the topic, and is an indicator of what they know, don't know, or learned from the lesson or unit of instruction. Student-written dialogues can be one of the options for demonstrating what was learned. Writing a dialogue can be an assignment for all students, or it can be an opportunity to provide further evidence of learning for a portfolio, an extra credit project, or a challenge assignment for students who enjoy writing, or for students who need more practice writing. See dialogues *20.1 Bryce and Michel Muse About Molar Mass* (Chemistry) , *11.1 Classifying Rocks* (Earth/Space), and *9.7 Hip and Hop Develop Muscles and More Muscles* (Biology I) for examples.

Why?

- When students are writing a dialogue, they have to build the conversation using accurate notions of the science concepts and ideas; student-written dialogue reveals misconceptions and what the learner knows, or doesn't know.

- Creating dialogues promotes writing skills, as drafting a story line is something students rarely get an opportunity to do.

- Crafting a dialogue promotes creativity and fosters the use of imagination to develop a narrative between two characters.

- Students must learn something about the content in order to write an accurate dialogue. Their writing has to make sense and be an accurate reflection of the topic.

- Writing dialogues requires crafting a conversation and attempting to create a logical interchange using two different perspectives - a difficult, but a valuable thing for students to attempt. Many students function from an egocentric viewpoint. Therefore, writing a dialogue from two perspectives helps them break away from one viewpoint.

How?

- Assign specific topics and content to embed into the dialogue. For example, in earth science, assign a dialogue based on the geology of aquifers and have students incorporate the controversy of how irrigation systems lower the levels of aquifers and cause rifts between farmers and communities who draw their water from the aquifer (or vice versa).

- Give students parameters for length, number of characters, and a tips sheet for writing a good dialogue.

- Provide students with a scoring matrix that is going to be used to score the dialogues (see the following page for an example).

- Ask students to create a video of their dialogue exchange and submit it to the teacher.

For Students Writing Dialogues – Have you Included?

Desired Qualities	Point Value	Score
Is clearly written		
Addresses the targeted goals and intended outcomes		
Clearly identifies the setting		
Identifies the intended audience		
Targets desired content		
Written level appropriate for the intended audience		
The content knowledge is accurate		
Length of dialogue – not too long, not too short		
Uses humor (appropriate humor)		
Incorporates local, regional or state settings, issues or people		
Incorporates national or international settings, issues or people		
Deals with a significant issue or important topic		
Includes prompts for gestures or voice inflection		
Includes suggestions for props (when appropriate)		
Creatively written, interesting to read		
Other -		
Total Points		

Teacher Tips for Using Dialogues

Like every teaching strategy, there are things to do that will make the activity more effective and useful. For example:

- Be selective about which dialogues to do and how often to use them. Anything gets dull if overused.
- Encourage students to follow the prompts and act out the motions.
- Stress to students that this activity is entirely what they make of it – they can make it fun or boring – it's up to them.
- Provide props when appropriate; wearing a historically relevant hat helps the student assume the role of the character. Physical props that help to explain position or to give concreteness to ideas can be useful and often necessary in terms of the learner being able to understand the positioning or context of the situation. For example, using a sphere of some sort, representing the moon, allows the student to move the "moon" and show the other student what they are talking about as they act out their part.
- Expand the dialogue to be more than verbal: 1) Have characters conduct mini-experiments that provide data, 2) Give a picture or photo for making the words in the dialogue more concrete, 3) Use motion to provide a concrete link to the conversation, phrase or word in the dialogue.
- Perform a dialogue with younger students. A teacher and parent-helper, or older students can perform a dialogue for another class.

The Benefits of Using Dialogues In Your Classroom

Along with maximizing student engagement, there are a multitude of positive reasons for using dialogues. For example, dialogues:

- can be used at all levels of instruction, and in most subject areas.
- actively involve all of the students in the class.
- connect learning with social-emotional parts of the brain, therefore increasing the chances that the material will be retained by the learner.
- are a productive and energetic break from the normal routine of class.
- give students a chance to shine, when otherwise they do not.
- connect oral and written language to the use of objects, action and activities; students do something along with the dialogue, thereby magnifying the learning effect.
- encourage students to read material they might otherwise just skim.
- engage students in a fun and enjoyable way.
- provide an outlet for energy release by getting students up and moving.
- reduce the risk of participating because there is no whole-class audience.
- promote social interaction between reluctant students.
- put the material into the context of a story - it is often easier for students to remember material in the context of a story.
- can be used as an introduction to new material, or as a review of previously covered material.
- provide students with another source of information for studying and review.
- reach students via auditory, kinesthetic and visual learning modes.

Guidelines and Suggestions for Writing Your Own Dialogues

After experience with using dialogues in the classroom, you may find that you have a need for a particular dialogue that is tailored to your specific topic or students. Here are some suggestions for writing a dialogue on your own.

1. Clearly define the purpose of the dialogue. What is it that will be accomplished by using the dialogue? It might be a content goal, a process goal, a social skill development goal, or any other potentially desirable outcome found in typical lessons. The goal might be as simple, but valuable, such as giving students an opportunity to develop better listening skills or oral communication skills.

2. Set the context of the interaction – where and why is it taking place? Notice how some of the dialogues in this book begin with a narrative that sets the context for the conversation.

3. Consider putting a local or regional context to the dialogue. Developing a story line that takes place in the bayous of Louisiana may be more discrepant to students who live in Montana than a setting in which they already have some familiarity. On the other hand, one may have written the dialogue in that manner because it is the goal to develop an awareness of the geography, people, flora or fauna of the southern coastal wetlands.

4. Consider making it personal to the school or the town where the students live. Include local parks, stores, names of people such as the teacher. In the original form, the dialogues included in this book contained names of teachers or local places that made the dialogues more relevant to the classroom or local area. For example, instead of just “the river,” the original dialogue had the name of the local river that all students knew of, and instead of just “the teacher,” dialogues referred to Mr. Zimmer or Ms. Cattey. Instead of “the local ice cream shop,” the original dialogue spoke of the local “Scoops Ice Cream Shop.” It is worth the time to modify dialogues to personalize them to the local area or local personnel. In some dialogues there has been a space left to insert the teacher’s name.

   Perhaps poke light-hearted fun at the teacher (but not at students) and before inserting another person’s name, obtain their permission and blessing. When using their name, let them read the dialogue and get their stamp of approval prior to using the dialogue.

5. Use fictional characters, historical figures, real or imaginary people, animals or plants.

6. Use appropriate word choices for the targeted grade level.

7. Tailor the dialogue to fit the needs of the students (vocabulary, use of props, use of objects and animated gestures and motions).

8. Pick one topic and stick to it – an entire chapter three will not fit into one dialogue.

9. Write the dialogue so that what one person says impacts what the other person says.

10. Consider from whose point of view the conversation takes place (might use a giraffe, human, plant, fish, etc.).

11. Total length is important – don't make it too long. Consider one to two pages of dialogue maximum.

12. Limit the length of one particular interchange, or one person's statement. One character's turn to speak should not be too long.

13. Use shorter sentences for young children.

14. Some teachers write these at a level slightly higher than the verbal levels of their students, and pair up with another teacher to act these out in front of their class.

15. Incorporate pictures as deemed useful or necessary.

16. Use clues and prompts for acting to help the interchange proceed, and for the characters to develop a colorful demeanor.

17. Double-check the content knowledge embedded into the dialogue – is it correct?

18. Incorporate a sense of humor, or a sense of seriousness, when appropriate.

19. Dialogues often work best when involving two people, but for some scenarios one might choose to use three or four people.

For Teachers Writing Dialogues – Have you Included?

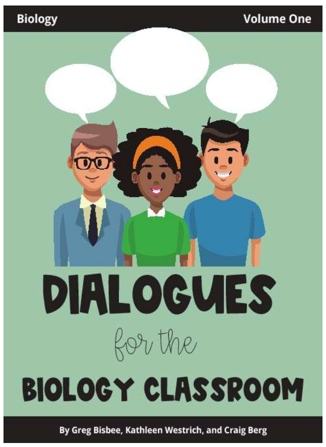
Choose and use the criteria pertaining to the desired outcomes for the students.

- Clearly identifies the setting
- Targets desired content
- Targets desired social skill
- The content knowledge is accurate
- Uses humor (appropriate humor)
- Length of dialogue – not too long, not too short
- Describes the intended audience and contains a suggestion for grade level use
- Is clearly written to address the targeted goals and intended outcomes
- Written at an age-appropriate level for the intended audience
- Incorporates local, regional or state settings, issues or people
- Incorporates national or international settings, issues or people
- Deals with a significant issue or important topic
- Includes prompts for gestures or voice inflection
- Includes suggestions for props (when appropriate)
- Creatively written, interesting to read

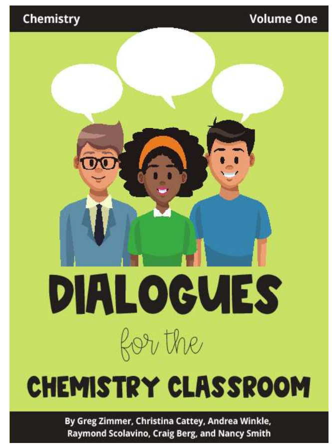
Section III - Example Dialogues

This section contains the Table of Contents, Abstracts and sample dialogues for the various volumes of science dialogues. Looking through the Table of Contents and the Abstracts will help to uncover the multitude of dialogues that can be incorporated into your science instruction, and the samples provided will make it easy to test out and witness the effectiveness of dialogues, and see first-hand the student enthusiasm for wanting to do more of them.

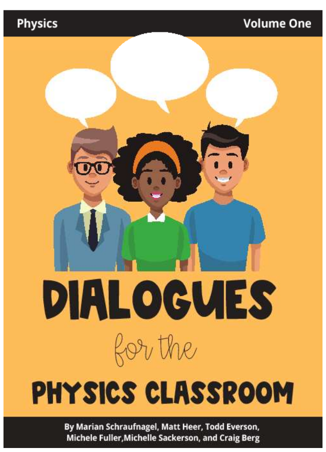
Biology I



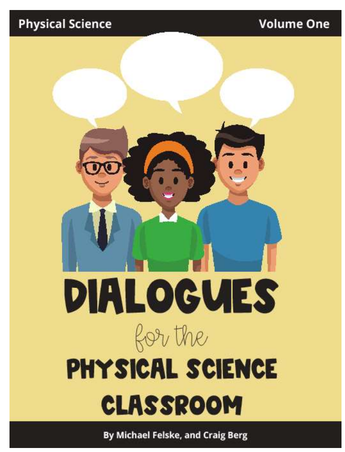
Chemistry I



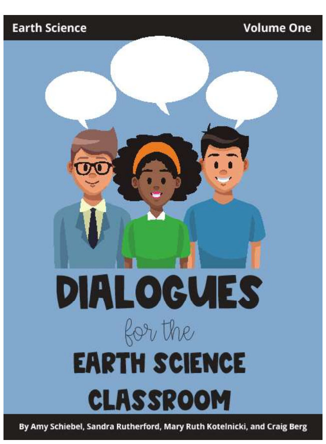
Physics I



Physical Science I



Earth Science I



Biology

Volume One

DIALOGUES for the BIOLOGY CLASSROOM

By Greg Bisbee, Kathleen Westrich, and Craig Berg

Biology I - Table Of Contents

Biology I Dialogue Abstracts

Unit 1 - An Introduction to Biology

1.1 Pip and Pep Discuss the Finer Points of Dialogues - Pip and Pep talk about the ingredients of a dialogue and how they work. Reading this dialogue will give you an insight into what dialogues can do for students. This is not a dialogue for students; we use this dialogue to introduce other teachers to dialogues. Reading it first will give you a better notion of how dialogues work and why you should consider using them.

1.2 Pip and Pep Begin Biology - An Introduction to Dialogues: Students discuss what is coming up in biology class using *Dialogue*s for the first time and find out that *Dialogues* are like a short two-person play.

1.3 Riff and Raff and the Meaning of Life: What do all living things have in common? Riff and Raff discuss what it means to state that something is "living."

Science terms or concepts include the following: breathe, skeleton, mushroom, bacterium, sponge, fungi, photosynthetic autotroph, reproduction, species, organisms, DNA, sexual and asexual reproduction, genetic code, homeostasis, environment, populations.

Unit 2 - Research and Science

2.1 Pip and Pep Analyze Statistics: Pip and Pep discuss the importance of math and statistics in research and data analysis.

Science terms or concepts include the following: placebo, biologically inactive, experimental and control groups, mean, median and mode, measures of centrality, dispersion, variance, standard deviation.

2.2 Hip and Hop Do Research: Hip and Hop were assigned to research a particular infectious disease for biology class and begin a discussion in the lunch room about this project. Hop is excited about guinea worms and Hip, who was handed malaria, is not too thrilled. They learn about reliable resources when doing scientific research and which resources might be more reliable than others.

Science terms or concepts include the following: reliable sources, epidemiology, interlibrary loan, wiki, locally accessible databases.

Teaching Note: If you want to take advantage of the positive effects of humor in the classroom, consider using Abbot and Costello's "Who's On First," a great video to show students after they have completed dialogue 2.2.

Unit 3 - The Chemistry of Life

3.1 B&B Contemplate Life – A Dialogue About Biomolecules: Bing and Bong are consuming ice cream and talking about how chemistry and biomolecules such as DNA, carbohydrates, proteins and such are a part of living and, therefore, included in the study of biology.

Science terms or concepts include the following: cells, membranes, organelles, molecules, atoms, digestion, diffusion, hormones, carbohydrates, fats, starch, oils, protein, biomolecules, lipids, nucleic acids, polymers and monomers, hydrolysis.

3.2 Water Ya Know – A Play in One Act: Zip and Zap are sitting at an outdoor café overlooking the local river, drinking ice tea, and discussing who was the greatest superhero, when Zip decides to direct the conversation toward the importance of water and the properties that make it such a valuable molecule for living things.

Science terms or concepts include the following: properties of water, melting point, boiling point, Celsius scale, phases, specific heat, evaporation, temperature regulation, thermometer, transpiration, density, hydrogen bonding, polar molecule, crystalline structure, surface tension, cohesion.

3.3 Act I – Democritus and His Dog – What is "Stuff" Made of?: Democritus is sitting outside on a bench with his hungry dog, Titan, discussing what things are made of. Democritus explains to Titan that all things are made of "matter," of course, and that everything can be broken down to the smallest part called an atom. While Titan shows some interest, he naturally turns his attention back to his stomach and getting some food.

Science terms or concepts include the following: invisible particles, matter, relative size of atoms.

3.4 Pip and Pep Converse About Chemistry: Pip and Pep are hanging out in their former physical science classroom thinking about the good old days when they thought physical science was cool, but hadn't really had a taste of cool until experiencing biology class. They begin to realize how their success in biology was founded on things they did in physical science class. Students can locate as many as 29 science terms in this story.

Science terms or concepts include the following: chemistry word search.

3.5 B&B Analyze Atoms: Bing and Bong are at the Custard Shoppe where Bong is juggling and he confesses that he still doesn't understand atoms. Therefore, Bing proceeds to tutor Bong to remediate his lack of understanding of this foundational aspect of science knowledge.

Science terms or concepts include the following: atoms, protons, electrons, neutrons, periodic table, purified, chemical symbol, molecule, compound, chemical bonds, ionic and covalent bonds, polar covalent bond, charges, polar molecule.

3.6 Pip and Pep Contemplate Enzymes: Pip and Pep discuss enzymes and how critical enzymes are for speeding up reactions and breaking down food.

Science terms or concepts include the following: enzymes, history of enzyme discovery, proteins, catalyst, substrate, reaction products.

Unit 4 - Cells

4.1 Wei and Noé at the Movies: Wei and Noé have just watched the movie *The Blob* and they discuss how the movie relates to biology class in terms of respiration and diffusion of gases across a membrane. Version 1 and Version 2.

Science terms or concepts include the following: respiration, diffusion, membrane, biological gas exchange, molecule, calculating the diffusion coefficient, surface area to volume ratio.

4.2 As the Cell Divides – A Cell Cycle Drama: Hip and Hop are in the science lab looking through microscopes at cells, discussing the cycle of cell division.

Science terms and concepts include the following: DNA, nuclei, chromosomes, mitosis, cytokinesis, proteins, organelles, replicate, asexual, cell division, mitosis, cell cycle.

4.3 The Life and Divide of Cells: Zip and Zap are in the dorm room, studying cell division for the upcoming biology exam.

Science terms and concepts include the following: mitosis, daughter cells, DNA, phases, chromosome, diploid, haploid, sperm, egg, gametes, meiosis, phases and process of cell division.

4.4 Pip and Pep Discuss the Snail-Elodea Lab: Pip and Pep are at the coffee shop, talking about the snail-elodea lab and clarifying the point of the lab, which was to look at photosynthesis and respiration in action. This dialogue is used to reinforce the concepts of the lab that students have just completed. A copy of a respiration and photosynthesis lab from Flinn Scientific can be found at www.flinnsci.com/documents/demopdfs/biology/bf0141.00.pdf

Science terms and concepts include the following: relationship, cellular respiration, energy, waste products, photosynthesis, indicator.

4.5 Wei and Noé Contemplate Floppy Carrots: Wei and Noé are planning a big biology party and are puzzled because the veggies have lost their crispness and are now limp. They need to fix this problem quick before their guests arrive.

Science terms and concepts include the following: diffusion, osmosis, higher and lower concentration, membrane, molecules.

4.6 Cell Organelle Project: This is an assignment that can be given to biology students for which they can write a dialogue to demonstrate their understanding of cell organelles.

Science terms and concepts include the following: cell wall, chloroplasts, cytoplasm, cytoskeleton, endoplasmic reticulum, golgi bodies, lysosomes/peroxisomes, mitochondria, mucleolus, nucleus, ribosomes, vacuoles, cell organelles.

Unit 5 - Genetics

5.1 Wei and Noé Discuss DNA: Wei is working as an histologist's assistant and Noé walks in and a discussion of Wei's job leads to more conversation of genomes and DNA.

Science terms and concepts include the following: histology, proteins, genome equivalence, cells, zygote, mitosis, chromosomes, daughter cells, genetic engineering, hypothesis of genome equivalence, cloning.

5.2 Riff and Raff Find (Gene) Expression: Riff and Raff are preparing for the upcoming biology quiz and discussing protein synthesis. A question sheet is included.

Science terms and concepts include the following: protein synthesis, proteins, gene expression, amino acids, ribosomes, transcription and translation, nucleic acid, RNA, chromosomes, genes, trait, cytoplasm, messenger RNA, codon.

5.3 B&B and the Elusive Epigenome: Bong's recitation of lines of Shakespeare fosters a review of DNA and discussion of how environmental factors can change methyl group arrangement and therefore gene expression.

Science terms and concepts include the following: epigenome, gene expression, DNA sequence, molecule, gene messenger RNA, ribosomes, proteins, methyl groups, methylation patterns, inherited, variation, gene expression, epigenome, DNA replication.

5.4 The Mysterious Case of Puerperal Fever - A Historical Dialogue: It is the 1800's and a deadly disease call Puerperal Fever is killing women who are delivering their babies in hospitals. Dr. Ignac Semmelweis' beliefs about the cause of this disease differs from those of his supervisor, Dr. Johann Klein, and Semmelweis works to determine the real cause of the disease.

Science terms and concepts include the following: disease, fever, death rate, child birth, midwives, transmission, misasma theory, epidemic, disease particles, symptoms, cadaver, autopsies, dilute, solution, procedure.

5.5 Pip and Pep Discuss DNA, Cookbooks and Analogies: Pip and Pep are pondering their biology assignment which takes them into the perplexing world of the structure and composition of DNA. This introduces the vocabulary used in DNA by using analogies and also stresses using diagrams to study.

Science terms and concepts include: codon, gene, chromosome, genome, double helix, protein, bases, amino acids.

5.6 Discuss DNA Replication: Bing and Bong are in the library studying DNA replication and attempting to clarify the process.

Science terms and concepts include the following: double helix, molecules, replication, enzyme, hydrogen bonds, nitrogen base, nucleotides, biotechnology, DNA replication.

5.7 Wei and Noé Dissect DNA: Our two friends have been learning about DNA and are preparing for the upcoming quiz. Noé quizzes Wei on some important key facts about the structure of DNA.

Science terms and concepts include the following: nucleotide, phosphate, nitrogen base, DNA, monomer, polymer, complementary bases, Chargaff's Rule, structure and components of DNA, genome equivalence.

5.8 Wei and Noé Discuss Meiosis: Wei and Noé are in the biology room and begin to discuss the details of meiosis, while making comparisons to mitosis, which they studied last week.

Science terms and concepts include the following: mitosis, meiosis, DNA, chromosomes, daughter cells, synapsis, homologous chromosomes, sperm and egg cell, fertilized egg.

Unit 6 - Classification and Evolution

6.1 Wei and Noé Discuss the Science of Classification: Wei and Noé are in the biology room, looking through the syllabus and scanning the topics they will be studying, when Noé pauses and wonders what taxonomy is all about. Wei and Noé realize they know much more about classification than they realize.

Science terms and concepts include the following: taxonomy, species, Linnaeus, kingdoms, classification, taxonomy, species definition, scientific names.

6.2 Pip Helps Pep's Thinking Stretch: Pip and Pep are at the zoo focusing their attention on the very long necks of the giraffe. Pip tutors Pep on how that feature is an example of natural selection.

Science terms and concepts include the following: evolved, natural selection, variation, camouflaged, generations, fittest, how genetic variation gives individuals an advantage over other individuals and how the fittest individual contributes to natural selection in populations over time, evolution.

6.3 Pip and Pep Meet a Mythical Creature: Hiking on forest trail, our two adventurers come across an unknown creature and use their stellar biology skills to try to classify this creature.

Science terms and concepts include the following: kingdom, phylum, class, order, family, genus, species, muticellular, prokaryote, archaebacterium, eubacterium, eukaryote, domain, animalia, plantae, protista, fungi, photosynthesize, cell walls, cell membranes, chordata, vertebrate, reptilia.

6.4 The Amazing History of Taxonomy: In this dialogue scientist 1 and scientist 2 are discussing the need for a system of naming living things in order to reduce the confusion resulting from multiple and differing names for the same single organism.

Science terms and concepts include the following: taxonomy, kingdom, phylum, class, order, family, genus, species, Animalia, Plantae, Fungi, Protista, Monera, Archaebackteria, Bacteria, Eubacteria, Eurkaryote.

Unit 7 - Viruses

7.1 Hip and Hop Catch Up on Viruses: Hip and Hop are out on a Saturday night for a meal and a movie, looking forward to the horror film showing the spread of a bioengineered virus that turns its victims into angry, blood-thirsty vegetables. However, Hip is not as thrilled as Hop is, as he begins to feel queasy, but they share what they know about viruses and how they compare to other living things.

Science terms and concepts include the following: viruses, cells, homeostasis, parasitic, DNA, RNA, protein, ribosomes, cytoplasm, characteristics of viruses and characteristics of living things

7.2 Pip and Pep Talk About Sex!: Pip and Pep are hanging out and find themselves talking about prokaryotes, bacteria and sex.

Science terms and concepts include the following: monerans, prokaryotes, nucleus, sexual reproduction, asexual, binary fission, DNA, horizontal gene transfer, horizontal gene transfer, sexual versus asexual reproduction.

7.3 Wei and Noé - Night of the Living Prions: Our two characters are hanging out and talking about an article that Noé is reading, which focuses on prions and Creutzfeldt-Jakob disease. This scares the two and they discuss how the protein folds are affected and the seemingly zombie-like states that result from misfolded proteins.

Science terms and concepts include the following: prions, proteins, DNA, RNA, TSE particles, nucleic acids, Creutzfeldt-Jakob disease, chronic wasting, enzymes, plaques.

7.4 Wei and Noé: Prions - The Sequel: Wei and Noé are back to talking about prions, this time, how prions are beneficial to living organisms, with a bit of the nature of science thrown into the discussion.

Science terms and concepts include the following: prions, proteins, abnormal folding, genetic diversity, biofilms, hormones, nature of science.

Unit 8 - Plants

8.1 Pip and Pep Admire the Festive Fall Foliage: Pep convinced Pip to join the cross-country team, and our friends are doing their after-school workout admiring the beautiful fall foliage and discussing leaf color change.

Science terms and concepts include the following: pigment, chlorophyll, anthocyanin, abscission layer, hormones, why and how leaves change color, and why leaves fall from the tree.

8.2 Zip and Zap Look at Leaves – Part I: Zap is standing in the local school prairie area, thinking about the biology lab and looking confused when Zip walks up and they begin to discuss the marvels and characteristics of plants.

Science terms and concepts include the following: epidermis cells, symbiotic, stomates, photosynthesis, evaporation, structure and function of plant leafs, the leaf surface.

8.3 Zip and Zap Still Looking at Leaves – Part II: Zip and Zap have shrunk down to the size of single cells and have entered the plant leaf through the stomata and are touring the inside of the plant leaf.

Science terms and concepts include the following: epidermal cells, palisade and spongy mesophyll cells, cuticle, epidermis, photosynthesis, structure and function of plant leafs, internal leaf anatomy.

8.4 Wei and Noé Search for Buried Treasure!: Wei and Noé have been sent out into the field to search for the seed bank at the prairie restoration area. Noé is confused and thinks they are looking for buried treasure, so Wei has to clarify the intent of the assignment and help Noé understand the critical importance of seeds and dispersal.

Science terms and concepts include the following: seed bank, dormant, photosynthesis, habitat, flowering, seeds, germinate, sprout, species, seed dispersal, seeds as an energy source for other critters.

8.5 Wei and Noé Talk About Separation: Wei and Noé are walking along the local river and Wei is consoling Noé about being separated from her “binky” blanket, which takes them into a discussion about separation and chemicals during the process of chromatography.

Science terms and concepts include the following: leaf pigments, paper chromatography, molecules, chromatography, chemical separation according to molecule size, various methods of chromatography.

8.6 It’s A Seedy Business: Wei and Noé are working on a group project for biology class, designing a plant that fits into a particular habitat.

Science terms and concepts include the following: characteristics that aid in survival, seed dispersal.

Unit 9 - The Human Body

9.1 Your Epidermis is Showing!: Pip is reading on a park bench when Pep walks by. Pip jokes to Pep that his epidermis is showing, which spurs another tutoring session by Pep on skin structure and function.

Science terms and concepts include the following: epidermis, integument, melanin, pigment, keratin, protein, immune system, dermatologist, dermis, hypodermis, subcutaneous, structure and function of skin.

9.2 I Vant to Suck Your Blood: Riff and Raff are on a self-guided tour of a castle in Transylvania, thinking and talking about Dracula, when they discuss the components and importance of blood.

Science terms or concepts include the following: blood, tissues, organs, red cells, white cells, platelets, plasma, biconcave cells, capillaries, oxygen, nutrients, wastes, kidneys, urine, lungs, carbon dioxide, proteins, germs, bacteria, viruses, immune system, pathogens, what the various components of blood do for the living individual.

9.3 Hip and Hop Love Them Hot Wings!: Hip and Hop are out at their favorite restaurant called "Nothing But Chicken." As they order their meal of wings and drummies, Hop decides to expound on all he knows about ligaments, bones and skin. (Note - also copy the one-page handout included.)

Science terms and concepts include the following: ligaments, cartilage, subcutaneous, fat, tendons, muscle, and numerous names of specific bones and skeletal structures, general structure of various skeletal components and connective tissues.

9.4 The Romance is Gone: Hip and Hop are at the local mall looking for Valentine's cards, which begins a conversation about hearts and how blood flows through the heart and picks up oxygen. (Note - also copy the one-page handout included.)

Science terms and concepts include the following: vessels, valves, heart, chambers, amphibians, mammalian, hemoglobin, lungs, atrium, vena cava, aorta, pulmonary, ventricle, heart structure, blood flow through the heart and how blood gets oxygenated.

9.5 Zip and Zap Tour The Alimentary Canal: Zip and Zap are eating ice cream at the amusement park talking about their last ride on a water roller coaster, something called the Alimentary Canal. Zip decides to expound on his knowledge of the digestive tract and uses the stages of the ride to relate to the digestive tract and tutor Zap in the process.

Science terms and concepts include the following: organ, digestive tract, esophagus, stomach, proteins, mucus, small intestine, carbohydrates, lipids, large intestine, kidneys, urine, structure and processes involved when food enters and moves through the digestive tract or the alimentary canal.

9.6 Ehh and Pee - Measurement in Science: Anatomy students, Ehh and Pee, are discussing units of measurements and various systems of measurements before they begin measuring, charting and graphing various body spans.

Science terms and concepts include the following: systems of measurements, standardized systems, International System of Units, data gathering, analysis and graphing.

9.7 Hip and Hop Develop Muscles and More Muscles: Hip and Hop are in the gym, discussing losing weight, burning off fat, and working their muscles.

Science terms and concepts include the following: antagonistic muscle pairs, cardiovascular exercise, contract, relax, muscle fibers, skeletal muscle, smooth muscle, cardiac muscle,involuntary, voluntary

9.8 Zip and Zap - An Antagonistic Pair: Zip and Zap are feeling the effects of eating too much at Thanksgiving when the hit they gym and begin talking about how muscles work in pairs.

Science terms and concepts include the following: antagonistic muscle pairs, contraction, relaxation, various muscle names

9.9 Pip and Pep Ponder Boogers and Breathing, Form and Function: From spoons to nose hairs to boogers, Pip and Pep are talking about the relationship between form and function. (A good follow up article regarding the shape of the outer ear and hearing can be found at http://discovermagazine.com/1999/feb/whatsapinnafor1596)

Science terms and concepts include the following: structure, form, function, and the relationship between form and function.

Unit 10 - Ecology

10.1 Wei and Noé Discover the Prairie: Wei and Noé are discussing the historical loss of prairies, prairie restoration, prairie plant characteristics and diversity of life in the prairie.

Science terms and concepts include the following: biomass, ecosystem, native species, invasive species, diversity, characteristics of prairie plants and diversity of life in prairie ecosystems.

10.2 Pip and Pep and the Tragedy of the Commons: In 1968, Garrett Hardin initiated the concept of the “commons” which has now expanded to include biology, economics and mathematics. Pip is helping Pep understand this concept.

Science terms and concepts include the following: sharing of resources in a commons.

10.3 Zip and Zap in a Showdown: Our two friends are studying biology and break for pizza when Zap uses this opportunity to explain the details of an ecological niche.

Science terms and concepts include the following: ecology, ecological niche, organism,habitat, host, parasites.

10.4 B&B Discuss the Patterns of Populations: Bing and Bong are eating lunch as they discuss the concept of populations.

Science terms and concepts include the following: populations, nutrients, organism, environment, doubling time, limiting factors, density-dependent, density-independent, carrying capacity.

10.5 Pip and Pep Predict Populations: Pizza seems to give our two friends extra insight into concepts of biology. In this case, Pip and Pep are chewing on the idea of using quadrats to sample and then predict populations.

Science terms and concepts include the following: sampling, estimating populations, quadrats, proportions, density of species, random samples.

10.6 Hip and Hop Enjoy Cycling: Hip and Hop are riding their bicycles and venture off into a discussion of the various biogeochemical cycles that are important in the natural world.

Science terms and concepts include the following: biogeochemical cycles, water cycle, xylem, photosynthesis, turgor pressure, molecules, diffuse, stomates, evaporation, transpiration, humidity, carbon cycle, nitrogen cycle, phosphorus cycle, glucose, energy, cellular respiration, aerobic.

Unit 11 - Miscellaneous

11.1 Pip and Pep Go To Open House: This Pip and Pep dialogue is designed to be used when parents attend an open house. When reading the dialogue, parents are introduced to the course description, goals, syllabus and grading policies. This helps parents understand what the course is about and by reading the interesting introduction via a dialogue.

11.2 Pip and Pep - Conversations Concerning Creative Controversy: This is a dialogue we used to introduce a teaching strategy called Creative Controversy, also call Structured Controversy, in which students wrestle with the pros and cons of a science-based issue or ethical dilemma. See the Framework Module called *Biology - Issues and Ethical Dilemmas*.

1.1 Pip and Pep Discuss the Finer Points of Dialogues

Pip and Pep are two high school science teachers who LOVE science. Even as best friends growing up, it seemed that they were always discussing the wonders of science. Now that they are both science teachers, their love for science has only grown (isn't that a heart-warming story?)! We find our pair of extremely enthusiastic educators at the event of the year—the State Science Teachers Conference.

Pep: *[looking around at the room]* Wow, Pip…this conference is really impressive. Everything is so…***professional!*** But…what are all these people doing here?

Pip: *[rolls eyes]* Pep…these people are here to hear us talk about dialogues, remember?

Pep: What?!?! You told me we were coming here for pizza and soda! I don't remember you saying anything about a presentation!

Pip: Now calm down, Pep. You know this stuff! We're just going to talk about using dialogues in science class.

Pep: Oh, science! I could talk about science all day. You know that there are two kinds of teachers, right?

Pip: Uh…elementary and secondary? *[looks at Pep questioningly]*

Pep: Noooo…science teachers and teachers who WISH they were science teachers!

Pip: I'm sure you believe that, Pep. But let's stick to the topic—dialogues! I suppose we should begin by telling everyone what dialogues are.

Pep: That's probably a good place to start. A dialogue is a scripted discussion about… well, **anything!** It's really just a mini-play *[dramatically]*… **a drama !**… **a comedy !**… **a tragedy!**

Pip: *[under her breath]* Talk about drama…

Pep: I love to use dialogues in the classroom to **preview** a unit and give the students an overview of the topic…and to get them excited about the upcoming material.

Pip: I also like to use dialogues **during** the unit to reinforce learning and to check for understanding. Using them at the **end** of the unit is a great way to summarize the material and wrap it all up. I can focus my students on the things they should have learned!

Pep: That's right! And, dialogues have an esteemed history as an educational tool—they were used by great scientists and teachers such as Plato and Galileo.

Pip: Dialogues are so useful in the classroom. The science-y students love the content and the humor of a well-written dialogue.

Pep: And the English lit/drama kids love it because it's like a mini-play. They get to act it out and be all drama-y!

Pip: I like dialogues because they get every student involved in the discussion. You know how you always have those really quiet students who just don't want to talk?

Pep: *[nostalgically]* Yeah…I was one of those.

Pip: What?!? Pep, remember me? We went to school together…you were NEVER one of those kids! Usually, the teacher couldn't get you to **stop** talking!

Pep: Well… we'll just have to agree to disagree on that point.

Pip: *[rolls her eyes]* Sure, Pep. Anyway, dialogues give **those** students a chance to participate anonymously—since everyone in the room is talking at the same time, no one really stands out.

Pep: That's right! Dialogues give students a chance to practice their reading skills in a non-threatening environment. Just about every one of my students seriously needs practice with reading.

Pip: You said it! And the great thing is that, when they are done, they have a note sheet. Since I wrote it, I am sure that the material is correct and focuses on the points that I feel are important.

Pep: And, it's so much more personal than something from a textbook. And…no offense to the hard-working textbook authors…it's **a lot** more fun to read.

Pip: Right you are! I insert references to local places and people to make it more individualized. For example, using the local burger joint or ice cream shop as a setting gives my students a personal link to the dialogue.

Pep: Absolutely! I often put something in there that refers to events at school…or to the fact that I'm such an incredibly interesting, funny, and hard-working teacher!

Pip: *[not convinced]* Uh huh…anyway, dialogues are such a useful educational tool for the classroom, it will be easy to talk about how to use them effectively with students.

Pep: OK…fine…you've convinced me. I'll do the presentation with you. But you still owe me pizza and soda afterward!

Author - Greg Bisbee

1.2 Pip & Pep Begin Biology: An Introduction to Dialogues

This is a play. Until now, the usual way to encounter a play was for a large audience to sit and watch as a small number of actors performed. This seems very passive to me. So instead, everyone will perform the play simultaneously while a single person (me) watches the performances. While this play may not be as dramatic and engaging as Romeo and Juliet or Days of Our Lives, it is a play nevertheless, and plays are meant to be acted. So don't just read the words in some ho-hum tone of voice. Enter into it! Become your character! And follow the stage directions, too!

