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A framework for culturally responsive teaching:
Effectively implementing culturally responsive
instruction in the science classroom

E. D.

Fall 2013

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instruction in the science classroom

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Chapter 1: Introduction

Over the past decade, one of the greatest challenges facing classroom teachers has been the rapidly changing composition of student populations. In 1996, 36% of the student population consisted of students of color (Bryan & Atwater, 2002). Current demographic studies show that students of color now make up over 40% of the student population, nationally, and this number is expected to continue to grow (Suriel & Atwater, 2012). Classrooms are now populated by Asian, Black, Latino, Native American, and English language learner students while the number of teachers who come from these culturally diverse backgrounds remains less than 10% (Bryan & Atwater, 2002). The American classroom remains a place where white teachers are responsible for educating students of color.

While this is not necessarily a negative scenario, it can be problematic if teachers are unable or ill equipped to address the multicultural needs of these students in their classrooms. Unfortunately, studies have shown that most teachers *do not* feel prepared to provide instruction for these groups of students (Villegas & Lucas, 2002). At the undergraduate level, teacher preparation programs seem to minimize the incorporation of multicultural, bilingual, and urban education into their curricula. Even more concerning is the observation that educational researchers themselves seem to have placed such educational settings, particularly in the area of science, as a low priority (Jablon, 2012). What research has been conducted is rarely carried out in true urban settings with studies preferring to partner with school districts on the urban/suburban fringes that do not truly reflect urban demographics or culture.

With the National Council for Accreditation of Teacher Education calling for teachers to build classrooms that are responsive to cultural needs, there has been an increasing lens placed on meeting cultural and linguistic needs of students (Suriel & Atwater, 2012). However,

adoption of this new focus continues to be weak in the science classroom where implementing multicultural pedagogy often seems to encourage the promotion of misconceptions under the guise of recognizing “alternative ways of knowing” (Lee, 2003). In order to provide high quality and equitable science education, science teachers must find ways to bridge the disconnections between students’ cultures and science without sacrificing the integrity of the content. A potential solution to this quandary is present in the theory and pedagogy behind culturally responsive instruction.

Chapter 2: Review of Literature

The Achievement Gap

Educators and educational reformers have been seeking a means by which to close the achievement gap for decades. This gap refers to the disparity in academic performance seen primarily between black (and other minorities) and white students. A large body of research documents the academic disparities with which these students enter primary school and which remains until they reach the secondary level. Some evidence suggests that this gap in science performance continues to grow throughout students’ secondary education (Bacharach & Baumeister, 2003). In fact, it has been proposed that by the end of their secondary school career, minority students are 2-3 years behind their white peers in both general and scientific literacy (Suriel & Atwater, 2012). A further example of these academic discrepancies is illustrated by Berliner (2006) in the analysis of data from the Third International Mathematics and Sciences Study (TIMSS). When the United States data was disaggregated into African American, White, and Hispanic students, the science scores of the White students ranked in the top four countries. The Hispanic students only performed better than two of the participating countries and the

Black students performed worse than all other countries. This discrepancy in performance seems to support the accusation that racism still permeates the design of educational curricula and courses (Bryan & Atwater, 2002). The very foundation of the educational system is built on the principles of a white-centric capitalist culture that tacitly discriminates against those from different backgrounds.

At the classroom level, pedagogical decisions by teachers may also contribute to an unconscious form of discrimination, particularly in those schools that have large populations of culturally diverse students from lower socioeconomic statuses. The relationship between culture and class is complicated. While some groups will share cultural norms regardless of their SES, these class differences still reside within the culture (Lee, 2003). There is not much research looking at what these differences may look like as large scale science assessments do not disaggregate data into paired variables such as SES-by-ethnicity or subgroups within ethnicities. Despite these uncertainties, it is clear that pedagogical practices such as using inquiry-based instruction can be more challenging for students who come from different cultures. Inquiry becomes significantly more difficult for students who come from homes where asking questions, independently finding answers, and problem solving is not encouraged. Furthermore, different cultures place different emphases on respect for teacher and adult authority. While white Western culture tends to encourage argumentation and reasoning from evidence, other cultures prioritize the authority of expert knowledge sources (Lee, 2003). All students enter the science classroom with different ways of knowing the natural world and it becomes the teacher's responsibility to identify the continuities and discontinuities between the student's linguistic and cultural background and science norms. Teachers who fail to understand differences in discourse patterns and cultural principles are more likely to assume limited understanding on the part of

their students and will be less equipped to assess and instruct their students. These cultural barriers between student homes and science norms frequently go unrecognized. Teachers don't comprehend that students may not engage in questioning because it is deemed disrespectful. Students may not realize that scientific argumentation is incongruent with the emotional appeals that are often used within their cultural norms. Where Western science focuses on skepticism, critical thinking, and independent thought, many non-white cultures emphasize cooperation, consensus, communal support, and an acceptance of spiritual and supernatural explanations. These discrepancies in norms are not incompatible with science instruction. Rather, they need to be integrated into teacher practice and should serve as a starting point from which a scaffold is built to understanding of science practices and norms.

Young Learners' Attitudes Toward Science

There is the possibility, of course, that cultural differences may irreparably turn culturally diverse students off from science. It is already well-established that students from different SES enter the primary grades with substantially different levels of academic competencies. Perhaps similar disparities and competencies in science also exist between students from culturally varied backgrounds. Research on the science conceptions of elementary students is rare as some argue that children at such young ages are not developmentally capable of exhibiting such understandings (Walls, 2012). However, some researchers have sought to document the views that primary students hold of science. Walls (2012) in particular studied a group of low-income African American 3rd graders with the intent of identifying their conceptions of science and elucidating the possible contribution that cultural and SES backgrounds made in a student's

understanding of science. He also sought to investigate the self-efficacy that these students demonstrated in science.

The responses provided by these students suggested that in 3rd grade, these low income African American students had very positive and hopeful attitudes toward science. They associated science with positive characteristics including intelligence, studiousness, and happiness. In their Draw-A-Scientist test, most students projected themselves into the roles of scientists and many expressed the goal of becoming a scientist. Furthermore, when asked to articulate what science *is*, students demonstrated a degree of clarity and understanding that would seem appropriate for their developmental levels. Students identified science as a tool that humans use to learn about the world and its surroundings and consistently expressed the essentialness of experimentation. Repeated emphasis was also placed on science as a means to invent or discover novel things and phenomena (Walls, 2012). It would seem that at young ages, these children, regardless of their SES or cultural background are well equipped to thrive in science. However, one lurking dichotomy was uncovered. Even though their Draw-A-Scientist tests indicated personal identification with the role, student results on the Identify-A-Scientist test told a subtly different story. When shown pictures of scientists from different cultures, students were most likely to select a white male as “the” scientists. Furthermore, they demonstrated the greatest certainty on accompanying Likert scales that the white male was “the” scientist. Clearly, even at the primary levels, students have somehow already picked up on cues that suggest that there is something essentially “white” about science. Whether they gain this belief from home, school, media, or the cultural conflict between home/school environments remains unknown.

Conley, Pintrich, Vekiri, & Harrison (2004) further explored the differences and development in epistemological beliefs in elementary science students. In their study of 5th graders, the authors sought to investigate how epistemologies change and develop in elementary students who participate in consistent inquiry-based science. They further proposed to examine the relationships between these changes and gender, ethnicity, and socioeconomic status. Students were evaluated on 4 epistemological dimensions including: source of knowledge, certainty of knowledge, development of knowledge, and justification of claims. Ultimately, the students showed slight increases in the sophistication of their epistemological beliefs with the greatest impacts on source and certainty of knowledge. When data was disaggregated by demographics, the only factor that appeared to be correlated with the formation of epistemological beliefs was that of socioeconomic status (Although as previously noted, the relationship between SES and ethnicity is often difficult to disentangle). On average, students from lower SES had significantly less sophisticated beliefs on learning and knowledge placing heavy emphasis on external authorities and single correct answer.

The association between lower SES and lower scores in the 4 epistemological dimensions reveals a challenge for teachers in areas with large populations of low SES students. Even controlling for achievement, these students still score lower which means that even high performing students can have naïvely formed epistemological beliefs. If instruction is not provided to help to mature these beliefs, these students will continue to be at a disadvantage in science courses at the secondary and post-secondary level as more sophisticated reasoning and argumentation is required. Given the gains made by students in the fifth grade, Conley et al. (2004) suggest that by addressing these deficits early with a hands-on or inquiry-based instructional approach, lower SES students can be pushed in the direction of more sophisticated

epistemological beliefs. This needs to be addressed early before achievement becomes impacted severely enough to influence attitude, self-efficacy beliefs, and achievement in science as is commonly seen in the middle grades.

Within the educational literature, self-efficacy refers to one's ability to successfully carry out a task and looks in particular at an individual's beliefs about their abilities (Kararslan & Sungur, 2011). Those with a higher degree of self-efficacy believe in their ability to complete a task and show greater efforts and persistence even in the face of failure. Self-efficacy can be subject specific and students who believe in their own science abilities have been shown to engage with science and complete more challenging tasks. Students with low science self-efficacy are, by contrast, avoidant of such activities. There is a consistency in the literature demonstrating a connection between science achievement and student self-efficacy and it has been illustrated consistently that student self-efficacy shows a particular decline between grades 6-8. In their study of student self-efficacy in science, Kararslan & Sungur (2011) investigated the relationship between socioeconomic status and changes in self-efficacy across grade 5-8. The data confirmed the trend of declining beliefs in self-efficacy across grade levels and also revealed various correlations between self-efficacy and indicators of SES. Factors such as number of books, frequency of buying a newspaper, and income were all positively correlated with self-efficacy confirming the idea that students from lower SES brackets will show greater declines in self-efficacy and therefore are at greater risk of low achievement in science.

Teacher Contributions to Disparity

What happens from the middle elementary years to high school that causes such a shift in attitude and performance? Some researchers, at least, would argue that it is the beliefs and

attitudes of teachers themselves that contribute to this declining academic performance. Research has consistently demonstrated that a teacher's beliefs, particularly those beliefs on race, ethnicity, class, culture, and gender, have significant influences on classroom practices (Bryan & Atwater, 2002). These beliefs impact everything from lesson planning, assessment, evaluation, expectations of students, decision-making regarding students, and even interactions with students.