Pip and Pep are two high school sophomores who have just entered the wonderful world of biology.

Pep: *[with a look of excitement]* Pip!!! You're in this class, too?

Pip: *[also excited]* Yes, I am Pep. How fortunate that the two of us have the same biology class. Now we will be able to talk about our favorite topic—biology—all the time!!

Pep: I hope we get to sit in the front row! That's the best place in the whole room! Then we can be right up front to hear about all of the exciting biology! I've heard that ____________________ (teacher's name) is the best, funniest teacher in the whole school!

Pip: And to have our teacher _________________ AND biology together…what could be better? But I have to admit that I'm not sure what this class includes. Classes like physics and chemistry are small, insignificant sciences so it is easy to cover those during a semester or year course. But biology is nearly EVERYTHING… how do you cover all that in one course?

Pep: You're right Pip. You can't possibly cover all of biology in one course or even in one lifetime. This is a SURVEY course.

Pip: A survey? Alright!! I just filled out a survey at the mall last weekend and now I'm in a drawing to win….

Pep: *[interrupting]* Pip! You are so dense sometimes. A survey course is one that covers many things, but only a little bit. We just won't go really in-depth about any one topic.

Pip: Oh…of course. So that means that we'll collect bugs, and monitor plant populations, and study single-celled pond critters, and…

Pep: *[interrupting*] Yes, yes, yes…but not just outdoor stuff, Pip. A lot of biology takes place inside—in the lab. Look at all the DNA work, and using microscopes, and computers, and cell biology, and dissections, just to name a few.

Pip: OK, I get the point…biology is done all over the place!

Pep: Bingo, Pip! *[gets a thoughtful yet puzzled look on his face]* But I have a question: Even though I love biology—who wouldn't?—what good is it if I'm not going to be a biologist?

Pip: Are you kidding?! Biology is almost EVERYTHING!!! If you are an athlete, or a parent, or have parents you will have to make all kinds of decisions during your life that will involve biology. Some of them may be life-and-death decisions… hopefully, most of them won't be. A basic knowledge of biology is essential for getting by in today's society. And there are thousands of jobs that depend on a very thorough knowledge of biology.

Pep: That's right…like doctors, nurses, veterinarians, physical therapists, physical trainers, nutritionists, foresters, marine biologists, microbiologists…

Pip: *[interrupting]* Aren't those just really small biologists?

Pep: *[looking a little irritated]*…pharmacists, researchers, brewmasters…

Pip: *[interrupting again]* What's that? Brewmasters? Pep, I think your brain turned to mush during the summer. Why would someone who makes beer need to know about biology?

Pep: Well, Pip…beer is made using yeast. Yeast is a single-celled organism that converts sugars into alcohol and carbon dioxide. So you need a very good knowledge of yeast and the conditions necessary for it to survive and flourish!

Pip: *[a look of "oh, I see!"]* Oh, I see!!! I guess that makes sense. So biology IS an important subject. But I've heard that this is a really hard class…what if I struggle with some of the material?

Pep: No problem! All sophomores take biology so there are lots of students around who would love to help you out. Plus, I've heard that our wonderful teacher is very happy to help out when students are having trouble.

Pip: Well that's good to hear! AND, s/he is available

- before school,
- ___________,
- ___________,
- ___________, and
- after school.

Pep: *[looking toward the door]* Oh…here comes ______________ (teacher's name). I just LOVE biology!!!

Author - Greg Bisbee

2.1 Pip & Pep Analyze Statistics

In this exciting exchange, Pip and Pep talk about the importance of math and statistics in research and in data analysis.

Pip: Hey, Pep! What are you up to? You look like you're really into that article.

Pep: Hi Pip! I was just reading this article in the newspaper about a medical study and a new drug that they're testing.

Pip: You look a little confused…is there something that you don't understand about it?

Pep: Very perceptive, as usual, Pip. I understand the article but I have one question. They give half of the patients in this study the new drug and they give the other half a sugar pill—they call it a placebo. So…half of the patients don't even get the medication!

Pip: That's right! It's because of something called the placebo effect. The human brain is a very powerful thing, Pep. Doctors found out a long time ago that if a person thought they were getting a strong medicine, that they felt better. It didn't matter what they took but the fact that they really believed that it would help them that made the difference.

Pep: So, if you are testing a new drug, you also have to give a placebo—a biologically inactive substance—to compare with to make sure that the cure isn't simply all in the mind. But that's not my question. In some studies, the difference between the drug and the control is really huge—there's no doubt that the drug works. In other studies, there's not that big a difference between the two groups. How do doctors and scientists decide if there's a big enough difference between the ex perimental group and control group to say something works?

Pip: Wow! That's a great question, Pep! And that, my friend, takes us into the wide, wide world of statistics. Prepare yourself for an exciting journey, my fellow math traveler.

Pep: *[looking unimpressed]* Math…exciting…uh huh. Lead away, Pip.

Pip: Statistics is a big field, Pep. Because results and data can come in so many different forms, you can't just use one statistical analysis for everything. Even when a scientist knows what he or she wants to study, he often has to design the research in a certain way to be able to analyze the results in a meaningful way.

Pep: I happen to know some statistics, Pip. We've already learned about mean, median, and mode in math class. Those are all measures of centrality. They look at where the middle of the data is—just in different ways.

Pip: Exactly, Pep. The other factor reported in data is the dispersion. This tells us how spread out the data is. Examples of dispersion are variance and standard deviation. And all of this is used to describe the data that we have collected. In fact, take a look at the two data sets on table 1. What do you notice about them? *[they both look at the accompanying data sheet].*

Pep: Uhhhhh…they are a bunch of numbers?

Pip: Well, they are…but let's look more closely. You figure out the average (or mean) of the first data set and I'll figure out the average for the second data set. *[Pip and Pep do this]*.

Pep: *[proudly]* My data averaged 7.0! How about yours, Pip? Can you beat a 7.0???

Pip: Oddly enough, mine also averaged 7.0, Pep.

Pep: *[shocked]* What???! How can that be? Look at the data!!! My data was a very nice, orderly set…yours was all over the place! How can they be the same???

Pip: I think that is the point _______________ (teacher's name) is making in giving us this exercise, Pep. The data is NOT the same. While they may have the same mean, that's just one part of it. The second factor—dispersion—is very different.

Pep: Oh….I see what you are saying, Pip. So how do we look at the dispersion factor?

Pip: Let's take the data from Table 1 and look at it a little differently. Take the numbers from each data set to fill in Table 2. For example, since there were no values (numbers) from 0 to 4 in the first data set, write zeroes in those spaces. There was one value of 5, there were two 6's, and four 7's…so we'll fill in those numbers. *[Pip and Pep fill in Table 2].*

Pep: Hey, ____________________ (teacher's name) was nice enough to provide us with a blank graph so we can easily graph the data!!! S/he is such a thoughtful teacher!!! *[Pip & Pep graph the data on the graph provided].*

Pip: What does the graph tell you, Pep? How would you interpret it?

Pep: It's hard to believe that the two data sets have the same averages…they look so different!

Pep: So what you're saying is that the right statistical test would tell me if the differences between the drug group and the placebo group are significant.

Pip: Right you are, Pep.

Author - Greg Bisbee

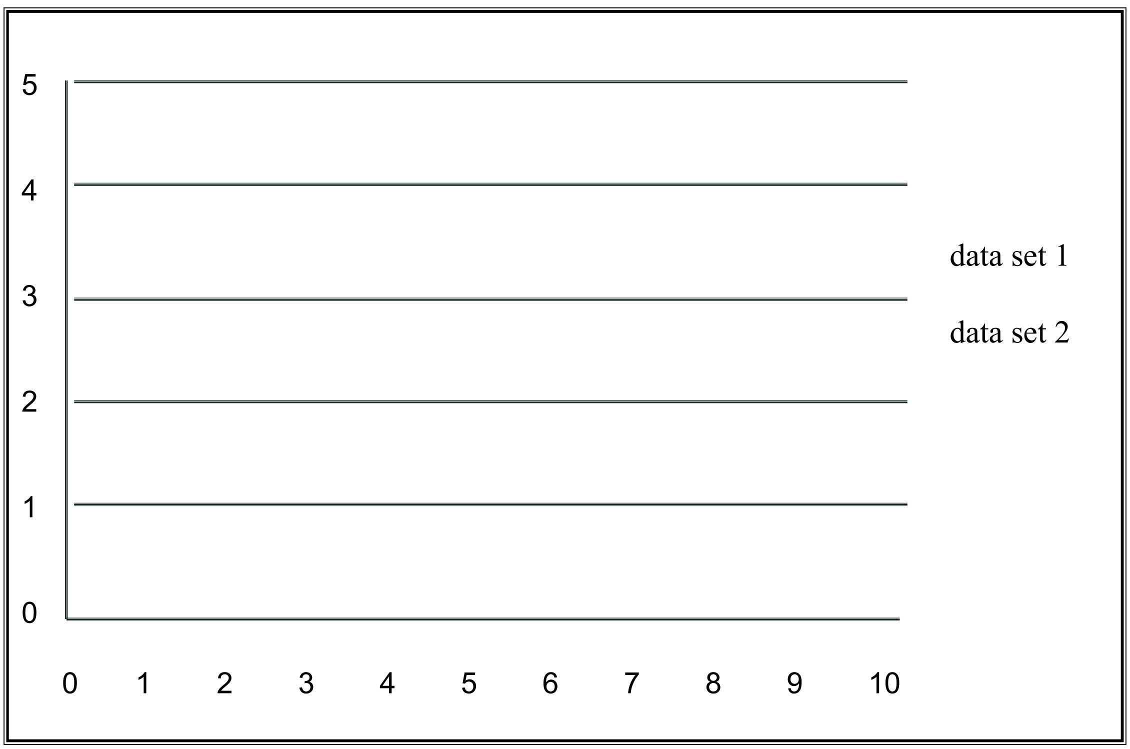
Table 1.

	Data Set 1	Data Set 2
	7	9
	5	3
	9	9
	7	5
	8	8
	7	9
	6	10
	6	4
	7	9
	8	4
Average		

Table 2.

	frequency	
value	data set 1	data set 2
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

FREQUENCY GRAPH



3.2 Water Ya Know? A Play in One Act

Zip and Zap are sitting at an outdoor café looking out over the Bark River and drinking iced coffee drinks. They have just finished the classic discussion of who was the greater superhero—Batman or Superman. Zip puts down his glass and sighs. Then, looking thoughtfully at Zap, Zip speaks…

Zip: Let's talk about something more interesting, Zap. I'm tired of this subject.

Zap: Good idea, Zip. Why don't we talk about biology!!! That's one of the most interesting subjects, I think you'll agree.

Zip: By all means, let it be biology. Why not begin with the most important and interesting subject in all of biology?

Zap: *[looking somewhat embarrassed]* Uh…I don't think we should…um, you don't mean…..

Zip: Of course—water!!! Agua! Wasser! What could be more important and interesting that that? Let's talk about water.

Zap: *[looking very doubtful]* Water?! How can water be important to biology? I think you are all wet, Zip.

Zip: Not at all. Don't you realize 75% of the surface of the Earth is covered with water, and that 45 to 95% of the weight of all active living things is water?! What could be more vital? And the properties of water…well, if water did not have the properties it does, it is quite possible that there would be no life at all, not even in our town!

Zap: I know a few things about water. It's made up of two atoms of hydrogen and one of oxygen. Its melting point is 0^{o}C and its boiling point is 100^{o}C. In fact, the Celsius scale was set up with these properties of water as the reference points for the scale. Water is one of those rare substances that can exist in all phases—solid, liquid, and gas—within the normal range of temperatures on Earth.

Zip: I knew this would be more interesting than philosophy. And there is so much more. One biologically very important property of water is its ability to absorb heat energy without increasing in temperature very much. This is called its "specific heat," and it is important for the temperature stability of many biological systems.

Zap: I once saw a performer who boiled water in a paper cup! The water very efficiently carried away all the heat so that the paper never reached its burning point!

Zip: Not only that, but evaporating water absorbs an enormous amount of heat, which makes it a good method of cooling for temperature regulation.

Zap: I know a good way to test this, Zip. Take one of those pieces of cloth and dunk it in the water. Squeeze the excess water out of it then wrap it around the end of a thermometer. I will wrap the dry cloth around the end of the other thermometer. *[Zip and Zap do this].*

Zip: I get it…the thermometer will measure the cooling effect of the evaporation. This will show us why animals sweat and will also show one of the benefits of transpiration in plants. The evaporating water cools down the critter! Let's give the thermometers a couple minutes before we check the temperatures…

Zip: There are many more interesting characteristics related to water, Zap. Take some of the ice in that cup and put it in your glass of water. *[Zap puts ice into the water]* What do you see?

Zap: Nothing. The ice is just floating there in the water like it always does.

Zip: Just because that is such a common event doesn't make it any less amazing. Most substances get continually more dense as their temperatures are reduced. So if you put a solid piece of most materials into the liquid phase, the solid sinks. If you freeze a container of ethanol, it freezes from the bottom up because the solid ethanol is denser than the liquid. Not so with water. Its density increases as the temperature goes down until it reaches 4oC, but that turns out to be as dense as it gets. Below 4oC, it becomes less dense again…thus, ice floats!!!

Zap: *[stands up, very excited]* OF COURSE!!! I see now how important that is to living things!!! *[looks around a little embarrassed then sits back down]* Think if ice sank…ponds would freeze from the bottom up, and life in lakes where there is a cold winter would be impossible (not to mention that playing hockey outside might be really difficult). But, why does ice float?

Zip: I think it is because of the hydrogen bonding water undergoes. Water is a polar molecule. The electric charges on the molecule are not evenly distributed, so there are a positive end and a negative end to a water molecule. The hydrogen atoms of neighboring water molecules are attracted by the oxygen atoms so that there is some structure even to liquid water. This hydrogen bonding imposes a crystalline structure to water in the solid phase that spreads the molecules out more, making them less dense. And if the ice is less dense, it floats. But this hydrogen bonding, now that I mention it, is responsible for some other properties of water.

Zap: I can think of one already. Take that paper clip sitting on the table and VERY carefully lay it on the surface of the water. If you do it carefully and gently enough you can get the paper clip to float on the surface of the liquid! *[Zip gives it a try]* That's due to a property of water called "surface tension." The water molecules attract each other through hydrogen bonding and form a surface that can hold up much denser materials!

Zip: And surface tension is simply a form of cohesion—the ability of water molecules to stick to each other. That's why water forms such nice drops. In fact, I have a good practical demonstration of cohesion. Take one of these pennies and put it on a piece of paper towel. I will do the same thing. *[Zip and Zap both do this.]* Just to make it interesting, smear a tiny amount of that dish soap on your penny.

Zap: OK *[Zap does this]*. I see where you are going with this! Now we will each see how many drops of water we can fit onto our pennies. Make sure that we both have the "tails" side facing up.

[Zip and Zap use the disposable pipettes available to put individual drops of water onto their respective pennies—being sure to count the number of drops that stay on the penny's surface; write the results in the space provided below AND copy them onto the table on the board].

# of drops on a normal penny = _______

# of drops on a soapy penny = _______

Zip: Wow! Look at that, Zap…there's definitely a difference between the two pennies. *[Zip points out the differences between the normal penny and the soaped penny].*

Zap: You're right, Zip. Obviously, the soap…*[Zap explains what the soap does to the water].*

Zip: Hey…let's take a look at the thermometers!.

Dry temp =

Moist temp =

Zap: Wow again, Zip! Look at those temperature differences. The water evaporating from the cloth…*[Zap explains the effect].*

Zap: Well, Zip, this has been another interesting discussion, after all. And someone has been nice enough to write all of the penny data on that blackboard. *[Zip and Zap turn their attention to the front of the room and copy the class data].*

Trial #	# of drops - normal penny	# of drops - soaped penny
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
range		
average		

Adapted from: Donald Cronkite & Chris Oswald, Hope College, Holland, MI by Greg Bisbee

5.4 The Mysterious Case of Puerperal Fever: A Historical Dialogue

Puerperal (pyū-ûr'-pər-əl) fever was a deadly disease that affected women during the 1800's. Its cause was unknown, but women who delivered their babies in hospitals across Europe and America were dying from this disease. Ignác Semmelweis practiced medicine under the supervision of Johann Klein at Vienna's Allgemeine Krankenhaus during the mid-1800's. While Klein accepted the miasma theory of disease, Semmelweis looked for a better explanation to the problem of puerperal fever.

Klein: [walking up to Semmelweis] So, there, Semmelweis…what are you examining so intently?

Semmelweis: Good afternoon, Dr. Klein. I'm re-examining this data on deaths due to puerperal fever. The comparison between the First Ward and Second Ward is striking!

Klein: Oh, good grief!!! Why are you wasting your time on that? You have far more important things to work on. Everyone knows that these deaths are due to bad air! They are an unavoidable part of childbirth.

Semmelweis: I have to respectfully disagree, Doctor. If you examine the data, you will see that the death rate in the Second Ward, run by midwives, is consistently less than 2%. In the First Division, where doctors examine the patients, the death rate was 17% last year.

Klein: You are not suggesting that the doctors are causing this condition, are you, Semmelweis?

Semmelweis: Look at the data, Doctor! The First Ward averages 600 to 800 deaths to puerperal fever each year while the Second Ward averages 60 deaths.

Klein: To suggest that doctors play some part in the transmission of this disease is absurd! Disease and death are an inescapable part of medicine. Besides, puerperal fever is found in hospitals across Europe—this is not just a localized problem!

Semmelweis: Puerperal fever is common in many hospitals but there is no such epidemic in the cities and towns of Europe. Women who deliver their babies at home do not suffer this disease. Even the women who give birth in the streets and alleyways have a far lower chance of death than the women in our own hospital!!

Klein: While I will reluctantly admit that these figures are correct, I do not believe that we have any part in spreading this disease. The miasma theory explains this unfortunate epidemic.

Semmelweis: But this disease does not follow the patterns of a typical epidemic. The death rate due to puerperal fever does not vary with the seasons or the weather and it does not seem to spread from person to person outside of hospitals.

Klein: There is clearly bad air in the First Ward. The Miasma Theory explains the difference in death rates…this conversation is pointless! If we scrub the floors, wash the bedding, and re-paint the walls, deaths will predictably decline.

Semmelweis: But we have tried that before. As you say, the deaths will decline, but only for a number of days. Then they rapidly increase to previous levels. Meanwhile, the rates in the Second Ward have never approached such high numbers of deaths. There must be some tangible reason for this difference!

Klein: Again, bad air! While it is true that no one has ever actually determined how miasma causes epidemics, it is firmly established that it does occur. How else can you explain why disease occurs in some areas but not others? Bad air causes disease!

Semmelweis: But it has also been suggested by some that small disease particles could spread and cause disease.

Klein: [mockingly] Oh, sure…invisible particles that cause disease. What a convenient explanation—we can't see them or detect them, but they float around and make us sick. Who would believe something like that?

Semmelweis: We can't see or detect bad air either! That is no better explanation than invisible particles.

Semmelweis was convinced that there had to be something in the First Clinic that was causing puerperal fever. In March 1847, Semmelweis returned to Vienna from vacation to learn that Jakob Kolletschka, a doctor he much admired, died only days after being stuck in the finger with a scalpel during an autopsy. His death showed the same symptoms as puerperal fever. Semmelweis was devastated and was determined to find the cause of this disease.

Klein: Good day, Semmelweis! So sorry to hear about Jakob…I know he was a good friend and a mentor. It was a tragic accident!

Semmelweis: Thank you for your kind words, Dr. Klein. As odd as it might seem, I believe that Professor Kolletschka's death has provided me the insight to solve the problem of puerperal fever.

Klein: [skeptical] Really? I don't see how that is possible. There really is not much in common between giving birth and performing an autopsy…how could they result in the same cause of death?

Semmelweis: Professor Kolletschka's symptoms and physical condition were exactly like those of the women who died of puerperal fever. So, if the contamination of Professor Kolletschka's blood came from the infection by cadaver particles, then puerperal fever must come from the same source.

Klein: How would you suggest that the women became infected? Certainly they did not come in contact with cadavers or autopsies. That does not seem to me to be a reasonable solution to this problem. I don't see how the women could contact the cadaver particles.

Semmelweis: But, in fact, they could! Is it not true that doctors and medical students frequently work on autopsies in the morning before going to perform examinations on patients?

Klein: Yes, that is correct. Are you saying that doctors and medical students carry the disease particles with them from the deadhouse to the patients? Many of the doctors wash their hands with water before moving to patient examinations. If nothing else, the smell from the cadavers makes it necessary.

Semmelweis: Exactly! But even washing with water does not entirely eliminate the smell. I suspect that some of the particles—but not all—are rinsed off with water. Many of the particles remain on the doctor's hands, clothes, and instruments.

Klein: Let's say, for the sake of argument, that you are correct. How would you propose to destroy this disease particle?

Semmelweis: We have long used chloride solutions to eliminate putrid odors from our equipment and bedding. I suspect that chloride solution destroys the particles—if we washed our hands with a dilute chloride solution, it should severely reduce the incidence of puerperal fever.

Klein: The doctors will not hear of it! Asking them to wash with a chloride solution will seem unnecessary and foolish. They will protest this change in procedure.

Semmelweis: Then I will enforce it myself. No one will enter the First Division without washing before and after examinations.

In mid-May of 1847, Semmelweis did as he proposed and placed a bowl of dilute chloride solution at the entrance of the First Division and insisted that every doctor and medical student wash before and after examining a woman in labor. Medical personnel did protest but within a few weeks the death rate plummeted. During the rest of the year, the death rate due to puerperal fever in the First Division dropped to 3%. Unfortunately, Semmelweis did not publish a description of his theory or carry out the necessary laboratory experiments. As a result, puerperal fever continued in other hospitals for many more years.

Background Source - Nuland, S.B. 2003. The Doctors' Plague: germs, childbed fever, and the strange story of Ignac Semmelweis. New York: W.W. Norton & Co.

Author - Greg Bisbee

5.8 Wei and Noé Discuss Meiosis

Wei and Noé (pronounced way and no way) are two biology students who—like all high school students—love discussing biology! Today Wei and Noé are discussing one of life's many wonders—the process of meiosis. We find our two scholars in the biology room…Wei is looking over the biology book as Noé walks up.

Noé: Hey, Wei! What are you reading?

Wei: *[looks up from the biology book]* Hey, Noé…just looking over our reading assignment. I can't believe all of the processes that we need to learn for biology class. First there were photosynthesis and respiration, then DNA replication, protein synthesis, mitosis…and now meiosis!!!

Noé: I know…well, that's life! It's a complicated business, being alive. So…do you understand the meiotic process?

Wei: Well enough, I think. It's pretty much the same as mitosis—just twice! So that makes it a little easier to remember.

Noé: What I think is interesting is how the cell divides twice rather than once, but the DNA still only replicates once during the cell cycle—like for mitosis. The result is something quite different than what we find in mitosis.

Wei: How so, Noé?

Noé: Well…the DNA replicates once, right? But then in Mitosis the chromosomes and the cell only divide once. So we double the DNA and one half goes to one cell and the other half goes to the second cell ... we end up with the same thing we started with…but two cells. In a human—the result is two cells, each with 46 chromosomes…identical (genetically) to the original.

Wei: OK…but with meiosis, the cell divides twice even thought the DNA replication occurrs only once. So, instead of making two cells, we end up with four cells. By the end of this process, each one of the four cells only has one-half the DNA of the original cell. Right?

Noé: Exactly! So for humans, a cell going through meiosis produces 4 daughter cells, each with only 23 chromosomes.

Wei: Right!!! And to make it even more interesting, all four of those daughter cells are different genetic mixes of information—they are all genetically different!

Noé: No way!

Wei: Way!

Noé: But how does that happen, Wei? The process does not seem that different from mitosis…and those cells end up being genetically the same.

Wei: Great question my curious friend! This happens because of synapsis!

Noé: Synapsis???! What's that?

Wei: Synapsis is the step at the beginning of meiosis in which homologous chromosomes pair up.

Noé: "Homologous chromosomes"…I know I should know what those are. What are they?

Wei: You know that we have 46 chromosomes. But they occur in pairs! That's because we each have one of each chromosome from each parent. Our largest chromosome is called the #1 chromosome (yeah, I know…really innovative naming system). You have two #1 chromosomes—one from your mom and one from your dad—those two #1 chromosomes are homologous. During synapsis, all of your homologous chromosomes line up.

Noé: *[excited]* Now I remember! And during synapsis, the homologous chromosomes swap chunks of DNA…kind of like shuffling a deck of cards. This mixes up the DNA and adds diversity. By the time the chromosomes separate, the cells are all genetically different.

Wei: But that brings up a question, Noé. Why would we—or any critter—WANT a cell with only one-half the normal amount of DNA? I mean, it seems that having less than the normal DNA would be a problem for the cell.

Noé: Good thinking, Wei! And, normally, you would be right. A cell with too little or too much DNA is in for trouble!! But meiosis results in a special type of cell—one with a very specific purpose.

Wei: I can't imagine how 1/2 the normal amount of DNA would be useful…

Noé: I'll give you a hint. When would you put two half-cells together to make a complete cell?

Wei: Is this another one of your dumb biology jokes? 'Cause they are not funny!

Noé: First of all, my biology jokes are hilarious! And, no, this isn't a joke…it's a hint.

Wei: OK, OK…let me think…two cells combining to form one normal cell. So for humans, two cells, each with 23 chromosomes would combine to form one cell with the normal 46 chromosomes. *[thinking hard]* Hmmm…*[excited]* I know!!!! That sounds like fertilization! The combination of an egg cell and a sperm cell to form a fertilized egg!!!

Noé: Way to go, Wei! So meiosis produces the reproductive cells—the ones that need to have only one-half the normal DNA.

Wei: So when an egg cell with 23 chromosomes combines with a sperm cell with 23 chromosomes, you get a fertilized egg with 46 chromosomes—the correct number for us humans!

Noé: See, Wei…that's not so hard after all. And, like the rest of biology, it really is quite fun!! Oh… ____________________ (teacher's name) is ready to get started! *[Wei and Noé turn to the front of the room].*

Author - Greg Bisbee

9.1 “Your Epidermis is Showing!”

It is late morning. Pip is sitting on a park bench reading when he sees Pep walk by.

Pip: Hey Pep!! Your epidermis is showing! *(laughs out loud at his own joke)*

Pep: Oh, hey Pip, I didn’t see you sitting there! What was that you said? *(looking confused)*

Pip: Oh, I was just making a joke. You know… your epidermis is the outer layer of your skin! So your epidermis “is showing”, get it? *(laughs again)*

Pep: Gee, you’re a pretty funny guy *(raising one eyebrow and smirking)*. But did you know that your skin, or your integument, is really a lot more complicated than just that outer layer we can see?

Pip: Really? I thought skin was pretty simple. I mean, all it does is cover up our insides, right?

Pep: *(sighs loudly)* Well, not really. The outer layer, the epidermis, is there to protect us, but there are two more layers underneath it that do important things too!

Pip: *(sits down next to Pep on the bench)* Oh ya, smarty pants? So what does the epidermis have to protect us from?

Pep: Well, for starters, the epidermis is the only layer that contains melanin, the pigment that gives our skin its color. This melanin protects us from damaging ultraviolet rays made by the sun.

Pip: *(excited)* Kind of like our own built-in sunscreen lotion! Wow, I had no idea!

Pep: And not only that, the epidermis protects us by preventing germs from getting into our bodies!

Pip: *(a look of disbelief on his face)* Now, come on, Pep, how can it possibly do that?

Pep: *(talking with a bit of arrogance)* Quite easily, Pip. All of the cells of the epidermis are filled with a water-resistant protein called keratin. This protein forms a barrier so that bacteria and other things can’t get through it. This is called the “first line of defense” of our immune system!

Pip: *(slaps the table)* Man, Pep. You are just full of information today. What’s got into you?

Pep: Well…. actually, I’ve been thinking about becoming a dermatologist someday, and this is all stuff I might need to know!

Pip: That’s great Pep! *(pats him on the back)* What else have you learned? You said there were two other layers underneath the epidermis, right?

Pep: Ya, there’s three layers total. The epidermis is the thinnest layer. The layer underneath is called the dermis. This thicker layer doesn’t have any melanin in it, but it does have sweat glands, sebaceous glands, hair, nerves, blood vessels, and tiny muscles! *(nodding his head)* Quite amazing really!

Pip: *(shaking his head)* You're right, Pep, the skin is a lot more complicated than I thought! I know what a sweat gland is, but *(looks confused)* what the heck is a seb…., how did you say it, gland?

Pep: It's pronounced *(talks real slow)* seb-a-shus gland. It's basically an oil gland.

Pip: Hmmm… *(talks real slow)* seb-a-shus gland. Do you mean to tell me that sweat and oil aren't the same thing?

Pep: Oh no, not even close! Sweat is made of water and salt, and oil, is well, like fat! Sweat comes out of pores, and oil comes out next to each hair. The oil, called sebum, makes our skin greasy and causes pimples!

Pip: *(look of disgust on his face)* I could do without that!

Pep: Ya, me too. *(look of disgust)* But the oil, or sebum, is also what makes our skin stay soft and supple. We don't make as much sebum when we age, and our skin gets drier.

Pip: We can't win either way, hey? Pimples when we're young, dry skin when we're old. *(laughs out loud)* That is a bummer!

Pep: So, do you want to hear about the next layer of skin, Pip? *(eyebrows raised, smiling excitedly)*

Pip: *(rolls his eyes)* Uh… sure… Pep, if it makes you happy…

Pep: *(cuts off Pip mid-sentence)* Great! The third and deepest layer is called the hypodermis, or subcutaneous. Both words mean the same thing.

Pip: *(trying not to yawn)* What do those words mean, Pep?

Pep: Well, sub and hypo mean "below", derm and cutane mean "skin". So what do you think, Pip?

Pip: Hmmm… *(looking at the sky, thinking)* I guess subcutaneous and hypodermis must both mean "below skin"! Is that right, Pep?

Pep: *(smiling)* Sure is! Good job, Pip! Do you know what this deep layer is mostly made of?

Pip: Oh, I know this one Pep! You haven't talked yet about fat! And I know that the extra fat that we eat builds up underneath the skin in the deepest layer! In fact, overweight people have a thicker hypodermis than average weight people!

Pep: Maybe you should be the dermatologist, Pip! You know quite a bit!

Pip: Yes, I do. *(smiling)* Well, Pep, I have to go get lunch. Care to join me?

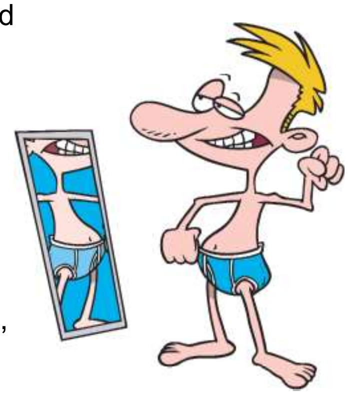
Both Pip and Pep get up and walk towards the nearby café. On their walk, both of them daydream about becoming dermatologists, happy and confident about their knowledge of the integument.

Author - K. M. Westrich

9.7 Hip and Hop Develop Muscles and More Muscles

Hip: *[walks into the gymnasium]* Wow Hop, you've lost some weight!

Hop: *[steps onto the scale]* Two pounds actually. It's not much compared to the others. They lost more pounds than me.



Hip: Maybe you've gained some of the pounds back from working out. That can happen when lifting weights.

Hop: Really? I come here to lose weight, not to gain it. I don't want to work hard to gain weight, I can easily do that by eating fast food!

Hip: Well, you haven't gained fat. You may lose fat by burning it off when you do your running and jumping rope, but by lifting weights, you are exercising your muscles, making them thicker. For equal volumes, muscle is more dense and weighs more than fat.

Hop: Really? So I burn off the fat with cardiovascular exercise, but at the same time I'm creating more muscle by lifting weights? That makes me feel better.

Hip: That's good. Did you know that on average, 50% of our body weight is all muscle?

Hop: No I didn't. Isn't that just buff people?

Hip: Actually, everyone has muscles, Hop! We need them for movement in our bodies!

Hop: I thought we had different types of muscles that do different things.

Hip: Well, we do. But all muscle tissue can contract and relax.

Hop: How does it do that?

Hip: By the muscle fibers sliding past one another. When the fibers are far apart, the muscle is relaxed, or lengthened. When the fibers slide past and towards each other, the muscle is contracted or shortened.

Hop: Then what are the different types of muscles?

Hip: The three main types are skeletal muscle, smooth muscle, and cardiac muscle.

Hop: Which one is the best?

Hip: There is not best, they all have different functions.

Hop: But you said they all allow movement!

Hip: They do, Hop, but their movements help out different processes in the body.

Hop: So, are you going to fill me in, or what?

Hip: Okay, okay. The skeletal muscle is in charge of movement of the body. It allows locomotion, meaning we can move from one location to another. You have control over these muscles.

Hop: Where is the skeletal muscle found in us?

Hip: It's what makes all the muscles attached to our skeleton. Without these muscles, you couldn't move your arms or legs, bend your waist, or turn your head.

Hop: Okay. That makes sense, Hip. These are the muscles I work when lifting weights. What about smooth muscle?

Hip: Smooth muscle is found in the organs of the digestive tract. The esophagus, stomach, and intestines are examples. They move involuntarily, which means you can't control them. When this muscle contracts, food is pushed through our digestive system. The food can't move through us by itself, it has to be pushed.

Hop: Are blood vessels smooth muscle too?

Hip: Yes, Hop. Veins and arteries also have a layer of smooth muscle to help the blood flow.

Hop: What was the last muscle type you mentioned?

Hip: Well, we mentioned skeletal and smooth already, so the last major type is cardiac muscle. Where do you think this type is found, Hop?

Hop: I've heard the word cardiac before, so I think it must have something to do with the heart.

Hip: Cardiac muscle is actually what our heart is made of. When the heart muscle contracts, it pushes the blood out of it to the rest the body.

Hop: Is that what is meant by pumping the blood?

Hip: Yes it is. Blood can't move by itself, it must be pushed. If I squeeze your open water bottle here, what would happen to the water inside?

Hop: It would come squirting out the top.

Hip: And that's what the heart does to the blood when it contracts.

Hop: I get it! All muscles move by contracting and relaxing, but there are different types to help move our skeleton, push the food we eat, and keep our blood flowing!

Hip: I'm glad I could help you out Hop.

Hop: Thanks for the lesson, Hip. Now I've got to get back to building that skeletal muscle!

Chemistry Volume One

DIALOGUES for the CHEMISTRY CLASSROOM

By Greg Zimmer, Christina Cattey, Andrea Winkle, Raymond Scolavino, Craig Berg, and Nancy Smith

Chemistry I - Table Of Contents

Chemistry I Dialogue Abstracts

Unit 1 - Measurement and Lab Safety

1.1 Skip and Chip Do Something Significant – Part 1: Skip and Chip are learning about significant digits and get a bit overwhelmed by the rules. In Part 1, they learn the addition and subtraction rules.

Science concepts or terms included: accuracy, decimals, precision, significant digits, uncertainty.

1.2 Skip and Chip Do Something Significant – Part 2: Skip and Chip continue to learn about significant digits, this time focusing on the multiplication and division rules.

Science concepts or terms included: non-zero digits, significant digits.

1.3 Jib and Jab Talk Lab Practices To Improve Their Game: Jib and Jab discuss the importance of safety, proper measurements, and correct use of tools for measuring.

Science concepts or terms included: lab safety, measurements and tools for measuring.

1.4 In Da Lab With Whiz and Bang: Bang is indiscriminately mixing chemicals. Whiz freaks out over Bang's unsafe behavior.

Science concepts or terms include: lab safety.

Unit 2 - Matter

2.1 Reaction Trip to Property Park with Whiz and Bang: Whiz and Bang are working on an assignment that helps them learn about chemical and physical properties and changes.

Science concepts or terms include: chemical properties, physical properties.

2.2 Mass Versus Weight: Diff helps Duff with ideas about how mass and weight differ.

Science concepts or terms include: atoms, gravity, mass, matter, measurement, molecules, weight.

2.3 The Changing State of Matter – Tiff and Tuff Compress Gases: Tiff and Tuff are grilling outside and run out of gas. They discuss what happens to compressed gases.

Science concepts or terms include: change of state, compression, gas, gas laws, liquid.

2.4 Gases Have Masses: Sis and Sas converse about how gases have mass and do a little experiment to demonstrate the concept.

Science concepts or terms include: air, gases, mass, molecules.

2.5 Identifying Heterogeneous Versus Homogeneous: Ping and Pong are studying chemistry and arguing about cows while trying to understand homogeneous vs heterogeneous.

Science concepts or terms include: heterogeneous solutions , homogenous solutions,

2.6 Ice Formation on Lakes: In this episode, Perch and Bluegill are pondering the amazing characteristics of water and what happens when the temperature drops below a certain point.

Science concepts or terms include: bonding angle, crystalline structure, density, phase changes, properties of water, temperature.

2.7 Skip and Chip: Put Your Tongue on the Flagpole?: Following their discussion on how particles keep their distance from each other, Skip and Chip now discuss liquid and solid samples.

Science concepts or terms include: freezing, kinetic theory, melting, particles, solids, states of matter, sublimation, vibrational energy.

2.8 Water Surface Tension: Spidy and Strider are discussing how to get across the pond. Strider is suggesting Spidy can make use of water surface tension and walk right across.

Science concepts or terms include: hydrogen bonding, intermolecular forces, polar molecule, water molecule, water surface tension.

Unit 3 - Atomic Structure

3.1 Skip and Chip are Professional Atom Talkers: Skip and Chip learn about atoms from ancient times through the Thomson model.

Science concepts or terms include: atom, atomic model, Chadwick, combustion, Dalton, Democritus, electron, energy, matter, Millikin, negative charge, neutron, proton, substance, Thomson.

3.2 Skip and Chip Try Some Modeling: Skip and Chip continue their discussion with the Thomson model of the atom and the models proposed thereafter.

Science concepts or terms included: alpha particles, atom, atomic models, Bohr, DeBroglie, Einstein, electrons, Heisenberg Uncertainty Principle, negative charge, nucleus, orbits, positive charge, quantum model, Rutherford Experiment, Schrödinger, Schrödinger Wave Equation model, sub-atomic, Thomson Model.

Unit 4 - Periodic Table

4.1 Elementown: Clemens and Dimitri tour the real estate and properties included on the periodic table.

Science concepts or terms include: chalcogens, density, electronegativities, electrons, energy level, halogens, ionization energies, melting points, metallic, metalloids, noble gases, non-metallic, periodic table, valence electrons.

4.2 Biff and Baff Calculate Mass – What?: Biff and Baff are talking about the difference between mass number and atomic number.

Science concepts or terms included: atom, atomic number, isotopes, mass number, neutrons, nucleus, percentage, protons, weighted equation.

Unit 5 - Chemical Formulas - Nomenclature

5.1 Jib and Jab Offer Tips for Naming Formulas: Jib and Jab are working on naming chemical formulas, trying to find a system to help remember proper names when given chemical formulas.

Science concepts or terms included: anions, bond, cation, charge, chemical formulas, element, formula, Greek Method, molecule, molecular compounds, positive and negative charges, prefixes, subscript, suffix, symbol.

5.2 Jib and Jab Encounter the Acid Wash: Jib and Jab discuss how acids are named.

Science concepts or terms included: acid, amphoteric, anions, bases, binary acids, cations, element, ionic, metal, naming compounds, polyatomic.

5.3 Jib and Jab Find the Formula: Jib and Jab are working on chemistry in the library, struggling to write chemical formulas.

Science concepts of terms included: atomic symbol, binary molecular compounds, elements, ionic compounds, ions, polyatomic ions.

Unit 6 - The Mole

6.1 Zip and Zap Converse About Avogadro's Number: Zip helps Zap understand the relationship between atomic mass and Avogadro's Number.

Science concepts or terms include: atomic mass, Avogadro's Number, periodic table.

6.2 Whiz and Bang Marvel at Moles: Today our two students are discussing the mole concept.

Science concepts or terms included: atomic size, atomic mass units, exponent, exponential notation, mass numbers, periodic table, submicroscopic, the mole concept, unit label.

6.3 Riff and Raff and the Perfect Percent Composition of Pizza: Riff and Raff are consuming a pizza and discussing percent composition in terms of the pizza ingredients.

Science concepts or terms included: atomic masses, grams, mass, mole, percent, percent composition.

6.4 Itsy and Bitsy Count on Empirical Formulas: Itsy and Bitsy use the concept of empirical formulas to help them while at work at an ice cream parlor.

Science concepts or terms included: empirical formula, molecular formula, ratio.

Unit 7 - Chemical Reactions

7.1 Skip and Chip Keep Their Distance: Skip and Chip resume a conversation about dating and relate it to a better understanding of gas and liquid particles and how they interact.

Science concepts or terms included: collisions, decomposition reactions, elastic, energy transfer, ideal gases, particle motion, single-replacement reaction.

7.2 Single vs Double Replacement Reactions – The Sherry Jinger Show: Kiff and Kaff are discussing how an episode of the Sherry Jinger show models single versus double replacement reactions in chemistry.

Science concepts or terms include: bonding, double replacement reactions, ionic compound, metal, non-metal, single replacement reactions.

Unit 8 - Stoichiometry

8.1 Criss and Cross Get Stoiched About Stoichiometry: Baking chocolate chip cookies, Criss and Cross relate stoichiometry to the ingredients for cookie dough.

Science concepts or terms included: atom, compounds, elements, reactants, stoichiometry.

8.2 Criss and Cross Get Limited By Their Reagents: Criss and Cross discuss limiting reagents as it applies to their cookie baking extravaganza yesterday.

Science concepts of terms included: balanced equations, limiting reagent, stoichiometry.

8.3 Counting Atoms in a Balanced Equation: Diff and Duff attempt to balance the reactants and the products of hydrogen combining with oxygen.

Science concepts or terms included: atoms, balancing equations, coefficients, element, formula, Law of Conservation of Matter, products, reactants, subscript.

8.4 The Why to Stoichiometry: An Enlightening Experience: Rant and Rave dig into the reason why stoichiometry is an important part of chemistry.

Science concepts or terms include: balanced equations, conversions, grams, moles, stoichiometry.

Unit 9 - Chemical Bonding

9.1 Let's Get Romantic: Tassy and Bro meet at school, work together in Chemistry class to test mystery powders and have a discussion on ionic bonding.

Science concepts or terms included: anion, bond properties, cation, covalent, electron, ionic, ions, metal, negative, non-metal, positive, sub-atomic particle.

Unit 10 - Molecular Structure

10.1 Riff and Raff Clean Up the Difference between Ionic and Molecular Compounds: Riff and Raff discuss the difference between sharing and transferring electrons while doing dishes.

Science concepts or terms included: electrons, ionic, molecular, octet rule, valence shell.

10.2 Ying and Yang Fill Their Orbitals: Ying and Yang discuss how to fill electron orbitals based on the three principles. They practice at the end.

Science concepts or terms included: Aufbau principle, electron configuration, Hund's Rule, orbitals, Pauli exclusion principle, quantum numbers.

10.3 Biff and Buff Discuss Ion Formation – Part 1: Biff and Buff are studying for a chemistry test and sort out how ions are formed.

Science concepts or terms included: charge, electrons, ionic compounds, negative, neutral positive.

10.4 Ion Formation – How Does It Lose An Electron? – Part 2: Biff and Buff continue their discussion about ion formation, focusing in on how an element can actually lose an electron.

Science concepts or terms included: electron configuration, energy levels, ion formation, ionic bonding, orbitals, quantum numbers, stable orbitals.

Unit 11 - Gas Laws

11.1 Jib and Jab - Full of Hot Air?: On a snowy winter day, Jab relates his difficulty of getting floating balloons home for a birthday party.

Science concepts or terms included: Charles Law, particles, pressure, temperature, volume.

11.2 Gas Laws and How A Straw Works: Liff and Luff are eating at a restaurant and discuss how sipping through a straw relates to Boyle's law.

Science concepts or terms include: Boyle's Law, gas, gas laws, liquid, pressure, volume.

11.3 Tiff and Tuff Go To the Recycling Center and Dangers of Compressed Gases: Tiff and Tuff are discussing what can go into the recycling bin and ponder the dangers of aerosol cans that are still pressurized when accompanied by increases in temperature.

Science concepts or terms included: Guy-Lussacs Law, gases, pressure, temperature.

11.4 Using the Gas Laws Formula: Determining Relationships Among Variables: Zim and Zoom examine the Ideal Gas Law and realize that if they really understand the relationships between pressure, temperature and volume, that they can figure out the formula without having to memorize it.

Science concepts or terms include: Ideal Gas Law, pressure, temperature, volume.

11.5 Combined Gas Law Conference: Boyle, Charles and Gay-Lussac are attending a scientific conference and discuss variables that factor into the gas laws.

Science concepts or terms include: ballooning, combined gas law, direct relationships, inverse relationships, pressure, temperature, volume.

Unit 12 - Solutions and Colloids

12.1 Skip and Chip Talk About Solutions, Suspensions and Colloids: On a road trip, Skip and Chip discuss the differences between solutions, suspensions and colloids.

Science concepts or terms included: Brownian motion, collisions, colloid, fog, gravity, particles, semi-permeable membrane, solution, suspension, Tyndall effect.

12.2 Jib Waters Down the Fun: Jib and Jab are attempting to make more punch for the party and end up discussing ratios and proportions in order to get the right mix.

Science concepts or terms included: concentration, dilution, proportion, ratio, solute, volume.

12.3 Riff and Raff Get Saturated: Riff and Raff relate working at a restaurant to saturation.

Science concepts or terms included: saturation, solute, solutions, solvent, supersaturated, unsaturated.

12.4 Solutions, Suspensions and Colloids: Kailey and Kyle are discussing the differences between, and characteristics of solutions, suspensions and colloids.

Science concepts or terms include: colloids, dissolved, solute, solution, solvent, suspension.

12.5 Concentrations – Why So Many Different Types?: In this episode, Zip and Zap ponder using Molarity to make up solutions.

Science concepts or terms include: concentration, molality, molarity, Moles, solutions.

12.6 Riff and Raff Get Creative with Colligative: Riff is studying chemistry, attempting to understand colligative properties. Raff provides some insights and tutoring so they can go snowboarding.

Science concepts or terms included: boiling point depression, colligative properties, freezing point depression, saturated solution, solute.

Unit 13 - Reaction Rates and Chemical Equilibrium

13.1 Riff and Raff Find Their Equilibrium: Having just finished Chemistry class, Riff and Raff clear up some confusion about Le Chatelier's Principle.

Science concepts or terms included: balanced reactions, endothermic, equilibrium, exothermic, heat, Le Chatelier's Principle, moles, pressure, temperature.

Unit 14 - Thermodynamics

14.1 Zip and Zap Argue Over Entropy: Our two students are planning on doing a chemistry experiment in Zip's room but the mess gets in the way.

Science concepts or terms included: dispersal of energy, energy, entropy, Second Law of Thermodynamics.

Unit 15 - Acids and Bases

15.1 Strengths of Acids and Bases: Giff and Guff examine and discuss acids and bases and their strengths.

Science concepts or terms include: acids, bases, bond, dissociates, ion, mole, strength of reaction.

15.2 Acids, Bases and Salts – Oh My!: Kailey and Kyle are eating lunch and discussing why a substance is acidic and how the pH scale provides an indication of the strength of an acid.

Science concepts or terms include: acid, base, hydrogen ion, hydronium ion, pH scale, salt, strength of acids.

15.3 Acids In Our Body and Beyond: Kailey and Kyle continue their discussion about acids in relation to their bodies and acids in the environment.

Science concepts or terms include: acids, acid mine drainage, acid rain, bases, buffers, neutralize, pH, salts, strong versus weak acid, vehicle emissions.

15.4 Quick! Get the Base!: In this conversation, Kailey and Kyle discuss characteristics of bases and how bases can neutralize acids.

Science concepts or terms include: acids, alkaline, bases, hydronium ion, hydroxide ion, neutralize, pH, disassociation.

15.5 Riff and Raff Get Titrated: Riff helps Raff clear up confusion about their titration lab.

Science concepts or terms included: acid, base, concentration, indicator, ions, moles, pH titration.

15.6 Acid/Base – Strength vs. Corrosiveness: Pat is prepping for an upcoming chemistry lab on acids and tutors Tap on the difference between strength of an acid and the corrosiveness of an acid.

Science concepts of terms included: acid corrosiveness, acid strength, disassociates, ions, molecules.

Unit 16 - Oxidation and Reduction

16.1 Zip and Zap Sport Spontaneous: Hoping to go for a bike ride, Zip's bike is affected by rusting and may derail their plans.

Science concepts or terms include: entropy, Gibbs Free Energy, process, rust, spontaneous reaction.

Unit 17 - Nuclear Chemistry

17.1 Quinn and Finn Nuke Some Snacks: After school, Quinn and Finn are microwaving some food and discussing radiation.

Science concepts or terms included: electromagnetic energy, free radicals, ionizing, microwave, non-ionizing, nuclear power, radiation.

Unit 18 - Organic Chemistry

18.1 Whiz and Bang Sing About Functional Groups: Whiz uses a song to help Bang learn about differences between organic functional groups.

Science concepts or terms include: aldehydes, alkanes, alkenes, alkynes, amides, amines, esters, haloalkanes, ketones, organic functional groups.

18.2 That's Not Plastic, It's A Polymer!: Kailey and Sam are chatting about her car shopping episode. She tells Sam about the interaction with the car salesman who needed some help with understanding polymers and car bodies.

Science concepts or terms include: chain scission, covalent bonds, molecule, monomers, natural or synthetic, ozone, polymerization, polymers, tensile strength.

18.3 VOC's Take Over the Library: Kyle and Sam enter the library and are overpowered by the smell from the new carpet, which prompts a discussion about volatile organic compounds and toxicity.

Science concepts or terms include: boiling point, evaporate, pressure, sublimate, temperature, toxicity, vapor pressure,volatile organic compounds.

Unit 19 - Chemistry Literacy in Today's World

19.1 Skip and Chip Contemplate Alternative Fuels: Skip and Chip run out of gas and ponder a trucker's thoughts about alternative fuels.

Science concepts or terms include: alternative fuels, compressed natural gas, cost/ benefits of fuels ethanol, hydrogen.

19.2 Ban Chemicals Now!: While walking around downtown one Saturday afternoon, Pep comes across her friend Pip at a protest in the park, where the people are shouting "Ban DHMO!" Pep suggests that Pip learn a bit more about DHMO before continuing to protest.

Science concepts or terms included: carcinogenic, cell membranes, chemical compound, DHMO, DNA, hydroxyl acid, mutate, nervous system, scientific literacy, toxic.

19.3 Catching More Fish Than Mercury: Charlie and Sam learn about mercury in fish and the effects on humans and the environment.

Science concepts or terms include: biomagnification, contaminants, environmental toxins, lethal dosage, mercury.

Unit 20 - Student-generated Dialogues

20.1 Bryce and Michel Muse About Molar Mass: Bryce was at Drew's birthday party and watched him inhale some helium from one of the balloons. Drew's voice pitch sharply increased, suddenly making everything he said amusing. Bryce, wondering how this strange phenomenon happened asked his good friend Michel who was taking AP chemistry.

Science concepts or terms include: density, helium, inert gas, mole, molecular mass, sound waves.

20.2 What's So Wondrous About Water?: This dialogue takes place after school has ended. Joey is about to leave to go study for chemistry at home when he runs into Sam. He wonders if she can help him study why hydrogen bonds make water so important.

Science concepts or terms include: bonds, boiling point, molecules, surface tension, vapor pressure.

1.3 Jib and Jab Talk Lab Practices to Improve Their Game

Jib and Jab enter their lab station and discuss the importance of safety, proper measurements, and correct use of tools for measuring.

Jib: I'm pumped. We're in the same class! I think we should be lab partners, if we get to pick.

Jab: Sure, that would be good, but our lab reports are 30% of our grade so we really need to do good work. We are also using some chemicals and equipment this semester that could harm us.

Jib: Well, I've never had a lab accident, so I'm not worried. In the past I had no problem doing the lab reports either. Sometimes I even finished up the conclusion questions on the day they were due while we were passing them in to the teacher. I'd usually get 8 out of 10, which is O.K.

Jab: It is important to me that we do a little bit better than 8 out of 10. We are in high school and the transcript for this class will go in with our college applications. I want to have the best chance to get into a good college. As for you, I think it would help you if there was some improvement in your science grade this year. While a "B" will keep your parents off your back, many colleges would be impressed if you improved to an "A" this year. It would show you are a serious student.

Jib: Hey Jab, look at this lab, it involves doing density measurements and a calculation. I've done this before!

Jab: But watch out Jib, the standard is higher and we have to figure out quite a bit of the procedure on our own now. By the way, you need to get your goggles on.

Jib: Dude, we're just measuring solids right now, I don't think they will jump up and hit my eye.

Jab: Right Jib, but look at the other side of the table. The people we are sharing our lab sink with are starting with liquids. They go in the sink when they are done and did you notice the water pressure in those sinks? Some of the liquids are corrosive and could splash back toward us so we should wear goggles.

Jib: I did notice that the water really comes out of those skinny faucets. I guess it could splash around if someone was not careful. I see your point about the goggles - I don't want their chemicals in my eyes. Thanks for the reminder.

Jab: Now let's get to work. The mass is easy with the digital scale but the volume will require some calculations. I have a mass of 16.61 grams on the digital scale. *(hands sample to Jib)*

Jib: The metal sample thing has measurements of .5 by .5 by 1.5. Let's get the calculator.

Jab: Wait! Did you use inches or centimeters? It looks like more than 1.5 centimeters long.

Jib: Well, I never liked that metric stuff; I mean we're in America after all.

Jab: But Jib, we already measured the mass in grams. Grams per cubic inch makes no sense. Grams is the right label for mass, cm is right for volume. The rest of the world knows that.

Jib: O.K., O.K. how about 1.27cm x 1.27cm x 3.81 cm. = 6.145149 is the volume.

Jab: I think you have too many numbers and you don't have a label. So if you multiplied cm x cm x cm it equals centimeters cubed, cc or cm^3 which is the same amount as milliliters too.

Jib: Can we just keep all my numbers and then round at the end? We can take 16.61 grams divided by 6.145149 cm^3 which gives us 2.702945. What are we going to use for the label?

Jab: Grams / cm^3 works Jib. We should round those numbers. I think the significant digit thing says we pick the measured piece with the smallest number of digits, but that's another story.

Jib: So that would give us 2.70 grams/cm^3.

Jib and Jab do all the solids and start liquids.

Jab: Hey - let's weigh this acetic acid then measure the volume quick.

Jib: Sure, but why are you using a beaker to measure volume? The procedure says to pick the most appropriate tool to measure volume.

Jab: Well, I'm sure as heck not going to use a ruler. Oh, I just noticed the volume on this beaker is only +/- 5.0%. Maybe I'll try this graduated cylinder it's only + /- .25%.

Jib: So, we need to get into the habit of reading the labels on the tools before we measure with them. The graduated cylinder is lighter too, so the digital balance won't freak out.

Jab: Yep, that beaker was too heavy for the digital scale; it only goes to 100.00 grams. We better not put anything too heavy on there. I've heard they are about 300 bucks each.

Jib: So, notice the scale has a "zero" key on it. Put the cylinder on, zero it, and add our acid.

Jab: It looks like 8.59 grams for the mass. *(now holding the cylinder)* Volume is about 8 mL.

Jib: Exactly 8 mL Jab? Or close to 8 mL? Maybe you should set down the graduated cylinder.

Jab: Oh yeah, now it looks like 8.20mL. That will give us 3 digits for our answer.

Jib: 8.59 grams divided by 8.2 mL = 1.05 grams / mL. I think those measurements were good.

Jab: Definitely, the right tools, careful measurements and safety make for good lab results.

Jib: And maybe better than an 8.00 out of 10.0 on the report for me!

Author – Greg Zimmer

5.1 Jib and Jab Offer Tips for Naming Formulas

Jib and Jab are working on naming some chemical formulas and try to find a system to remember the proper names when given chemical formulas.

Jib: These formulas all seem to look alike Jab. I have a tough time getting the names right. Half the time it seems I used the wrong set of rules. I just used that Greek method for everything on this handout to keep it simple, but half of the problems are wrong.

Jab: Stay positive Jib, I will help with the names and formulas.

Jib: Yeah I know, it's all about having the right attitude. I know at least some chemical formulas use the fancy Greek prefixes. I kind of like them because they represent a number of elements. Mono, Di, Tri, Tetra, Penta, Hexa, Hepta, Octa, Nona, Deca. It's just like counting to ten in Greek. I tried using them for everything, but half of my answers were wrong.

Jab: That system works great for molecular compounds or molecules. The prefixes will always represent the subscript on the element described like in this example. In the name the prefixes come first, but in the formula, the subscript comes after the element's symbol. BUT, that system only works when there is no cation.

Jib: So Jab, I think you're saying: "When the cation's away the molecules play?"

Jab: True enough Jib - corny - but if that helps you remember, use it.

Jib: Sounds great, kind of easy actually. I'll just remember " When the cation's away the molecules play, then we use a Greek prefix today." Can we talk about the positive part now? I like that whole cation-anion bonding thing. It reminds me of love. *(Jib gets a little dreamy eyed)*

Jab: Come-on Jib, back to the books here. It's time to find a way to identify cations. The periodic table will give us a good clue and we can usually use it on the test! So look at the two columns furthest to the left. They are either IA and IIA or just "1" and "2".

Jib: O.K. let's go, a one and a two and a…..

Jab: *(interrupts)* Ah, Jib, aka Lawrence Welk, let's not get distracted. The cations that have only one charge are from atoms in the first two columns, plus Aluminum. For naming the compound, say the name of the cation and then the name of the element that makes the anion with the suffix " –ide".

Jib: Kind of like the anion is hiding out at the end of the formula, heh Jab? Darn anions; they changed their names and hid because they were stolen electrons, making them negative.

Jab: Sure, that works. You have an odd way Jib, but you are right. There is more to the naming too. If a cation comes from those little transition metal columns, or if they are Tin, Lead, or one of a few others on the right side of the table, then you need to be more specific about the name.

Jib: Specific, like what? Cations are positive, anions are negative.

Jab: Well, it is a good idea to focus on the anions, because although they are negative, you can count on them having a specific charge, which is the key to naming formulas that contain a transition metal. You need to remember that the columns near the right side of the table will form anions. The anions in column 15 (sometimes called 5A) have a charge of -3; column 16 (6A) anions have a charge of -2; and column 17 (7A) have a charge of -1. You can count on it.

Jib: That's awesome! I bet those anions in 7A must really like to bond with the cations in 1A!

Jab: True, but we'll deal with those bonds at another time. There is a different set of rules for writing the formulas. Right now, let's just get the names right.

Jib: O.K, so if I have a cation, like Iron for example, and it is attached to that anion Chloride, I can call it Iron Chloride right?

Jab: You are really close Jib. But Iron can be either +2 or +3 and you need to figure out which one it is before you finish the formula. We know Chloride has a -1 charge whenever it bonds, but sometimes three chlorides bond to an Iron ion and other times only two chlorides bond to the Iron ion.

Jib: So if there are three Chlorides the Iron is +3 charged and if there are two the Iron is +2?

Jab: Yes. So let's use that information to make the name more specific. Both are a type of Iron Chloride, but to tell the reader what the charge on the cation is, you put the charge in a set of parenthesis in the name after the cation name Iron, but before the anion name Chloride.

Jib: So the Iron with three chlorides attached is called Iron (III) Chloride and the one with two Chlorides attached is Iron (II) Chloride right?

Jab: I think you have it. Now there are still some folks that use a Latin system to identify the cations, but this systematic way of naming is really straight forward.

Jib: You know, I think I'll stick with the systematic system for ionic compounds and the Greek prefixes for the molecular compounds. I'll skip the Latin names for now until I need them. Thanks Jab. Think you could help me write formulas once I have the names down?

Jab: For sure Jib. Let's catch that one later. I have some ideas for that too.

Author – Greg Zimmer

6.2 Whiz and Bang Marvel at Moles

Taking a break in the school cafeteria, Whiz and Bang are discussing the mole concept.

Whiz: Hello, Bang! You look depressed, did someone take your cookie or something?

Bang: No, I am completely confused in chemistry right now. We are learning this mole stuff and it is like the teacher is talking in a different language.

Whiz: If you would like, I can help you. I am a little bit of a "whiz" in chemistry. Get it Bang? I am a "whiz" in chemistry. *(sitting down next to Bang and nudging him on the shoulder)*

Bang: Ha, ha, I get it. I am so perplexed, my brain is tired, and I have a quiz 8th hour.

Whiz: Let's use some analogies. Sometimes using real everyday objects and ideas helps us understand what is happening on the submicroscopic level a little easier.

Bang: Now you are talking in a different language. If I wanted a foreign language I would have taken Spanish like my mom wanted me to.

Whiz: Díos mío! *(oh my goodness)* It isn't that difficult. Chemists talk about the submicroscopic because all the chemistry magic in reactions and with elements and compounds happens at a level so small that you can't even see it with high powered microscopes. The submicroscopic. What do you remember about the mole Bang?

Bang: I know that it is some sort of number that has an exponent in it and somehow is related to the periodic table or something.

Whiz: Good, we are half way there. A mole is a counting number like a dozen equals 12. A mole is equal to 6.02×10^{23rd}. That is 602 with 21 zeroes after it, the reason it is in exponential notation is because it is so big. Chemists need a number so big because atoms and molecules are so small. In order to measure atoms out on our lab equipment we need to work with a large quantity of them.

Bang: So, how big of a number is that? I can't picture it; I know what a dozen cookies taste like.

Whiz: A mole of marshmallows (6.02×10^{23rd} marshmallows) would cover the United States to a depth of 6500 miles (105,000 km) with marshmallows. Astronomers estimate that there is approximately a mole of stars in the universe. If you counted 1 mole of sheep as you were trying to fall asleep, it would take you 19 billion years, and that is counting by a million sheep per second and never falling asleep.

Bang: Wait a minute, hold up. If a mole is that large of a number, how the heck can we use our lab equipment in class to measure it?

Whiz: That's the thing Bang, it is an analogy. I can fit a mole of carbon atoms in the palm of my hand, yet a mole of marshmallows covers the United States in a gooey mess. So what is the difference in size between a marshmallow and a carbon atom?

Bang: I got it Whiz; atoms are really, really small compared to marshmallows. Even if you have a lot of them they still don't take up much space. But what does this have to do with the periodic table?

Whiz: This is where things get really cool. Do you remember the unit label for the mass numbers on the periodic table?

Bang: Yeah, it was a.m.u. or atomic mass unit or something, but those units didn't make any sense because none of our scales measure in a.m.u.'s.

Whiz: Exactly, the a.m.u. was the unit label for just one atom of an element. We just learned that in order to work with atoms you need a lot of them, how about using a mole of atoms? So if I had a mole of carbon atoms, how many atoms would that be?

Bang: Let me think, a dozen atoms would be 12 so a mole would be 6.02×10^{23} atoms.

Whiz: Awesome, you got it. So, what we know is that number on the periodic table works with the unit a.m.u.'s but we can change the unit label to grams when we are talking about a mole of atoms. One atom of carbon has a mass of 12.0 amu's but 6.02×10^{23rd} atoms of carbon has a mass of 12.0 g. Scientist use this molar mass number as a conversion factor to change units from atoms to moles to grams.

Bang: Hey, that is what the next problem is. How in the world do I do that?

Whiz: Let's use an analogy again. Say there are 40 nickels = 1 roll of nickels and each nickel = 5 cents. So, if you have 3 rolls of nickels, how many nickels do you have?

Bang: I am going to set this up the way we did in chemistry class.
3 rolls of nickels x $\frac{40 \text{ nickels}}{1 \text{ roll}}$ = 120 nickels.

Whiz: You have it, if each nickel is worth 5 cents, how much money is that 3 rolls of nickels worth?

Bang: Again set it up like we did before. 120 nickels x $\frac{5 \text{ cents}}{1 \text{ nickel}}$ = 600 cents

Whiz: Now let's use carbon. If you know that 1 mole of carbon = 6.02×10^{23} atoms of carbon, how many atoms do you have if you have 5 moles of carbon?

Bang: $5 \text{ moles of carbon} \times \frac{6.02\times10^{23} \text{ atoms of carbon}}{1 \text{ mole of carbon}} = 3 \times 10^{24}$ atoms of Carbon

I think I can even turn that into grams for you also.
I know that 1 mole of carbon = 12.0 grams.
So: $5 \text{ moles of carbon} \times \frac{12.0 \text{ g of carbon}}{1 \text{ mole of carbon}} = 60$ grams of carbon

Whiz: Bang, I think you are going to do a "Bang up" job on that quiz today. Get it, "bang up" job.

Bang: *(chuckling)* Thanks for your help, Whiz, this mole stuff is marvelous.

Author – Nancy Smith

8.1 Criss and Cross Get Stoiched About Stoichiometry

Criss and Cross are in the kitchen about to bake some chocolate chip cookies.

Criss: *(jumping up and down)* OOOOWWEEEE I can't WAIT for these cookies!

Cross: Me too! I love baking!

Criss: While they are in the oven we should probably start on that stoichiometry homework we have.

Cross: *(annoyed)* You HAD to remind me. Stoichiometry? I mean is that even a real word? I think our teacher just says it to sound smart.

Criss: I thought the same thing! Unfortunately, I looked it up, and it is a real word.

Cross: *(disappointed)* Seriously? Dang, well there goes that excuse.

Criss: Yep, the 'stoich' part means elements, and the 'metry' part means measure.

Cross: So we need to measure some elements? Well I don't know how we are going to do that…aren't elements super small? *(flustered)* And I don't even have a ruler at home!

Criss: Well, each ATOM of an element is small, but we usually aren't dealing with just one atom. And we CERTAINLY don't need rulers! We measure elements and compounds in grams and liters and stuff like that.

Cross: Fine, fine. But seriously, who needs stoichiometry?

Criss: Um, we do?

Cross: For what? I'm not gunna be a chemist!

Criss: *(matter-of-factly)* Actually, we are using stoichiometry RIGHT now.

Cross: Don't be ridiculous. We are baking COOKIES. **COOKIES.** Not elements.

Criss: Yes, thank you Cross. But check it out… stoichiometry is all about measuring and calculating the amount of product you can make with your reactants or the amounts of reactants you need to make a certain amount of product.

Cross: *(astonished)* But even with COOKIES??

Criss: Yes Cross, with COOKIES! SHEESH! The cookies are the products…

Cross: *(interrupting)* …and the ingredients are the reactants.

Criss: Indeed! You are finally pickin' up what I'm layin' down! So we are trying to make enough cookies for our whole chemistry class, and we have 24 students in there.

Cross: Yep, but the recipe only makes a dozen cookies. I don't really wanna make little baby cookies, so I guess we'll have to double the recipe.

Criss: Sounds good. *(pointing to a piece of paper)* So let's jot the recipe down on this paper here.

Cross: *(reading from a computer screen)* Ok, the recipe online says we need one cup of flour, half a teaspoon of baking soda, half a cup of butter, three-quarters cup of sugar, one egg, and a cup of chocolate chips.

Cross writes the following on a piece of paper…

1 c flour + ½ tsp baking soda + ½ c butter + ¾ c sugar + 1 egg + 1 c chips = 12 cookies

Criss: Looks delicious! So you were saying that we needed to double the recipe. What would that look like?

Cross doubles the recipe on the same piece of paper…DO THAT HERE!

__ c flour + __ tsp baking soda + __c butter + __c sugar + __ egg + __ c chips = ___ cookies

Criss: That there is some delicious lookin' stoichiometry!

Cross: *(surprised)* THAT is stoichiometry?? That's as easy as pie…er…cookies.

Criss: That's what I'm saying! You knew how much product you wanted to make, so you followed the recipe and you were able to figure out how much of all the ingredients you needed!

Cross: And when we get to that chemistry homework, our recipe is a balanced equation! I knew I spent all that time balancing equations for something!

Criss: Yep! Lucky for us, someone already balanced our cookie equation!

Cross: So you also said that stoichiometry involved figuring out how much product you can make from a certain amount of reactants. How's that work?

Criss: Well, let's say we raided your cabinets and found all your flour, all your baking soda, all your butter, all your sugar, all your eggs, and all your chocolate chips and piled them here on the counter. *(pointing at the counter)*

Cross: *(eyes getting wider)* That sounds like a B-E-A-UTIFUL sight.

Criss: I know. *(starting to daydream and then snapping out of it)* So anyways, if we had all that stuff piled on the counter, we could use our recipe to figure out the maximum number of cookies we could make.

Cross: Oooohhhhh. Makes sense. We would have to see how much of each ingredient we have and then see how many batches of cookies we could make. But don't you think that one ingredient will run out first?

Criss: Definitely. I think our teacher mentioned something about a "limiting reagent" that we are learning about tomorrow. Maybe that has something to do with it.

Cross: Hmm, well maybe I don't mind this stoichiometry stuff as much as I thought I did.

Criss: Awesome! Now let's get these ingredients mixed up so we can throw 'em in the oven and go crank out that homework.

Cross: Sounds good, should be a cake walk!

Author - Christina Cattey

15.2 Acids, Bases and Salts – Oh My!

Kailey and Kyle are chomping on a burger and fries, washing it down with a soda, when Kyle wonders about the acidity of the soda.

Kyle: Yum, Yum! These baby butter burgers are beyond beliceous!

Kailey: Beliceous?

Kyle: Well, I couldn't think of a proper word to describe good tasting that started with a b, so I invented one.

Kailey: Right. How about tasty, scrumptious, flavorsome, mouth-watering, appetizing – stick to the King's English would you?

Kyle: Seeing as you are not going to give me any linguistic latitude, how about this question. Remember in chemistry class our teacher said that next week we were studying acids, bases and salts? I heard Sam say that sodas contain citric acid. And, my pop was talking about battery acid and not getting any on his skin or clothes and he wore goggles just to protect his eyes. How come I don't have to wear goggles drinking my soda?

Kailey: Ok, great question Kyle. First of all, there is an acid in sodas, and also in batteries to help with the storage of electrical charges. There are also acids in our bodies, and in the air – perhaps you have heard of acid rain. So it is important that you understand the essence of acids, and also bases.

Kyle: Right – I have heard of bases but I'm really unclear of the connection to acids. So just tell me enough so the next time Sam mentions acids, I can rock star impress him with my knowledge.

Kailey: So, let's start really simple with the definition of an acid – any compound that contains hydrogen atoms, when added to water, releases hydrogen ions. Let me break that down for you. An acid gives away a hydrogen ion which then bonds with water to form a hydronium ion – H^+ plus H_2O forms $H30^+$ ion – a hydronium ion.

Kyle: OK, I am still with you - maybe.

Kailey: So here is the formula for what happens with the acid HCL into water – HCL + $H_20 = H_30 + Cl^-$, or if you had Sulfuric acid to water it is $H_2SO_4 + H_2O = H_3O^+$

Kyle: Ok. That makes sense. I see the pattern with the hydronium ion being created. So, how about bases?

Kailey: Hold on cowboy. We will hold off on bases until you understand more about acids. Now, you might have heard the names of other acids such as carbonic, or nitric acid.

Kyle: Right – and again, my soda can lists citric acid as one of the ingredients.

Kailey: And you can drink the soda without hurting yourself. But sulfuric and nitric acids are quite dangerous and would burn your skin, or really damage your eyes if you accidentally spilled some on you.

Kyle: Yup – when my pop, dad – not soda, got a new battery, he had to add the sulfuric acid into the battery cells, and he was super careful about pouring it in. He made me stand way back so nothing could splash on me.

Kailey: Well that make sense because I think sulfuric acid is much more dangerous than carbonic acid. But let's take a look at the difference. First, there is a scale that is used to indicate how strong or weak an acid is and it's called the pH scale. The pH scale ranges from 0 – 14, and anything in the middle, with a pH of 7, is called neutral, higher than 7 is called basic, lower than 7 is called acidic.