One belief commonly held by teachers, either directly or subconsciously, is the assumption that students from culturally diverse backgrounds are less capable than other students (Bryan & Atwater, 2002). This leads to teachers constructing simpler goals, giving students less autonomy, and providing fewer opportunities for peer interactions in learning. Further studies suggest that these practices are supported by beliefs that student motivation is lacking and that these students lack internal control. To compensate for this, teachers feel that the need to maintain tighter control on their classrooms. In fact, some teachers even hold on to a belief that for students of color and lower SES, failure is inevitable.

Many other misconceptions surrounding teacher beliefs towards students of color, low SES, and other cultures have been identified. For example, some teachers believe that there are external factors (home life, parental involvement, family stability, community dynamic) that cannot be overcome by teaching. In particular, there is a gross misconception that parents of these children do not want to be involved in their children's education (Bryan & Atwater, 2002). This belief does not take into account different cultural expectations surrounding roles and responsibilities in education. Many traditional cultures maintain that education is an area reserved for the teacher-expert instead of parents. Nor does it acknowledge the reality that many parents of students from different cultural backgrounds are intimidated and confused by many of

the forms of communication and practices that are used in education. Clearly, lack of cultural understanding on the part of teachers perpetuates this misunderstanding.

Students exhibiting cultural “otherness” also receive different forms of attention from teachers. While white students receive reinforcement and praise for academic performance, “Other” students receive more reinforcement for behavior (Bryan & Atwater, 2002).

Furthermore, black males receive fewer interactions than their white counterparts with their teachers and the praise that they do receive is 4-10 times more likely to be qualified. The academic achievement of these students is generally attributed to external factors while the academic success of white students is attributed to their own effort and motivation. Most concerning, though, is the teacher belief that culturally diverse students *are* simply less capable academically (Bryan & Atwater, 2002). Even when these students perform on par with their white and higher SES peers, teachers still perceive them as being less able. Harboring this belief leads teachers to implement a less rigorous curriculum and a more authoritarian management style which ultimately yields a more negative classroom environment.

Whether teachers hold to these beliefs consciously or unconsciously is almost a moot point, though if the former is the case it perhaps raises concerns about an individual’s fitness for teaching in culturally diverse schools. Bryan & Atwater (2002), propose that these beliefs are first rooted in hearsay but then are incorrectly confirmed by teacher observations of student behavior that result from an “absence of synchronization” between the teacher’s cultural background and that of the student. There remains an intense need for research in this area regarding teacher beliefs of culturally diverse students as well as a need for exploration and elucidation of an individual’s beliefs at the teacher training level. Many pre-service teachers enter into their undergraduate degrees with beliefs and attitudes that have already been shaped

during their childhood (Bryan & Atwater, 2002). Without exploring and articulating these beliefs, teachers may continue in ignorance of their own preconceptions and how these preconceptions impact their practice.

One such belief is a “dysconscious racism”, or purposefully overlooking racial differences (Bryan & Atwater, 2002). This is not meant as a harmful attitude, but in the setting of education, it communicates its own disparity: that some students are privileged and some students are disadvantaged and need to have that portion of their persona ignored. This belief most likely stems from the United States’ emphasis on equality and the incorrect equating of equality with sameness. However, in order to be truly equal, it is necessary to understand how to respond equitably to student differences. Failure to see student differences communicates that there is something negative about their background and heritage. The implied message to the student is that they need to hide who they are.

Some teachers do make the effort to bridge the asynchrony that divides them from their student populations. A number of studies have examined the preparation of teachers to teach Asian, Black, Latino, Native American, and English language learner students (Atwater, et al., 2010). These studies have largely demonstrated wide ranges in teachers’ experiences based on social class backgrounds and social classes of their students. Differences in these backgrounds lead to perceived differences in attitudes, lifestyle, and social networking which can impact instruction and interaction with students. Unsurprisingly, teachers with similar backgrounds to their students were more likely to understand those students whereas those from disparate backgrounds tended to experience tension and communication barriers with the “Others”.

Although some teacher preparation programs have attempted to develop coursework to promote multicultural science teachers, most continue to exhibit 3 primary problems: lack of

teacher understanding about students' home-life and communities, failure to make teachers aware of their own beliefs and prejudices, and failure to provide teachers with the understandings and skills necessary to create effective multicultural instruction (Bryan & Atwater, 2002). In a study of instructional practices of provisionally certified teachers completing an alternative certification program, participants were surveyed regarding their conceptions of multicultural education and how they practiced culturally responsive instruction in their classrooms (Atwater et al., 2010). In analyzing in depth interviews with two of the participants, it was revealed that neither participant had a concrete understanding of what multicultural education meant or looked like. While both expressed the desire to implement culturally responsive instruction, they lacked guidance and exemplar models for their practice and therefore largely failed to tailor their instruction to cultural backgrounds. One of the participants even seemed to lack an understanding of the connections between race, ethnicity, and academic performance.

Bridging the Achievement Gap: Culturally Responsive Instruction

Contributing to the deficit in multicultural education and culturally responsive teaching is a misinterpretation of what such practice entails. Multicultural education goes beyond simply trying to teach tolerance and instead promotes the idea that education should be equitable for all students. According to Suriel & Atwater (2010), defining characteristics include: antiracist orientations, opposition to social inequality, and opposition to the power structures dispersed through education. One concrete and practical tool that teachers can make use of to evaluate their level of multicultural practice is the four-level assessment proposed by Banks which identified progressive levels of sophistication in multicultural education integration (Suriel & Atwater, 2012). Level 1 is the "Contributions Approach" which seeks to highlight holidays,

important figures, foods, and other cultural customs that are periodically celebrated. The “Additive Approach” entails adding similar kinds of information into lessons and curricula without changing the content. The third level is the “Transformative Approach” which begins to shift the curricula to include and validate other cultural perspectives by giving students the opportunity to explore content, themes, and issues from other perspectives. The final level is the “Action Approach” which emphasizes decision-making as related to personal, social, and political problems. It is at this 4th level that multicultural education begins to reach the ideal of pursuing social justice for which Atwater et al. also advocate. Unfortunately, in studies examining teacher practice according to Banks’ typologies, the majority of teachers implemented lessons that only reached level 1 or 2 suggesting a continued confusion on how to achieve these higher levels of cultural integration and relevance (Suriel & Atwater, 2012). Intriguingly, those who were able to reach the upper tiers of Banks’ typologies were not those with greater education or similar cultural backgrounds, but rather were individuals who, at one point, had possessed the experience of being the “Other”.

Throughout the literature, culturally responsive teaching is characterized by a number of different principles. Villegas and Lucas (2002) argue that teachers need to comprehensively infuse their curriculum with six elements to effectively implement culturally responsive teaching including: sociocultural consciousness, affirming views of students from diverse backgrounds, viewing themselves as agents of change, understanding how learners construct knowledge, knowing about lives of students, and using knowledge to design instruction around prior knowledge.

A common thread across much of the literature on multicultural education has been the need for an understanding of their own sociocultural identities. Villegas and Lucas (2002) take

this one step farther and argue that teacher's must understand that patterns of thought, behavior, and being are in fact influenced by culture and one's position in the social order. They further contend that teachers must understand how different social positions are entwined with differential access to power and that, to a large degree, schools have been used to sustain these power divisions. Americans are socialized to believe in the power of education and subscribe to the belief that it is a meritorious system. Those who work harder and have greater gifts will achieve more and will ultimately earn a higher status coupled with greater power access. This logic is imbued with the concept of who "deserves" more and who "deserves" less. Unfortunately, many of the structures, practices, and expectations used by schools are actually designed (consciously or not) in favor of the richer, white, male segments of society (Villegas & Lucas, 2002). Without these understandings, teachers will most likely not value the need to embrace culturally responsive instructional practices.

Teacher attitudes towards students from different backgrounds has already been discussed with in-depth detail and Villegas and Lucas (2002) largely reiterate what has already been put forward. Teachers need to provide acknowledgment and respect for students' different cultural beliefs and behaviors while also educating them in mainstream norms. The teacher's philosophy should be to *add* to student experience and not to replace them. Such affirming attitudes should be coupled with high expectations, rigorous curricula, and the implementation of self-monitoring strategies for students to manage their own learning. Such tacit practices communicate the belief that all students are capable of high achievement.

Villegas & Lucas (2002) also echo Atwater et al. in arguing that culturally responsive instruction must be coupled with social justice. In the case of Villegas & Lucas, however, they articulate this stance in the context of school structures and change rather than in the community.

Teachers who understand the connection between education and societal change but who also recognize the dominance given to thinking, talking, and behaving like the dominant social group are morally obligated to work to change these structures. Despite all of the barriers facing them, teachers have to maintain the ability to honestly critique these structures while also sustaining efforts and hope towards transitioning away from such inequities. This particular attribute of culturally responsive education seems particularly daunting, and therefore important, in light of recent national trends towards centralized standards- the Common Core- and increased standardized testing.

The latter 3 elements (adoption of constructivist learning theories, knowing about lives of students, and using knowledge of students to inform instructional choices) of culturally responsive instruction articulated by Villegas & Lucas are all tightly connected. The necessity of constructivist learning views should be no surprise to science educators and, in fact, should be one congruency that makes a transition to multicultural education easier. Adopting constructivist views demands that we acknowledge the value and foundation in our students' personal and cultural experiences with respect to their learning (Villegas & Lucas, 2002). The unique models, frameworks, and schemata that emerge from these different cultural contexts demands that teachers use their own cultural knowledge to help students bridge their current knowledge to the new academic knowledge. In order to do this effectively, teachers must get to know as much about their students' home lives, traditions, and communities as possible. Given the variety of backgrounds, students will reach different understandings of content at different rates (38 & Lucas, 2002). While this requires teachers to continuously plan and monitor student growth, it also provides an opportunity for student sharing of different perspectives which helps to validate individual backgrounds. A constructivist approach also naturally pushes students to greater

critical thinking and more rigorous learning experiences. By carefully selecting instructional practices that are compatible with student backgrounds and that help them build from their own prior experiences, science content can be made more readily accessible to those from culturally diverse backgrounds.

By comparison, Gay (2002) has identified 5 elements that she considers to be the foundation of culturally responsive education. Like Villegas & Lucas (2002), Gay highlights the importance of having knowledge of cultural diversity and selecting instructional practices based in the context of a student's ethnic group. She also notes the need for developing a multicultural curriculum, instituting supportive learning communities, and communication.

Common sense dictates that good teachers must have mastery of content and skills and Gay (2002) extends this requirement for knowledge to include knowledge of our student populations. Understanding of cultural values such as the emphasis on communal living, cooperative problem solving, adult-child interactions, and gender roles impacts students' motivation and ability to be successful in the classroom. In addition to knowledge of cultural social interactions, teachers must be knowledgeable about "cultural particularities", achievements, and contributions to their content area.