Kyle: OK – so that's easy to remember. A for acidic is first in the alphabet, so I can remember it comes first, from 0-7, and B for basic comes second and therefore is 7-14 on the pH scale.

Kailey: Hey, that's a good way to remember it. Now 7 is neutral right, neither acid nor base. But the strength of the acid comes from how many hydronium ions are in the solution. An acid with a pH of 3 has a lot more hydronium ions than an acid with a pH of 6. And an acid with a pH of 1 has a lot more hydronium ions than a pH of 3. Follow me.

Kyle: Sure, but going from a pH of 3 down to a pH of 1 isn't much of a change.

Kailey: You know, I also believed that, but, here's the deal. And listen closely to this. A pH of 5 is ten times stronger of an acid than a pH of 6. And it is stronger because what Kyle?

Kyle: Stronger because of more hydronium ions, right?

Kailey: Ooooh! My budding scholar. You have broken away from your butter burger long enough to pay attention. That gives me goose bumps. But more on strength of an acid. An acid with a pH of 4 is also ten times stronger than something with a pH of 5. And a pH of 3 is how many times stronger than a pH of 4?

Kyle: Well I guess the pattern seems to be a ten-fold change with a drop of one number, right?

Kailey: Right. But how much stronger is a pH of 4 than a pH of 6?

Kyle: *(confidently)* Well, that's easy - 20 times stronger.

Kailey: *(shaking head)* Nope. Check this math out. If a pH of 4 is ten times stronger than a pH of 5, and a pH of 5 is ten times stronger than a pH of 6, then 10 times 10 equals 100, so a pH of 4 is 100 times stronger than a pH of 6.

Kyle: I see. So check this out. Then a pH of 3 is 1000 times stronger than a pH of 6, because 10 x 10 x 10 equals 1000. Right?

Kailey: *(almost swooning)* Kyle, you are so quick to catch on – I'm quite proud of you.

Kyle: *(blushing)* Thanks Kailey – It is really no big deal.

Kailey: One more thing. A strong acid has many more H_30^+ ions than a weak acid – the science term is disassociates more. And to put acids into perspective, a stomach acid might be a pH of around 1, while vinegar is about 3, and soda water is about 4.

Kyle: So to use my new knowledge of pH, stomach acid is 10,000 times more acid than soda water.

Kailey: Right! You are pretty quick on the calculations there Kyle. Hey, my food is getting cold. Let's pick up this conversation later and talk about the importance of acids in our lives.

Kyle: Sure, I don't quite get the acid rain thing. Maybe you can fill me in on that phenomenon. I am really worried about all the times I went out and played in the pouring rain. But now I know it is dependent upon the strength of the acid, and I am not really sure how dangerous it was to play in the rain.

Kailey: We can talk about that later. But now I want to finish my burger really fast just to make it to class on time.

Author - Craig Berg

19.2 Ban Chemicals Now!

While walking around downtown one Saturday afternoon, Pep comes across her friend Pip at a protest in the park.

Pip: *(shouting)* Ban DHMO! Ban DHMO!

Pep: *(goes up to Pip in the crowd)* What is DHMO?

Pip: DHMO is a dangerous chemical that needs to be banned now!

Pep: I've never heard of this. What is it?

Pip: It is a colorless and odorless chemical compound that has been shown to mutate DNA, disrupt cell membranes, and chemically alter your nervous system!

Pep: Wow! That sounds dangerous! What else does it do?

Pip: Check this out *(hands Pep a handout Fact Sheet that teachers could create from any number of Ban DHMO websites)*.

Pep: This says that the U.S. Government and Centers for Disease Control do NOT classify this as toxic OR carcinogenic yet, the components of DHMO are in dangerous compounds like sulfuric acid and nitroglycerine. It's even been implicated in the deaths of thousands of people each year!

Pip: *(outraged)* I know- which is why I am protesting to ban this chemical today! I found out about it from my buddy Stan, and he got me involved with this group trying to ban it.

Pep: Well, if it is so bad, why is it used at all?

Pip: It's currently used as an industrial solvent and coolant and in nuclear power plants. It's also used to make Styrofoam, produce biological and chemical weapons, and as a fire retardant!

Pep: Why isn't there more public outrage about this?

Pip: *(confused)* I really don't know. I guess the politicians aren't aware of it or are supporting the businesses which use it now.

Pep: That's so surprising- just look at this fact sheet. (*looks over fact Sheet with Pip)* It's also called hydroxyl acid, contributes to the greenhouse effect, may cause severe burns, is fatal if inhaled, and has been found in cancerous tumors! So, what can I do to help?

Pip: Sign this petition now and grab a sign!

Pep: Well, I'd love to join you but I think I should learn some more.

Pip: Why? It's all listed right here on the DHMO Fact Sheet.

Pep: Well, my dad always says be careful what you sign, and he always tells me to be careful what I read. I mean this DHMO sounds so scary, but could there be another side to this story?

Pip: Not for me! It hurts the environment and kills people. That's all I need to know!

YOUR TURN:

1. Research and write about DHMO and its effects. Summarize your research with your position on this chemical. Would you protest with Pip?

2. Explain methods used to educate and/or incite the public about other dangerous chemicals.

Author – Robin Kroyer Kubicek and Scott Gundrum

20.1 Bryce and Michel Muse About Molar Mass

While having lunch on his birthday, Drew inhales some helium from one of his balloons. His voice's pitch sharply increased, suddenly making everything he said amusing. Everyone was content with just watching and enjoying Drew's antics but not Bryce. Bryce, unlike everyone else, wanted to know how this strange phenomenon happened. Bryce, while on his quest for answers, learned that his good friend Michel was in AP chemistry, so one day between classes he cornered him in a back hallway and demanded answers!

Bryce: Hey Mike!

Michel: Oh hey Bryce.

Bryce: I have a question.

Michel: Shoot, but make it quick I have to make it to my next class before the bell.

Bryce: Alright, yesterday at lunch I saw Drew inhale some helium then suddenly his voice was a few octaves higher, I heard you were good at science, do you know what was going on?

Michel: Well, helium is a lot less dense than the air we breathe, six times less to be exact, so when you inhale it and try to talk, the sound waves you create travel a lot faster making which makes your voice sound much higher.

Bryce: But how come it's ok to inhale helium?

Michel: Helium is actually an inert gas, which means it's not doing much in its free time. Because of this fact it's ok to breathe it in. Well, kind of. What I'm saying is, it's ok to do it as a joke once in awhile, but don't try to live on the stuff. Funny thing is helium's not the only gas that affects your voice; Sulfur Hexafluoride does the complete opposite.

Bryce: How does that one work?

Michel: Sorry Bryce I've got to get to my class, maybe we can talk about this later.

Bryce: No!

Michel: What?

Bryce: You can't just answer one question then leave me here with another!

Michel: What are you talking about?

Bryce: I've been up for 36 hours trying to find out how helium worked and now you're going to leave me with a different question?

Michel: Dude, why didn't you just Google it?

Bryce: That's beside the point! I need to know!

Michel: Ok, I'll tell you just calm down.

Bryce: Thank you.

Michel: Like I said, Sulfur Hexafluoride works much like Helium. While helium is six times lighter than air, Sulfur Hexafluoride or SF6 as some people call it, is six times heavier than air, which causes the opposite effect; it makes your voice become very deep by slowing down the sound waves.

Bryce: Is that gas inert as well?

Michel: Yep, which means is safe to inhale in small quantities.

Bryce: Thank you so much for your help, I really appreciate it.

Michel: No problem, can I go to my class now?

Bryce: Hold on, I have another question.

Michel: Really? Hurry up I'm going to be late.

Bryce: What if I inhale equal parts helium and SF6? Would my voice go back to normal?

Michel: Nope, your voice would still get deeper.

Bryce: Really?

Michel: Yah, see, helium has a molar mass of 4 grams per mole and SF6 has a molar mass of around 146 grams per mole so if we had equal parts sf6 and helium its molar mass would be 75 grams per mole but airs molar mass is about 29 grams per mole. So it would actually take 4 parts helium to 1 part SF6 to sound normal.

Bryce: Ok thanks, I have to go, I don't want to be late to my class.

Michel: But your class is right there and mines across the building!

Bryce: You should have left earlier then.

Michel: I tried but you kept me here answering your questions!

Bryce: Well you better start running if you don't want to be late!

Author – Lucas Jackson

Physics Volume One

DIALOGUES for the PHYSICS CLASSROOM

By Marian Schraufnagel, Matt Heer, Todd Everson,
Michele Fuller,Michelle Sackerson, and Craig Berg

Physics I - Table Of Contents

Physics I Dialogue Abstracts

Unit 1 - Measurement

1.1 Measure What?: Zig and Zag are attempting to connect phones with computers and discuss the advantages or disadvantages of Metric units versus English units.

Science concepts or terms include: accuracy, conversion factors, decimals, English System of Measurement, International System of Units, length, mass, measuring, Metric System, volume.

1.2 Significant Figures are NASdy: Pip and Pep attempt to understand the rules of significant figures.

Science concepts or terms include: non-zero numbers, significant figures, where is the decimal?

1.3 Hockel and Ockel Discuss Density: Our two friends discuss the concept of density in terms of mass, volume and cookies.

Science concepts or terms include: density, mass property of a substance, volume.

Unit 2 - Graphing

2.1 Graph a Giraffe: Nix and Nox are hanging out at the zoo looking at the giraffes, and talking about the first few weeks of their physics course. They have a discussion about making good graphs.

Science concepts or terms include: dependent variable, independent variable, line of best fit, relationships, slope, uncertainty, y intercept.

2.2 Hip and Hop Practice Graphing: Hip and Hop have a data set and are trying to figure out how to graph the data.

Science concepts or terms include: graphing construction and interpretation.

Unit 3 - Linear Motion

3.1 Zip and Zap Talk Vectors: 3 + 4 = 5?: Zip and Zap are having lunch when they start chewing on the topic of vectors.

Science concepts or terms include: displacement, magnitude, scalars, vectors.

3.2 Hockel and Ockel Discover the Difference in Graphing Distance vs. Displacement: Hockel and Ockel are working together in their physics classroom. The teacher has just explained differences between distance and displacement. Hockel and Ockel are reviewing and applying what they learned.

Science concepts or terms include: displacement, distance, graphing, reference point, scalar quantity, vector quantity.

3.3 Move It!: Rip and Rap are studying for a physics quiz and trying to sort out motion terms.

Science concepts or terms include: displacement, direction, distance, magnitude, measurements, motion, position, reference point, scalars, theory, vectors.

3.4 The Instantaneous Average Speed: Zip and Zap are taking a ride in a car and wrestle with how to compute average speed of an object.

Science concepts or terms include: average speed, distance, instantaneous speed, miles per hour, time.

3.5 Let's Get Going: In this dialogue, as they watch vehicles on the highway, Tex and Lex are wondering how force and mass affect the acceleration of trucks.

Science concepts or terms include: acceleration, direct relationship, factors affecting speed, forces, gravity, inverse relationship, Isaac Newton, mass vs weight, velocity, F=M x A.

3.6 Speed Ain't Acceleration: Zip and Zap are in Zip's car cruising downtown on a Friday night, sitting side by side in the front seat, hitting the occasional bump and turning the occasional corner.

Science concepts or terms include: accelerate, constant speed, velocity.

3.7 Hip and Hop Learn How To Interpret Graphs: Hip and Hop are puzzling over speed and velocity graphs.

Science concepts or terms include: distance, graph interpretation, speed, time, velocity.

3.8 Hockel and Ockel Figure Out Newton's 3rd Law: Hockel and Ockel use springs and scales to help figure out Newton's 3rd Law.

Science concepts or terms include: action, net force, Newtons, Newton's 3rd Law, reaction, unbalanced force.

Unit 4 - Forces

4.1 May the Force Be With You!: Tick and Tock are sitting in their car in the ditch pondering the forces needed to get back on the road.

Science concepts or terms include: contact forces, field forces, force, friction, gravity, magnetism, static electricity.

4.2 Simple, Simple Machines: Zip and Zap discuss simple machines, mechanical advantage and efficiency.

Science concepts or terms include: efficiency, force, friction, mechanical advantage, resistance, simple machines.

4.3 Problem Under Glass: Washing dishes causes our two characters to ponder how air pressure can keep water in an upside down glass.

Science concepts or terms include: accelerate, air pressure, equilibrium, gravity, mass, pressure transmission, volume.

4.4 Let's Fly Away: Pip and Pep are talking about an upcoming flight and wonder about how planes stay in the air.

Science concepts or terms include: aerodynamics, airstream, Bernoulli's Principle, cohesive, drag, forces, lift, thrust, wing shape.

4.5 I Love Levers: Tick and Tock have stopped at the seesaw on their way home so they could put off studying for a physics test and relate the seesaw to the study of levers.

Science concepts or terms include: Archimedes, balance, first, second, and third class levers, forces, fulcrum, gravity, Law of the Lever, lever, simple machine, volume, weight.

4.6 Pressure Play: Pip and Pep are watching workmen connect pipes to a water main and wonder about the size of pipes and pressure of the water flowing within them.

Science concepts or terms include: Bernoulli's Principle, how size of pipe affects water pressure, pressure.

Unit 5 - Gravity

5.1 What Goes Up Must Come Down: Aristotle and Galileo Discuss Falling Objects: In this dialogue, Aristotle travels in time to meet with Galileo and discuss their contrasting ideas about the physics of falling objects.

Science concepts or terms include: air resistance, forces on falling objects, Four Element Theory, hypothesis, repetition of tests, scientific evidence, scientific methods.

5.2 Gravity of the Situation: Newton and Hooke, competitors for scientific fame in the late 1600's, argue for the merits of their contrasting ideas related to the composition of light and the equation describing gravitational force.

Science concepts or terms include: composition of light, evidence, gravity, inverse relationship, inverse squared relationship, Universal Gravitation Equation.

5.3 Weighty and Massive Ideas About Gravity: Zip and Zap are lifting weights, discussing weight versus mass and gravitational force.

Science concepts or terms include: direction, energy, force, magnitude, mass, Newtons, scalar, vector, weight.

Unit 6 - Rotational Motion & Projectile Motion

6.1 Compare and Contrast Translational and Rotational Motion: Hip and Hop are in the middle of a physics class, attempting to compare translational motion with rotational motion.

Science concepts or terms include: acceleration, angular velocity, angular displacement, constant velocity, displacement, rotational motion, translational motion.

6.2 Come Fly With Me: After playing softball in Physical Education class, Kit and Kat enter the physics classroom and discuss the forces affecting the motion of a projectile.

Science concepts or terms include: arc, components, horizontal force, hypothesis, independent force, initial velocity, parabola, projectile, trajectory, vectors, vertical force.

Unit 7 - Momentum and Impulse

7.1 Hip and Hop Get Impulsive: Hip and Hop are spectators at a football game and the conversation turns to momentum and impulse.

Science concepts or terms include: car air bags, gymnastics and forces, impulse, mass, momentum, motion, speed.

7.2 Hockel and Ockel Become Impulsive: In the backyard, jumping on a trampoline, Hockel and Ockel discuss momentum and impulse.

Science concepts or terms include: impulse, inverse relationship, mass, momentum, velocity, F x t= I.

7.3 12 x 1 not equal to 6 x 2: Pip and Pep are playing with Newton's Cradle and thinking about the factors affecting the colliding spheres.

Science concepts or terms include: collision, conservation of momentum, kinetic energy, Law of Conservation of Energy, mass, momentum.

7.4 Bowling with Newton: Pip and Pep are still playing with a Newton's Cradle made of bowling balls, and compare their understanding of the Law of Conservation of Momentum with what is happening to the swinging spheres.

Science concepts or terms include: Law of Conservation of Momentum, momentum.

Unit 8 - Energy, Work and Power

8.1 Gasoline Versus Diesel Engines: Pip and Pep discuss the differnces between using gas or diesel fuel, and the difference in the engines that use each.

Science concepts or terms include: compressions, engine, power, temperature, torque, weight.

8.2 Roller Coasters: Zig and Zag are two physics students talking about roller coasters. They're trying to use their physics knowledge to figure out how fast a new ride will go.

Science concepts or terms include: air resistance, closed system, friction, gravity, kinetic energy, Law of Conservation of Energy, potential energy.

8.3 Hockel and Ockel Get Energized: Hockel and Ockel are riding their bikes when their thoughts turn to potential and kinetic energy.

Science concepts or terms include: energy conversion, gravity, kinetic energy, mass, potential energy.

Unit 9 - Thermal Energy: Heat and Temperature

9.1 To Heat or Not to Heat?: Zip and Zap are discussing thermodynamics as applied to heating a home.

Science concepts or terms include: heat, insulator, Newton's Law of Cooling, temperature, thermostat.

9.2 Hip and Hop Talk Temperature: Hip and Hop walking through snow, slush and ice from the bus stop to school and ponder temperature and various units for measuring temperature.

Science concepts or terms include: absolute zero, Celsius, Fahrenheit, freezing point, ice, Kelvin, kinetic energy, molecular motion, Rankin, slush, snow, temperature.

Unit 10 - Gas and States of Matter

10.1 Snow on the Mountain: Pip and Pep watch a hawk soaring on an air current and begin to wonder how air pressure, temperature and other factors come into play in their lives.

Science concepts or terms include: air pressure, boiling point, condensation, expansion.

10.2 Combined Gas Law: After conducting some experiments, Boyle, Charles and Gay-Lussac discuss the results they had concerning the relationships they found between pressure, volume and temperature.

Science concepts or terms include: Combined Gas Law, gas, pressure, temperature, volume, PV/T

10.3 Using Gas Law Formula to Determine Relationships Between Variables: Zim and Zoom discuss how they think they did on their chemistry quiz and how to use the gas law formula.

Science concepts or terms include: direct relationship, inverse relationship, pressure, volume, PV=nRT.

10.4 Full of Hot Air: On a snowy winter day, Jib and Jab are eating in the school cafeteria, and chewing on the events of the past weekend.

Science concepts or terms include: Charles' Law, Graham's Law, particle motion, speed, temperature.

10.5 Gas has Mass: Sis and Sas are doing an experiment to show that gas has mass.

Science concepts or terms include: gas, mass.

10.6 Changing State of Matter: Tiff and Tuff are getting ready for a barbecue when Tuff realizes he is out of propane gas for the grill. They discuss how gas changes when pressure is applied.

Science concepts or terms include: changes in pressure, gas.

10.7 Go to the Recycling Center: Tiff and Tuff discuss how the pressure of gas changes when temperature is changed- Gay Lussac's law.

Science concepts or terms include: Gay Lussac's Law, pressure, temperature.

Unit 11 - Waves

11.1 Hockel and Ockel Learn to Wave: Our two friends are in their physics class working with a slinky and studying wave action.

Science concepts or terms include: compression, electromagnetic wave, longitudinal, moving particles, sound, transverse, waves.

11.2 Hip and Hop Talk About Waves: Hip and Hop are at the beach where a discussion of waves takes place.

Science concepts or terms include: energy, medium, molecules, waves.

11.3 A Dip in the Pool : Zip and Zap Discuss Light Waves: Zip and Zap are lounging in the pool and pondering the spreading of water waves and light waves.

Science concepts or terms include: disturbances, electromagnetic field, light, wavelength, waves.

Unit 12 - Sound

12.1 Wha'd You Say?: Nip and Tuck are talking about a rock concert they attended last weekend and now Nip's ears are still ringing.

Science concepts or terms include: decibels, ear buds, hair cells, hearing aids, hearing loss, high frequency, log relationship, loudness, perception, sound energy.

12.2 If a Tree Falls in the Forest: Zip and Zap Discuss Sound: Zip and Zap are on a fishing trip when they ponder sources and transmission of sound.

Science concepts or terms include: eardrum, mechanical radiant energy, infrasound, pitch, pressure waves, medium, pressure variation, sound, tone, transmission, ultrasound.

Unit 13 - Light and Color

13.1 Hip and Hop Learn Why the Sunset Appears Red: After learning about why the sky is blue, Hip and Hop tackle the challenge of finding out why the sunset appears red.

Science concepts or terms include: atmosphere, colors, frequencies, light, wavelengths.

13.2 Color Harmony: Pip and Pep are riding the after-school bus, see a rainbow, and discuss light and color and the possibility of "light harmonies."

Science concepts or terms include: eyes, color, frequency, light, waves.

13.3 Wave Particle Duality of Light: It is the 1600's and Isaac Newton and Christian Huygens have conflicting views on the composition of light.

Science concepts or terms include: diffraction, energy, evidence, interference, Law of Reflection, light, medium, particle model, properties, refraction, wave model.

13.4 The Frosting Baster: Pip and Pep are chatting about Pip's frosting baster and realize how changing the height relates to the Inverse Square Law.

Science concepts or terms include: Inverse Square Law, light intensity.

13.5 Color Mixing: Zig and Zag Ponder Primary Colors in Light and Pigments: Zig is captivated by colors and engages Zag in a discussion about how primary colors differ in light and pigments.

Science concepts or terms include: additive method of color mixing, light reflection and absorption, primary colors of light, pixels, primary colors of pigments, secondary colors, subtractive method of color mixing, wavelengths.

Unit 14 - Optics

14.1 I've Got My Eye On You: Hip and Hop are two physics students talking about eye problems and how lenses and laser surgery fix the problem.

Science concepts or terms include: Ben Franklin, bifocal lenses, concave lenses, convex lenses, farsightedness, laser surgery, nearsightedness, retina.

Unit 15 - Static Electricity

15.1 I Get a Charge Out of You: Nip and Tuck talk about static electricity, what causes shocks, and why it's more common in winter.

Science concepts or terms include: charges attract, electronegativity, electrons, grounding, humidity, opposite unbalanced charges.

15.2 Hockel and Ockel Learn the Shocking Truth: Ockel accidentally bumps Hockel and receives a shock, which prompts a discussion about static electricity.

Science concepts or terms include: conductors, cumulating charges, electrical charges, electron, friction, grounding, negative, nucleus, positive, proton, static electricity.

Unit 16 - Current Electricity

16.1 Parallel and Series Circuits: Hockel and Ockel Go With the Flow: In this episode our two characters attempt to make sense out of electric currents and how a series circuit differs from a parallel circuit.

Science concepts or terms include: circuits, electricity, parallel, resistance, series.

16.2 Battle of Currents: Nip and Tuck, two physics students, are wondering about a rumor they've heard that the U.S. uses alternating current and Europe uses direct current electricity.

Science concepts or terms include: adapters, alternating current, direct current, Edison, electrons, frequency, Hertz, Tesla, transformers, transmission, voltage, Westinghouse.

16.3 Current, Voltage and Resistance, Oh My!: While Zip and Zap are hard at work trying to fix a leak in the plumbing, they discuss the similarities between plumbing and electricity.

Science concepts or terms include: conductors, current, electrons, insulators, Ohm's Law, resistance, voltage.

16.4 The Discovery of the Battery: Galvani, a biologist, and Volta, a physicist, discuss their recent findings related to electricity and the discovery of the battery.

Science concepts or terms include: evidence, experiment, Galvani's experiment, Leyden Jar, static electricity, Voltaic Pile Battery.

Unit 17 - Magnetism

17.1 Hip and Hop Talk About Magnets: Hip and Hop are on a hiking trip where the use of their compass leads to a discussion about magnets.

Science concepts or terms include: compass, magnetic field, magnetic north, magnetic poles, magnets.

17.2 Hockel and Ockel Repel and Attract: Hockel and Ockel use paper clips and magnets to help them better understand magnetism.

Science concepts or terms include: atomic level, current, directional spin, electrons, magnetic field, magnetism, magnets, nucleus.

Unit 18 - The Atom

18.1 History of the Atom: A Conversation Between Democritus and Schrödinger: Democritus, a Greek philosopher, has transported through time to meet Austrian physicist Erwin Schrödinger, the father of quantum mechanics. Together they discuss the changing model of the atom, through time, as new discoveries are made.

Science concepts or terms include: atomic theory, Chadwick's neutron discovery, changing model of the atom, Dalton and The Atomic Theory, history of science, J.J. Thomson and "The Plumb Pudding Model," Neils Bohr, Rutherford, Schrödinger-Heisenberg Electron Cloud Model, The Gold Foil Experiment.

18.2 Learn About the Atom: Hop tutors Hip about the atom.

Science concepts or terms include: atom, electrons, energy levels, forces, neutrons, nucleus, protons.

18.3 Atom Smashers: Tick and Tock are discussing the new Large Hadron Collider particle accelerator and the unanticipated benefits of pure research.

Science concepts or terms include: Big Bang, dark energy, dark matter, hadrons, Large Hadron Collider, leptons, muon, neutrino, particle physics, protons, pure scientific research, quarks.

Unit 19 - Nuclear Physics

19.1 Discovery of Radioactivity: Henri Becquerel: It is the late 1890's and electricity is just being developed. Henri Becquerel is about to make another important discovery and is talking to his wife about his work that sets up the discovery of radioactivity.

Science concepts or terms include: energy, experiment, hypothesis, phosphorescence, scientific methods, spectrum, uranium, variables, X-ray.

19.2 Learn About Radioactivity: Hip and Hop ponder Tsunamis, nuclear power plants, microwave ovens and radiation.

Science concepts or terms include: electromagnetic spectrum, nuclear power plants, radiation.

Unit 20 - Quantum Theory and Relativity

20.1 Time Travel - Part 1: Pip and Pep are chatting about a movie they have just watched that was based on time travel.

Science concepts or terms include: Theory of Relativity, time travel.

20.2 Time Travel - Part 2: Pip and Pep continue their discussion about time travel and Einstein's ideas about the speed of light and how your reference point can affect time.

Science concepts or terms include: Einstein, speed of light, time travel.

Unit 21 - Creative Controversy

21.1 Pip and Pep - Conversations Concerning Creative Controversy: This is a dialogue we used to introduce a teaching strategy called Creative Controversy, also call Structured Controversy, in which students wrestle with the pros and cons of a science-based issue or ethical dilemma.

Science Concepts or terms include: a teaching strategy.

1.2 Significant Figures are NASdy

Pip and Pep attempt to understand the rules of significant figures.

Pip: *(exasperated, with forehead on the desk)* I can't stand significant figures. I never understood them before, now I have to do them again in Physics!

Pep: *(cool, calm, collected, and in a comforting voice, patting Pip on the back)* Don't worry. They're not that bad. Just remember that they're NASdy!

Pip: Nasty. Of course they're nasty! That's why my head is on the desk. You're not helping.

Pep: No no no. You misunderstand me. I mean NASdy. It's an acronym that stands for never, always, sometimes, decimal, yes.

Pip: *(with head still on the desk, but coming around)* Never, always, sometimes, decimal, yes. I'm listening.

Pep: It's a word that helps with which zeros are significant in a number. That's where most people have problems. Everyone knows that a non-zero number is significant, but it's the zeros that trip them.

Pip: *(bolting upright and slapping the desk excitedly with their hand)* OMG! You read my mind. I can't stand those zeros. I never know when they are or aren't. If this works, my problems are solved. You have my full attention.

Pep: Ok. You see how the acronym starts with the letter N; it's on the left side. It means that any zero on the left of any number is <u>N</u>ever significant. Take the number 0.0004. It only has one significant figure.

Pip: So the number 0.0305 has two significant figures! I get it!

Pep: Slow down there Thunder! Next the A. See how the A is in the middle of N and S. The A stands for <u>A</u>lways. Zeros in the middle of two non-zero numbers are always significant. So your number of 0.0305 actually has 3 significant figures. The zeros on the left are never and the zero in between is always.

Pip: Whoa. This is like witchcraft! So the number 3006 has four!

Pep: Exactly. Now you're getting the hang of NASdy. You can probably guess what the S stands for?

Pip: *(clapping hands quickly)* Sometimes! Zeros on the right are sometimes significant!

Pep: You got it. Zeros on the right are sometimes significant. Remember the 'dy' on the end of NASdy? Well, that 'dy' stands for Decimal Yes! Zeros to the right are not significant if there is no decimal point. If there is a decimal point, all the zeros on the right of a number are significant.

Pip: Let me see if I get you. The number 7000 has only 1 significant figure because there is no decimal point, but the number 7000.0 has 5 significant figures because there is a decimal?

Pep: *(patting Pip on the back and winking)* You got it! Now let's see if I can give you a hard one! The number 0.000500600.

Pip: Let's see. NASdy. The first four zeros are Never significant. The middle two are Always. And those last two are sometimes… hmm… Since there is a decimal, then the last two are. Soooooooooo adding the four zeros that are with the two non-zero numbers makes six. So six!

Pep: *(mimicking a bell)* Ding Ding Ding Ding! Correct!

Pip: Wow. I can't believe I've gone so long without knowing NASdy! This changes everything!

Pep: Just remember that significant figures are NASdy and life is good!

Pip: *(shaking hands vigorously with Pep)* Thanks Pep!

Author – Matt Heer

3.6 Speed Ain't Acceleration

Zip and Zap are in Zip's car cruising downtown on a Friday night, sitting side by side in the front seat, hitting the occasional bump and turning the occasional corner.

Zip: Check this out Zap; I'm going to show you a magic trick.

Zap: How about you just keep your eyes on the road. I'm not in the mood to see an ambulance magically appear.

Zip: No, check this out. I can magically make the car accelerate backwards but make it's velocity continue forwards.

Zap: I don't get it. How can you make something accelerate backwards, but move forward? You'd have to cut the car in two!

Zip: Are you ready?

(waving hand magically, and simultaneously applying the brake)

Subsisto Plaustrum!

Zip and Zap's heads go forward to simulate braking

Zap: All you did was hit the brake; I thought you were going to accelerate backwards?

Zip: We did! Watch I can now accelerate forward!

(waving hand magically again and this time stomping on the gas)

Accelero Plaustrum!

Zip and Zap's heads now go backwards from accelerating

Zap: I get it, so in both cases we were still moving forward; when we braked and when we accelerated. But in the first case we accelerated backwards, when we applied the brake, and in the second case we accelerated forward, when we hit the gas.

Zip: You got it. It's a common physics mistake to think that acceleration's direction is linked to velocity's direction. Usually in physics we assign a direction to be positive and negative. In this case we could say that forward is positive and backward is the negative direction.

Zap: So it would be pretty simple to show another situation of having your velocity be 'negative' and your acceleration also be 'negative'. That would mean we would go backwards and get faster!

Zip: Exactamundo amigo! We could even show our velocity being negative and our acceleration to be positive.

Zap: That would mean we would be traveling backward and slowing down. Hey, speaking of positives and negatives, is it possible to have a velocity or acceleration of zero?

Zip: Sure. A velocity of zero means something is standing still. An acceleration of zero means that it isn't getting faster or slower. It could be stopped, or it could be moving at a constant speed.

Zap: So is it possible to have a velocity of zero but have a negative acceleration?

Zip: Sure it is! Ready for another magic trick!

Author – Matt Heer

7.1 Hip ‘n Hop Get Impulsive

We join Hip ‘n Hop at a football game where they begin to have a discussion on momentum and impulse.

Hip: *(surprised)* Holy Cow! Look at how big that lineman is!

Hop: Oh of course! Linemen need a lot of mass.

Hip: *(sighing)* Of course you would bring physics into this…

Hop: Well duh! Football is a game that involves a lot of momentum!

Hip: I know I am going to regret asking this… but what is momentum?

Hop: *(excitedly)* Momentum is mass in motion. All objects have mass, so if they are moving, then they have momentum!

Hip: So all of the different football players have mass, so when the play begins, they are all moving and therefore they all have momentum.

Hop: *(nodding)* Right! An object can have a large amount of momentum by either having a large amount of mass, or a high speed, or both!

Hip: So a semi-truck would have a large amount of momentum even when it is moving very slowly because of its large mass. But it would be possible for a small car to have an equal amount of momentum because it is moving really fast.

Hop: Exactly! Can you think of a situation in which all objects have the same momentum?

Hip: Ummm… Since all objects have mass, it must have something to do with the speed… *(shouting excitedly)* I GOT IT! It has to be when their speed is zero!

Hop: Yep! Momentum is pretty easy to understand. But about as easy as and even more interesting than just plain momentum is the change in momentum, or impulse.

Hip: *(hesitantly)* Wait… I think I know something about this… momentum is always conserved, right?

Hop: Yes it is. When we focus on a system, we can account for all of the momentum and where it is transferred between different objects.

Hip: *(questioning)* So if momentum is always conserved, then how can we look at impulse, or a change in momentum? Shouldn’t it always be the same?

Hop: That is a good question. For impulse, we focus on just one object to see what happens with its change in momentum.

Hip: Oh, OK. Since single objects don't normally lose mass, then we must be talking about when an object loses or gains speed!

Hop: Exactly! Just like when one football player tackles another. The first football player had some amount of momentum, mass and speed, but once he is tackled, he has zero momentum since his speed has decreased to zero!

Hip: *(surprised)* Some of those tackles look pretty rough. Does it always hurt to have a change in momentum?

Hop: Not necessarily… this change in momentum, or impulse, can be calculated by multiplying force by time.

Hip: Well, if we assume a football player is generally always the same mass and gets very close to the same maximum speed, then their impulse should always be about the same.

Hop: Right, but what makes the change in momentum different for the football player, is how much force is involved in the tackle and how much time it takes for the change in speed to happen.

Hip: *(confused)* I'm a little lost still…

Hop: Ok, let's use car airbags as an example.

Hip: OK.

Hop: Let's say that you are traveling in a car and you end up in an accident. If the car doesn't have airbags, your head could hit the dashboard. The force that will bring your head to a stop is quite large and the time it takes is very small. Now we know, if you have this same accident but in a car that has airbags, your head will experience the same impulse. However, this time, instead of your head hitting the dash, your head will compress into the airbag. In this scenario, the time it takes to bring your head to a stop is much longer, so in order to have the same impulse, the force is decreased!

Dashboard: Impulse = F t   Airbag: Impulse = F t

Hip: *(excited)* OH! So this is also the same reason why the football players all wear pads!

Hop: Exactly!

Hip: If they played without pads, then the time it takes to change their momentum would be very small and the force they feel would be really large. However, with the foam pads, the time it takes to change the momentum is much longer and the force they feel is much lower!

Hop: You've got it!

Hip: This is crazy! I have so many examples rushing through my head right now!

Hop: *(surprised)* Oh yeah? Like what?

Hip: Well, boxers don't just keep their bodies still and take the hits, they move around. If they are moving with the punch, then the time is increased and the force is decreased.

Hop: *(nodding)* Yep.

Hip: Or like when gymnasts bend their knees on landings! If they landed straight legged it would be a small amount of time for their bodies to come to a stop so they would feel a large force. But they bend their knees, increasing the time of the impulse to decrease the force their body experiences.

Hop: *(laughing)* For someone who was reluctant to start a conversation about physics, you sure have taken to this topic!

Hip: True! Enough talk though – let's focus on the momentum and impulse happening on the field.

Hop: Sounds good! Our team sure has the momentum going right now being up 14 – 0 already! Let's hope there is no impulse anytime soon!

Come up with your own example of impulse:

Author – Michele Fuller

10.3 Using the Gas Law Formula to Determine Relationships Among Variables

Zim and Zoom discuss how they think they did on their chemistry quiz and how to use the Gas Law Formula.

Zim: So how did you do on the test today in chemistry?

Zoom: I don't think I did very well. I could not remember where the "n" goes in the ideal gas law. You know, the number of moles variable.

Zim: You mean in the formula PV=nRT?

Zoom: Yes but I memorized it as PV over nT equals R (the gas law constant). I forgot if the n goes on top with the Pressure and Volume or below with R. I think I put it with the PV, which means I got all of the math stuff wrong. I have to find a better way to memorize formulas.

Zim: But Zoom, you know the relationships among the variables. Right?

Zoom: What do you mean?

Zim: What is the relationship between Pressure and Volume when dealing with gases?

Zoom: Like in the lab we did with the syringe and air?

Zim: Exactly.

Zoom: The syringe began with a certain volume of air; I think I started with 15.0 ml of air. When I added more pressure to the top of the syringe the volume of the air decreased, a whole lot too - I think it ended at 2.0 ml.

Zim: So what is the relationship among the two variables pressure and volume?

Zoom: I don't know. I try not to pry into the private lives of others.

Zim: Very funny. You know what I mean.

Zoom: Ok. So as the pressure variable increased the volume variable decreased. That means they are inversely related.

Zim: Right. So what is the relationship among pressure and temperature?

Zoom: That was another lab we did.

Zim: We heated cans with stoppers in them and measured the pressure and temperature. That was fun, especially when the corks would pop off the tops.

Zoom: Especially when one cork bounced off the head of Mr. S. Thank goodness he was wearing his goggles.

Zim: Well let me think. Since both the pressure and temperature both increased they have a direct relationship.

Zoom: Correct.

Zim: So how does this help me with memorizing the ideal gas law formula?

Zoom: You're still not getting it. Remember we did that dialogue activity a couple of days ago regarding the combined gas laws?

Zim: Yea, that was pretty a cool dialogue. I remember if two variables are inversely related, like Pressure and Volume, you put them next to each other and if they directly related, like Volume and Temperature, they go above and below each other.

Zoom: Right again. So think how you memorized the ideal gas law formula PV = R. You could not remember if "n" goes on top with PV or on the bottom with T.

Zim: Right. So what you're telling me is if I know the relationship between "n" and any of the other variables I can figure out where it goes.

Zoom: Now you are cooking with gas.

Zim: Nice pun. Let me compare Pressure with "n". If "n" is the number of moles of gas and I increase the number of moles of gas the pressure should increase too, assuming the volume is constant. So according to the concept they have a direct relationship. So "n" would go on the bottom.

Zoom: Correct I think you got it.

Zim: Hold on, let's see if it works for Volume. If I put "n" on the bottom that would mean a direct relationship. So if I increase the number of moles of gas then the volume should increase too, assuming the pressure is constant. That seems correct also.

Zoom: Right again. So if you understand the relationship among the variables you can figure out how they are arranged in the formula.

Zim: This is great. So if I forget a formula all I need to do is think of the relationship among the variables and I should be able to figure out the formula.

Zoom: So now you do not have to rely 100% on your memory of formulas.

Zim: I wish I knew this before taking the test.

Author – Ray Scolavino

13.5 Color Mixing

Zig is captivated by colors and engages Zag in a discussion about how primary colors differ in light and pigments.

Zig: *(in a dreamy state of mind)* Aren't bright colors beautiful?

Zag: *(nodding head and agreeing)* Yeah, colors make everything more fun.

Zig: Those colors are so vivid. I really enjoy looking at sunsets and rainbows.

Zag: Me too Zig. My favorites are my collection of hot colored sunglasses. My car is a bold midnight blue. I even remember my first box of 64 crayons. I loved looking at all those colors.

Zig: It's fun to mix colors to see how they blend together to make new colors.

Zag: I remember when my elementary teacher told us that three primary colors could be mixed to make any other color. It didn't seem possible.

Zig: But it's true. When I worked the stage lights for a play, we mixed red and green lights to make a yellow light glow on the actors.

Zag: *(Zag throws up his/her arms and exclaims)* What are you talking about? Red and green mixed together make a dark brown, not yellow!

Zig: *(Zip with equal force states)* No! The primary colors are red, blue, and green. We can mix them together in equal amounts to make white light.

Zag: *(shaking head)* I don't think so. Red, blue, and green mixed will make a mess of dark brown or black. Yuck! Besides the primary colors we learned in elementary school were red, blue, and yellow. Now we know that the red is really a hot pink called magenta, and the blue is really a blue-green color called cyan. So the real primary colors are magenta, cyan, and yellow.

Zig: No. I can prove it to you. Take a magnifying glass and look closely at your TV screen. You will see just three colors in the little pixels - red, blue, and green. These three primary colors of light can mix to form any other color.

Zag: I say the primary colors are magenta, cyan, and yellow. And I can prove it to you! Just look at the ink cartridges inside your color printer. The three colors of ink are magenta, cyan, and yellow. These three primary colors can be mixed to form any other color.

Zig: *(puzzled)* I see your point. How does this work? It seems like we are both right. The only thing that is different is I'm talking about colored light and you're talking about colored pigments. I wonder why they are different.

Zag: *(putting hand on chin and looking contemplative)* Let's see. When I mix the three primary pigments of magenta, cyan, and yellow in equal amounts, I get black. Black means no light gets to our eyes. You said that when you mix red, blue, and green light equally, you get white light. White means that all the colors of light get to our eyes.

Zig: Mixing colored light is an additive process where the different light waves add to each other to create the new color that we see.

Zag: Pigment colors don't work that way. Pigments are chemicals that absorb certain wavelengths of light and reflect the rest. The light that is reflected is the blend of colors that we see. Pigments use a subtractive method of seeing color. For example, you see my red shirt. All the colors in white light strike the shirt, but only the red light is reflected. The other colors from the white light are absorbed in the shirt and make the electrons in the shirt vibrate a little faster.

Zig: So we're both right??? The primary colors of light are red, blue, and green. When two primary colors are mixed together, we get the secondary colors. The secondary colors of light are magenta, cyan, and yellow.

Zag: WOW! The primary colors of pigment are magenta, cyan, and yellow. When we mix to get the secondary colors of pigment, we get red, blue, and green. We're just the opposite.

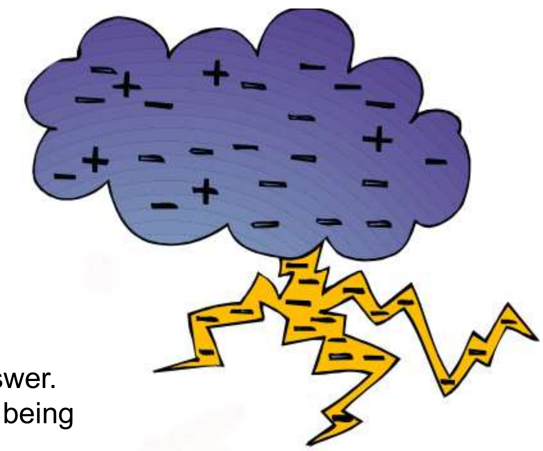
Zig: Isn't life amazing? Who'd have thought that? I thought color mixing was all the same.

Zag: Every time I turn around, it seems like I learn something new about how things work. Isn't physics cool?

Author - Marian Schraufnagel

15.1 I Get A Charge Out Of You!

On a chilly January night, Nip slides across the car seat for a good night kiss from Tuck, when they're both surprised by a big shock as their lips touch. The spark takes them aback and they start wondering what jsut happened.



Nip: *(amazed)* Wow! What happened?

Tuck: *(laughing)* That must have been the "sparks of love!"

Nip: My lip is still tingling. I can't believe it.

Tuck: Mine, too. I wonder why we got a shock. That never happened before.

Nip: I bet there's some physics involved in the answer. I vaguely remember something about sparks being electrons jumping from one place to another.

Tuck: That's right. Now I remember that from chemistry. Electrons can get rubbed off of some materials easily to form ions.

Nip: Oh yeah. When atoms hold their electrons tightly, they have high electronegativity. When the electrons are loosely bound to the atom, that is low electronegativity.

Tuck: Since the electrons are on the outside of the atom, if there's low electronegativity, the electrons can be rubbed off by friction with another material.

Nip: So when I slid across the car seat, I must have rubbed some electrons off, right?

Tuck: Right. Then you had an unbalanced total charge…. more positive charges than negative.

Nip: But, wait a minute. I could have rubbed some electrons onto myself from the car seat. How do we know which way the electrons moved?

Tuck: Yes, that could have happened. The way we know is by which material has a higher electronegativity. The higher the electronegativity, the more likely the electrons will adhere. Many plastics have high electronegativities.

Nip: I remember now. Cloth, like wool and cotton, usually have low electronegativity.

Tuck: So, what probably happened was the electrons moved from your clothes to the vinyl car seat and left you with extra positive charges.

Nip: *(puzzled)* Okay, but I still don't get why we both got a shock when we kissed.

Tuck: Remember "opposite charges attract?" Since you were positively charged and I was neutral, some of my electrons were attracted to you.

Nip: *(flirting)* I hope your electrons aren't the only thing that is attracted to me.

Tuck: *(giggling)* Never mind about that. Behave!

Nip: Okay, but after you lost some electrons, wouldn't you be positively charged?

Tuck: You're right, but I'm indirectly touching the ground. When you're grounded, adding or subtracting a few electrons doesn't really change your overall neutral state.

Nip: *(chuckling)* That gives a whole new meaning to the word "grounded."

Tuck: *(getting nervous)* Yeah, if I don't get inside soon, I'll be grounded.

Nip: *(puzzled)* So, why now? This never happened in the summer.

Tuck: I think it has something to do with the humidity in the air. In the summer, the air is warm and full of water molecules. In the winter, the air is cold and very dry.

Nip: I have noticed there's more static electricity in the winter. In the morning, my hair is wild and I need to wet it down to get the static controlled.

Tuck: Exactly! Water molecules are polar and attract excess electrons. So dry air allows electrons to build up, and humid air bleeds extra electrons off objects so they don't build up.

Nip: *(flirting)* Aaah, now I see why we got shocked. I really think we should try that again. Maybe we can get it right this time.

Tuck: *(laughing)* I think my folks will be wondering why I haven't come in the house yet. I'd better go. Maybe we can try out some physics experiments some other time.

Author - Marian Schraufnagel

18.1 History of the Atom: A Conversation Between Democritus and Schrödinger

Democritus, a Greek philosopher, has transported through time to meet Austrian physicist Erwin Schrödinger, the father of quantum mechanics. Together they discuss the changing model of the atom, through time as new discoveries are made.

Schrödinger: Democritus, good to see you! So much has happened since you were in Greece, in 460 B.C.

Democritus: *(looking astonished)* Really? After much thinking and deliberation, I was sure that what I declared to be an "atom" was the end. It would be infinitely small and indivisible.

Schrödinger: It was the end for almost 2000 years. Not until the early 1800's when the English chemist John Dalton experimented, did scientists begin the next 200 years of discoveries.

Democritus: *(with a confused look on his face)* English?? What is English? And thinking further, what is a chemist?

Schrödinger: Oh forgive me. There have been so many changes! Can we make that a separate conversation?

Democritus: Of course.

Schrödinger: Where were we? Oh yes, Dalton. He was the first to propose The Atomic Theory and in it, he envisioned the atom as a solid, indivisible sphere. This was the model used until the late 1800's.

Democritus: *(jumping up and down)* Aha! I knew it was indivisible!

Schrödinger: (*patiently explaining)* That was the model until J.J. Thomson, another English chemist, came along in 1897 and discovered the electron, a negatively charged particle in the atom.

Democritus: Astounding! That means for the first time, it was known that the atom has parts. No more solid sphere!

Schrödinger: Yes, exactly. Thomson's model for the atom was known as "The Plum Pudding Model". The negative particles were like plums in a positively charged pudding.

Democritus: I am adding pudding to the list for later. Was that it?

Schrödinger: Oh no. Ernest Rutherford, from New Zealand, came to England as a research student under J.J. Thomson in 1894. Rutherford was there when the electron was discovered and then went on to his own experiments.

Democritus: And what did he find?

Schrödinger: Well, Rutherford did the famous Gold Foil Experiment. Uuh… add that to your list too, it was a very cool experiment. As a result, he concluded that there is a nucleus, which is very, very small and positively charged and that the electrons were moving around it.

Democritus: *(nodding)* That makes perfect sense. Positive to balance the negative. Perfect sense.

Schrödinger: Shortly after Rutherford, Neils Bohr, a Danish scientist, created a new model. Like Rutherford, he had the positive nucleus in the middle, but the electrons were in specific orbits and set distances from the nucleus. It was a model similar to that of the solar system: nucleus in the middle like the sun and the electrons orbited like the planets around the sun.

Democritus: S-O-LA-R S-Y-S-T-E-M. Got it.

Schrödinger: In the mid 1920's, I proposed a wave model for electrons while German physicist Werner Heisenberg described electrons using a particle model. Together, they depicted electrons in an "electron cloud" rather than specific orbits like Bohr's model. This is the model that is used today.

Democritus: So that is the end? No more to find?

Schrödinger: Not quite… One more major part of the atom. In 1932, James Chadwick found the neutron, which has no charge and is in the nucleus. NOW we are done with the 3 main subatomic particles, their charge and location in the atom.

Democritus: Main…There is more?

Schrödinger: Oh yes. Much, much more. Perhaps you could do some research on the Internet to read through the latest information.

Democritus: *(rubbing his forehead)* Internet??

Author – Michelle Sackerson

Earth Science Volume One

DIALOGUES for the EARTH SCIENCE CLASSROOM

By Amy Schiebel, Sandra Rutherford, Mary Ruth Kotelnicki, and Craig Berg

Earth Science I - Table Of Contents

Earth/Space I Dialogue Abstracts

1. Thinking Like A Geologist

1.1 What Geologists Study: Rocky and Plato discuss just what it is that a geologist studies. They will find that geology is a very diverse and wide-ranging science.

Science terms or concepts include the following: archaeologist, astrogeologist, fossils, gemologist, geological engineer, geologist, Lithology, mineralogist, mining engineer, oceanographer, paleontologist, petrologist, petrology, sedimentologist, stratigrapher.

1.2 A Track Record in Reverse: Rocky and Plato are watching a basketball game and end up talking about the uniform nature of earth processes ,track records, making predictions, and traveling backwards in time. They start by taking about how we can use how people have behaved int eh past to predict how they will behave in the future. And then take that concept and turn it around to think about how the concept of Uniformitarianism helps geologists unravel Earth history.

Science terms or concepts include the following: earth history, the present is the key to the past, uniformitarianism.

1.3 A Scientific Upheaval: Rocky and Plato chat about an upcoming vacation to Canyonlands National Park where a controversy exists about a very strange feature. The role of new data in changing hypotheses is explored. Students will be introduced to the role that controversy and competing hypotheses play in scientific discovery.

Science terms or concepts include the following: crater, meteorite impact, salt dome, shatter cone, shocked quartz, the role of controversy in science, the role of evidence in hypothesis formation.

1.4 I See the Same But I Don't Think the Same: Plato is working on a building project he began a few days ago. Rocky comes in to his workshop and they eventually find themselves discussing the need for good instructions and good observations and the lessons learned from science. This dialogue emphasizes the need to write clear procedures and to separate observations and the conclusions drawn from those observations in scientific writing. Students learn that many very old geological descriptions are still used as data today.

Science terms or concepts include the following: catapult, experiment, geologist, observation, qualitative vs. quantitative descriptions.

1.5 In Order Please: In this dialogue, Mini and Plato discuss the Law of Superposition.

Science terms or concepts include the following: Law of Superposition, original horizontality, relative dating, sedimentary rocks, sediments, tectonic activity.

1.6 Round and Round the Carbon Goes, and Where it Stops May Determine Our Future: Rocky and Plato discuss the carbon cycle and learn something about the nature of scientific predictions.

Science terms or concepts include the following: atmosphere, carbon, carbon credits, carbon cycle, carbon dioxide, climate change, coal, fossil fuels, molecules, petroleum.

1.7 Studying the Rocks: In this dialogue Azurite and Malachite work on a class project and learn about geology research. They learn that there is not only one scientific method but many different methodologies that scientists use.

Science terms or concepts include the following: hypothesis, multiple working hypotheses, scientific method.

2. Rocks and Minerals

2.1 Minerals and Cleavage: Rocky and Plato try to identify three similar minerals using their distinctive cleavage.

Science terms or concepts include the following: cleavage, conchoidal fracture, hardness, metallic, mineral properties, minerals, non-metallic, perpendicular, plains of weakness, right angles.

2.2 Relative Hardness: How Soft is Soft?: In this dialogue, Rocky and Plato struggle with the idea of a mineral being "soft." They are coming home from school and Plato is harboring a grudge against Rocky for a mishap in gym class.

Science terms or concepts include the following: analogy, mineral hardness, Moh's Hardness Scale.

2.3 A Symbol of Our Love: Rocky and Plato contemplate the symbol of unending love. What makes for the perfect engagement ring? The concept that minerals are defined by their composition and crystal structure is explored. The connection between these factors and a mineral's properties are also discussed.

Science terms or concepts include the following: chemical bonding, crystals, elements, mineral hardness, Moh's Hardness Scale.

2.4 Rocky's Rocks and Minerals: In this dialogue, Rocky and Plato discuss the difference between rocks and minerals.

Science terms or concepts include the following: crystalline structure, granite, internal structure, mica, minerals, rocks.

2.5 Colorful Crystals Big and Small: Rocky and Plato try to determine what makes granitic rocks look very different in regards to both color and crystal size. In the process they find out the importance of evidence in creating an explanation.

Science terms or concepts include the following: crystals, granite, igneous rocks, limestone, metamorphic rocks, quartz, relationship between chemistry of a magma and the kind of igneous rock that eventually results from the cooling of that magma sedimentary rocks, the relationship between cooling rates and crystal sizes, variety among granites.

2.6 Rock On!: In this Dialogue, Amber and Opal talk to their science teacher about the difference between rocks and rock music. The discuss the essential features of Sedimentary, Igneous and Metamorphic rocks.

Science terms or concepts include the following: igneous rocks, metamorphic rocks, sedimentary rocks, the rock cycle.

2.7 The Ultimate Question…Where Did I Come From?: In this dialogue, two stalagmites are having a conversation about their formation. They come to understand that water caries the minerals that stalactites and stalagmites need to grow. Plop helps Drop, through a series of questions, to use his observations to create an explanation for the roll of dripping water in stalactite and stalagmite formation.

Science terms or concepts include the following: deposition, observation, stalactite, stalagmite.

2.8 Holding it up: Bridge Foundations: Rocky and Plato are walking through their town and are a bit dismayed to see that a grand old bridge is closed and slated for demolition. They will learn about different rock types and how engineers have to pay attention to those types when building foundations.

Science terms or concepts include the following: bridge foundations, footings, fossils, limestone, resistance to weathering, sedimentary rock, sediments, shale.

2.9 Hot Bodies: How Minerals Differentiate in Cooling Magma: The conversation you are about to experience is a very rare chance to see inside a magma chamber. It is so hot in that gargantuan blob of molten rock that the microphones usually melt. Plus, it is so deep underground that we usually run out of wire before any information is transmitted back… and the wire melts. Due to a fantastic new technology we were able to capture this snippet of conversation between an oxygen atom (O) and a silicon atom (Si).

Science terms or concepts include the following: atoms, oxygen, magma chamber, silicon.

Teaching Note: Students will need to know that atoms bond together to form different mineral. It eludes to how magmatic differentiation takes place and thus leads to different kinds of internal igneous rocks. This can serve as a precursor to Bowen's Reaction Series. It also shows that Oxygen and Silicon are the most abundant elements and often are left to bond with each other forming quartz(SiO_2)-rich rocks.

3. Fossils

3.1 Finding Fossils: What Can We Learn from "Reading the Rocks?": Big Al and Big Hal are sitting at the kitchen table having a cup of coffee chatting about the weather. Later they go out fossil hunting. They learn about the relationship between paleo-environments and the fossils found in the rocks as well as the relationship between life assemblages and fossil assemblages.

Science terms or concepts include the following: paleontologist, fossils, Cephalopod, squid, *Tyrannasaurus rex*, animal communities, reconstruction of paleo-environments.

3.2 Fossil Formation: In this dialogue Rocky and Plato are outside their school. Plato has a shovel and is digging a hole in the ground.

Science terms or concepts include the following: fossil, formation of fossils, geologic time, sedimentary rocks.

3.3 Fossil Hunting: In this dialogue Rocky and Plato discuss a recent fossil hunting trip. They discuss what parts of a living animal get preserved in the rock record.

Science terms or concepts include the following: fossils, gastropods, how paleontologists determine what an animal was like when only the fossilized hard parts remain, invertebrates, paleontologist, shells as the remains of animals, uncertainty in science.

3.4 Fossils and Dragons: In this dialogue, Rocky and Plato talk about books, dragons, fossils, probability and science. They explore the possibility of dragons being real, being a construct based on an inaccurate interpretation of fossil evidence or a figment of an active imagination. The role of uncertainty in science is discussed.

Science terms or concepts include the following: fossils, Plate Tectonics, probability, Pterosaurs, *Quetzulcoatilus*, species.

4. Earthquakes and Volcanoes

4.1 Hawaiian Vacation Part I: Piles of Pahoehoe: In this dialogue, two friends, Amber and Opal are talking to their science teacher Mr. Cinnabar about his recent trip to Hawaii. They will learn about a famous type of lava and the meaning of it's strange sounding name.

Science terms or concepts include the following: Hawaiian Islands, igneous rocks, lava, metamorphic rocks, Pahoehoe, sedimentary rocks, volcanoes.

4.2 Hawaiian Vacation Part II: Aaaaaaaaaaa: In this Dialogue, Amber and Opal are back to visit Mr. Cinnabar and find out more about the Hawaiian volcanoes. This time they will learn about Aa lava and pillow lava.

Science terms or concepts include the following: Aa, lava, Pahoehoe.

4.3 Amber and Opal Learn About Pahoehoe, Aa, and Pillow Lava: Amber and Opal are learning more from Mr. Cinnabar about the Island's volcanic rocks types.

Science terms or concepts include the following: heat, igneous, lava, metamorphic, pressure, sedimentary, texture, volcanoes.

5. Plate Tectonics

5.1 "Marginal" Evidence for Plate Tectonics: In this dialogue, Plato and Rocky talk about the first evidence for Continental Drift which gave rise to the theory of Plate Tectonics. They start by taking an historical look at Alfred Wegener's ideas and the data that was available to him at the time. They briefly explore the problem that Wegener had in gaining acceptance for his ideas because he lacked a plausible explanation for the mechanism driving plate movement.

Science terms or concepts include the following: plate tectonics, continental drift, essential role of evidence, Alfred Wegener, theory, development of a theory, Pangaea, fossils, mechanism, scientific explanations may change when new data is available.

Teaching Note: This is the first in a series of four dialogues about the development of the theory of plate tectonics. They are best used in order as they do tend to build and develop ideas. However, they can be used independently and are complete as stand-alone dialogues.

5.2 Plate Tectonic Evidence: Magnets in the Rocks: Rocky and Plato discuss magnetic fields, magnetic reversals, and the nature of scientific thought.

Science terms or concepts include the following: Alfred Wegener, basalt, continental drift, crystals, data, Earth's magnetic field, evidence, experiments, *Glossopterus*, magma, magnetic reversals, magnetite, observations, oceanic rifts, plate tectonics, scientific theory.

5.3 Plate Tectonics: The Mechanism: In this dialogue, Rocky and Plato talk about a mechanism for moving the continents around.

Science terms or concepts include the following: Alfred Wegener, continental margins, convection currents, evidence, metaphor, meteorologist, rifts, theory.

5.4 Plate Tectonics and the Notion of a Scientific Theory: In this dialogue, Plato and Rocky talk about the nature of theories and the meaning of words to better understand plate tectonic theory.

Science terms or concepts include the following: data, nano, NASA, plate tectonics, subduction zone, theory, volcano.

5.5 Rumble, Rattle and Wriggle with the Rocks: In this dialogue, Rocky and Plato talk about the connection between plate boundaries and earth quakes.

Science terms, or concepts include the following: convergent boundary, divergent boundary, plate boundaries, Plate Tectonics, relationship between plate boundaries and earthquakes, new data can cause theories to be changed, transform boundary.

6. Water and the Atmosphere

6.1 Water Ya Know?: A Play in One Act: Zip and Zap are sitting at an outdoor café overlooking the local river and discussing who is the greatest superhero. Zip decides to direct the conversation toward the importance of water and the properties that make it such a valuable molecule for living things.

Science terms or concepts include the following: boiling point, Celsius scale, cohesion, crystalline structure,density, evaporation, hydrogen bonding, melting point, phases, polar molecule, properties of water, specific heat, surface tension, temperature regulation, thermometer, transpiration.

6.2 The Pressure is on! Is the Bottle Better?: Plato and Rocky talk about bottled water and whether or not it is better than the water that comes out of most taps. They delve into what the word "artesian" means and its connection to water quality.

Science terms or concepts include the following: aquifer, artesian well, impermeable, models, pressure, water well.

6.3 Cold Fronts: Plato and Rocky talk about rainy weather, picnics and cold fronts.

Science terms or concepts include the following: cold front, weather.

6.4 Groundwater, Cows, Bacteria, and Horror Movies: In this dialogue, Rocky and Plato discuss the possibility of cow parts coming out of a faucet. They learn that sink holes, groundwater and what happens on the surface are all connected.

Science terms or concepts include the following: acid, bacteria, caves, chlorine, contamination, dissolves, fossils, groundwater, limestone, sink hole.

6.5 Follow the Carbon: Today Clownie the clown fish and Coral, a polyp from a coral reef discuss where carbon goes in the ocean.

Science terms or concepts include the following: acidic, atmosphere, Bromothymol Blue, calcite, carbon, carbonic acid, dissolve, elements, ion, mineral, oxygen, precipitate.

6.6 Heat Storage: Today Clownie and Coral discuss the heat capacity of water which is an amazing property, that regulates the environment in which ocean animals live.

Science terms or concepts include the following: equator, heat capacity, molecule.

6.7 In and Out: In this dialogue, Rocky and Plato take an invigorating walk and learn that there is more in the air than just oxygen.

Science terms or concepts include the following: air, atmosphere, carbon dioxide, gasses, global climate change, methane, oxygen.

6.8 Keeping it Even: In this dialogue Rocky and Plato discuss the effects of large bodies of water on air temperature.

Science terms or concepts include the following: energy, lake effect, Lake Michigan, temperature.

6.9 Wherever the Wind Blows: In this dialogue Rocky and Plato examine the connection between wind and waves.

Science terms or concepts include the following: fetch, ripples, the connection between wind and waves, waves.

7. Oceanography

7.1 A Salty Solution: Hal and Sal (a play on Halite and Salt) discuss the need for salt in our bodies and the origin of salt in the oceans. Along the way they give some insight into fair tests and good experimental design.They also discuss the complexity of ocean systems, and how scientists and nonscientists might interpret the term "fresh water" differently. In the end they take away a simple experiment they can do at home or in school.

Science terms or concepts include the following: concentration expressed as pounds per cubic foot, circulation, evaporation and precipitation, evaporation rate in determining salinity in the oceans, freshwater influx, fresh water vs. salt water, origin of salts in the ocean, salinity, the interplay between temperature.

Teaching notes: In the dialogue a brief experiment is described. Starting with a glass of tap water, students can put salt in, a few grains at a time, and see how much has to be added before they reach the threshold for taste. This could be done at home or in class. The idea of a threshold could be introduced at that time.

7.2 Finding the Bottom: In this dialogue, Rocky and Plato talk about the history of ocean exploration and learn something about the nature of science. They discuss the formation of NOAA and talk about what was going on in society that led to increased attention paid to the oceans.

Science terms or concepts include the following: evidence, National Oceanic and Atmospheric Administration, ocean floor, oceanographer, the relationship between science and technology.

7.3 The Shape of the Floor: In this dialogue, Plato and Rocky discuss the geometry of the sea floor.

Science terms or concepts include the following: abyssal plain, Atlantic Ocean, continental shelf, continental slope, deep ocean basin, magma, sea floor, topography.

7.4 **What is Under the Ocean Water?:** Today Clownie and Coral discuss the different features found on the seafloor. It is not flat as they first thought!

Science terms or concepts include the following: abyssal hills, abyssal plain, basaltic crust, continental rise, continental shelf, continental slope, Marianas Trench, mid-ocean ridge, oceanic trench, seamounts.

7.5 Waterworld Could Have Been a Reality: Today Clownie and Coral discuss the different types of crust on Earth and how things could have been different if they didn't exist.

Science terms or concepts include the following: basalt, density, Earth's crust, granite, iron, magnesium, mantle, scientific model.

7.6 Ride the Surface Current: Today Clownie and Coral discuss the movement of ocean surface currents. Included is a link to an activity created by NOAA that asks students to plot the movement of some toys spilled at sea to see how materials can be used to track the direction and speed of surface currents. This can be downloaded and printed for student use.

Science terms or concepts include the following: equator, Gulf Stream, latitude, longitude, Pacific Ocean.

7.7 Ride the Waves: Today Clownie and Coral discuss the movement of ocean waves. This dialogue best follows "Ride the Surface Current."

Science terms or concepts include the following: molecules, surface current, waves.

7.8 Salty Versus Fresh: Today Clownie and Coral discuss the differences between fresh and salt water. A demonstration is described that the teacher could do for the class to see. Alternately, the students could be given the described, or similar, materials and allowed to experiment themselves.

Science terms or concepts include the following: cubic centimeters, dissolved, ions, mass, water density.

7.9 Ocean Temperatures: Today Clownie and Coral discuss the temperature variations in the ocean water column. A diagram of the layers in the water column follows the dialogue. Students are asked to label the layers as described in the dialogue.

Science terms or concepts include the following: deep layer, lagoon, mixed layer, temperature in degrees C (Celsius), thermocline, transition zone,water column.

7.10 **Only One Ocean:** Today Clownie, the clown fish and Coral, a polyp from a coral reef discuss the ocean and all its names. Students fill in the names of the different oceans on a map while seeing that all of the oceans are really one continuous, connected body of water.

Science terms or concepts include the following: Arctic Ocean, Atlantic Ocean, Beaufort Sea, Greenland Sea, Indian Ocean, Norwegian Sea, Pacific Ocean, Southern Ocean.

8. Surface Processes

8.1 Evidence for Glaciers: A Mile of Ice Makes Gardening Difficult: In this dialogue, Plato and Rocky are on a hike in a nature center and contemplate how we know that environments were not always as we see them today. In this dialogue the role of evidence in creating scientific explanations is reinforced, and the formation of various basic glacial landforms is described.

Science terms or concepts include the following: continental ice sheet, explanations are based on evidence, geologic time, Ice Age, indian mounds, scientific kettle lakes, terminal moraine.

8.2 Forever and Ever…or at Least Until the End of Summer: In this dialogue, Mini and Plato talk about mountains and valleys and the ever-changing face of planet Earth. Mini starts by lamenting the premature death of her garden plants which leads her to contemplate about other things that never seem to change. Plato helps her to rethink her notion of the permanence of landforms.

Science terms or concepts include the following: geologic time, metaphor, Plate Tectonic Theory, the changing nature of Earth's surface, the importance of skepticism in science.

8.3 I am Freezing: Formation of a Glacier: In this dialogue, Plato and Mini are standing on a glacier and discussing how they form.

Science terms or concepts include the following: alpine glacier, continental glacier, saber-toothed cats, wooly mammoth.

8.4 The Rocky Story of Soil Formation: In this dialogue, Loam and Silt eat carrots and ponder where soil comes from. They learn about the connection between rocks and soil and that different soil types have different characteristics. Loam and Silt are common soil types.

Science terms or concepts include the following: plants are part of the soil formation process, soil, soil starts as rock.

8.5 You Win Some You Lose Some, or a Game of Sediment Hide and Seek: Plato and Rocky talk about an upcoming geode hunt and learn a bit about stream dynamics in the process.

Science terms or concepts include the following: crystals, fast moving water has a lot of energy and slow moving water has less energy, geode, geologist, mineral, rock, sand bars, water moves faster on the outside edge of a river bend than on the inside edge of the bend.

9. Space Science

9.1 Gas Giant: In this dialogue Rocky and Plato discuss the nature of a gas giant.

Science terms or concepts include the following: Gas Giants, helium, hydrogen, Jupiter, naming of planets, Neptune, planet, pressure, Saturn, Uranus.

9.2 Love, Stars, and the Power of Metaphors: In this dialogue, Rocky and Plato talk poetically about the night sky but come to realize how the words we choose can affect the way we think about stars.

Science terms or concepts include the following: metaphor, scientific language.

9.3 Silly Ideas, Bad Explanations and Other Things I Knew to be True: In this dialogue Rocky and Plato are lying on their backs contemplating the night sky.

Science terms or concepts include the following: explanations based on observations, half-moon, phases of the moon, observations, patterns, predictions, science models.

10. Maps

10.1 From Here to There the Easy Way: Plato helps Rocky create a map to find directions between two points.

Science terms, or concepts include the following: maps can be made on many scales to depict many things, map key or legend, Maps use symbols and scale to create a graphic representation of something.

11. Student Examples

11.1 Classifying Rocks: Rocky and Plato try to classify three rocks by their rock groups.

Scientific terms, or concepts include the following: crystal, extrusive, igneous, limestone, magma, metamorphic, precipitate, sedimentary, sediment layers.

11.2 The Rock Cycle's Affect on a Young Rock's Life: Young and old granite are discussing the three types of rocks.

Science terms, or concepts include the following: granite, gneiss, heat, lava, magma, pressure, sedimentary.

1.3 A Scientific Upheaval

In this dialogue, Rocky and Plato chat about an upcoming vacation to Canyonlands National Park where a controversy exists about a very strange feature. The role of new data in changing hypotheses is explored.

Rocky: *[excitedly]* Guess what?

Plato: What?

Rocky: That is not much of a guess! I mean really guess.

Plato: *[exasperated]* How do you expect me to guess? I have no data at all to go on. Guess what you ate for breakfast? Guess what your sister's middle name is? Guess what your mother ate the day you were born? Give me a clue.

Rocky: You took all the fun out of my announcement so I am just going to tell you. My family is going on a trip to Utah over spring break this year.

Plato: That is totally cool. You're lucky; we are just going to visit my uncle in Ohio.

Rocky: Well, it isn't *all* great. My folks want to take a big hike to a place called Upheaval Dome. How gross does that sound? All I can picture is a big bowl that millions of people have puked into. I would much rather go see some cool geology.

Plato: *[head shaking in disbelief]* You aren't going to look at a puke collection. Upheaval Dome *is* a geological formation and a very controversial one.

Rocky: How can a bunch of rocks be controversial? They just sit there and look cool.

Plato: Some of the people that look at the rocks and think they are cool are geologists. They look at, or study, the rocks to determine why they look the way they do. What is their history?

Rocky: So how is any of that controversial?

Plato: For many years people have thought that the dome was caused by a salt dome, a big glob of salt lying under the layers of rock, pushed up through the layers and caused the funky looking crater that is there now.

Rocky: How can something push up from a crater? Isn't a crater a depression?

Plato: Yes, it is now, but that feature is pretty old so what we see is what is left after lots of rock has eroded away.

Rocky: *[confused]* Upheaval Dome is really a crater?

Plato: I saw some photos on the internet. It is a circular crater with what looks like a smaller dome in the center. The geology looks pretty complicated.

Rocky: That's cool, but not controversial.

Plato: The controversy is that there are now geologists that think the crater might not be made from a salt dome pushing up but from a meteorite that smashed into the Earth there and made a crater.

Rocky: *[excitedly]* A meteorite impact! That is cooler than a salt dome. Those are pretty different ways to get to a crater. Is there any evidence for either of them?

Plato: Good question. Both of them make sense and much of the evidence can be used to support both hypotheses.

Rocky: So how will they decide which hypothesis is correct?

Plato: Since no one was around to see the crater form we might never know which one is correct. But there does seem to be some new evidence to indicate that the meteorite impact idea is more likely.

Rocky: What kind of evidence can they use to support the meteorite impact idea?

Plato: One is shatter cones. These are things that form when shock waves from the meteorite impact leave behind groves in the rock. And then there is something called shocked quartz…

Rocky: *[interrupting]* Let me guess, it is quartz that is shocked when hit by a meteorite?

Plato: It is shocked from an energetic impact. They can't say for sure that it was a meteorite that hit it but it certainly could have been. The biggest problem for the "salt dome hypothesis" folks is that we now have instruments that can tell us if there is actually a salt dome under the crater. They haven't been able to find any salt dome.

Rocky: It looks like the evidence is pointing to the meteorite impact idea. I am glad. I would much rather hike to see a meteorite impact crater. Do you think that this could be the meteorite that killed the dinosaurs?

Plato: Interesting question. They think that this crater was formed about 60 million years ago which puts it at round about the right time for the dinosaur extinction, but I think that that impact was bigger and maybe a bit earlier, if I remember my geologic time scale that is. Who knows, as geologists collect more and more data, we may find that there are changes to, or refinements of, other questions we think we have the answers for.