When it comes to designing culturally relevant curricula, Gay (2002), concedes that teachers only have a certain amount of influence given that they must adhere to the formal curricula posed by their respective states and districts. However, teachers are charged with the responsibility of analyzing, assessing, and modifying these curricula. In particular, teachers should be primed to look for omissions of topics such as coverage of racism, historical brutalities, powerlessness, and other controversial topics. Teachers are also directed to assess the curricula for overemphasis on other topics including: highlighting only a few high-profile

individuals from other races, only including African American examples to compensate for lack of diversity, and placing too much focus on factual knowledge instead of values, attitudes, and experiences (Gay, 2002). Gay also pushes teachers to evaluate their symbolic curriculum (posters, bulletin boards, etc.) for ethnic diversity and to pull in societal curriculum (media) for critical analysis on presentation of ethnic groups and how such presentations impact those groups and perceptions of those groups.

When Gay discusses the need to build supportive and caring learning communities, she intends something very different from warmth and safety. This meaning of caring is one in which the teacher maintains the highest of expectations for students while using knowledge of ethnic differences to culturally scaffold instruction so students can meet expectations while still valuing their backgrounds (Gay, 2002). Giving classrooms and groups of students the identity of learning communities is also more reflective of many of the cultural backgrounds that students bring with them. Many students come from environments where the welfare of the group is of greater importance than the welfare of any individual. This type of thinking is radically different from typical school and classroom structures and promotes integrating learning about academic knowledge with personal, moral, social, cultural, and political skills in the context of these learning communities.

Awareness of how different cultures communicate is another key piece of training that teachers need in order to effectively communicate and teach diverse students. Intellectual thought is in fact culturally encoded and shaped in the way a culture communicates (Gay, 2002). Different cultures place different emphases on context, logic and rhythm, vocabulary usage, intonation, and body movements, among other characteristics. It is these other discourse features that are often more difficult for teachers to recognize and understand. Embedded in this

understanding of communication is also the recognition of and adaptation to different protocols of participation. This is a particular stumbling block for many teachers as traditional school structures follow a passive-receptive style of communication while many groups of other ethnicities use an active-participatory role (Gay, 2002). Similarly, the ways in which ethnicities organize their thinking in words also differs. Schools demand that students employ a topic centered approach to writing and discussion which is direct, linear, and focused while many students come from backgrounds that use a topic-chaining communication style. One of the skills that teachers need to have and need to instill in their students is the ability to code-shift in different settings and to move back and forth between these communication styles.

Gay's final principle for delivering culturally responsive instruction is really very similar to the final three elements provided by Villegas & Lucas. Referring to it as "Cultural Congruency" in classroom instruction, Gay is really articulating that teachers need to pair their cultural understandings with pedagogical approaches that are compatible with student backgrounds (2002). Cultural understandings should also inform modifications and scaffolding of other instructional approaches to make them accessible to students whose cultural backgrounds have not prepared them for more traditional school structures.

While all of these interpretations of culturally responsive teaching are valuable, they focus primarily on school structures and teacher attitudes and beliefs. They do little to concretely identify *how* to implement culturally responsive practices in the classroom. Perhaps the only individual to have attempted defining the pedagogy of culturally responsive instruction is Sharroky Hollie. Hollie identifies four pedagogical areas that teachers need to focus on in order to create a culturally responsive classroom: classroom management, academic literacy, academic vocabulary, academic language, and learning environment (2012). His primary focus is on

recognizing that nonstandard languages implement cogent and valuable linguistic forms. Instead of denigrating the linguistic forms that a student uses at home and in the community, they must be given opportunities to communicate this way in the classroom and must be explicitly taught how to switch from this home language to the academic language that is expected of them. To that end, students need explicit practice in identifying which linguistic form is appropriate (situational appropriateness) and in transitioning between home and academic language (code switching). Furthermore, students need explicit connections between academic vocabulary and their home vocabulary. Hollie also argues that students need access to texts that validate their home culture, but they also need strategies to engage with and connect to texts that are not congruent with their home culture (2012).

In addition to this concept of situational appropriateness in linguistic behavior, Hollie explores the idea of culturally inappropriate behavior. Different cultures have different norms for behavior. While these cultural norms are not right or wrong, they may be inappropriate in different contexts (Hollie, 2012). Teachers of students from culturally diverse backgrounds need to be knowledgeable about their student's cultures so that they can discern between culturally inappropriate behaviors, and behaviors that are wrong. For example, students shouting out answers in class instead of waiting to be called on are often reprimanded or disciplined for being disruptive. However, many of these students come from cultures where a call and response discourse style is entirely accepted. The student's behavior is not wrong, it is simply being applied in the wrong setting. Much like students must be taught how to recognize and use situationally appropriate language, they must also be taught to recognize and use situationally appropriate behaviors (Hollie, 2012)

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Teaching Through Analogies

Analogies can be a particularly effective tool for engaging culturally diverse students and propelling them towards a deep understanding of science concepts. Research over the past several decades has shifted scientists' and educators' understanding of how the human brain is best able to learn. Instead of trying to exercise memory skills and commit factual information to memory, learners need to be able to relate what they are learning to what they already know. By establishing meaningful relationships and structure between concepts, students are able to reduce memory load and retain more content within a large organizational framework which also leads them, theoretically, to a richer understanding of the material. Such an approach to instruction also promotes the development of flexibility in thinking, problem-solving, and critical thinking skills (BaJaoude & Tamim, 2008). Generative learning strategies, which include analogies along with summarizing and answering questions, are those which force students to engage in exactly this own shaping of understanding based on prior knowledge and experiences. While the latter two strategies tend to be more familiar to students, they do not provide the culturally responsive potential of analogies.

Analogies serve as a bridge between old and new information. They hook students' interest, provide a visual structure, reveal misunderstandings, and force students to revise their conceptual understandings (BaJaoude & Tamim, 2008). Analogies are particularly important in science instruction as they have historically been instrumental in leading to developments and progression in scientific thinking and understanding of the world (Brawn & Salter, 2010). They function as both an instructional and scientific tool. For minority students who demonstrate deficits in scientific literacy, it is imperative that they receive exposure to this form of scientific reasoning so that they can become familiar and comfortable with it. As BouJaoude and Tamim

(2008) discovered in their study on generative learning strategies, students preferred answering questions over using analogies and saw greater value and application in the use of questions and summaries. Those students who preferred the use of analogies largely held that opinion because they were fun. While this points to the potential for analogies to engage students with content, it also reinforces the reality that students prefer those strategies that are familiar to them because they can be used with greater ease. Students from culturally diverse backgrounds in particular tend to disengage more readily when a task is unfamiliar or challenging, especially if this arises due to conflicting cultural boundaries or linguistic differences. Therefore it is essential that analogies be used often to ensure student comfort with the strategy and to foster an understanding of its value.

Of course, this frequent implementation must be done skillfully and with full understanding of the potential that analogies have for fostering misconceptions. In its most basic conception, an analogy is a form of similarity. One popular form of analogy derives from structure mapping theory (Brown & Salter, 2010). This theory states that analogies involve the mapping of knowledge from a known domain (source) to an unknown domain (target). The base has attributes that are linked by relations which are also true of the target and it is the consistency of these relations, not the attributes, which makes a strong analogy. At its optimum, the base and domain should have a large number of shared relations and a small number of shared attributes. The reason for this is that the more attributes that are shared between the base and domain, the more similar these objects are in reality to the point of being identical objects. The challenge in using analogies occurs because, from the stand-point of constructivist theories, analogies can only be used successfully if an individual already has an understanding of both the source and the target (Niebert et al. 2012). A teacher's rationale for using an analogy is generally to use the

known to discover the unknown. Naivety on the part of the students can mean that their personal experiences with both source and target can lead to a substantially different understanding of the analogy as they search for similarities. This can be especially true of students with diverse cultural backgrounds as the examples and experiences that a teacher selects to use as the source can be foreign or carry a completely different connotation in their cultural experience. However, this power of connotation is also where the power of analogy lies for these same students. If a teacher is well-versed in their students' culture(s), they should be able to select appropriate source domains that will make a concept accessible to those students and enhance their understanding. Just as powerful is the practice of encouraging students to develop their own analogies drawing on their own personal experiences. Such student-generated analogies not only reveal understanding and misconception but can also be used to illustrate the similarities and nuances between cultures while also validating a student's heritage.

The subjectivity of personal experience and understanding of language does pose a challenge to the effective use of analogies in a culturally diverse classroom. However, this difficulty is not dissimilar from the challenge that would be found in any classroom as every individual constructs meaning based on their own prior knowledge and individual experience (Niebert et al, 2012). Is it even possible to generate and use universal foundational knowledge? A partial answer can be found in the theory of experientialism (a synthesis of research from linguistics, neurobiology, philosophy, and science education). Experientialism argues that abstract concepts are commonly understood within domains of knowledge that result from physical/social, or "embodied", experiences. These include basic relational concepts such as verticality, front/back, inside/outside, container, etc, which are structured into schemata which become the structure by which all other concepts are understood. While many science concepts

are not based on directly embodied experiences, teachers have the responsibility of finding models and imaginative thinking that can be used to help students experience a concept as directly as possible.

Not only do educators need to teach students *about* analogy, they need to make sure that they are using good analogies, and they need to explain the structure and limits of analogies (Brown & Salter, 2010). Effective analogies, especially for non-white students, must provide – to the greatest extent possible- culturally relevant embodied source and target domains. Multiple exposures to analogy and different analogies are needed to build familiarity and appreciation for the nuances in each. Furthermore, the teacher has the responsibility of guiding students in an explication and assessment of an analogy’s strengths and weaknesses. By consciously building this into their practice, educators will provide concrete and relevant experiences that students can use to bridge their background knowledge to a deep and lasting understanding of science concepts. The use of analogies must be explicit. Through the careful selection of universal or culturally appropriate source domains, teachers can help move their minority students into a greater understanding of science content while also challenging them to evaluate the strengths and weaknesses of these analogies thereby provoking students to deeper and more authentic scientific reasoning.

Explicating the Nature of Science

Current understandings and acceptances about the nature of science (NOS) are not entirely universal. However, the bulk of research surrounding this subject reveals 7 tenets that have become widely accepted. These include the understandings that: scientific knowledge is tentative, science is rooted in empiricism, science is subjective, science makes use of creativity,

it is socially and culturally shaped, there is a distinction between observation and inference, and laws and theories represent different kinds of knowledge (Sevim & Pekbay, 2012).