Rocky: I like that about science. There isn't just one right answer and then we write it down in books and stop thinking about it. More technology lets us collect different data and different data can lead to different explanations. Science is cool.

Author - Amy Schiebel

2.9 Holding it up: Bridge Foundations

Rocky and Plato are walking through their town and are a bit dismayed to see that a grand old bridge is closed and slated for demolition.

Plato: I can't believe how long this bridge has been out.

Rocky: I sort of miss that bridge. It was kind of an icon around here.

Plato: Mostly I like new high-tech stuff but that old bridge was kinda cool. I liked that it didn't look like all the other bridges around here. Too bad they had to tear it down.

Rocky: There is so much more traffic around here now than when this was built back in the late 1800's.

Plato: I have seen pictures of our town from that era in social studies. There were still horses and carriages on the streets when this was built. I am sure that all the trucks that we have now put much more stress on the old bridge.

Rocky: But why don't they put the new bridge right where the old one was? The new one is about half a mile away. It seems like it would have been cheaper to just rebuild a new one here.

Plato: My dad dragged me to a city council meeting when they were talking about this. It was kinda boring but I did learn some stuff about the new bridge. Some of the adults asked the same question that you just did.

Rocky: So what did they say?

Plato: The conversation was sort of like ours just was. They said that the old bridge was designed by engineers to withstand a certain amount of stress. At the time it was the stress of a couple of horse drawn carriages and maybe a farm wagon. The new stresses of SUVs, semis, and dump trucks were just too much for it. The wooden beams and braces were bending and starting to crack. They were afraid that it might break under the next heavy truck so they closed it.

Rocky: I get why they need a new bridge but why did they have to move it?

Plato: The ends of the bridge are anchored to the rocks on either side of the river. Apparently the rocks where this old bridge is are not very strong…sort of like the old wooden parts of the bridge weren't very strong. So they have to move the bridge to a place where the bedrock, the rocks at the surface here, are stronger and won't fail under the stress of the new bridge and all the heavy traffic that will be on it.

Rocky: What? I have a couple of problems with what you just said. There are strong and weak rocks? I never thought of a rock and being soft or weak. You also said that if they move to a different location they will find different rocks? How does that work? I thought all the rocks around here were the same. I see lots of those beige gray ones that have fossils in then. I have even collected some of those fossils. So what is this about different rocks?

Plato: Let's take these one at a time. Remember when we went to the cemetery with your Aunt Flossie? We were wandering around looking at the head stones. Some were really easy to read and looked like new even though they were really old. Others were all smoothed over and worn away, even though they were not that old. Some rocks resist weathering better than others. Not that I am equating head stones to bridge foundations but you can see that different rocks have different properties and respond differently to different stresses. They told us that the old bridge foundation is on shale. That is a sedimentary rock that is easily broken apart.

Rocky: I guess you're right. Even some of my fossils were easier to pick out of some of the rocks than others were. So, I can see that there are variations in their characteristics. Where are these different rocks located?

Plato: They showed us a map. What I remember is that around here we have mostly limestone and a little bit of shale and these are found in layers. The limestone is the rock you have been collecting fossils from. There isn't much shale and it is located in layers between the limestone.

Rocky: How did that shale get in between the limestone?

Plato: These are both rocks that are made from sediments that were deposited under water. They indicate something about the depth of water and some other things that make for different kinds of sediments. I don't remember the details, but as sea level changed, different kinds of sediments were deposited that turned into different kinds of rocks.

Rocky: I know that the limestone is a pretty strong blocky rock. What is shale like?

Plato: At that city council meeting a geologist brought in a sample of the shale. It is made of thin layers that can break apart pretty easily. He said it was fissile. I think that is why it is not as strong as the limestone.

Rocky: Why are we talking about these rocks? Oh yah, the bridge. What does limestone and shale have to do with the bridge and why they are moving it?

Plato: As luck would have, it the old bridge has its footings in the shale. They probably didn't pay attention to the rocks they were setting the original bridge on since it didn't have to hold that much weight. It just happened to be the kind of rock that was in the area that they wanted to set the bridge. The geological engineers said that that kind of rock does not have the properties that it needs to hold up the new bridge. So they are moving the bridge to where the limestone is.

Rocky: There is more to rocks than I thought. I used to think of them only in terms of getting fossils out and finding ones in the right shape to skip. I wonder if there are more different properties that are useful to know about.

Plato: Probably. If people can make entire careers out of studying rocks there must be more to them than we think.

Author - Amy Schiebel

5.2 Plate Tectonics Evidence: Magnets in the Rocks

Rocky and Plato discuss magnetic fields, magnetic reversals, and the nature of scientific thought.

Rocky: Last time we were together we were talking about the theory of plate tectonics.

Plato: And what do you remember?

Rocky: The idea started in the early 1900s with a scientist called Alfred Wegener. He called it continental drift. He had evidence from the way the continents fit together and also from fossils.

Plato: What about the fossils?

Rocky: Is this a quiz?

Plato: Yes.

Rocky: Well then! There are fossils of land animals that are all from the same rock layer that are now separated by oceans. There were plants too, but you didn't say much about them. How did I do?

Plato: Very well. The plants are called *Glossopterus*. Look it up on the internet when you have a chance.

Rocky: You promised to tell me about more evidence for plate tectonics, because frankly I am still a bit skeptical.

Plato: OK. Let's see what you think of today's evidence.

Rocky: So, let's get started. What do you have for me?

Plato: I think that today we will talk about magnetic reversals.

Rocky: I have magnets. And I can turn them around. So what is the big deal?

Plato: This is magnetic reversal on a grand scale. Right now we are surrounded by Earth's magnetic field. You know that when you hold a compass, the needle will point to magnetic north.

Rocky: The North Pole.

Plato: Actually, there are two north poles. One is geographic north, which is what most people call the North Pole, and the other is magnetic north, which is where your compass points. When there is a magnetic reversal your compass would point to what we now call the South Pole.

Rocky: That is a big reversal. But what possible evidence could there be of that happening? It is not like there have been compasses around for that long; certainly not for millions of years.

Plato: Actually there have been compasses around for almost as long as there have been rocks. Only these compasses are crystals of a mineral called magnetite. When these crystals form, by cooling from a magma, they orient themselves in line with the existing magnetic field, just like the needle in your compass. When the rocks these minerals are in cool and harden these little magnetic needles are locked in place. This records the position of magnetic north at the time the rocks cooled.

Rocky: How is this related to plate tectonics?

Plato: Magnetite is rather abundant in a rock called basalt and basalt is the rock that makes up the floor of the ocean. Remember that Wegener thought that at one point, a long time ago, all of the continents were part of one big land mass. This broke up and the pieces moved apart. When we look at these pieces of magnetite in the rocks were the continents are now they point in lots of different directions. It is difficult to explain how that could happen unless we move them back to where Wegener proposed they were when they formed . Then all the little compass needles point to the North Pole.

Rocky: Hmm. I am trying to think of another explanation for why the compass needles would point in different directions.

Plato: While you ponder that, I will add another piece of magnetic data for you to consider. On either side of these large oceanic rifts we see alternating bands of rocks that show north being north and then north pointing to what we currently consider south. And the bands match on either side of the rifts.

Rocky: It would be harder to come up with a different explanation for both those bits of data.

Plato: And remember, a good theory has to explain *all* of the data and not just a few bits here and there.

Rocky: That must be why it took so long for plate tectonic theory to be developed.

Plato: Lots of different people did many experiments and made many observations and all of them had to fit together into one explanation.

Rocky: What happens when new observations and new data comes along?

Plato: Either it fits neatly into the current explanation, or the theory has to change to accommodate the new information.

Rocky: So *that* is why it sometimes seems like scientists are changing their minds. They are changing their minds based on new data.

Plato: Yes, and that is a good skill for all of us to have, don't you think?

Rocky: I knew a kid once and thought he was really nice. But the longer I knew him the more I saw him do some really mean stuff, especially to little kids. I changed my mind based on that new data alright.

Plato: An open mind and the ability to make decisions based on data are key skills if you want to be a scientist.

Author - Amy Schiebel

7.1 A Salty Solution

Hal and Sal discuss the need for salt in our bodies and the origin of salt in the oceans.

HAL: Have you ever tried this sports drink?

SAL: No, I usually prefer water. Those sports drinks always taste too salty to me.

HAL: I am not really a fan either. I wonder why they put so much salt in them. I saw this show last night about two guys that got lost at sea and drifted for weeks in a rubber raft. One of them got so thirsty that he drank the water out of the ocean. He ended up dead and they said it was because he drank the salty water. Hey, I am not going to die if I drink this am I? *[suddenly looking frightened and gazing suspiciously at the drink]*

SAL: Your body needs some salt. You are actually about as salty inside as sea water is—at least the sea water that was in the seas 500 million years ago. When people sweat a lot they lose some salts and those drinks are meant to replace that. They really are not for couch potatoes like you to just sit and drink.

HAL: Hey! *[looking indignant]* I will have you know that I did not sit on the couch once yet today. If we are so salty inside, then why is it harmful to drink seawater?

SAL: For one thing, your kidneys regulate the amount of salt in your body. For the system to work your urine has to be less salty than ocean water. If the water that you drink has a higher salt concentration than that, then your kidneys actually pull water out of your body to dilute the urine. This causes you to dehydrate. That is bad. Eventually your kidneys will shut down and that is not good either.

HAL: It sure would be handy of the oceans would be full of fresh water instead of salty water. Then we could drink that just like we can fresh water.

SAL: That would help with our shortage of fresh water on the planet as well. There are ways of removing salt from ocean water, but it is expensive…and it wouldn't help those folks that get lost at sea.

HAL: Why are the oceans so salty anyway? All of the water that goes into them is fresh. Rivers carry fresh water and rain is fresh water. How did the oceans get so salty?

SAL: First we have to define "fresh water."

HAL: To me it means that there is nothing in the water but H_2O. Nothing else in there. Totally pure.

SAL: That certainly does not describe what is running in rivers or even what comes down as rain. Different elements such as sodium and chloride, which come together to make the compound we use as table salt, and magnesium and other things are dissolved out of rocks and soils as river water runs over them. Even rain can pick things up from the molecules in the air as it falls. So, even the water that we think of as "fresh" has a bit of salt in it.

HAL: But it doesn't taste salty. I have gotten plenty of lake and river water in my mouth when I go swimming. They don't taste salty at all.

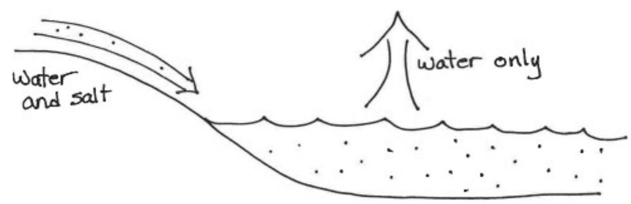
SAL: You could do a little experiment with that. Take some fresh water from your tap and put just a few grains of salt in it. Give it a taste. Do you think you could taste that?

HAL: Probably not, but I might give it a try at home tonight.

SAL: You can keep adding salt a tiny bit at a time and see when you can first taste it. It would be better if someone else gave you the water. Sometimes salty and sometimes fresh so you are not expecting any specific taste. That would be a better experiment. What you would find is that if the concentration of salt is small enough you won't taste it…but it is still there. As it turns out a cubic foot of ocean water contains about 2.2 pounds of salt and a cubic foot of Lake Michigan water contains about 0.01 pounds of salt.

HAL: So rivers and rain carry tiny amounts of salt to the oceans. But there is a BIG difference between 0.01 pounds and 2.2 pounds of salt per cubic foot. I still don't get how the oceans get so salty.

SAL: That mostly has to do with evaporation. Water that evaporates is pretty much just hydrogen and oxygen combined as the water molecule. That "pure" water you talked about. So water that is a little salty goes in and only pure water goes out. Take a look at this sketch I made for you.



HAL: So over time, the oceans got saltier and saltier. Are they still getting saltier?

SAL: As you can imagine, the salinity of the oceans depends on more than just how much salt is going in. It also depends on the amount of water that is coming in. If there is more rainfall, and if more glaciers melt, then there is more fresh water in the oceans to dilute the salt. A warming planet will melt more glaciers which will decrease salinity but a warmer ocean will also have a higher rate of evaporation which would tend to increase the salinity.

HAL: This is getting complicated. It sounds like the salinity can go up and down depending on climate. I would guess that the salinity of sea water is not the same everywhere either. If melting glaciers add fresh water then the oceans at the poles might be less salty.

SAL: Good thinking! That is indeed generally true. And seas that are warmer and near the equator, especially if they do not have good circulation with the open ocean, tend to concentrate dissolved solids and thus have a higher salinity.

HAL: Once again, systems in nature are more complex, and interesting, that I ever thought.

Author - Amy Schiebel

8.1 Evidence for Glaciers: A Mile of Ice Makes Gardening Difficult

In this dialogue, Plato and Rocky are on a hike in a nature center and contemplate how we know that environments were not always as we see them today.

Rocky: I love doing these kinds of hikes. The park service puts up these interpretive signs and lets us know what we are looking at.

Plato: Check this one out. These small hills here are really Indian mounds. They built these all over this area. Archaeologists have found stuff inside some of them that gives us clues to what they were made for.

Rocky: What kind of Indians built them?

Plato: It says here that they started to arrive here about 10 or 12 thousand years ago.

Rocky: I wonder why they came then. Why not before? This must have been a nice place with all these forests and lakes: lots of food and water available and all that.

Plato: Maybe it was that mile-thick layer of ice that made this place a bit less habitable.

Rocky: Hah, good joke. But seriously, I wonder why they weren't here earlier. Maybe there were other more fierce folks here that kept them away.

Plato: I am not joking. Up until about 12,000 years ago this area was under a giant continental ice sheet. At times it was over a mile think.

Rocky: Do you really expect me to believe that? I know it gets cold here in the winter but everything melts in the summer. It would have had to have been really cold all the time for that to happen. I know that the North Pole is always cold and covered with ice but not way down here in Wisconsin.

Plato: What you choose to believe or not is your business. Science is based on evidence. Scientists create the best explanation for the evidence they have.

Rocky: So what kind of evidence do they have for that story about there being a mile of ice here?

Plato: All those small lakes around here are one thing. Those are called kettle lakes. They formed when the ice was retreating and left behind some big chunks. Those chunks melted and made the lakes. If you look at a big map of this area you can see a long ridge that is make up of soil and rocks of all sizes. As the ice advanced it acted like a bulldozer shoving soil and rocks in front of it. When it stopped advancing and started melting that ridge of materials stayed there as a ridge. They call that the terminal moraine. Terminal means end and moraine is what any ridge of material that looks like, and is formed like that, that is called. That is just a sample of the kinds of things they use as evidence.

Rocky: But no one was there at the time to see it; no one that could take pictures and leave them in neat albums for us. Besides, I thought that scientists did experiments and stuff like that. Do they make some big glacier and see how it behaves?

Plato: Experiments are only one way that scientists collect evidence. Geologists have to look at all kinds of evidence. Parts of it are historical so they can't always do experiments like a biologist or chemist can. They study the rocks and landforms all around the world and then put forth explanations that work with all the evidence. Some experiments can be done in the lab and some mathematically. All of that goes together to create their explanations. Right now there are big continental glaciers in different parts of the world. Geologists can observe how they work and the material they deposit and then assume that the way things are happening now are pretty much the same as they were thousands or even millions of years ago.

Rocky: Ok, give me some more evidence. This could make sense. It just seems like such a change from what it is like now.

Plato: The key to understanding a lot in geology is based on something that is the hardest thing of all to understand.

Rocky: What's so hard to understand?

Plato: That would be geologic time. What is the oldest thing you know?

Rocky: Mr. Biddle, the art teacher.

Plato: Go older, lots older…

Rocky: How about World War II, no, even older is World War I.

Plato: World War I ended in 1918. So to keep the numbers round let's say that is about 100 years ago. You would have to wait from the end of World War I until now about 120 times to get to when the last ice left this area—sort of a weird way to think about that much time. Does that work for you?

Rocky: Yes and no. I can tell it is a long time, but I don't really have any real feel for how long that is.

Plato: Scientists deal with that all the time. They can *feel* one way but have to rely on evidence and come to logical conclusions even if their emotions tell them something else.

Rocky: OK. I am going to try to just "think" about the evidence…even if it "feels" funny. What were you saying about old?

Plato: There is old and then there is *old*. Not to complicate things more than they need to be but in terms of geologic time the end of the Ice Age is very recent. Most of earth history is way older than that. And by way older, I mean *way* older.

Rocky: Are you avoiding giving me more evidence for those big, thick glaciers?

Plato: No, sorry. How about two more, and then we had better move on? There are certain kinds of rocks that are found up in Canada. We find big chunks, lots of them, way down here. People would not have been able to carry them down and rivers would not have brought them down in that kind of pattern. But where we find them is exactly where they would be if a glacier dragged them down.

Rocky: I guess the glaciers would have rocks in front like that bulldozer you talked about. It could also have rocks under them that got kind of plowed along the bottom.

Plato: Now you are thinking like a scientist. Those rocks being “plowed” along under the glacier are part of another piece of evidence. They made big gouges in the bedrock as they were scraped along under that thick ice. We see groves that show not only where the glacier was but also in what direction it moved in.

Rocky: I am not sure that I totally buy the idea of a mile or more of ice on top of where we are now but I will think about it. Maybe if I get more evidence it will make more sense.

Plato: Keeping an open mind is the most important thing. Let’s move on. Indian mounds led us to a discussion about continental glaciers. I can’t wait to see what is at the next stop.

Author - Amy Schiebel

9.1 Giant Gas

In this dialogue Rocky and Plato discuss the nature of a gas giant.

Rocky: I have a dream.

Plato: Have you been reading about Dr. Martin Luther King?

Rocky: Who? Does he have dreams, too?

Plato: Yes, he is very famous for his dream, but apparently that is not what you were thinking of. What kind of weird dream did you have this time?

Rocky: Not a weird dream like the kind I have when I sleep. I mean that I have a goal: a serious dream for the future.

Plato: Goals are good. What is your dream?

Rocky: First of all, you know that Saturn is my favorite planet. My uncle has a telescope and we could see Saturn last night. I could hardly believe that from so far away I could see the rings around Saturn.

Plato: And it has a bajillion moons. Maybe a bajillion is a bit of an overstatement. I think there are 62 moons, but that is a lot compared to our meager 1.

Rocky: My dream is*...[dramatic pause]…[proudly]* I want to be the first person to land on Saturn!

Plato: I thought you said this was serious. You can't land on Saturn.

Rocky: I know that I can't land there *now*. *[fast and excited]* I need a ship and of course I need to go to astronaut school and will probably need to work for some big rich company that wants to explore Saturn and loves it as much as I do…

Plato: Slow down, buddy. I think that there are a few things that might prevent you from landing on Saturn that are a bit more fundamental than even having a ship to get you there.

Rocky: …and that would be…

Plato: In order to land on a planet you need…well…land.

Rocky: *[defensively]* The planet definitely exists; I saw that big ball in the telescope last night!

Plato: Of course it exists. And you definitely saw that big ball. But that is a big ball of *gas*, not of rocks and soil like Earth or the Moon or Mars.

Rocky: *[very puzzled]* Gas?

Plato: Have you ever heard of the gas giants? Four of the planets in our solar system are gas giants: Saturn, Neptune, Jupiter, and Uranus.

Rocky: Time out. How do you say Uranus anyway? If you put the accent on the first syllable it sounds too much like urine…yuck! And if you put the accent on the second syllable…double yuck!

Plato: It may be an unfortunate sounding name to us now, but it is named after the Greek god of the sky. Many of the planets were names for Greek or Roman gods. Your favorite planet Saturn is named after a Roman god. Just try not to giggle when you say Uranus and you will be fine. Back to Saturn, OK?

Rocky: You were talking about gas giants. Do you mean to tell me that no part of Saturn is made of rock?

Plato: We used to think that. But now it is thought that each of the gas giants have a rocky core. Saturn is thought to have a core of iron, nickel and rock, much like Earth's. The next layer is metallic hydrogen followed by layers of liquid hydrogen and helium. On the outside is a thick layer of gas. Like 1000 kilometers thick

Rocky: That's a lot of gas! But saying it is a gas giant isn't altogether true either. It should be called a solid-liquid-gas giant. *[pausing and thinking]* Saying the sequence solid, liquid, gas reminds me of something we did in science last week. If you take solid water—ice—and heat it up you get liquid water and if you keep adding heat you get water vapor—a gas. It works the other way too. Cool down water vapor and you get liquid water and cool that down and you get ice.

Plato: And you can do the same with pressure. If you increase the pressure on water vapor, even if you keep the temperature the same, you get liquid water and if you keep increasing the pressure you get solid water or ice.

Rocky: Could that have something to do with the internal structure of Saturn? It seems to follow the same pattern.

Plato: That is exactly what scientists think is going on. The center is under great pressure and is very hot. As you move out towards the surface of the planet the pressure decreases and so does the density of the material.

Rocky: I never think about being able to see gas. Smell yes, see no.

Plato: That is one of the beautiful things about science. It makes us think about things in different ways and it stretches the way we think about everyday things.

Rocky: One more thing. Is Uranus a gas giant? Because if it is that is I will be spending tonight making some of the best science jokes ever.

Plato: Why do I talk to you?

Author - Amy Schiebel

11.1 Classifying Rocks

Rocky and Plato try to classify three rocks by their rock groups.

Rocky: This is impossible! How am I supposed to know what groups these random rocks are in without identifying them?

Plato: It's not impossible. You just have to think a little bit harder. Haven't you learned even a little bit about the rock groups?

Rocky: Of course I have. There are three of them: sedimentary, igneous, and metamorphic.

Plato: Then surely you should know that this isn't as hard as it seems. If you know how rocks from each group are formed, then you won't even have to know what specific rock they are. What do you know about the formation of sedimentary rocks?

Rocky: I know that they are formed from sediments.

Plato: Okay, but that's not what I meant. Sedimentary rocks form when sediments layer on top of one another and then cement together over time.

Rocky: Oh, well I knew that... But isn't there also a sedimentary rock that forms because of a chemical reaction?

Plato: You're right. Limestone would be an example because it forms from a precipitate of calcium carbonate in the oceans.

Rocky: Interesting. But how does that help me?

Plato: Well, if you know this, then you can try to find which rock looks like it has layers because of the sediment layers. However, metamorphic rocks can also look like they have layers.

Rocky: Then how do I tell the two apart?

Plato: Well, sedimentary rocks look more layered while the metamorphic rocks look more marbled with stripes. It's just something that you need to watch for.

Rocky: Ill keep that in mind. What about igneous rocks?

Plato: I'm sure you already know how these are formed.

Rocky: Isn't it volcano eruptions?

Plato: Well, sometimes it is. Extrusive rocks form from volcanic eruptions and cool quickly at Earth's surface, while intrusive rocks form underground from hardened magma. The difference between the two is crystal size. The longer the cooling time for the rock, the bigger the rock's crystals will be.

Rocky: Do igneous rocks always have crystals? Obsidian is an igneous rock, but doesn't have any crystals.

Plato: No, they don't, obsidian being an exception. Usually when classifying igneous rocks, you want to look for crystals in a recently broken section of the rock. And that doesn't mean you're allowed to break them now.

Rocky: Okay, great. Now which is which?

Plato: Very funny. You better get started.

Author - Gwen Pyeatt

Physical Science Volume One

DIALOGUES for the PHYSICAL SCIENCE CLASSROOM

By Michael Felske, and Craig Berg

Physical Science I - Table Of Contents

Physical Science I Dialogue Abstracts

Unit 1 - What is Science?

1.1 Why Science?: Kailey and Kyle are hanging out by the pond at the park, late in a summer's day, when their conversation turns to discussing reasons why science originated.

Science concepts or terms include: how science works, nature of science, what is science?

1.2 What is Science?: Kailey and Kyle are watching the sunset over the pond in the park when a need to locate cookies causes them to turn to a discussion of what defines science.

Science concepts or terms include: doing science daily, how science works, scientific methods.

1.3 Hypotheses, Theories and Laws, Oh My!: Kailey and Kyle are still at the park, when darkness settles in and they wrestle with the difference between hypothesis, theories and laws.

Science concepts or terms include: experiments, explanations, hypotheses, laws, scientific evidence, scientific question, theories.

Unit 2 - Properties of Matter Part 1: Floating and Sinking

2.1 What is Stuff?: Kyle is sitting at the firepit in his back yard with his friend Sam making s'mores. They're talking about girls, and the difference between matter and energy.

Science concepts or terms include: matter vs energy, waves.

2.2 What is Stuff Made of?: Friends Kyle and Sam are hanging, making s'mores on a cool summer night. Kyle is curious about what matter is made of and how to talk about it.

Science concepts or terms include: matter vs energy.

2.3 Packedtogetherness: To Float or Not to Float? – Kyle and Sam are hanging out at the park pond on a summer's day. Kyle is skipping stones on the pond and they begin discussing why geese float and rocks sink using the term "packedtogetheridness."

Science concepts or terms include: density, floating, sinking.

2.4 Floating and Sinking: Kyle and Sam are continuing their discussion on why things float and sink, expanding their thinking using the concept of "density."

Science concepts or terms include: density, floating, sinking.

2.5 Floating and Sinking, Sinking and Floating: Kyle and Sam do a lab activity using alcohol, water and a candle in order to explore floating and sinking and better understand how density and perhaps gravity plays a role.

Science concepts or terms include: density, floating, gravity, sinking.

2.6 Flinking: Kyle challenges Sam to make something "flink" so they begin to get the materials needed to try it out.

Science concepts or terms include: floating, sinking.

2.7 Sink, Sank, Float, Flink: Seeing the results of the flinking experiment, Kyle and Sam discuss how the behavior of the gum in salt water was like Kyle's experience swimming in the Great Salt Lake. They proceed to try another "flinking" lab using only water this time.

Science concepts or terms include: density, floating, sinking.

2.8 Dive! Dive! Dive!: Kyle and Sam are using an eye dropper to explore the concept of pressure affecting floating and sinking and work to refine their notion of what factors affect whether something floats or sinks.

Science concepts or terms include: buoyancy, floating, gravity, pressure, sinking.

Unit 3 - Properties of Matter Part 2 - Air and Water

3.1 Squishability: Kyle is walking back from Sam's with his dropper diver when he runs into Kailey. He shows her how it works and they discuss pressure, volume and how air has squishability and water doesn't.

Science concepts or terms include: air pressure, floating, sinking, submarine, volume.

3.2 Kyle's Theory of Squishability: Kyle and Kailey continue to explore the squishability of air and water using a syringe.

Science concepts or terms include: compressing air.

3.3 Water Drops on a Penny: Motivated by the concept of "pouring air" Kyle and Kailey begin by seeing how many drops of water they can add to the top of a penny laying flat on its side.

Science concepts or terms include: testing ideas.

3.4 Solids, Liquids and Gases, Oh My!: Thinking about what they learned from the drops on a penny experiment, Kyle and Kailey think about energy and movement of molecules to explain how liquids, gases and solids behave differently.

Science concepts or terms include: energy, gases, kinetic motion, kinetic theory, liquids, solids, variables.

3.5 Fast and Slow, Hot and Cold: Still contemplating "pouring air" Kyle and Kailey reconsider the dropper experiment and how changing the water temperature might affect the outcome.

Science concepts or terms include: density, hot and cold, particles, temperature, testing ideas.

3.6 Pour Me Some Air: Thinking they are finally ready to tackle the "pouring air" idea, Kyle announces that he can show Kailey an experiment using an upside down glass in a sink full of water, to better understand how to "pour air."

Science concepts or terms include: density, density of gases, floating, sinking.

3.7 The Wicked Witch and Changes: Referring to the Wizard of Oz, Kyle and Kailey discuss matter and chemical and physical changes.

Science concepts or terms include: chemical reaction, dissolving, fire, heat energy, liquid, melting, physical change, solid.

3.8 Changing Changes: Kyle and Kailey are discussing the differences between chemical and physical changes using examples they are familiar with.

Science concepts or terms include: boiling, chemical vs physical change, condensation, freezing, melting.

3.9 Water Ya Know – A Play in One Act: Sam and Kyle are sitting at an outdoor café overlooking the local river, drinking ice tea, and discussing who is the greatest superhero, when Zip decides to direct the conversation towards the importance of water and the properties that make it such a valuable molecule for living things.

Science concepts or terms include: properties of water, melting point, boiling point, Celsius scale, phases, specific heat, evaporation, temperature regulation, thermometer, transpiration, density, hydrogen bonding, polar molecule, crystalline structure, surface tension, cohesion.

Unit 4 - Atoms, Atomic Models and The Periodic Table

4.1 Shrewd Honesty: Sam and Kailey are at a school picnic in the park reflecting on Kyle's growing ability to think through ideas in science. They discuss how science springs from a desire to understand how things work and the need to explain the world around them.

Science concepts or terms include: biases, ideas in science, indirect evidence.

4.2 Knowing: Kailey and Sam wonder about what makes someone know that they know something and talk about how models work in science.

Science concepts or terms include: atomic models, atomic theory, confidence in scientific ideas.

4.3 A Balancing Act: Continuing the discussion about theories and models, Kailey and Sam think about how balance is critical with regard to chemical reactions and the structure of atoms.

Science concepts or terms include: atomic model, balanced charges, chemical reaction, compounds and molecules, electrons, theories in science.

4.4 Think of a Banana: Kyle and Sam continue with their discussion of atoms and reflect on how models of the atom have changed over time to better represent our understanding.

Science concepts or terms include: atomic models, atoms, Bohr Model, visual models.

4.5 Bohr-ing: Kyle and Sam discuss the Bohr model of the atom, balanced charges, atomic numbers, and movement of electrons around the nucleus of the atom, summed up by the Heisenberg Uncertainty Principle.

Science concepts or terms include: Bohr Model, charges, electron, mass number, neutron, periodic table, proton.

4.6 Now There are Two: Kyle and Sam use their understanding of the model of the atom to draw the electrons and protons for Hydrogen and Helium.

Science concepts or terms include: charges, electrons, neutrons, protons.

4.7 The Second Level: Expanding their understanding of the atom, Kyle and Sam continue with examining the protons and electrons of Lithium and in the process discuss energy levels, orbits and electronegativity values.

Science concepts or terms include: electronegativity, electrons, energy levels, orbits, protons, values.

4.8 And So On: Using their basic knowledge of electrons, protons and energy levels, Kyle and Sam continue with an indepth look at how the Periodic Table has been structured and the patterns that exist with the table.

Science concepts or terms include: periodic table patterns.

4.9 It's All About the Patterns: Kyle and Sam continue to discuss the Periodic Table and expand their understanding of how the Periodic Table was constructed according to the commonalities and differences between various atoms, and placing the atoms on the table in a manner that created visual patterns.

Science concepts or terms include: periodic table patterns, valnce electrons.

Unit 5 - Atoms, Valence Electrons and Bonding, Chemical Reactions

5.1 Magic: Kailey rejoins Kyle and Sam for a discussion of how science is like magic unless you understand the workings of chemistry.

Science concepts or terms include: alchemists, atom, chemical reaction, how science works.

5.2 Magic or Chemistry: Somewhat twitter-patted, but mostly perlexed, Kyle talks to Sam about more of the patterns that exist within the periodic table, and how valence electrons, with gains or losses, affect the balance of the atom.

Science concepts or terms include: chemical reactions, gain and loss of electrons, ion, periodic table patterns, valance electrons.

5.3 It's Definitely Not Magic: Kyle and Sam use the valence electrons, energy levels, and balance to figure out why sodium and chlorine combine to form salt.

Science concepts or terms include: energy levels, chemical reactions, valance electrons.

5.4 Lazy Electrons: Kyle and Kailey discuss how gain and loss of electrons seems to work according to thermodynamics and efficient energy use regarding movement of electrons.

Science concepts or terms include: balanced reactions, electrons, energy, thermodynamics.

5.5 Two Plus Six or Six Plus Two?: Kyle and Kailey discuss valence electrons and how various elements in the same column on the periodic table have patterns of similar valence electrons.

Science concepts or terms include: element, periodic table patterns, valance electrons.

5.6 Sharing is Caring: Kyle and Kailey expand their understanding of how electrons bond by discussing sharing electrons by covalent bonding and some of the complexities involved in bonding.

Science concepts or terms include: electrons, covalent bonding, ionic bonding.

5.7 Sharing is Caring (continued): Kyle and Kailey continue their discussion of bonding and how the electronegativity values affect whether an atom gains or loses electrons.

Science concepts or terms include: bonding, covalent bond, electronegativity values, energy gain or loss, valance electrons.

5.8 Sharing is Caring – Continued Again!: Kyle and Kailey continue with an explanation of how electronegativity values help predict how elements will bond in a chemical reaction.

Science concepts or terms include: bonds, electronegativity values, elements.

5.9 Balance: Kyle and Kailey return to talking about the idea of balance when elements bond to form molecules.

Science concepts or terms include: balanced chemical reactions.

Unit 6 - Chemical Equations, Reactions and Molecules

6.1 The Bigger Picture: Sam, Kyle and Kailey expand their knowledge of balancing charges in compounds to discussing balancing charges in chemical equations.

Science concepts or terms include: balanced charges in chemical equations.

6.2 Back to the Bigger Picture: Sam, Kyle and Kailey discuss the bigger picture of what it takes to balance the chemicals in a chemical equation.

Science concepts or terms include: blancing chemical equations, products and reactants.

6.3 When Does 1 + 1 not equal 2?: Sam, Kyle and Kailey continue their discussion of balancing equations.

Science concepts or terms include: balanced equations, products, reactants, valance electrons.

6.4 It's Like Dating: Sam, Kyle and Kailey discuss synthesis and decomposition reactions.

Science concepts or terms include: charges, decomposition reactions, ions, synthesis reactions.

6.5 Breaking Up is Hard to Do: Sam and Kyle chat about decomposition reactions and how activation energy levels, exothermic and endothermic factors affect reactions.

Science concepts or terms include: activation energy, decomposition reactions, endothermic, exothermic, molecules.

6.6 The Love Triangle: Sam, Kyle and Kailey discuss how single replacement reactions are similar to dating.

Science concepts or terms include: single replacement reactions.

6.7 Swing Your Partner Round and Round: Continuing to relate the familiar to the unknown, Sam, Kyle and Kailey talk about how square dancing is similar to double replacement reactions.

Science concepts or terms include: balanced equations, double replacement reactions.

6.8 A Balancing Act: Sam, Kyle and Kailey think and talk through how to balance the products in a double replacement reaction.

Science concepts or terms include: balanced equations, charges, double replacement reactions.

6.9 Nature Leads: Sam, Kyle and Kailey fine-tune their understanding of balancing equations by using coefficients to help balance both sides of the equation.

Science concepts or terms include: balancing equations, coefficients.

6.10 One More Thing: Looking at an exception to the rule, our three friends discuss how diatomic elements bond to form molecules.

Science concepts or terms include: covalent bonding, diatomic elements.

Unit 7 - Acids and Bases

7.1 Acids, Bases and Salts – Oh My!: Kailey and Kyle are chomping on a burger and fries, washing it down with a soda, when Kyle wonders about the acidity of the soda. Kailey tutors Kyle on the key aspects of acids and pH.

Science concepts or terms include: acid, base, hydrogen ions, hydronium ions, pH scale, salt, strength of acids.

7.2 Acids in Our Body and Beyond: Kyle and Kailey continue to chat about acids, this time about how pH levels in the body are critical, and how acids in the environment do a great deal of damage.

Science concepts or terms include: acid mine drainage, acid rain, acids, bases, buffers, neutralize, pH, salts, strong versus weak acid, vehicle emissions.

7.3 Bases: In this conversation, Kailey and Kyle discuss characteristics of bases and how bases can neutralize acids.

Science concepts or terms include: acids, alkaline, bases, disassociation, hydronium ions, hydroxide ions, neutralize, pH.

Unit 8 - Solutions, Suspensions and Colloids

8.1 Solutions, Suspensions and Colloids: Kailey and Kyle converse about the differences between solutions, suspensions and colloids, and also where they can be found in life.

Science concepts or terms include: colloids, dissolved, solute, solution, solvent, suspension.

Unit 9 - Organic Chemistry

9.1 Polymers: Kailey and Sam are chatting about her car shopping episode. She tells Sam about the interaction with the car salesman who needed some help with understanding polymers and car bodies.

Science concepts or terms include: chain scission, covalent bonds, molecule, monomers, natural or synthetic, ozone, polymerization, polymers, tensile strength.

9.2 VOC's Take Over the Library: Kyle and Sam enter the library and are overpowered by the smell from the new carpet, which prompts a discussion about volatile organic compounds and toxicity.

Science concepts or terms include: boiling point, evaporate, pressure, sublimate, temperature, toxicity, vapor pressure, volatile organic compounds.

Unit 10 - Chemistry in the World Around Us

10.1 Catching More Mercury Than Fish: Kyle and Sam are fishing while they discuss the effects of Mercury found in fish, on humans and the enviornment.

Science concepts or terms include: mercury poisoning, neurotransmitters, biomagnification.

10.2 Sam and Kyle Run Out of Gas: Sam and Kyle head out on another road trip, but soon discover that their gas mileage is not what they thought and they run out of gas. While being rescued by a truck driver named Kip, the discussion turns to alternative fuels for vehicles.

Science concepts or terms include: alternative fuels, ethanol, energy units, hybrid cars.

10.3 Ban Chemicals Now!: While walking around downtown one Saturday afternoon, Sam comes across her friend Kyle at a protest in the park. where people are shouting “Ban DHMO.”

Science concepts or terms include: scientific literacy.

Unit 11 - The Last Chat

11.1 The Big Ending (or maybe not): Wrapping up their discussions of science topics, Sam, Kyle and Kailey reflect on on how far Kyle has come in terms of understanding specific aspects of science, and how science actually works.

Science concepts or terms include: how science works.

1.3 Hypotheses, Theories & Laws, Oh My!

Kailey and Kyle are sitting by a pond in the local park at night.

Kyle: I'm glad you had extra batteries for that flashlight.

Kailey: Kyle, are you scared of the dark?!?

Kyle: No! It's just that it makes me nervous when I can't see what's out there.

Kailey: Are you afraid of ghosts or the Bogeyman?

Kyle: Don't you believe in ghosts?

Kailey: Kyle, there's no evidence that ghosts exist. Besides, with science, it's not a matter of believing, it's a matter of knowing.

Kyle: Oh, man. Here it comes, another science lesson from the professor. And how can you prove that ghosts don't exist?!?

Kailey: Kyle, what's wrong with wanting to know what's really going on? You act like it's a bad thing to want to be smarter, to really know what's going on. It so very-not-cool to be proud of your ignorance.

Kyle: I know what's going on. I'm not dumb....you're trying to prove you're smarter than me. But I know what's going on. You want to rub it in.

Kailey: Kyle, that's not even worthy of a response...wait, yes it is! Mark Twain once said; "It's not what you don't know that hurts you. It's what you think you know that ain't so...". In your case, you think ghosts exist!

Kyle: Well, go ahead; use your beloved scientific method to prove that they don't!

Kailey: *(sighing)* Where to begin, where to begin...First of all, Kyle, that's not the kind of thing science can do. It's like trying to prove there's life after death, it's not a scientific question. To do science you need to start with a testable question.

Kyle: You mean there's something that your almighty science can't do?

Kailey: Of course! Science has it's limits, and answering a question about ghosts is one of them. Science is based on evidence, Kyle. You need to make a hypothesis that you can test with an experiment.

Kyle: Well then, let me introduce you to Kyle's Theory of Ghosts. There are lots of people who say they have seen a ghost. They all can't be wrong. That's evidence enough for me.

Kailey: There was a time when everyone thought the world was flat, and they were all wrong. Do you even know what a scientific theory is, Kyle?

Kyle: Yeah, it's a way of explaining something, like ghosts.

Kailey: Not quite. Science is a bit more particular when it comes to the word theory. You are correct that a scientific theory is a way of explaining something in our natural world, but it is based on tested hypotheses and establish facts. It is based on all the available scientific evidence and has been subjected to the criticism of many scientists over time. It's not like one person can say out of the clear blue; "I have a theory on ghosts"!

Kyle: But isn't that exactly what happens when somebody does an experiment? They start by saying they think they know what's going on.

Kailey: You're confused here Kyle, although that's not unusual. What you're talking about is a hypothesis. You make a hypothesis at the beginning to answer a specific scientific question. Then you do an experiment to test your hypothesis. Theories come after lots of experiments and discussion and are bigger than a hypothesis.

Kyle: Big, huh?...kind of like your head, Megamind.

Kailey: *(shooting him a dirty look)* And once a theory is proposed, other scientists test it and look for ways to poke holes in it. It's called peer review, Kyle. If they can find a weakness, the theory breaks down. If they can't, the theory gets stronger.

Kyle: Whew! Making a theory gets complicated.

Kailey: And messy with lots of discussion and conflicting opinions. Science is really a conservative process and it takes lots of time for ideas to be accepted. New ideas have a tough time surviving once the scientific community gets hold of them. Science is a really skeptical process. Only explanations that hold up to lots of testing are accepted as scientific theories. And even then, if new evidence is discovered that pokes a hole in it, the theory crumbles and is thrown out. It's tough for a theory to survive.

Kyle: Well, then what do you do with a theory?

Kailey: That's exactly it!

Kyle: Huh?!?

Kailey: Exactly! It's what we do with theories that make them so important! First, they are useful. They are powerful explanations of things that happen in our natural world. Second, a good theory is predictive. In other words, a good theory can be used to explain what will happen in the future.

Kyle: Kind of like a fortune-teller...and why do you keep talking about the natural world?

Kailey: It's not anything like a fortune-teller! Have you been listening, Kyle?!? Because science only deals with the natural world and is supported by evidence. It does not deal with ghosts and things like that. Supernatural thinking is not scientific thinking, Kyle. You need to use something other than science to talk about ghosts.

Kyle: OK. So a hypothesis is an educated guess to an answer for a single question. And a theory is a rational explanation of a big event supported by evidence that explains what will happen in the future...right?

Kailey: Almost. We can't say for sure what will happen in the future. A scientific theory is our best explanation at the moment for some big event or process. Remember, science is conservative. We are reluctant to say a theory is absolutely true because theories can change with new evidence.

Kyle: Is that like a law then?

Kailey: Again, close but not quite. A scientific law has been tested over and over and always found to be true, like the law of gravity.

Kyle: I know that one! It did a lot of damage to me when I was learning to skateboard. But would that be cool if I could stop gravity! I could be like those guys in the movies who float through the air! I could fly!

Kailey: Kyle, gravity works, it's a law. If you really want to fly, talk to my dad. He's a flight instructor. Then you could learn about all sorts of scientific theories and laws about flight. It's called aerodynamics.

Kyle: Hmmm. Your dad likes me, right? That's a pretty good idea. It makes me think of another theory...

Author – Michael Felske

2.4 Packedtogetheridness: Floating and Sinking

Kyle and Sam are continuing their discussion on why things float and sink, expanding their thinking using the concept of "density."

Kyle: Packedtogetheridness, huh? Dude, I know you're a smart guy, but making up new words? Can you just do that?

Sam: Sure, why not? You get it, don't you?

Kyle: Yeah, but...

Sam: *(interrupting)* Density.

Kyle: Huh? What's that?

Sam: Packedtogetheridness. See?

Kyle: Man, you are smart! Packedtogetheridness is exactly what it sounds like. But density, not so much. So it's OK to invent your own words?

Sam: Shakespeare did it in the plays he wrote. Not that I'm anything like Shakespeare. Besides, we're not going to keep using packedtogetheriness. Now that you understand it, we're going to replace it with the real word, density.

Kyle: Aw. But I like packedtogetheridness. It's a fun word. It's a lot more fun than density. Density sounds like one of those boring words in a textbook, the kind you look for in a word search. Do we have to get rid of packedtogetheridness? I miss it already!

Sam: It's my way of making you more sophisticated and scientific.

Kyle: Ha! As if that's ever going to happen. You're a funny guy!

Sam: Yeah, you just watch. Anyway, words are just labels that get attached to ideas. Instead of going through the whole explanation of floating and sinking using packedtogetheridness, you can just say "density" and that represents the entire idea.

Kyle: That's fine as long as whomever I'm talking to speaks the same language...you know science-talk.

Sam: That's a good reason why everybody should know about science. It's a big topic in the 21st Century world we live in. Let's try an easy word. Float. Explain what it means.

Kyle: That's easy. It's the opposite of sink.

Sam: OK, wiseguy. Yes, those are opposites, sort of. But tell me what it means to float.

Kyle: Well, hmmm.

Sam: Take your time. It takes a bit to get the idea straight in your head before you can talk about it.

Kyle: *(pauses)* Alright. First, you've got to talk about two things; the thing that floats and what it floats on.

Sam: Something can't float unless it has something to float on.

Kyle: And you have to look at the packedtogetheridness for both...

Sam: *(interrupting)* Kyle...

Kyle: Oh, yeah. Density. So you have to look at the density of the thing that floats and compare it to the density of what it floats on.

Sam: Good. You're on to why it floats, but how about WHAT floating is?

Kyle: Oh! That's easy. Something is floating if it's on top of what it's floating on. You know, just sitting there...ah, floating...held up by the water.

Sam: Does it always have to be water?

Kyle: No, of course not. It could be orange juice or milk.

Sam: Delicious, nutritious! How about sinking?

Kyle: That's easy. It's just like the bowling ball in the elevator or the rock in the pond. Sinking is when one thing moves through the other thing and goes to the bottom.

Sam: Gravity works.

Kyle: What? Oh, yeah, I suppose, if you think about it. So, sinking is like gravity making something fall down.

Sam: Until it hits something more dense that will hold it up. What about in the International Space Station? It's up too high above earth for gravity to have any effect.

Kyle: Dude, you have a very weird brain!

Sam: Without gravity, there would be no sinking. In fact, in space, if you let go of a rock it would just stay there. Without gravity, there is no sinking. There is no falling down. And if you think about it, there is no down at all. And if there is no down, there is no up!

Kyle: Sink, sank, sunk, Dude. That's what you just did to my brain! Hey! How come we have three words for sink, but only one word for float? And what about that rock in the space station? If it's not floating or sinking, what word do we use to describe THAT?

Sam: Dude, you're brain is more ADHD than mine! So, now you're asking for an English lesson?

Kyle: What? No! Arrrg!

Author – Michael Felske

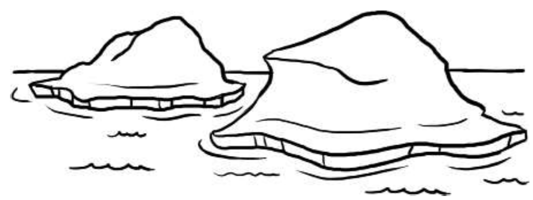
3.8 Changing Changes

Kyle and Kailey are discussing the differences between chemical and physical changes using examples they are familiar with.

Kyle: So, what's the difference between a physical change and a chemical change?

Kailey: Well, a physical change is just as the name suggests. It's only the appearance that changes. When liquid water freezes, it's still water, just in solid form.

Kyle: But ice doesn't look anything like water.



Kailey: Yes, but it's still good old H_2O.

Kyle: H_2O, the secret formula…

Kailey: It's no secret. It's the chemical formula for water…kind of like a recipe, although any self-respecting chemist would grimace to hear it called a recipe.

Kyle: Grimace?!? That sounds like a cartoon character of some sort. What kind of a word is that?

Kailey: *(sighing)* And here I thought you were getting more sophisticated.

Kyle: Yeah, well, how about we get back to changes?

Kailey: OK, fine. A physical change is when something has it's appearance changed. If you break glass, it's still glass. Water, ice and steam are all just forms of water that look different.

Kyle: In our last dialogue we talked about the Wicked Witch setting the Scarecrow on fire. That's not a physical change, is it?

Kailey: Burning is a chemical change. When you burn paper you end up with something totally different than what you started with. The paper was changed chemically into something other than paper.

Kyle: Kind of like when a magician turns a scarf into a rabbit.

Kailey: That's just a magician's trick, a slight-of-hand. Chemical changes can seem like magic though. Their explanation gets a bit, well, involved. How about we wait until the next chapter of dialogues to tackle chemical changes.

Kyle: That sounds good to me. I don't think I'm quite up to that yet.

Kailey: If you think about it, you have already explained the most common phase changes.

Kyle: Phase changes? Yeah, those are easy. Melting goes from a solid to a liquid. Boiling goes from a liquid to a gas. Adding heat energy makes those phase changes happen. Freezing goes from a liquid to a solid and…hmm. What do you call the one that goes from a gas to a liquid?

Kailey: Condensation, like when you take a hot shower in a cold bathroom. The hot water gas hits your cold mirror, slows down and turns back into a liquid.

Kyle: So, that's condensation on my mirror, not steam?

Kailey: Right. People say the mirror is steamed up, which is kind of true since steam is what hit the mirror.

Kyle: It's all about energy, isn't it? Adding heat causes melting and boiling. Taking away heat causes condensation and freezing. Hey, does that mean that a chunk of iron is frozen when it's at room temperature?

Kailey: Yep. Iron melts and freezes at almost 3000 degrees Fahrenheit. So, if room temperature is 70 degrees, it's really cold for iron and it's frozen solid.

Kyle: Weird…why did you say it melts and freezes at the same temperature?

Kailey: It depends on if heat energy is added or subtracted, but melting and freezing happen at the same temperatures.

Kyle: Is that true for condensation and boiling? *(pausing)* Never mind, it must be the same, for the same reason too.

Kailey: Yep, you're catching on!

Kyle: What about evaporation? Where does that fit in?

Kailey: It's the same phase change as boiling, going from a liquid to a gas. It just happens more slowly using heat from room temperature.

Kyle: Sure, since there is less heat energy at room temperature, it takes longer.

Kailey: Evaporation happens at the surface of a liquid. Boiling usually begins at the bottom, where heat is being added, like when you put a pan on a stove.

Kyle: What about dry ice? It doesn't melt, does it?

Kailey: It's called sublimation, going from a solid directly to a gas. If you leave ice cubes in a frost-free freezer for a really long time, the cubes get smaller. That's sublimation. It's kind of weird, but kind of cool too.

Author – Michael Felske

4.9 It's All About the Patterns

Kyle and Sam continue to discuss the Periodic Table. They expand their understanding of how the Periodic Table was constructed according to the commonalities and differences between various atoms. Their understanding improves when they see how the atoms on the table are placed in a manner that creates visual patterns.

Kyle: The Universe is full of them.

Sam: What, aliens?

Kyle: Maybe, but I was thinking of patterns. You can see them all over the place, nature is full of them.

Sam: Like with the Periodic Table.

Kyle: Exactly. It's so much easier than trying to memorize everything.

Sam: You mean if we recognize patterns, we can use them to predict what's going to happen next?

Kyle: Sort of...like with the Periodic Table. There are two basic patterns; the up and down one with the columns and the across one with rows.

Sam: Right. The atoms in each column have the same number of valence electrons.

Kyle: You mean the electrons on the outermost energy level?

Sam: Yeah. So if I ask you how many valence electrons the elements in column two have, you'd say...

Kyle: They all have two. And if I ask you how many valence electrons the elements in column thirteen have, you'd say...

Sam: They all have three. Not 13 because columns three through twelve are the transition elements that don't follow the pattern and we're skipping those for now.

Kyle: Well, yeah, but it's not that they don't follow a pattern; it's just not this pattern.

Sam: So, there are more patterns?

Kyle: Yeah, it's a complicated world out there with lots of patterns to figure out.

Sam: And that's one of the things that science does...look for patterns.

Kyle: It's a powerful idea. If you can find patterns, you can use them to predict what will happen. It's one of the cool things about science that helps make sense of the world we live in.

Sam: It's kind of like simplifying the whole world. KISS, right?

Kyle: Knowing patterns helps us KISS the entire world.

Sam: You would need a big mouth for that.

Kyle: And I know who has a mouth that big...

Sam: Hey! Are you sure you want to go there?!?

Kyle: Yeah, OK, forget I said that. Back to patterns with atoms.

Sam: That's why we're only looking at the electrons on the outside of the atom.

Kyle: It's because only the outside or valence electrons react in a chemical reaction.

Sam: It's the Tootsie Pop idea again. You have to start on the outside in order to get to the chocolaty, chewy inside.

Kyle: Another pattern, huh?

Sam: Yep. And then there's the pattern with energy levels in each row on the Periodic Table.

Kyle: Every atom in the hydrogen row has one energy level.

Sam: And all the atoms in the lithium row have two energy levels. Then the third row down has three energy levels, the fourth has four and so on.

Kyle: Patterns! It's so much easier than trying to memorize everything.

Sam: It helps us make sense out of seemingly complicated things. But, I'm still a bit confused. Why is helium way over on the other side of the Periodic Table above the elements with eight valence electrons?

Kyle: Well, that's another pattern. The elements in that last column don't react chemically because their outer energy level is full making them stable.

Sam: Oh yeah! I remember, helium has only two electrons and they fit into the first energy level. But since the first energy level only holds two electrons, helium is full with only two electrons.

Kyle: And the elements in column two are chemically reactive. Helium isn't.

Sam: Is that why the elements in the last column are all gases?

Kyle: Huh? Are you suggesting another pattern?

Sam: I dunno. But it seems peculiar. This may require more investigation...

Author – Michael Felske

5.3 It's Definitely not Magic

Kyle and Sam use the valence electrons, energy levels, and balance to figure out why sodium and chlorine combine to form salt.

Kyle: Can we continue now?

Sam: Sure...where were we? Oh yeah, chlorine reacting with sodium.

Kyle: You told me about how sodium becomes an ion by losing it's valence electron. I've been thinking about that with the idea of balance.

Sam: How so?

Kyle: Well, sodium's electron can't just be lost or thrown away. It's got to go somewhere. Besides, balance is like opposites canceling each other, so I was thinking that the opposite of losing is gaining. I'm guessing that chlorine gains the electron that sodium loses.

Sam: Outstanding! That's a great hypothesis. I bet you can figure the rest out from here.

Kyle: Why don't you just tell me?

Sam: That's not how we learn stuff...by being told. We really learn things when we can figure it out for ourselves. Besides, it's more fun this way.

Kyle: But it's much harder this way.

Sam: So what? Don't be dependent on me...do it yourself.

Kyle: This is why I'm exhausted when I come home from school even though I've just been sitting there all day. Using my brain is hard work.

Sam: No pain, no gain.

Kyle: *(grumbling)* Oh, alright. Let me see...we've been using the Periodic Table, so I think I'll start there. Chlorine...it's in column 17, so it's got seven valence electrons. Hey, that's it!

Sam: That was fast.

Kyle: But it falls right into place. The one electron that sodium lost isn't really lost. It goes into the valence energy level of chlorine to join up with the seven other electrons.

Sam: Yep. That way chlorine's valence energy level gets eight electrons and becomes stable.

Kyle: The valence energy level may be stable, but the entire atom is now out of balance.

Sam: That's a necessary part of the process. Chlorine now has 17 protons and 18 electrons. So, yeah, it's out of balance. But that's necessary for it to go back into balance as it turns into something new.

Kyle: Oh, wow! I just got goose bumps! Look it! Look it! Now that chlorine has gained the electron from sodium, it becomes an ion with a negative one charge. And since sodium lost an electron, it turned into a positive ion with a positive one charge...you know, 11 protons and 10 electrons.

Sam: ...and?

Kyle: There's the balancing act! The sodium ion is a positive one charge so it's attracted to the chlorine ion with a negative one charge.

Sam: And they balance each other when they come together...

Kyle: ...and make salt that tastes good on french fries...goose bumps!

Sam: Don't say that out loud. You'll sound like you're as big of a nerd as Kailey.

Kyle: And that's a bad thing?

Sam: YES!

Kyle: It's definitely not magic.

Sam: What, you and Kailey or chemistry?

Kyle: *(with a goofy smile)* Oh, there's definitely chemistry...

Sam: This is going to be really hard on me, I don't know if I'll be able to suffer through you two as a couple.

Kyle: No...It's science, not magic.

Sam: He's back! There's the Kyle we know and love!

Kyle: If I can just focus... such a simple idea; positive one plus negative one equals zero. It's so simple, yet it seems magical. Balance in chemistry is all about simple addition...positives and negatives adding up to zero.

Sam: Two nasty elements turning into something tasty on french fries. Sometimes simplicity in and of itself can seem magical.

Kyle: Yes, Obi-Wan.

Author – Michael Felske

7.1 Acids, Bases and Salts – Oh My!

Kailey and Kyle are chomping on a burger and fries, washing it down with a soda, when Kyle wonders about the acidity of the soda.

Kyle: Yum, Yum! These baby butter burgers are beyond beliceous!

Kailey: Beliceous?

Kyle: Well, I couldn't think of a proper word to describe good tasting that started with a b, so I invented one.

Kailey: Right. How about tasty, scrumptious, flavorsome, mouthwatering, appetizing – stick to the King's English would you?

Kyle: Seeing as my creativity does not impress you – how about this question. Remember in chemistry our teacher said next week we were studying acids, bases and salts? I heard Sam say that sodas are acidic. And, my pop was talking about battery acid and not getting any on his skin or clothes and he wore goggles just to protect his eyes. How come I don't have to wear goggles drinking my soda?

Kailey: Ok, great question Kyle. First of all, there is an acid in sodas, and in batteries to help with the storage of electrical charges. But there are also acids in our bodies, and in the air – perhaps you have heard of acid rain, but we will get to that later on. So it's important that you understand the essence of acids, and also bases.

Kyle: Right – I have heard of bases but I'm really unclear of the connection to acids.

Kailey: So, let's start really simple with the definition of an acid – any compound that contains hydrogen atoms, when added to water, releases hydrogen ions. Let me break that down for you. If you take an acid like HCl and add it to water, the H atom loses an electron and becomes H^+, the plus charge because it has lost the negative charge.

Kyle: All right – got it. How about bases?

Kailey: Hold on cowboy. We will hold off on bases until you understand more about acids. Now, you might have heard the names of other acids such as carbonic, sulfuric, or nitric acid.

Kyle: Right – my soda can has carbonic acid as one of the ingredients.

Kailey: Correcto mundo Kyle. And you can drink the soda without hurting yourself. But sulfuric and nitric acids are quite dangerous and would burn your skin, or really damage your eyes if you accidentally spilled some on you.

Kyle: Yup – when my pop, dad – not soda, got a new battery, he had to add the sulfuric acid into the battery cells, and he was super careful about pouring it in, and he made me stand way back so nothing could splash on me.

Kailey: Yes – I think sulfuric acid is much more dangerous than carbonic acid. But let's take a look at the difference. First, there is a scale that is used to indicate how strong or weak an acid is and it's called the pH scale. The pH scale ranges from 0 – 14, and anything in the middle, with a pH of 7, is called neutral, higher than 7 is called basic, lower than 7 is called acidic.

Kyle: OK – so that's easy to remember. A for acidic is first in the alphabet, so I can remember it comes first, from 0-7, and B for basic comes second and therefore is 7-14 on the pH scale.

Kailey: Hey, that's a good way to remember it. Now 7 is neutral right, neither acid nor base. But the strength of the acid comes from how many hydronium ions are in the solution. An acid with a pH of 3 has a lot more hydronium ions than an acid with a pH of 6. And an acid with a pH of 1 has a lot more hydronium ions than a pH of 3. Follow me.

Kyle: Sure, but going from a pH of 3 down to a pH of 1 isn't much of a change.

Kailey: You know, I also believed that but here's the deal. And listen closely to this. A pH of 5 is 10 times stronger of an acid than a pH of 6. And it is stronger because what Kyle?

Kyle: Stronger because of more hydronium ions, right?

Kailey: Ooooh! My budding scholar. You have broken away from your butter burger long enough to pay attention. That gives me goose bumps. But more on strength of an acid. An acid with a pH of 4 is also 10 times stronger than something with a pH of 5. And a pH of 3 is how many times stronger than a pH of 4?

Kyle: Well I guess the pattern seems to be a tenfold change with a drop of one number, right?

Kailey: Right. But how much stronger is a pH of 4 than a pH of 6?

Kyle: *(confidently)* Well, that's easy - 20 times stronger.

Kailey: *(giving Kyle a disappointed look)* Nope. Check this math out. If a pH of 4 is ten times stronger than a pH of 5, and a pH of 5 is ten times stronger than a pH of 6, then 10 times 10 equals 100, so a pH of 4 is 100 times stronger than a pH of 6.

Kyle: I see. So check this out. Then a pH of 3 is 1000 times stronger than a pH of 6, because 10 x 10 x 10 equals 1000. Right?

Kailey: *(almost swooning)* Kyle, you are so quick to catch on – I'm quite proud of you.

Kyle: *(blushing)* Thanks Kailey – It's really no big deal.

Kailey: My food is getting cold. Let's pick up this conversation later and talk about the importance of acids in our lives.

Kyle: Sure, I don't quite get the acid rain thing. Maybe you can fill me in on that phenomenon. I am really worried about all the times I went out and played in the pouring rain. But now I know it is dependent upon the strength of the acid.

Kailey: Right. More on that later. Now I have finish my burger

Author – Craig Berg

9.2 VOC's Take Over the Library

It's the first day of school and Kyle and Sam head to the library to hang out between classes. As they enter the library their noses are hit with a strong odor.

Sam: What the heck is that smell? It's overpowering my sniffer!

Kyle: Oh – tell me about it. That is really strong!

Sam: What's causing it to stink in here?

Kyle: Look. New carpet. This sort of smells like it did when we had new carpet put into our house.

Sam: *(drops to the floor and takes a whiff)* Holy moly batman – that's it. Why does new carpet give off such a toxic smell?

Kyle: Don't know for sure, but when we got new carpet, we actually opened all the windows and went to our cousins for a couple days until some of the smell left. When we returned, we could still smell it, but it wasn't so strong.

Sam: Let's stay here for bit, if we can stand it, and Google up new carpet and smell.

Kyle: Good idea.

Sam: So this website mentions that new carpet gives off volatile organic compounds.

Kyle: So organic is good right – like organic food. But volatile is not so good. Uncle Freddy seems like he is always angry and mom says he is a bit volatile.

Sam: OK. Let's start over and let me break this down for you. First, it says here that Volatile Organic Compounds or VOC's are given off as gases from some solids or liquids.

Kyle: So what we are smelling is a gas given off by the new carpet?

Sam: Right. Let's bump over to another web site and check out VOC's.

Kyle: Here it says that organic compounds are chemicals that have a high vapor pressure at ordinary, room temperature conditions and that the high vapor pressure results from a low boiling point, which causes large numbers of molecules to evaporate or sublimate from the liquid or solid form of the compound and go into the air. Sam - could you translate that into English for me?

Sam: Ok. I think there are some pieces in there that I understand. Something with a low boiling point means that the temperature doesn't need to be very hot for it to boil, and in this case they said evaporate or sublimate.

Kyle: What is the difference between evaporate and sublimate?

Sam: Remember in Physical Science when we talked about ice melting first into a puddle, then it going into the air by evaporation?

Kyle: Right.

Sam: And then we looked at how sometimes when the temperature and pressure are right, the water molecules can go directly into the air without going through the melting into a puddle phase? That is sublimation.

Kyle: Ok. Now I remember. It is just hard to think about because you can't see it go from solid to liquid – the ice cube just gets smaller.

Sam: And here it says that an organic compound called formaldehyde has a boiling point of -19 degrees C or -2 degrees F.

Kyle: Wait a minute – so it boils below freezing? At -2 degrees F?

Sam: And formaldehyde can emit from plywood, new paneling and other construction products. I bet new carpet emits some also. And here it indicates that paint, lacquers, paint strippers, cleaning supplies, pesticides, copiers and printers, glues and permanent markers can give off VOC's.

Kyle: Well that pretty much covers most of what we have in our basement and garage. All right – so it stinks. Other than irritate our noses, is it bad for us to be in here with the VOC's entering into our lungs?

Sam: Wait just a second. It also includes aerosol sprays, cleaners and disinfectants, moth repellants, air fresheners, hobby supplies and dry-cleaned clothing.

Kyle: Ok. That covers the rest of the house. I think our house could be VOC central. But back to my major concern. If I am going to be a sports superstar, or perhaps the next Jimmy Buffet, or perhaps I will rise to fame on Dancing with the Stars, are VOC's going to limit my chances of success?

Sam: Well in short, some VOC's are highly toxic and we don't know if others have long term health effects. Some are known to cause cancer, while others produce nose, eye and throat irritation, headaches, loss of coordination, and damage to the kidneys, liver, or central nervous system. Sometimes people just experience fatigue and dizziness.

Kyle: Ok. When this place airs out and the VOC's diminish, that's when I am coming back to the library. Not before.

Sam: I think that is probably a good decision. But you know, if you have all that stuff in your house, you might be exposed to VOC's at home and not know it.

Kyle: Well I think I am safe. I don't smell anything.

Sam: Look here. It says research on VOC's in homes have found an average of 2-5 times higher VOC's indoors than outdoors, and sometimes after doing things inside your house that you shouldn't, like paint stripping, levels raise to 1,000 times that of outdoor levels.

Kyle: So if I got this right, we probably shouldn't store paint, paint stripper, or other organic compounds in the house. We should at least take them out to the garage?

Sam: Probably a good way to go Kyle – just to be safe, get it out of the house and into the garage, or off to the hazardous waste recycling center.

Kyle: Hey I am going home after school to do a little inventory of the chemicals and paint we have sitting around. My rock star career can wait for bit until I reduce the chances of breathing in VOC's at home.

Sam: And I am going to see if I can get in to talk with the Principal. She should really close this library down for a couple days and vent the air in this room to the outside the building until the VOC's are reduced.

Kyle: You are going to see the Principal? Hey, my house can wait. I want to see you chat it up with the Principal.

Sam: Sure – watch and learn my man. A smooth talking Sam goes big time one-on-one with the Principal. Better call my mom and have her on stand-by to bail me out if things go badly.

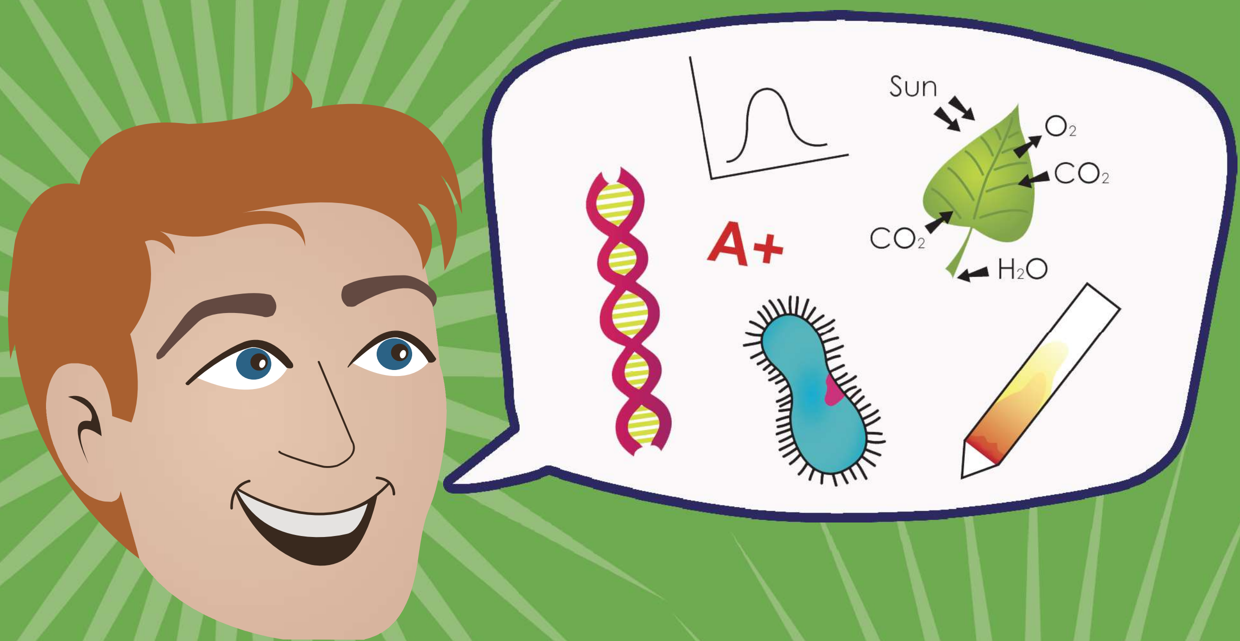
Author – Craig Berg

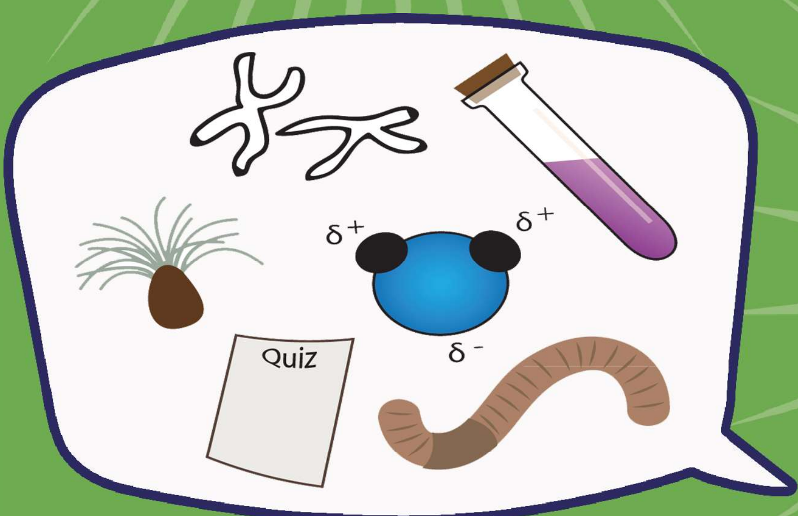
Volume 2

Dialogues

for the

Biology Classroom





Greg Bisbee, Craig Berg and Micheal Mullen

Dialogues for the Biology Classroom Volume 2 will be ready early in 2017.

Email doc@moosemosspress.com if you wish to be notified when it is ready for sale.

Biology II - Examples of Titles

Pip and Pep Discover E.Coli Bacteria
Zig and Zag Discover How Muscles Work
Wei and Noe - Hit Me With Your Best Shot (Immune System and Vaccinations)
Hip and Hop Study Histology
Rip and Rap Go Hiking (vacuoles and turgor pressure)
Pip and Pep Are Thinking Like A Scientist
Wei and Noe Illustrating Interactions (trophic cascades)
How's Your Homeostasis?
Bing and Bong Are Serious about Cells (parts of the cell)
Insane to the Membrane!:
Schwann and Schleiden Discuss the Cell Theory Over a Good Cup of Coffee
Zip and Zap Experience Cycles in the Biosphere:
Wei and Noe Examine the Nature of Science
Too Much Caffeine!
Wei and Noe In Taking One for the Herd – Part 1 (herd immunity and epidemiology)
Where There's Smoke
Wei and Noe In Taking One for the Herd – Part 2 (herd immunity and epidemiology)
Life is Cellular
Wei and Noe Examine People, Patterns and Immunization
Bedbug Badness:
Wei and Noe: Geology Rocks (sedimentary, igneous, metamorphic & fossils)
Riff and Raff Get the Lead Out
Wei and Noe: Consider Conservation (charismatic mega-fauna)
Riff and Raff Babble About Bubbles in the Bloodstream:
Wei and Noe: Chlorine Countdown (chlorine, drinking water)
Zip and Zap Choose Paper versus Plastic
Wei and Noe: Chatter About Checklists (positive effects of using checklists when doing tasks)
Zip and Zap In Dust Mites Are Us
Wei and Noe: A Case of Altered Evidence (science misconduct – autism and vaccinations)
My Oh Meiosis:
Wei and Noe: Boffo About Buffers
Myo and Geo: Batty About Biology (bats)
Myo and Geo: Things That Go Bump in the Night(fungi, wihtenose syndrome in bats)
Wei and Noe: Scientific Tools (Aero-ecology, weather radar and determining bat populations,
technology and science)
Wei and Noe: Learning About Learning
Biodiversity
Colony Collapse
Competition
Genetic Toolkit
Insects and Flowers

Biology II Dialogue - Example Abstracts

Pip and Pep Discover E.Coli Bacteria: Pep spent yesterday at the beach, and now only Pip is enjoying breakfast, as Pep has an upset stomach, probably due to the bacteria E.Coli.