Instructing students in the nature of science has been a goal of American education since the 1920s (Karakas, 2011). However, in recent years, there has been an increased push for emphasis on NOS in the classroom as an essential component of scientific literacy. In fact, it has now been identified as one of the foremost objectives of science educators. There are numerous reasons to initiate NOS instruction at the primary and secondary levels of education. Having adequate NOS conceptions supports and enriches science teaching while also enhancing the learning of students (Wan et al., 2011). This seems to be particularly true for minority students who do come from cultures that value different ways of knowing. For students whose cultural backgrounds emphasize communal learning or valuing authority, the culture of the science community can seem foreign and potentially confrontational. Without developing an understanding of the rules guiding knowledge development, these students may simply view science as an adversary that cannot be understood or challenged and therefore are more likely to disengage from and avoid the content. By making the rules and principles of science explicit to these students, they become able to understand the process and have a greater likelihood of reconciling their own cultural beliefs with the “beliefs” and attitudes of the scientific community (Karakas, 2011). Understanding the nature of science is also essential beyond the walls of the classroom. Adequate NOS conceptions allow individuals to make sense of socio-scientific issues and enables them to participate in intelligent discussion and informed decision-making. Perhaps most importantly for students from culturally diverse backgrounds, understanding NOS *does* help them understand the role and relationships between their own cultures and science and it provides a lens by which others can appreciate these varied cultural-scientific relationships.

There are 3 general approaches to developing NOS in the classroom: the historical approach, the implicit approach, and the explicit-reflective approach (Sevim & Pekbay, 2012). In American education, the former two strategies have been used with minimal success. The historical approach assumes that by exposing students to the historical progression of scientific development, they will simply intuit and develop correct NOS conceptions from the provided examples. Similarly, the implicit approach incorrectly suggests that students can simply absorb NOS principles by participating in science practices and inquiry. These approaches achieve minimal change in student understandings and may in fact leave minority students even more confused. Current research suggests that in order to improve NOS development, lessons and activities must be explicitly structured for the construction of adequate NOS perceptions. In their study of pre-service teachers, Sevim & Pekbay (2012) assessed the impact of a course committed to developing the nature of science in pre-service teachers. Over this 3 month period of participating in explicit NOS developing activities with facilitated discussion and reflections, participants showed significant (albeit uneven) growth in all NOS tenets assessed.

Intriguingly, research has consistently demonstrated that teachers, professors, and scientists themselves exhibit variable understandings of NOS. In his study of undergraduate science professors, Karakas (2011) showed that these practitioners of science had their own nuanced opinions on the relationship between laws and theories as well as a limited recognition of the relationship/influences between society and culture on scientific thinking. This failure of the scientific community to appreciate the ties between culture and science is predictable and highlights one of the particular challenges of making science instruction culturally responsive. Most scientists, and presumably science teachers by extension, are not coded to think this way. Yet this blind spot does not appear to be exclusive to scientists of the Western world. While the

NOS tenets promoted in the literature do tend to be largely Western in origin, studies of scientists and science education in other cultures has revealed compatible beliefs. In a study of Chinese educators, science teachers iterated their belief that science instruction was too knowledge loaded and needed to integrate more explicit NOS development to enrich the content, increase student interest in science, and help confront pseudo-sciences which hold a greater prestige and role in Chinese culture (Wan et al., 2011).

Unfortunately, many science educators are in fact entirely unaware of NOS tenets. Studies of pre-service teachers have illustrated that soon-to-be science teachers hold NOS conceptions that are largely inadequate especially in the areas of the tentative and subjective elements of scientific knowledge as well as the role that social and cultural influences can play in shaping scientific knowledge (Sevim & Pekbay, 2012). This is a disservice to all students but particularly to those who enter the science classroom with culturally dissimilar values and attitudes. In order to overcome these deficits and produce students *and* teachers who have fully formed NOS understandings, education must change its approach to addressing NOS understandings. Instead of relying on the absorption of NOS principles indirectly through studying the historical development of scientific ideas or through participation in inquiry activities and science processes, teachers need to specifically plan lessons and activities that shape students' understanding of NOS. In particular, they need experiences that help them confront the reality that science knowledge is subject to change when presented with new evidence, the role of background knowledge in the shaping of conclusions, and the creativity needed for finding patterns in data or developing models (Sevim & Pekbay, 2012). Many inquiry activities that are currently used are readily adaptable to this purpose. The key, however, is for the teacher to be able to directly connect the thinking and processes that occur in these activities

with NOS principles and to compare these processes with those used in non-scientific reasoning and thinking.

The noted disparity in actual scientists' NOS perceptions does call for a word of caution. As Karakas (2011) suggests, it is possible that an individual's NOS views may be shaped to some degree by their respective scientific discipline. This suggests that NOS principles should not be approached and taught as dogmatic rules. The general recommendations are not to teach NOS as a set of rules that must be adhered to but rather to be approached through experiences and activities that force students to confront their perceptions of science and wrestle with how such knowledge is constructed. This approach provides authentic engagement in scientific reasoning and develops the flexibility and ability needed to critique others' and one's own reasoning. These are soft principles that provide a lens for understanding how and why science operates.

Concerns and Considerations for Implementation

In recent years, the United States has begun to take a more centralized approach to education, most notably with the adoption of the Common Core State Standards. Unfortunately, along with the adoption of these standards, there has been an increased emphasis on assessment of students and evaluation of teachers based on student performance. While the push to increase teacher accountability has merit, it also poses a challenge for those who do wish to implement culturally responsive instruction in their classrooms. With such intense pressure to reach achievement goals on testing, many teachers may feel pressured to adopt a more transmissive style of teaching in order to ensure that students reach appropriate testing outcomes. While this approach is detrimental for all students, it does particular harm to minority students and those

from culturally diverse backgrounds, thus perpetuating the academic achievement gap. Those teachers who wish to implement culturally responsive instruction may find themselves losing the autonomy and flexibility in curricular decisions that is needed to integrate different perspectives and cultural contexts into content areas. The substantive amounts of time that need to be put towards cultural integration, discussion, and reconciliation through analogies and exploring the nature of science may well be displaced by test preparation driven by the need to earn higher scores.

This scenario presents an interesting conundrum as the United States is not the only country trying to undergo educational reform. Like the United States, the Chinese government has been looking to implement new educational strategies to prepare their students for careers in the global economy (Wan et al., 2011). China has looked to the United States' past successes with science instruction as the inspiration for their future changes. In particular, Chinese science educators have been advocating for movement away from the transmissive, knowledge-loaded style that has historically characterized their education system. Unlike the United States, however, China seems to have a greater awareness of how historical, political, and social elements have shaped their educational structure and is making a concerted effort to reconcile their cultural values with necessary transitions in education. The United States, on the other hand, continues to disregard the failure of its mass production mindset towards education that continues to discriminate against different cultures and socioeconomic statuses (Suriel & Atwater, 2012).

It is also important to note that, while the theoretical constructs supporting culturally responsive instruction are substantial, there is little quantitative data or evidence validating the theory (Atwater et al., 2010). The science classroom in particular has been neglected when

considering the utility of such methods (Suriel & Atwater, 2012). In instances where studies have been conducted in science classrooms, the samples have generally been so small as to lack any reliable generalizability. With such minimal hard evidence supporting these practices, teachers who wish to implement culturally responsive instruction must do so with a deep understanding of the relevant principles and careful planning of instruction lest haphazard implementation discredit its value.

Chapter Three: Final project with 20 culturally responsive lessons

Narrative: Significance of Project

For the past 40 years, the phrase “culturally responsive teaching” has been bandied about the world of education. It has been described under at least half a dozen different names (Gay, 2000) and for many teachers it is used as a derisive term for fads in urban education reform. This attitude is largely attributable to the vague implementation of culturally responsive teaching (CRT) in school districts trying to address the needs of diverse student populations, mediate race relations, and close (or at least narrow) the ever-present achievement gap. Few researchers have attempted to concretely articulate the classroom practices that characterize CRT and its application to the science classroom has been particularly absent from the literature.

Given the low achievement of culturally diverse students in science, however, it is evident that educators must determine how to turn CRT into a reality. In urban centers in particular, students enter the classroom at young ages enthusiastic and eager to engage in science. By the time these same students reach middle school, this sense of curiosity and wonder has been extinguished. Science has become drudgery for them. It requires “doing too much”. Only those who are motivated to “pass the test” or who are able to keep their eyes on the long-term goal of graduation seem to display any desire to participate.

The goal of this project is to identify the core elements of CRT and to articulate a concrete framework for implementing culturally responsive teaching practices within the science classroom. By implementing this framework, teachers will be able to keep students enthusiastic about science by having them engage with content through practices that are culturally

compatible and by viewing content through a lens that is both relevant and compatible with their cultural identities.

A Comprehensive Framework for Culturally Responsive Teaching

In examining the body of literature on CRT, it becomes evident that CRT has applications for education at, at least, four different levels: external structures (federal and state governments), school structures, teacher knowledge and attitudes, and classroom practices (Jablon, 2012; Gay, 2002; Villegas & Lucas, 2002; Hollie, 2012). The external structures consist of elements that are largely out of the control of teachers including content standards and high stakes assessment practices. At this time, most would argue that these structures are largely incompatible with culturally responsive practices and changing them will take concerted efforts on the parts of all impacted constituencies: politicians, educators, parents, and students. Similarly, school structures, as identified by Jablon (2012), also tend to be largely outside the control of teachers. In some instances, schools have enough autonomy to make these changes, but too often these structures are dictated by the school district or the administrator.

Teacher knowledge and attitudes are largely those elements that have been continuously identified by proponents of CRT (figure 1). By adopting these attitudes and broadening knowledge in these areas, teachers equip themselves with the tools that they need to be effective culturally responsive teachers (Gay, 2002; Villegas & Lucas, 2002).

It is at the level of classroom practices, however, that CRT becomes most meaningful and can have a significant positive impact on student attitudes toward education and their overall achievement. In the classroom, there are six primary areas that can be modified to be culturally responsive: curriculum, management, academic language, literacy, conceptual frameworks, and learning environment. A summary of the core aspects of these elements can be found in table 1.

Curriculum

At the level of curriculum, teachers may not have excessive freedom to choose their content. However, teachers can still work within the bounds of state proscribed standards to examine issues of social justice, social inequity, and the role of power structures (Suriel & Atwater, 2012; Villegas & Lucas, 2002). These themes have deep roots in African American culture and are relevant to most minority cultures as they experience these realities throughout their lives. Many traditional cultures also place a much greater focus on the place of family and community in an individual's life. Finding ways to bring classroom content back to the community and the family can serve as a way to engage students' interests. Finally, all good teachers should work to find connections between the content they are teaching and their students' personal interests.

Management

The traditional Western model for classroom management requires specific cultural expectations. It focuses on individual learning, competition between students, and too often still subscribes to the model of students seated quietly and raising their hands to provide the correct answer to a question. The reality, however, is that every culture has different behavioral expectations (Gay, 2002; Hollie, 2012; Villegas & Lucas, 2002). For those students who struggle in the traditional structure of the Western classroom, their cultural expectations are often wildly different. African American and Latino students in particular tend to come from cultures that focus on communal learning. Building of knowledge is done in collaboration with others and should have the purpose of serving the group as a whole, not the individual. Furthermore, these cultures have different discourse styles and rich oral traditions as well as heritages that focus on rhythm and movement.

Teachers of these students must be aware of these cultural differences and strengths. They must build opportunities into the classroom for students to answer questions and carry out discussions while teaching situational appropriateness for behavior. Students need explicit protocols to tell them when it is okay to yell out an answer and when they must wait to be called on. They further need protocols to help them discern when learning can occur through noise group discussion and when they need to listen to others. Furthermore, teachers need to acknowledge students' heritages in rhythm and movement by building them into the classroom. Auditory attention signals can be used both to latch onto this sensitivity to rhythm while also helping to smooth transitions and introduce new protocols with attached behavioral expectations. Movement should be incorporated authentically to work in concert with learning (and not just to have students move for the sake of moving).

Academic Language

The classroom should be a safe space for students to communicate in their home language with their peers and, when appropriate, with the teacher. However, it is the teacher's role to help students learn that there is an academic language with which they must also be familiar (Hollie, 2012). The teacher must provide opportunities for students to learn the vocabulary and norms of that academic language and must help students translate their home language into that academic language. Opportunities must be provided for students to communicate about content in both linguistic forms and explicit bridging must occur between the two. This need to practice discerning situational appropriateness and code switching maintains the validity of their home language while giving them the skills to be academically successful.

Literacy

Texts that are used in the classroom (both fiction and nonfiction) often present Western characters and Western perspectives or experiences that are far removed from students. Teachers must find ways of integrating texts that provide experiences and characters that are relevant to students to help engage their interest and affirm their cultural heritages (Hollie, 2012). Furthermore, students may need explicit strategies to help them engage with text. This can be done by drawing on the oral storytelling heritages of many cultures.

Conceptual Frameworks

Designing responsive conceptual frameworks for the classroom has two main aspects. The first simply requires solid foundations in constructivism and understanding how students create knowledge. Teachers need to be aware of students' prior knowledge and preconceptions and they must provide appropriate experiences to either activate this knowledge, challenge it, or fill in gaps in experiences (Villegas & Lucas, 2002; Brown & Salter, 2010; Niebert et al. 2012). Activities and instruction must be structured to bridge students from their starting point to the desired end point. Whenever possible, hands-on experiences are preferable because they provide concrete objects and experiences from which students can build. For culturally diverse students, these hands-on opportunities also provide authentic opportunities for movement and therefore activate a cultural strength.

The second aspect to designing responsive conceptual frameworks lies in understanding how different cultures approach learning and building knowledge. As previously noted, while Western education often focuses on individual learning, many cultures place greater value on communal learning. If the whole group does not achieve the desired level of learning, then the whole group has failed (Hollie, 2013). The role of the teacher is often analogous to the role of the elder (Lee, 2003). While this makes the teacher a source of knowledge and expertise, this

expertise is only sought when the group itself cannot come to a consensus. This type of cultural focus requires a classroom that focuses heavily on group learning. This means not simply working in groups but also ensuring that all members are attaining mastery of the content.

Learning Environment

The classroom should be a space that is welcoming to all students. It is their home away from home and for many students it is the only safe space that they know. To this end, the learning environment should be reflective of the students who occupy it. Student work should be displayed (Hollie, 2012). The space itself should be flexibly arranged to meet student needs and should be accommodating to group work and movement. Multicultural libraries should be available and should be reflective of student heritages and interests. Furthermore, the room should display bulletin boards that are culturally relevant (showing the faces and cultures of the students in the room and how people from those cultures have contributed to or are impacted by the content area) and cultural aesthetics should be reflected (Gay, 2012; Hollie, 2012).

Table 1. Framework for culturally responsive teaching

<p>External Structures:</p> <ul style="list-style-type: none"> · Content standards · High Stakes Assessment Practices
<p>School Structures:</p> <ul style="list-style-type: none"> · Flexible Curriculum · Flexible Scheduling <ul style="list-style-type: none"> - For the establishment of long-term relationships with students · Conflict Resolution <ul style="list-style-type: none"> - School-wide focus on peer mediation · Interdisciplinary and Community Focus
<p>Teacher Knowledge and Attitudes:</p> <ul style="list-style-type: none"> · Sociocultural Awareness <ul style="list-style-type: none"> - Awareness of personal attitudes - Knowledge of diversity

<ul style="list-style-type: none"> - Knowledge of students' lives · Acceptance and Affirmation of Students from Diverse Backgrounds <ul style="list-style-type: none"> - Abolishment of "cultural deficit" perspective · Viewing Self as Agent of Change <ul style="list-style-type: none"> - School structures - Statewide curriculum - Political and social activism · Knowledge of Constructivism <ul style="list-style-type: none"> - Understanding how students build knowledge
<p>Classroom Practices:</p> <ul style="list-style-type: none"> · Curriculum <ul style="list-style-type: none"> - Focus on social justice, inequity, and power structures - Draws on students' experiences and interests - Can be brought back to family and community · Management <ul style="list-style-type: none"> - Gives students explicit protocols for responding to questions that teach/practice situational appropriateness - Gives students discussion protocols that teach/practice situational appropriateness - Makes use of auditory attention signals - Provides students with meaningful opportunities for movement · Academic Language <ul style="list-style-type: none"> - Gives students opportunities to speak in both home language and academic language - Explicitly bridges from home language to academic language - Explicit vocabulary instruction · Literacy <ul style="list-style-type: none"> - Provides students with culturally relevant ways to engage with texts - Uses texts that provide different cultural experiences and perceptions · Learning Environment <ul style="list-style-type: none"> - Displays student work - Space is used flexibly - Exhibits culturally relevant bulletin boards/displays - Contains multicultural libraries - Reflects cultural aesthetics · Conceptual Frameworks <ul style="list-style-type: none"> - Builds from student knowledge - Provides tangible experiences to fill holes in student experiences - Adopts culturally relevant roles for building knowledge <ul style="list-style-type: none"> o Teacher as elder/expert o Communal learning

A framework for culturally responsive teaching: Effectively implementing culturally responsive
instruction in the science classroom

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CRT Lesson #1: Diving Into Density**Subject/ grade level:** Middle School Science Grades 7-8**Topic:** Density**Materials:**

- glass bowl or aquarium filled with water
- small piece of metal (wedding ring is handy)
- large block of wood
- density blocks
- ruler
- triple beam balance
- calculator
- Diving into Density handouts
- Styrofoam peanuts
- cardboard box
- water
- salt
- food coloring
- measuring spoons
- graduated cylinders
- beakers
- test tubes
- test tube stands
- pipettes

NYS Standards:

Standard 4 Physical Setting: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Performance Indicator 3.1: Observe and describe properties of materials, such as density, conductivity, and solubility.

Major Understandings:

3.1h: Density can be described as the amount of matter that is in a given amount of space. If two objects have equal volume, but one has more mass, the one with more mass is denser.

Lesson objective(s):

Students will be able to...

- apply the concept of density to create a 3 layer density column
- explain why substances sink or float

ENGAGEMENT

Have an aquarium with water sitting at the front of the room. Ask students to predict what will happen if you drop a piece of wood (show them the block) and a piece of metal (show them the wedding ring) in the water¹: will each object sink or float? Ask students to stand² if they think the block of wood will sink. Look for volunteers from both a seated student and a standing student to justify their prediction. Repeat this for the wedding ring.

Some students will be convinced that the wedding ring will float and the wooden block will sink because the ring is lighter. Others know that the block will float and the ring will sink, but won't be able to explain why.

Carry out the demo and let students observe that the ring does in fact sink and the ring floats.

Ask them to consider how it is possible that the heavier of two objects can float while the lighter one sinks.

EXPLORATION

Tell students that they will be working in pairs to figure out how this phenomenon is possible. Each pair will need a set of density blocks, a ruler, a triple beam balance, and a calculator.

They will work with their partner to calculate the volume of each block and will measure the mass of each block. They will then predict which of the cubes will sink in water and which will float.

Give students 90 seconds to find their partner and collect all of the needed materials (It may be appropriate to play music³ while they are moving to serve as an auditory cue). Then give them 10-15 minutes to complete their investigation.

When the time is up, recall student attention to the front of the room with a "Class, yes"⁴.

With all eyes at the front of the room drop each density cube into the aquarium to see whether it sinks or floats and have students record the results and to draw the relative positions of the cubes in the water. Ask students to clap once⁵ if all of their predictions were correct.

EXPLANATION

Along with the results of the experiment, give students one more piece of info. Tell them that if they had a cube that was the same size as the other density cubes (about 8 cubic centimeters), the mass of that cube of water would be 8 grams.

Armed with that knowledge, have students look at their data and think about the question for 1 minute. Then have them turn to their partner and discuss it. To help students see the pattern, it may be helpful to ask them to specifically consider the relationship between the volume of the cubes and their mass.

After several minutes of discussion, use pick-a-stick⁶ to select several students to share their thinking. As students try to articulate their thinking, prompt them to try to use mathematical reasoning or to try drawing a picture to illustrate their thoughts.

Help students to articulate that although the cubes were all approximately the same size, they had very different masses. Those with larger masses were more likely to sink. In fact, those that had masses greater than the theoretical cube of water did sink while those with masses less than the theoretical water cube floated. Those with masses very close to the water cube, sometimes sunk part way.

Then show students how to calculate this ratio of mass to volume and have them calculate this for all of the density cubes (the third, unlabeled column on the handout).

Explain to students that this ratio of mass to volume is a property called density (label the third column) that describes how much mass an object has packed into a given amount of space. Model this by using Styrofoam peanuts. If they are placed lightly in a box, they are loosely packed and not very dense. If you start packing them in, you can fit more of them in the same amount of space and the object is denser.

ELABORATION

Write the generalization that denser substances sink and less dense substances float on the board where everyone can see it.