Science terms or concepts include: bacteria, E.Coli, pathogens, organismis, HIV, Malaria, immune system, bacteria counts, germs

Zig and Zag Discover How Muscles Work: Zig and Zag are lifting weights to get in shape for the next soccer season and talk about the structure and function of muscle fibers.

Science terms or concepts include: sacromeres, muscle fibers, bicep, motor neuron, neurotransmitter, Acetylcholine, ions, sodium, calcium, contraction, cramp, protein, myosin filaments, actin filaments, binding sites, ADP, ATP, cross-bridge

Hip and Hop Study Histology: Hip is watching Hop put on large amounts of skin moisturizer which prompts a discussion about the important function of connective tissue in the human body.

Science terms or concepts include: epithelial, connective, muscle and nervous, respiratory system, blood, lymph, sweat glands, pancreas, bladder, functions of connective tissue, cartilage, tendons, ligaments, skin, skeletal, cardiac, brain, spinal cord, peripheral nerves

Pip and Pep Are Thinking Like A Scientist: Pip and Pep are word wrangling over the topic of how science gets done and whether there is a method to the madness of doing science.

Science terms or concepts include: scientific methods, processes of science, problem, hypothesis, experiment, observations, conclusions, qualitative, quantitative, control, experiment, prediction, valid, trial and error, scientific information

Zip and Zap and Water Chemistry: Zip and Zap are fishing for trout and wonder about the various biotic and abiotic factors that keep the stream healthy and a good place for trout to live.

Science terms or concepts include: benthic macro invertebrates, turbidity, organic material, dissolved oxygen levels, water quality, aquatic plants, nutrient levels, nitrates, phosphates, fecal coli form bacteria, biochemical oxygen demand

How's Your Homeostasis?: Pip and Pep are discussing how the body maintains a stable internal environment.

Science terms or concepts include: homeostasis, body functions, concentration of fluids and nutrients, body temperature, blood vessels, dilation, vital organs, contraction of muscles, sweating, shivering, nervous system, integumentary system

Insane to the Membrane!: In this episode, Pip and Pep are pondering the movement of molecules through the cell membrane.

Science terms or concepts include: cell membrane, molecules, molecular collisions, atoms, ions, diffusion, higher concentration, lower concentration, kidney dialysis, selective barrier, facilitated diffusion, osmosis, filtration, blood proteins, active transport, energy, carrier molecules, sugars, amino acids, endocytosis, exocytosis

Zip and Zap Experience Cycles in the Biosphere: Zap is drawing biogeochemical cycles on the wall when Zip and Zap discuss what they know about the water cycle, carbon cycle and nitrogen cycle.

Science terms or concepts include: biogeochemical cycle, energy, matter, molecules, elements, chemical compounds, biosphere, evaporate, transpire, condense, precipitation, water cycle, carbon cycle, global warming, photosynthesis, phytoplankton, nitrogen cycle, atmosphere, proteins, producers, decomposers, ammonia, nitrogen fixation, soil bacteria, nitrates, nitrites, denitrification

Too Much Caffeine!: Today, Pip and Pep are discussing how signals travel down a nerve and how the chemical caffeine affects the nerve impulse.

Science terms or concepts include: central nervous system, nerve impulse, neurons, ions, sodium-potassium pumps, positive and negative charges, resting potential, axon, synapse, protein channels, action potential, potassium gates, resting potential

Where There's Smoke: Zig is watching TV when the smell of smoke from Zap's room catches his attention when then initiates a conversation around the implications of smoking cigarettes.

Science terms or concepts include: effects of nicotine, addiction, hormones, chemical messengers, lung macrophages, white blood cells, dopamine, epinephrine, neurotransmitter, cholesterol, blood clot, artery, nutrients, tissues

Life is Cellular: Hip and Hop are discussing some of the cool functions of the organelles in cells.

Science terms or concepts include: light microscope, telescope, eukaryotic, organelles, electron microscope, cell biologists, cells, organ, nucleus, prokaryotic, nuclei, cell membrane, cytoplasm, nucleolus, ribosomes, chromatin, protein, tissues, endoplasmic reticulum, detoxify, golgi apparatus, digestive enzymes, lysosomes, vacuoles, salts, proteins, carbohydrates, energy, mitochondria, ATP, cytoskeleton.

Bedbug Badness: Pad and Pod discuss the unexpected return of an ancient scourge—Cimex lectularius, the common bedbug.

Science terms or concepts include:

Riff and Raff Get the Lead Out: Riff is reading the newspaper and finds a story about the city attempting to sue paint manufacturers over lead paint used decades ago in the city's houses.

Science terms or concepts include:

Riff and Raff Babble About Bubbles in the Bloodstream:

Science terms or concepts include:

Zip and Zap Choose Paper versus Plastic: Zip and Zap are leaving the grocery store with ice cream, popcorn and a few other treats for the big weekend. As always the discussion turns to topics scientific!

Science terms or concepts include:

Zip and Zap In Dust Mites Are Us: Jib and Jab are watching TV during the daytime and Jab looks over toward the window and the beam of light shining into the room and sees a lot of suspended dust particles floating through the air.

Science terms or concepts include:

My Oh Meiosis: Jack and Zack are siblings waiting to see their newborn brother for the first time in the hospital. As they enter the room, Zack is visibly startled by the baby's full head of curly black hair (both brothers have straight blonde hair).

Science terms or concepts include:

Pad and Pod: Bedbug Badness!!!

In today's informative drama, Pad and Pod discuss the unexpected return of an ancient scourge—Cimex lectularius, the common bedbug.

Pad: [reading a newspaper article and laughing]…whew, that's hilarious!

Pod: Hey Pad, what are you reading...it certainly looks like you're enjoying it.

Pad: Oh, hi Pod! Yeah, I was reading this newspaper article about bedbugs… can you believe it??

Pod: [confused] Uh…OK. So what's the funny part?

Pad: Bedbugs? Really? They aren't real!!!

Pod: Of course they're real! Why would you think they're not?

Pad: Oh, come on…that's something my grandma used to tell me when I was little—"Sleep tight, don't let the bedbugs bite!" Bedbugs are just something that adults tell little kids—like monsters in the closet!

Pod: They are real, Pad! Uh…the bedbugs, not the monsters. Bedbugs are biting insects classified in the order Hemiptera. They are considered nest parasites and there are different species of bedbugs. Different species of bedbugs feed on different hosts—like birds and bats.

Pad: OK…if bedbugs are real, then how come I haven't heard anything about them—other than from my grandmother?

Pod: You just did—in that newspaper article. [thinking] But it is true…we haven't heard much from bedbugs lately. They kind of disappeared for 40 or 50 years.

Pad: Disappeared? What do you mean they disappeared?

Pod: Well, there are two species of bedbug that commonly affect people—Cimex lectularius and Cimex hemipterus. In the old days, people were commonly bitten by bedbugs and went to great lengths to control them.

Pad: What do you mean, Pod? [look of apprehension] This doesn't involve loss of limbs or anything like that…does it???

Pod: No, Pad. Bedbugs hide in mattresses and little crevices—in fact, they don't usually travel further than 5 or 10 feet from the bed.

Pad: [excited] Oh…that's why they are called bedbugs!!!

Pod: Exactly! Anyway…people used to restuff their mattresses, and pour boiling water over the bed frames. Later on, they dusted their beds with toxic insecticides—they killed the bedbugs, but it probably was not the best for them, either.

Pad: That all seems pretty extreme! What do these bites do to people? I know that some insects—like fleas, mosquitoes, and flies—can transmit disease through their bites or by carrying disease organisms on their bodies. Do bedbugs do that?

Pod: Actually, they do not…but scientists aren't really sure why not. For some reason, they don't seem to transmit diseases…they just leave a red, swollen bite mark. The mark is actually caused by our allergic reaction to a component of the saliva—just like with mosquitoes!

Pad: That still brings us back to WHY they disappeared then reappeared…is this like that tuberculosis thing? We hit tb with antibiotics and it seemed to disappear then came back with all kinds of antibiotic resistance. Now it's harder to treat than ever!!! That's really scary.

Pod: In this case, no one's really sure why it has happened. Bedbugs were never really studied very thoroughly—most of the research was just on how to get rid of them. Now that they're back, no one's really sure exactly what to do.

Pad: Well, there must be some suggestions on how to control them! I mean, with all our technology and chemicals and everything…

Pod: The best solution is prevention…make sure that you don't get bedbugs in the first place. If you already have them, sealing mattresses and cracks and vacuuming are the best ways to limit them.

Pad: Where would you even get them from? It doesn't seem like you would go to Bedbugs 'R Us (and why would you want to???). And I'm guessing that flower beds aren't the right kind of bed for finding bedbugs.

Pod: And you would be correct, my goofy friend! Right now, bedbugs spread through hotels and resorts. Someone accidentally brings them in on luggage and leaves some behind in the hotel room.

Pad: Oh, and then the next person unknowingly carries some away with them when they leave. And both people would take them to the next place they went—either a different hotel or home!

Pod: That's right. So they can spread pretty fast—all around the world!

Pad: Wow…all of this worry because of a tiny, little bug! It is fortunate that they don't cause disease or illness, though. That would be a big problem!

Author - Greg Bisbee

Riff and Raff "Get the Lead Out"

Riff is reading the newspaper and finds a story about the city attempting to sue paint manufacturers over lead paint used decades ago in the city's houses.

Riff: Look at this story Raff—the city is going to try to sue paint manufacturers for creating and selling lead paint.

Raff: Wait a minute! Hasn't it been decades since lead paint was manufactured and sold in this city…let alone any place in the U.S.?

Riff: Almost correct, my cranial companion. It says here that in the old days, some paints were made up of as much as 40% lead compounds. Then in 1953, paint industry standards reduced lead levels to 1.0% or 10,000 parts per million.

Raff: [thinking] Well…1% doesn't seem like it's a very high concentration. But 10,000 parts per million does—I guess it's all how you say it, huh?

Riff: It doesn't end there. In 1962, lead was reduced to .5% or 5,000 parts per million. Then, in 1977, the Lead Based Paint Poisoning Act reduced maximum allowable levels to 0.06%, which, my mathematical whiz buddy, you have probably already calculated to 600 parts per million.

Raff: So, let me get this straight. It is still legal to put lead in paint at very small levels, but in 1962, it became illegal to make and sell paint with dangerous levels of lead in it. So did paint companies keep making and selling paint with high levels of lead?

Riff: No, they followed the law and reduced the levels of lead in their paints.

Raff: I don't get it. How can you sue somebody who didn't violate the law?

Riff: That's a great question, Raff. And, while it's a very interesting question, it's beyond the realm of science to answer that one—that's more law or politics, I suppose.

Raff: But they quit selling paint with large amounts of lead a long time ago—why is it still an issue today?

Riff: Well, many of the older homes in the city were painted with lead paint prior to the ban. When the paint gets old, it cracks and breaks off, and paint dust and chips get spread around the house. Some of this lead can get into the human body and that is not good.

Raff: Into the body – how?

Riff: Well, you know how young children eat anything—like you eating Boxelder bugs and dirt when you were little. So kids get dust on their fingers, they put their fingers into their mouths, and—voila—lead dust in the body. Or they might pick up a paint chip from around a window and put that into their mouths.

Raff: So lead gets into the body. Is that really a problem? Lead's just a metal, isn't it?

Riff: Well, there is such a thing as lead poisoning. Lead can cause problems with the kidneys, brain, and bone marrow. Symptoms of high lead levels can include headaches, confusion, belly pain, vomiting, seizures, muscle weakness, hair loss and a low red blood cell count. Lower levels of lead can lead to difficulty paying attention, learning difficulties, behavior problems, and drop in IQ in young children.

Raff: OK…I see how it can get into the body and particularly into children, and the medical dangers associated with lead paint. But why not strip the lead paint off the walls and windows and eliminate the danger. You know, ba da bing—gone!

Riff: A good plan, but often these are inner city houses and the folks who live there cannot afford to remove the lead paint, or they just rent the place, and the landlord doesn't want the expense of removing the paint.

Raff: So the city decided to sue on behalf of the people who live in the homes?

Riff: Sort of, Raff. The city tries to help by having lead abatement programs where they come around and remove the lead paint. But it is expensive to do all that work on so many old houses.

Raff: Well, at least the people living in those houses would get safer places to live and get some compensation to address their medical problems associated with the lead.

Riff: Actually, Riff, the people living in the houses don't get any money…it's the city suing the paint companies, not the people.

Raff: Wait!!! What do you mean Riff? The people most affected don't get the money? Well, then, where does it all go (assuming the city wins, of course!)?

Riff: While you might think the people who are directly affected by the lead paint problem would get most of the cash settlement, it is the lawyers that get 60% of the cash, with the rest spread to lead abatement programs and perhaps a little bit to the homeowner.

Raff: Wow!!! [thinking again] I remember reading about some children's toys that came from China, and there was a recall of the products because they were painted with lead paint.

Riff: Righto Raffo – the government consumer product safety division had to let people know about it, and ask them to turn those toys back in for a refund.

Raff: Are there any other ways that people can get exposed to lead?

Riff: Well, until about 1995, there was lead put into gasoline, because the lead acted as a lubricant to help the engine run smoother—you know—take the knocks out of the engine. Gas pumps used to have leaded or unleaded fuels – now it is all unleaded fuels.

Raff: Interesting! But it's not like anyone ingested leaded gasoline!! How does that affect us?

Riff: There are some estimates that twice as much lead was used in leaded gasoline between 1940 and 1989 than was used in white lead pigmented paints from 1910 to 1989. And they think that seventy-five percent of that lead went into the environment and settled in soil and on buildings.

Raff: So that means that lead is really all around us…at least potentially.

Riff: Yes, and we also used to have pipes made out of lead—some of those carried drinking water. Imagine drinking water with lead in it—really bad, especially for younger children whose brains are developing. But we have tried to eliminate lead pipes. Historically, the Romans used lead pipes to carry their water. Some people wonder if their whole society wasn't affected by the lead poisoning.

Raff: Our house is kind of older. I'm going home to check our paint and pipes. How do I tell if it is lead or not?

Riff: Not too hard. First check to see if your home was built after 1986. If so, it probably didn't use lead pipes. You might see copper pipes or you might see plastic pipes in new homes because copper has become so expensive. But if it is not copper or plastic it could be made of galvanized steel. Lead pipes are a dull grey color and scratch or dent easily but steel pipes are not so soft.

Raff: How do I know if our house has lead paint?

Riff: The best way is to get some lead test strips. You can use these on the paint dust and chips. Or for your drinking water you can take a sample of water from your faucet and send it in to a lab for analysis to see if it contains any lead.

Raff: Okee dokee, Riff—good thing you read the newspaper! This is really serious stuff…and I'd hate to see me or my little brother affected by any lead in our environment!

Author - Craig Berg

Jib and Jab: Dust Mites Are Us

Jib and Jab are watching TV during the daytime and Jab looks over toward the window and the beam of light shining into the room and sees a lot of suspended dust particles floating through the air.

Jib: *(pointing and with a surprised look)* Hey jab, would you look at that?

Jab: What dude.

Jib: The beam of light shining in through the window. Look at all those dust particles floating in the air. When is the last time you vacuumed?

Jab: Yesterday.

Jib: *(looking disgusted)* Hardly – did you turn on the vacuum or just push it around with power off. Look at all that dust. It grosses me out!

Jab: You are so funny I forgot to laugh. Look, I really did vacuum yesterday, but much of dust is made up of our dead skins cells falling off our body.

Jib: Ok, stop – you're freaking me out – the stuff floating in the air is our dead skin cells?

Jab: Afraid so my fearless friend. But let me tell you something that will really freak you out. In this house, and probably your house, are thousands of little critters that feed on the dead skin cells.

Jib: Oh. My. Goodness. Jab – tell me your are making that up just to get my dander up.

Jab: Jib – "get my dander up" is a common expression and it means to get riled up about something, but the term dander actually is a word for dead skins cells.

Jib: Ok. Fine. But let's get back to the "critters." Tell me more about them.

Jab: Alright, but this is one of those things that even gives me the heebie-jeebies.

Jib: Come on dude – buck up and chuck up the info.

Jab: Alright, The little critters that live in this house by the thousands and eat dead skin cells are called "dust mites." They are quite small and you cannot see them with your eyes – it takes a microscope to see them.

Jib: Oh, in that case I'm going with the old adage "What you can't see, can't hurt you."

Jab: On the contrary my curious and conversational cowboy. Meaning, dust mites can be bad for you.

Jib: Enough Jab. Just give it up – how are they bad for me?

Jab: Ok. Dust mites are in carpets, on fabric drapes, fabric couches, bedspreads and sheets, and pillows. They thrive in warm and moist habitats, so when you are sleeping and shedding skin cells in your bed, the skin cells plus the moisture coming from your body is a perfect environment for the dust mites to survive.

Jib: What are you implying "Moisture from my body?"

Jab: No, no jib, get a grip! As we sleep our body is giving off moisture be expelling it from our lungs and sweating – there is always some moisture escaping our bodies, and that helps keep the sheets and pillow somewhat moist, although we cannot tell it, it is moist enough for the dust mites.

Jib: Look, I don't want these things crawling around on me while I am sleeping – can't I just buy some anti-dust mite spray and kill them where they lurk and snack?

Jab: Not! There isn't really any chemical way to get rid of them. But you can do a couple things to help reduce how many are in your house. For instance, if you have static electricity in your house, you probably don't have dust mites. You know when I walked across your carpet and I grabbed the channel changer out of your hand and got the tremendous shock?

Jib: Right, the batteries in that changer really zapped you!

Jab: Oh my – where do I begin. It wasn't the batteries in the channel changer that did it, it was me walking across the carpet and building up a static charge on my body, and when I touched your hand, the buildup of charges jumped to you as a static shock! Come on my bud, that is just basic science!

Jib: Yea, Ok, Ok. Just testing to see if you remember what we learned in physical science last year. But how does static electricity take care of dust mites? Does it shock them dead or what?

Jab: No – doesn't shock them. Static electricity is just a sign that your house is dry. If your house has enough moisture, you cannot form static electricity very easily. Static is just an indicator that the conditions in your house are not good for dust mites.

Jib: Ok, but if I don't have static and dry conditions what do I do?

Jab: Well my motivated friend, you can run the de-humidifier and take more moisture out of the air, something less than 50% humidity will bring the moisture content of the air to a more dryer condition that makes it more difficult for the dust mites to survive.

Jib: Alright – a big 10-4 on that one. Anything else I can do?

Jab: Probably the best thing to do for bedding is to wash your sheets and pillowcases every week, in very hot water and dry them in a hot dryer. That will kill off any dust mites that are on the bedding. But of course you might have the mattress pad to wash, and there is the mattress with the fabric cover that can hold dust mites. Another thing you can do is put your pillow into the freezer for a few hours because doing so will kill off dust mites.

Jib: Yea, right next to the popsicles. Is all that effort worth it?

Jab: Sure is if you are one of the people who are allergic to the dust mite feces that contains an allergen substance called DerP1. If you are allergic to DerP1 you might have asthmatic-like symptoms such as chronic sinus problems or eczema, which is that dry itchy skin condition.

Jib: So now I have to think about dust mite poop being on or around my body. See, sometimes I just don't want to know. If you hadn't told me about dust mites, I could just remain blissfully ignorant.

Jab: But where are you running off to?

Jib: It's too late – I can't ignore what I now know. I'm taking my pillow to the freezer Jab – and getting a popsicle – two birds with stone.

Author - Craig Berg

Insane to the Membrane!

A conversation with Zip and Zap about the movement of materials through cell membranes. Read the play with a partner then highlight the important science information.

Zip: *(finds Zap staring intently into his computer screen)* What with the puzzled look Zap?

Zap: Man o' man, I was just reading here that we have water molecules in our body traveling at more than a thousand miles per hour.

Zip: Really, you know the other day I drank a soda and had to use the bathroom a couple of seconds later.

Zap: (shaking his head) not only do water molecules travel that fast at body temperature but they also collide with other molecules at a rate of a million times a second.

Zip: That's just a couple more collisions than you had when you first got your temps.

Zap: Funny, if atoms, molecules and ions didn't travel that fast and have that many collisions then molecules wouldn't mix as easy and diffusion wouldn't occur.

Zip: Tell me more oh knowledgeable one.

Zap: You see, diffusion is a process by which molecules or ions move from an area of high concentration to an area of lower concentration. Like the diffusion of perfume when you open the bottle.

Zip: Or a fart in a crowded elevator?

Zap: Yes, unfortunately you're right. Kidney dialysis also uses diffusion to remove smaller waste molecules like urea from the blood and larger blood proteins that we need remain.

Zip: The smile on your face tells me there is more to this movement through cell membrane thing.

Zap: You're absolutely right. The cell membrane is a selective barrier which controls what goes in and out. It's really fascinating to see all of the processes for getting materials in and out of the cell. If any of these processes didn't work you would get very sick or die.

Zip: Go on Einstein.

Zap: Facilitated diffusion is a form of diffusion that uses carrier molecules to move large molecules across the membrane.

Zip: What about osmosis?

Zap: *(looking stunned)* Wow, yes osmosis is a special case of diffusion that moves water molecules from an area of high concentration to lower.

Zip: Can we ever force molecules across a membrane?

Zap: Sure it's called filtration. Blood is under pressure which forces smaller molecules into the surrounding tissue and larger molecules like blood proteins stay in the blood stream.

Zip: Isn't filtration how we make coffee?

Zap: Yes and all three of these processes move molecules from an area of high concentration to an area of low concentration.

Zip: What if molecules want to move against the concentration, like swimming upstream.

Zap: Well, amazingly enough they can also move across the membrane against the concentration.

Zip: Kinda like walking up the wrong side of the hallway?

Zap: Exactly and they both require energy. You see, active transport can move materials from an area of low concentration to high concentration but needs to burn energy to be able to pull it off. Actually, a cell may burn 40% of its energy supply to actively transport particles through the cell membrane.

Zip: That's insane!

Zap: Exactly, not only do cells burn lots of energy to move molecules or ions across their membranes but they also need special carrier molecules to do it.

Zip: My dad is a mail carrier who thinks he is special.

Zap: Ugh. Carrier molecules are in the cell membrane and help it move important molecules like sugars and amino acids that the cell needs to function across the membrane.

Zip: What if the molecule is too big?

Zap: Well, the cell will still use energy but, it can absorb the molecule or particle in a sack that it forms and pull it into the cell.

Zip: What is that called?

Zap: Endocytosis, and the cell can also secrete a substance stored in a sack in a process called exocytosis.

Zip: I get it, endocytosis for “In” the cell and exocytosis for “out” of the cell.

Zap: You know there may be hope for you yet.

Zip: You could say I’m not as diffused as I look.

Zap: Brother!

Author : Mike Mullen

Optional activity: Draw a diagram of each one of the “movement through the membrane” processes.

“Too much Caffeine!”

In this dialogue Zip and Zap are discussing how signals travel down a nerve which is called a nerve impulse.

Zip: You seem a little edgy today Zap.

Zap: Could be the 3 latte grandes.

Zip: Your neurons must be exhausted.

Zap: Yea, I imagine the caffeine is probably stimulating a few extra impulses in my central nervous system.

Zip: Wow you sounded a little sciencey there for a moment. A few extra impulses must have stimulated something in your brain. You may have stimulated some neurons into action.

Zap: Whatever, I do know that the nerve impulse travels down different types of neurons like electrical current travels through a wire.

Zip: Right you are my caffeinated friend. A nerve impulse is part electrical and part chemical. When a neuron is at rest the outside of the cell has an overall positive charge and the inside an overall negative charge.

Zap: I get the electrical part. When a person’s heart stops they use a defibulator to get it going again which is a lot of electricity. But what is the chemical part?

Zip: It has to do with the movement of ions across the neuron’s membrane. At rest the neuron’s cell membrane pumps sodium ions ($Na+$) out of the cell and potassium ions ($K+$) into the cell through sodium: potassium pumps. So the inside of the neuron contains more $K+$ and the outside more $Na+$.

Zap: I’m with you so far. I picture this long neuron with $Na+$ on the outside and $K+$ on the inside. But you said that the neuron is positive on the outside and negative on the inside. How does that happen when both of these ions have the same charge?

Zip: Maybe coffee is a good idea for you. Potassium ions can move easier across the membrane so when you lose more positive $K+$ from the inside it becomes more negative.

Zap: I get it. So positive on the outside and negative on the inside when it’s resting.

Zip: Correct. It’s called a “resting potential” although our neurons hardly ever rest. In fact impulses travel through the neurons every few milliseconds at a speed of about 200 meters per second.

Zap: Man that’s fast. I’m sure my caffeine induced impulses are hitting at least 200 m/s!

Zip: When a neuron is stimulated by caffeine or something in our environment an impulse travels down the axon from the cell body toward the axon terminals where it will cross a synapse and continue down another neuron.

Zap: But what happens to our ions during all of this excitement?

Zip: The neuron membrane contains thousands of protein channels that are generally closed. At the leading edge of the impulse sodium ion gates open and positively charged sodium ions flow into the neuron.

Zap: Won't the movement of Na+ ions change the charge inside and outside the neuron.

Zip: Wow, the caffeine has really stimulated your brain. Yes, the inside of the membrane temporarily becomes more positive than the outside. The changing of charges is called a nerve impulse or "action potential"

Zap: So far you've only talked about sodium ions, what happened to all those potassium ions?

Zip: When the action potential or nerve impulse passes potassium gates open behind the impulse and K+ flow outward which makes the nerve negative on the inside and positive on the outside again.

Zap: So behind the impulse the nerve goes back to resting potential and get's ready for another impulse to come along?

Zip: *(shaking his head)* Unbelievable. The flow of an impulse can be compared to a row of dominoes. The movement of Na+ inward pulls the impulse down the neuron like knocking over dominoes. The flow of K+ outward after the impulse is like putting them back up again.

Author: Mike Mullen

On the back of this sheet draw a diagram of a nerve impulse using 3 or 4 steps. Include both ions and label the action potential.

Zip and Zap Experience Cycles in the Biosphere

In this episode, Zip and Zap are pondering the water, carbon and nitrogen cycles that exist in the biosphere.

Zip: Hey Zap what's up with the huge drawings on the wall?

Zap: I can't seem to get these biogeochemical cycles right so decided to draw them out.

Zip: I can see why, it looks complicated.

Zap: It's not bad if you remember that energy is a one way flow but matter is recycled within and between ecosystems.

Zip: I'm not sure that really matters (giggling.)

Zap: Of course it does Bucky ball brain! These cycles have the ability to pass the same molecules around again and again in the biosphere. The breath that you just took contains thousands of oxygen molecules that could also have been used at one time by a fox that died centuries ago.

Zip: I would prefer if, that oxygen was once used by Megan Fox! *(starting to rain outside)*

Zap: *(shaking his head)* Whatever. You see elements, chemical compounds and other forms of matter are passed from one organism to another and from one part of the biosphere to another through these cycles. Like the rain falling outside.

Zip: I thought the rain came from clouds.

Zap: It does, but first it must evaporate from water or transpire from land and condense in clouds before precipitation can occur.

Zip: But, I thought you said it was a cycle. It seems like it stops there.

Zap: Not quite my water logged friend. As precipitation falls it runs along the ground until it finds a body of water or may seep into the soil and help restock our ground water. The water can be taken up again by plants and lost as transpiration or evaporate from surface waters and start the cycle again.

Zip: I get it. So the movement of water molecules in the environment can take many different forms but is basically a cycle. So we never really lose water but rather just cycle it.

Zap: I guess you were listening. That's why we call it a water cycle. But it's not the only cycle that exists in the environment.

Zip: I had a feeling this conversation wasn't over.

Zap: You're right. We also have the carbon cycle. Carbon is an important element in living tissues, your skeleton and combines with oxygen to form carbon dioxide in the atmosphere.

Zip: So my skeleton and bike frame are made of the same material?

Zap: Well yes, they both contain carbon but in different amounts. Your bike frame is also not a living material.

Zip: You obviously haven't seen me ride.

Zap: *(shaking his head)* Anyway, Carbon can be released by volcanoes or erosion of rocks. Carbon also is released into the atmosphere by: animals exhaling, mining, burning forests and coal power plants. We now know that harmful levels of carbon dioxide in the atmosphere can alter our climate and possibly lead to global warming.

Zip: I'm sure folks in Alaska may want a little global warming. If carbon can make its way into the atmosphere how does it complete a cycle?

Zap: Good question. Carbon can be taken in by plants in the water and on land. Kinda like carbon suckers.

Zip: I feel like a sucker for sitting here this long.

Zap: Land plants suck up carbon as carbon dioxide and become food for the animals which release the carbon dioxide when they exhale. Can you guess what happens to the land plants when they die, decompose and get covered by soil or water?

Zip: They no longer taste so good?

Zap: Funny….they become coal. And when we burn coal the carbon is released into the atmosphere as carbon dioxide.

Zip: That seems like a small cycle in itself.

Zap: It is and the same thing happens in water. Phytoplankton in the oceans suck up carbon dioxide during photosynthesis. They are then fed on by fish and other aquatic organisms. All of the animals in the oceans that are fed by phytoplankton exhale carbon dioxide and release the carbon into the water and atmosphere.

Zip: Sounds like a lot of cycles to me.

Zap: Your right it is. Carbon really cycles through the land, the oceans and in the atmosphere. But we think of it as one big carbon cycle because they are all related.

Zip: But the air isn't just carbon dioxide. Doesn't it have other gases in it like nitrogen?

Zap: (pointing at Zip) I know where most of the methane comes from too.

Zip: I can't help it if I like bean burritos. Nitrogen is another gas that makes up about 78% of our atmosphere and cycles through the soil and our tissues.

Zap: Like toilet paper

Zip: Not quite Einstein. Nitrogen is used to make amino acids which in turn are used to build proteins, our building blocks. Did you know that nitrogen gets released from the atmosphere during lightning storms? The rain that follows has lots of nitrogen in it.

Zap: Is that why everything looks so green after a lightning storm?

Zip: Way to go Mr. Discovery Channel. The nitrogen in rain is then taken up by producers like land plants and phytoplankton in the water. When these organisms die, decomposers return the nitrogen to the soil as ammonia. Ammonia can be released to the atmosphere or taken up again by producers.

Zap: Please continue oh great bearer of science stuff.

Zip: It's kinda funny that we have all this nitrogen in the atmosphere but few organisms can use it. We rely on bacteria in the soil to convert nitrogen gas into ammonia during nitrogen fixation.

Zap: So one bacteria in the soil does all the work?

Zip: Not really, we have other soil bacteria that convert ammonia into nitrates and nitrites that producers can quickly use. Consumers will eat the producers and reuse the nitrogen again to make their own protein.

Zap: I could see some protein right about now. Steak protein that is.

Zip: You can thank the nitrogen cycle for that steak you're about to demolish. The farm that produced that steak probably put nitrogen fertilizer and manure on their crops.

Zap: You had to say manure didn't you.

Zip: Ok fertilizer then. Bacteria in the soil convert the fertilizer to ammonia which makes the plants grow and they are eaten by cows. The cows produce waste that returns the nitrogen to the soil as ammonia again to start another cycle. Our friends the soil bacteria can convert ammonia to nitrates and nitrites which can be taken up by plants or turned into gas by denitrification.

Zap: I ate so much steak I could use some denitrification.

Zip: Not quite bovine brain. You see bacteria convert nitrates into nitrogen gas and the gas is released into the atmosphere to cycle again.

Zap: The only cycle I want to see or talk about right now is my Harley.

Author - Mike Mullen

My Oh Meiosis

Jack and Zack are siblings waiting to see their newborn brother for the first time in the hospital. As they enter the room, Zack is visibly startled by the baby's full head of curly black hair (both brothers have straight blonde hair).

Jack: Zack, you seem surprised!

Zack: *(wide-eyed)* Well, he doesn't look anything like us!

Jack: Aren't you in the beginning of your meiosis unit in your biology class?

Zack: Yes, but I haven't been paying too much attention. Isn't it the same as mitosis?

Jack: *(jokingly)* Oh little brother, you are lucky to have me and all of my profound wisdom!

Zack: *(rolls eyes)* Whatever, Jack. What does meiosis have to do with our new baby brother looking different from us anyway?

Jack: If you had been paying attention Zack you would know that meiosis is the process of cell division done by your germ cells to produce a type of cell called a gamete. **Gametes** are either sperm or eggs depending on if you are male or female. Just remember that your **somatic cells**- the cells making up most of your body- are the cells that go through mitosis and your **germ cells** go through meiosis to make eggs or sperm.

Zack: *(getting irritated)* Okay, but you still have not made your point man.

Jack: Okay, Okay. Our new brother looks different from us because meiosis is responsible for creating differences or variation among siblings. This is why not every kid from the same parents looks identical. This is quite unfortunate for you though because I am so good looking.

Zack: HA! Right. Actually this sounds a little familiar from class now. Let me get this straight: mitosis is how our body cells divide and after cytokinesis, **two** genetically identical cells are produced right?

Jack: Right on brother.

Zack: Okay, so now you are saying that meiosis is different than mitosis because it produces two different cells that end up making us look different from our siblings?

Jack: Not quite. Mitosis leaves you with two identical cells, each with 46 chromosomes, but meiosis leaves you with **four** different cells, each containing only half of the chromosomes which would be 23 chromosomes. Having two copies of each chromosome is called **diploid** and having just one copy of each chromosome is called **haploid** (which means you only have half the amount of chromosomes).

Zack: Oh yeah, I remember that a little now. This is so that when the sperm from the male and the egg from the female come together, their baby won't have 92 chromosomes and be a mutant, right?

Jack: Exactly, this allows babies to get half of their chromosomes from their mother and half from their father.

Zack: Got it. So is meiosis similar to mitosis? I remember that mitosis first goes through prophase which is where the chromosomes form, then these chromosomes line up in the center during metaphase, after that the **sister chromatids** get pulled apart in the center during anaphase. Finally telophase is when the nuclei divide and then cytokinesis occurs when the cytoplasms divide

Jack: They are very similar division processes except for a couple details. First, meiosis involves two separate cell divisions, whereas mitosis only involves one. Meiosis goes through what is called **Meiosis I** and **Meiosis II**. In mitosis, sister chromatids get separated during anaphase, but in Meiosis I, homologous chromosomes get separated instead. It is not until Meiosis II that the sister chromatids get separated.

Zack: Ok, so each of the four cells produced has a different sister chromatid from the initial homologous chromosome pair. Does this mean that each sperm cell in my body can have a different combination of genes?

Jack: *(shouts out)* Precisely! You will learn more about how that happens during this unit in Mrs. Flanigan's class. I didn't have her myself but heard all kinds of good things about her!

Zack: Ok, I can't wait!

Author - Karen Flanigan

Questions

Read the dialogue and answer the following questions

1. What type of cells in your body go through meiosis for division?

2. What type of cells in your body go through mitosis for division?

3. What are the **two** types of gametes?

4. Which type of gamete is found in males? In females?

    Males:

    Females:

5. Which type of cell division is responsible for the variation we see in humans, mitosis or meiosis?

6. How many cells are produced at the end of mitosis and meiosis?

    Mitosis:

    Meiosis:

7. How many chromosomes are found in sperm and egg cells?

8. What do the following terms mean based on the dialogue?

    Haploid:

    Diploid:

9. Why is it important that egg and sperm cells only have half of the genetic information that we see in our somatic cells?

10. Describe what happens in each phase of MITOSIS:

Prophase:

Metaphase:

Anaphase:

Telophase:

11. How many divisions are involved in Meiosis?

12. Name these divisions.

13. What gets lined up in the center of the cell and then pulled apart during mitosis? Be specific.

14. What gets lined up in the center of the cell and then pulled apart during the first division of Meiosis?

15. What gets lined up in the center of the cell and pulled apart during the second division of Meiosis?

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