Explain to students that they are going to try to apply this principal to liquids. Their goal is to try to make liquids with different densities and then to combine those liquids so that they create 3 layers. To make this happen they will have access to: water, salt, food coloring, measuring spoons, graduated cylinders, beakers, test tubes, and pipettes. They will continue to work with their partners. Focus students on the idea that density depends on the amount of mass in a given volume.

Give students 5 minutes to make a plan and check in with each group to advise them on their protocols. Then allow students to get materials and attempt to complete the challenge. After their first attempt, have partners pair up with another set of partners⁷ and compare protocols and

outcomes. Now in a group of four, they will revise their protocols to make a second attempt. It may help to bring their attention to the following areas:

1. What is your fixed volume?
2. Are you adding enough salt to appreciable change the density?
3. Is there a preferable order for adding the layers?

To prove that this can be done, it may be encouraging to show the following clip (but skip over the part that shows how much salt and water to use):

<http://www.youtube.com/watch?v=ZgDnGFvEOUg>

Have groups of 4 submit their revised protocols (they will attempt them the next day).

Then have them independently complete the following ticket-out-the-door:

Give students a particle drawing of a cube. Ask them to make particle drawings for a cube that is denser and a cube that is less dense.

EVALUATION

1. Standing polls
2. Questioning and discussion
3. Claps and Snaps
4. Think Pair Share
5. Density column protocols
6. Ticket-out-the-Door

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Hands-On-This investigation is structured around tangible objects and experiences on which students can fix their reasoning. This provides a conceptual bridge from a known object to a discoverable scientific concept.
2. Standing Polls-This strategy incorporates authentic movement into a lesson while assessing students and demanding participation and engagement from all individuals.
3. Move to Music-This management/transition strategy pairs time constraints with auditory cues and provides a meaningful way to incorporate music, rhythm, and motion into the classroom with a flare of fun.
4. Auditory Cues (Clap patterns, “Class, Yes”) - These are simple classroom management cues that can be taught and used throughout the entire school year to facilitate transitions in the classroom. These auditory cues draw on the cultural backgrounds that emphasize sound and rhythm.

5. Think Pair Share-The TPS protocol forces students to draw on their prior knowledge and beliefs before looking to the teacher for answers. It also fosters group work and communication with peers and draws on the oral and communal learning traditions of many student cultures

6. Pick-a-Stick-This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message that while working in groups every individual is still responsible for participating and understanding the content.

7. Group Work-Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition.

8. Claps and Snaps- asking for student concurrence with a clap/snap/stomp/whatever creates whole class participation when listening to one student's response and gives the teacher a chance to assess whole group understanding while incorporating African traditions of rhythm.

Extension and Additional Resources:

1. Depending on students' familiarity with the Periodic Table, it could be interesting to challenge them to find a metal that is less dense than water and to research why these metals aren't used to make objects float (they are all highly reactive metals that explode when combined with water.

2. Have students create the classic density column, but let them choose the different liquids to use. Challenge them to create a column with as many layers as possible.

3. Challenge students to explore how fish manage to rise and sink in water and what this has to do with density. This can lead to an exploration of density, buoyancy, and gravity.

CRT Lesson #2: Atoms Amuck

Subject/ grade level: Intermediate Science 7-8 ***This lesson was originally designed for an alternative setting self-contained 12:1:1 classroom.

Topic: Atomic Structure

Materials:

- wrapped box
- model nuclei (play dough surrounding square and round beads)
- tooth picks
- Uncovering the Atom notes
- Investigation Record sheets
- Rutherford Gold Foil reading

NYS Standards:

Standard 4 Physical Setting: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Performance Indicator 3.3: Develop mental models to explain common chemical reactions and changes in states of matter.

Major Understandings:

3.3a: All matter is made up of atoms. Atoms are far too small to see with a light microscope.

3.3e: The atoms of any one element are different from the atoms of other elements.

Lesson objective(s):

Students will be able to...

- model the process by which scientists discovered the structure of an atom
- identify atoms based on the number of protons

ENGAGEMENT

As students enter the classroom, have a wrapped box sitting at the front of the room. Ask students to tell you what is in the box without touching it, lifting it, shaking it (and without touching, lifting, moving, or shaking the table that it's sitting on)¹.

Use pick-a-stick² to force students to respond. Some students may give guesses. If they do, ask what they're basing their guess on. If they refuse to guess, ask them why?

Before students get frustrated or angry with you, ask them why they can't answer your question? Why is the task impossible?

Take volunteers and help them elaborate on the idea that if you can't touch the box, shake it, lift it, etc. and you can't see in to the box, you have no tools by which to make any observations. Now ask students to imagine that the box is so small that they can't even see it. Somehow, that makes an impossible task even harder.

EXPLORATION

Explain to students that for a long time, the atom was very much like the wrapped box. It was difficult for scientists to determine anything about the structure of the atom because atoms are so small and they had few tools with which to study them. Therefore, they had to get creative.

Inform students that they are going to be modeling one way that scientists were able to study the atom.

Each student will receive a ball of play dough representing an atom's nucleus. Inside the ball of play dough, there have been placed an unknown number of beads of two different types. There are square beads (protons) and round beads (neutrons) that are approximately the same size, but the square beads have a large hole in them while the round beads have a very small hole. Using toothpicks to poke into and through the ball, students are to try to determine how many of each kind of bead are in their ball of playdough¹.

Pass out balls of play dough, toothpicks, and the "Exploring the Atom: Investigation Record". Make sure students make their hypothesis before starting their investigation. Make sure they know that they will have to be able to explain their strategy for approaching this task and the observations they made that lead to their conclusion.

Give students 5-10 minutes to work. Then have them turn to a partner and share what they have experienced so far³. Give students another 5 minutes to finalize their conclusions.

When they are done, regain the class' attention with a "Class, Yes"⁴. Ask them to show with a Fist-to-Five⁵ how confident they are about correctly determining the structure of their "nucleus". Then give them permission to open up their nucleus and see if they were right. After 1-2 minutes, ask students to give a one clap if their conclusion was correct⁶.

EXPLANATION

Ask for volunteers to share their experiences with the activity. Was it difficult? Why or why not? Why was it difficult to be certain that every proton and neutron had been discovered in the

nucleus?

Pass out the “Uncovering the Atom” review notes and quickly run through them. Emphasize the last bullet point on the notes- that scientists continue to develop a better model of the atom.

Like in the activity the students carried out, there is always uncertainty and more to be discovered about the structure of the atom so our explanations and models of it are never 100% correct.

Next, pass out the Rutherford Gold Foil experiment reading. Have students read it silently to themselves and answer the questions independently. Encourage them to connect the reading with their experiences during the atom activity.

ELABORATION

Explain to students that their homework is going to be to teach someone at home about the atom and to have them take a short quiz. Students should use their remaining time to create the short lesson that they will use to teach their family member about the atom.

EVALUATION

1. Uncovering the atom activity and investigation record
2. Think Pair Share
3. Gold Foil Experiment Questions

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Hands-On-This investigation is structured around tangible objects and experiences on which students can fix their reasoning. This provides a conceptual bridge from a known object to a discoverable scientific concept.
2. Pick-a-stick-This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message that while working in groups every individual is still responsible for participating and understanding the content.
3. Think-Pair-Share-The TPS protocol forces students to draw on their prior knowledge and beliefs before looking to the teacher for answers. It also fosters group work and communication with peers while drawing on the oral and communal learning traditions of many student cultures.
4. Auditory Cues-These are simple classroom management cues that can be taught and used throughout the entire school year to facilitate transitions in the classroom. These auditory cues draw on the cultural backgrounds that emphasize sound and rhythm.

5. **Fist-to-Five**-This is an easy assessment tool that incorporates brief motion/gestures by which students can indicate their level of comfort or confidence on a topic.

6. **Claps and Snaps**- Asking for student concurrence with a clap/snap/stomp/whatever creates whole class participation when listening to one student's response and gives the teacher a chance to assess all students while incorporating African traditions of rhythm.

Extension and Additional Resources:

1. Have students develop full lessons and activities to teach an elementary class about the atom. Then actually visit an elementary school and teach those lessons.

2. Have students create time lines, movies, or raps chronicling the development of their understanding of the atom.

CRT Lesson #3: Matter Matters

Subject/ grade level: Intermediate Science 7-8, may also be appropriate for High School Chemistry 9-12

Topic: Phases of Matter

Materials:

- balloon
- string
- textbooks
- freezer
- Exploring Matter Handouts
- poster paper
- Sign with formula for volume of a sphere
- Bins for each group of students containing the following:
 - wooden block
 - beaker of water
 - triple beam balance
 - graduate cylinder
 - balloon
 - ruler
 - calculator
- Jar of marbles
- Glass baking dish with single layer of marbles
- Envelopes with words/phrases for concept map
- tape
- Large colored paper
- Smart Board/projector

NYS Standards:

Standard 4 Physical Setting: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Performance Indicator 3.1: Observe and describe properties of materials such as density, conductivity, and solubility.

Major Understandings:

3.1c: The motion of particles helps to explain the phases of matter as well as changes from one phase to another. The phase in which matter exists depends on the attractive forces among its particles.

3.1d: Gases have neither a determined shape nor a definite volume. Gases assume the shape and volume of a closed container.

3.1f: A liquid has a definite volume, but takes the shape of a container

3.1e: A solid has a definite shape and volume. Particles resist a change in position.

Lesson objective(s):

Students will be able to...

-characterize the three phases of matter

- use particle theory to explain the properties of different phases of matter

ENGAGEMENT

Begin class by inflating a balloon¹ and holding it up for students to consider. Ask students the following:

1. What's inside the balloon? (air, carbon dioxide)
2. What is air? or What phase of matter is air (gas)
3. Do you think I can shrink the size of this balloon without letting any of the air out? Clap once if you think yes (wait for response). Stomp once if you think no (wait for response)².

Tell students that you are going to run an experiment. Take a piece of yarn and wrap it around the balloon at its largest circumference. Cut the string to be exactly that circumference. To provide for a second measure of the size of the balloon, place two textbooks on either side of the balloon so that they are touching it and measure the diameter. Record the diameter on a clearly displayed sheet of poster paper.

Explain to students that you are going to put the balloon into a freezer for 30-40 minutes while they are working on their lab. When they are finished with the lab, you will re-measure the balloon in front of the class.

EXPLORATION

Pass out the Exploring Matter handout to students. Ask for volunteers to provide a definition for the word matter. Record student definitions of matter on the board. Then give students the science definition of matter and have them write it on their Exploring Matter handouts.

The definition that they will be working with states that matter is anything that has volume and mass. Explain to students that today they will be investigating/proving that solids, liquids, and gases are all made of matter. To do so they must demonstrate that all 3 possess these characteristics. They will also be exploring some other properties of solids, liquids, and gases. To complete this investigation, students may work in groups of 2-3. Give them 60 seconds to get into groups⁴ (it may be appropriate to play music while students are moving).

Notify students that they will be working with volume and mass today. Ask students to raise their hands if they are strong at using a triple beam balance. Write their names on the front board and label as triple beam experts. Then ask for volunteers to serve as volume experts and record their names on the board³. Inform students that if they have questions on finding mass or volume, these are the people they should ask. Finally, tell students that they will be skipping over the question about changing the volume of gas until the end of class.

The materials that students need should already have been placed in bins and once students are in their groups the bins should be distributed to them.

The investigation is fairly self-explanatory but students may get stuck at the following parts:

1. They may need to review how to calculate the volume of a rectangular prism.
- 2 They need to review how to use a triple beam balance.
3. Students must calculate the mass of the balloon before they find its volume.
4. Students may need some guidance in how to find the mass of the balloon. This process may require the teacher, but after the teacher instructs one or two groups, they should be able to teach the others.
5. To calculate the volume of the balloon, we will approximate its shape to be that of a sphere.

The formula to calculate the volume of a sphere is $V = 4/3(\pi)r^3$ (this formula should be posted clearly at the front of the room). Students will need to use creative problem solving to find r .

Depending on the competencies of the students at measuring and following directions. This activity can take anywhere from 20-40 minutes. Groups that finish early should assist other groups with measuring or can begin work on the conclusion questions.

When all groups have finished, reclaim materials and then retrieve the balloon from the freezer. When you re-measure its diameter and circumference, students should see that the string around the circumference is shorter and when placed between books set at the original diameter, there is now space between the balloon and the books. This means we were able to change the volume of the balloon without taking any gas away.

Students may challenge this and may argue that the balloon leaked.

To combat this misconception, show the following video:

<http://www.youtube.com/watch?v=ZgTTUuJZAFs>

EXPLANATION

The balloon video presents a pretty good explanation of what's happening at the particle level of matter, but changes are most students don't have a strong enough conception of particles to truly internalize it.

Use pick-a-stick⁵ to select a student to try to summarize what the video said about particles and matter. The video may need to be replayed a second time. Continue to use pick-a-stick to select a student to define particle. If students are confused about this term, have the do a quick Think-Pair-Share with a partner⁶ and then share out. For this lesson, students only need to know that particles are the small pieces that make up matter (some students may be able to throw out the terms atoms and molecules).

So the first piece of information that we need to accept is that matter is made of particles.

Then show the first 4 minutes of this Bill Nye clip:
<http://www.youtube.com/watch?v=Gxwj24mREyA>

Again, use pick-a-stick⁵ to get students to summarize the concepts addressed in the Bill Nye clip:

1. The atoms/particles in different phases of matter are moving at different speeds
2. To change the speed of particles (and therefore to change phases of matter) you to add or take away energy.

ELABORATION

Model this with marbles in a jar and a shallow layer of marbles in a glass baking dish. Ask students to respond to your questions with a shout out⁷:

“When I hold the jar of marbles, where each marble is a particle, still, am I putting in energy?”
(no)

“The particle marbles of science aren’t moving very much so what phase of matter are they?”
(solid)

(move to the baking dish) “When I shift this baking dish from side to side, am I putting in energy?” (yes)

“So the particle marbles of science begin to move a little. What phase does this represent?”
(liquid)

(go back to the jar) “Now when I shake this jar, am I putting in energy?” (yes)

“A lot or a little?” (a lot)

“So what phase does this represent?” (gas)

To summarize their understanding of the topic, pass out envelopes with words and phrases relating to phases of matter. Have students work with their lab partners to generate a concept web of their understanding of the phases of matter. At the bottom of their concept map they should also try to answer the question: how does particle theory explain the properties of different phases of matter? Final products should be taped in place on a sheet of paper. Students will then complete the conclusion questions to their lab and/or will take it home to finish for homework.

EVALUATION

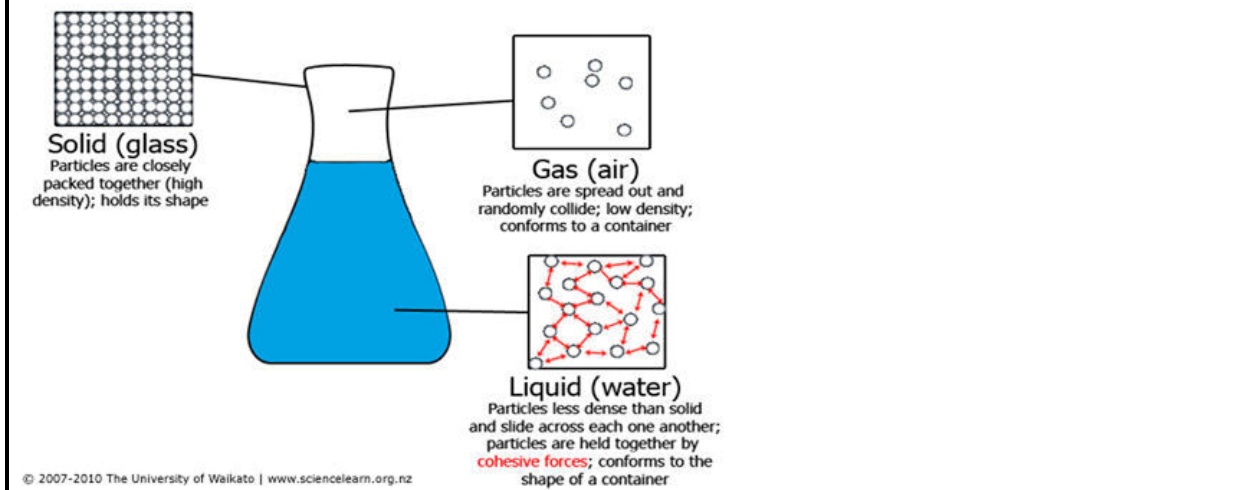
1. Questioning
2. Claps and Snaps
3. Exploring Matter lab and conclusion questions
4. Pick-a-Stick Questions
5. Shout out
6. Concept Map

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Hands-On-This investigation is structured around tangible objects and experiences on which students can fix their reasoning. This provides a conceptual bridge from a known object to a discoverable scientific concept. This is particularly important in chemistry where so many of the concepts are based on objects that can't be seen or handled.
2. Claps and Snaps- Asking for student concurrence with a clap/snap/stomp/whatever creates whole class participation when listening to one student's response and gives the teacher a chance to assess all students while incorporating African traditions of rhythm.
3. Circle the Sage- This is a modified version of Circle the Sage. Students self-identify as experts on a topic and then teach any classmates who need help with that topic. Looking to peers for instruction is at the heart of communal learning and also affirms student knowledge and skills without suggesting a deficit on the part of other students.
4. Group Work-Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition.
5. Pick-a-Stick-This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message that, while working in groups, every individual is still responsible for participating and understanding the content.
6. Think-Pair-Share-The TPS protocol forces students to draw on their prior knowledge and beliefs before looking to the teacher for answers. It also fosters group work and communication with peers with draws on the oral and communal traditions of many student cultures
7. Shout out-This protocol serves to check whole class understanding by engaging students in a form of cultural discourse that is closer to their home cultures as it mirrors the call-and-response discourse styles of African traditions. This also provides code switching practice as students must be cognizant of when it is appropriate to shout out and when they must listen to a specific individual.

Extension and Additional Resources:

1. Watching the rest of the Bill Nye clip can give students more evidence for the particle nature of matter.
2. Students could make posters of objects that contain all three phases of matter and could generate particle diagrams for each of the different phases to demonstrate understanding of the concept and to provide a visual by which to teach their peers. Example:



CRT Lesson #4: Patterns of Periodicity

Subject/ grade level: Intermediate Science 7-8, may also be appropriate for High School Chemistry 9-12

Topic: Periodic Table

Materials:

- Periodic table analogy cards (can be purchased online- Product is produced by Hubbard scientific *or* you can make your own card)
- Getting to Know the Periodic Table handouts
- The Periodic Table of Elements reading
- computers
- textbooks

NYS Standards:

Standard 4 Physical Setting: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Performance Indicator 3.3: Develop mental models to explain common chemical reactions and changes in states of matter.

Major Understandings:

3.3f: There are more than 100 elements. Elements combine in a multitude of ways to produce compounds that account for all living and nonliving substances. Few elements are found in their pure form.

3.3g: The periodic table is one useful model for classifying elements. The periodic table can be used to predict properties of elements (metals, nonmetals, and noble gases).

Lesson objective(s):

Students will be able to ...

- explain and model the process by which the Periodic Table was organized
- navigate the Periodic Table

ENGAGEMENT

Open the lesson by asking students to create a pattern. Remind students that they have been working with patterns since elementary school in math and music. A pattern can be any sequence that follows a rule that allows someone to predict the next item in the pattern. Patterns can be made with numbers, pictures, sounds, beats¹, etc. Give students 2-3 minutes to create a pattern: visual, numeric, or rhythmic.

Then have them find a partner. Partners should exchange patterns and try to draw or create the next 3 items in the pattern². They should then check each other's work and confirm (or correct) their partner's work.

Call students attention back to the front of the room with an auditory cue (a clap pattern would be appropriate, given the topic)³. Ask for volunteers to share their patterns with the class. Try to elicit a visual, numeric, and rhythmic pattern from students.

EXPLORATION

Tell students that they are going to be solving a puzzle today involving patterns because, as much as patterns are central in math, they are also important in science.

Either hand out a single card to each student, or place an image of 2 or 3 of the cards up on the Smart Board.

Give students 90 seconds to identify as many properties/characteristics of the card(s) as they can. If students struggle with the concept of "properties" or "characteristics", simply ask them to make observations about the cards. After 90 seconds is up, use whip around⁴ to have students list off the properties they identified or the observations they made. Students may repeat responses that have already been given but when they give their answer they need to either state "One property of the card was..." or "One thing I observed about the card was..." As students give their answers, novel responses should be listed on two sheets of poster paper (one for properties, and one for observations).

After all responses have been given, loo over the list of properties to see if students identified all 6 (color, notches, stars, holes, whole numbers, decimals). For students who struggle with the concept of "characteristics/properties", help them see how individual observations can be generalized into those 6 properties.

Explain to students that they will be receiving a set of 23 of these cards. Their task will be to work in groups to organizer the 23 cards so that they demonstrate a pattern^{5,6}. However, because the cards have 6 different properties, each one of the properties has to follow a pattern. The cards do not have to be arranged in a single line (and in fact, it is impossible to do so and preserve a pattern for all 6 properties).

Count students off into groups of 4 and given them 30 seconds to find their groups. Once they are in their groups, hand out sets of cards and let them begin.

Students will require significant amounts of time to complete this activity. Some groups will find patterns faster than others. Some groups will need more hints than others. Throughout the activity, the following guiding questions may be helpful:

1. Start with one property first: color is probably the easiest
2. Patterns can (and will) exist going across rows, down columns, and even along diagonals.
3. Stars, holes, and notches are the next easiest patterns to find.
4. The decimals are the most difficult pattern to determine. May want to ignore them entirely
5. Make sure students write the rule/articulate the pattern

After letting students struggle and work for some time, inform students that there is one more piece of information that they need to know: There are actually supposed to be 24 cards in their set. One card has been removed so there will be a hole somewhere in their pattern. It is their job to arrange the cards in the correct sequence, with a gap for the missing card. Then they should be able to use their patterns to predict what the missing card looks like (with respect to all 6 properties).

Give students another 20 minutes or so to revise their thinking and the arrangement of their cards. When time is up, students must be prepared to explain to the class what patterns they used to arrange their cards and they must share their predictions for the missing card. Use the Roll'Em⁷ protocol to select the order of groups and the individual who is going to share out.

Allow all groups to share. Then ask students to give a Fist-to-Five⁸ to share how confident they are of their predictions for the missing card.

Finally reveal the missing card and let students compare it to their predictions. You may or may not want to share the “correct” arrangement for the cards.

EXPLANATION

At the point, as students to silently reflect on why they were asked to engage in this activity. Ask for a moment of silence (90 seconds)⁹ while they reflect. Then use pick-a-stick¹⁰ to get student thoughts.

This discussion can bring up multiple points about the nature of scientists and how scientists make sense of information, use observations, make and revise hypotheses etc.

Point out to students that in science, the amount of data that is being analyzed is often very large. Ask them to imagine how difficult the card task would have been using 60 cards with an unknown number of cards missing. Ask them to use the “Raise a Righteous Hand”¹¹ protocol to share how they'd react to such a task.

After getting student responses, explain to them that a scientist, did in fact go through this exact

process with 60 items and that he spent several years making sense of it.

Hand out copies of “The Periodic Table of Elements” reading. Tell students that as you read this story of Dmitri Mendeleev out loud to them¹², they should be following along and noting questions that they have or identifying main ideas.

Read aloud the text (dramatically) but stop after each paragraph to have students summarize and tell the story back to you (use pick-a-stick to select students). Students can pass on summarizing/retelling but if they can’t retell, they need to either ask a question about the text or identify where they got confused. If they admit they weren’t listening, they will reread the section out loud.

ELABORATION

Explain to students that they will now begin to become familiar with the Periodic Table as scientists know and use it today. Pass out copies of “Getting to Know the Periodic Table”. Allow students to work independently or in pairs to complete the self-guided tour of the Periodic Table.

EVALUATION

1. TPS- make a pattern
2. Periodic Table analogy
3. Summarizing/questions during read aloud
4. Getting to know the Periodic Table handouts

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Relevance of Content to Students- Patterns are deeply rooted in African culture both in art and music. By allowing students to incorporate their knowledge of musical patterns into this lesson, it validates a central part of their culture and creates a valuable bridge that allows students to engage with the concept of patterns in science.
2. Think-Pair-Share-The TPS protocol forces students to draw on their prior knowledge and beliefs before looking to the teacher for answers. It also fosters group work and communication with peers and draws on the oral and communal traditions of many student cultures
3. Auditory Cues-These are simple classroom management cues that can be taught and used throughout the entire school year to facilitate transitions in the classroom. These auditory cues draw on the cultural backgrounds that emphasize sound and rhythm.
4. Whip Around-This protocol allows students to practice explicit turn taking, but it does so at a rapid pace. It maintains accountability for every student in the room, checks for overall

understanding, but does so while validating every student's response.

5. Group Work- Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition.

6. Hands-On-This investigation is structured around tangible objects and experiences on which students can fix their reasoning. This provides a conceptual bridge from a known object to a discoverable scientific concept.

7. Roll'Em-This strategy ensures that every individual is participating in group work. It particularly obligates group members to be cognizant of engaging every other member in the group and ensuring that every individual has an understanding of the group's thoughts, findings, and questions. To implement, each group is assigned a number (1-6) and each individual within each group is also assigned a number (1-6). The teacher rolls a pair of dice. The two numbers identify the group # and the # of the individual in the group who must share.

8. Fist-to-Five-This is an easy assessment tool that incorporates brief motion/gestures by which students can indicate their level of comfort or confidence on a topic.

9. Moment of Silence-This protocol draws on students' experiences with using moments of silence to commemorate and recognize somber events. It evokes the notion that the question at hand is serious and requires silent contemplation.

10. Pick-a-stick-This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message that while working in groups every individual is still responsible for participating and understanding the content.

11. Raise a Righteous Hand-This protocol explicitly practices turn-taking, thus giving students the opportunity to actively practice a skill/behavior that is often expected in the traditional classroom but with which many students from other cultures lack practice. It also provides students with the opportunity to voice personal experiences and reinforces the value of those personal experiences as students are given their particular turn to speak their thoughts.

12. Responsive Literacy Strategy: Read Aloud- This literacy strategy is evocative of the storytelling traditions that are common in African American and Latino cultures. It emphasizes the teacher's role as the elder and enables students to focus on listening.

Extension and Additional Resources:

1. Extend the Periodic table analogy to the actual periodic table. Create cards for elements of the Periodic Table including the atomic mass, atomic number, and other properties that students can manage (melting points, conduct electricity, etc.). Have students conduct different sorts and see

how they would group elements or see how they would sequence the elements based on the information given.

2. Although they don't need this level of understanding at the intermediate level, students could research patterns of periodicity in the table. They could complete graphing activities comparing atomic number to electronegativity or ionization energy to identify trends in the table.

CRT Lesson #5: What's In a Name?**Subject/ grade level:** High School Chemistry 9-12**Topic:** Naming Organic Compounds**Materials:**

- Envelopes with hydrocarbon structural formulas labeled with names (should contain 30 compounds: all alkanes, alkenes, and alkynes meth-dec)
- Computers
- Hydrocarbon Prefixes and Suffixes handouts
- Poster paper

NYS Standards:

Standard 4 Physical Setting: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 3: Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Performance Indicator 3.1: Explain the properties of materials in terms of the arrangement and properties of the atoms that compose them.

Major Understandings:

- 3.1ff: Organic compounds contain carbon atoms, which bond to one another in chains, rings, and networks to form a variety of structures. Organic compounds can be named using the IUPAC system.
- 3.1gg: Hydrocarbons are compounds that contain only carbon and hydrogen. Saturated hydrocarbons contain only single carbon-carbon bonds. Unsaturated hydrocarbons contain at least one multiple carbon-carbon bond.
- 3.1hh: Organic acids, alcohols, esters, aldehydes, ketones, ethers, halides, amines, amides, and amino acids are categories of organic compounds that differ in their structures. Functional groups impart distinctive physical and chemical properties to organic compounds.

Lesson objective(s):

Students will be able to...

- name saturated hydrocarbons
- name unsaturated hydrocarbons

ENGAGEMENT

Have students start class by completing a quick-write. They will have 8 minutes to write the story of their name¹. In their quick-write, they should answer the following questions:

1. Who were they named for?
2. What does their name tell me about them?
3. What does their name mean to them?
4. How do they feel about their name?

Once time is up, share your own quick-write as the teacher. Then ask students to raise a righteous hand² if they would like to share the story of their name. Call on students to share and let as many share as possible.

After sharing stories, ask students to think about what would happen if we didn't have names or if everyone used a different name everyday (teachers can throw in the example of students referring to their teachers as just "Miss" or "Mister" instead of learning their names and how confusing that can get). Teachers may also want to see if students remember how biologists have approached the naming problem with binary nomenclature.

The big idea here is that scientists use naming systems to communicate clearly and precisely and the names that they use generally have meaning and provide information about the objects being named. The same is true of chemists and the way they talk about chemicals. The focus today is on organic chemicals.

EXPLORATION

Explain to students that they will be working with partners³ to try to make sense of the naming system that scientists do use to talk about organic compounds. Students will receive envelopes with 30 different organic compounds (structural formulas provided) labeled with their names. They will work with their partners to figure out what the parts of the name mean by sorting and categorizing the compounds⁴.

Give students 30 seconds to make a silent appointment⁵ with their partner and move to sit next to them. Pass out envelopes and have students begin sorting out their hydrocarbons. Once students have started to make groups and classify their hydrocarbons, provide them with poster paper and marker to start recording their observations and the inferences they have made. Students may need the hint to try to connect the name with the structural formula. Others may need the blatant hint to count carbon atoms.

If groups manage to figure out the connection between all of the prefixes and number of carbon atoms and/or the connections between suffixes and the number of bonds, encourage them to find a second way to sort the compounds. If groups find both connections and have large amounts of

time left, it may be prudent to have additional envelopes with compounds that introduce other functional groups.

EXPLANATION

After 10 minutes or so, call students attention back to the whole class with an auditory cue (“Class”, “yes”)⁵. Have one member of each group post their observations/inferences at the front of the room. Then use pick-a-stick⁶ to have individuals share what they discovered. Continue to use pick-a-stick to have students elaborate on findings and identify all of the connections between a compound’s name and its structural formula.

Hand out copies of “Hydrocarbon Prefixes and Suffixes”. Quickly fill in the notes with students. When looking at the suffixes, be sure to go over the difference between saturated (all carbon bonds are used in single bonds between other carbons or hydrogen) and unsaturated hydrocarbons (can potentially hold more hydrogens).

Next, explain to students that the best way to automatically recognize the meanings of these prefixes and suffixes is to practice with them. Inform them that they will be partaking in three rounds of practice. Each round will begin using shout out⁷ with all students yelling out the answers. When students seem comfortable, it will change to whip around⁸ and every student will have to answer.

Round 1: Give students the number of carbons, ask for the prefix

Round 2: Give students the name of a compound; ask for the number of carbons.

Round 3: Give students the name of a compound; ask for the type of bond.

While naming compounds, throw in some alcohols, ketones, etc. to show that these prefixes remain universal.

ELABORATION

When students are comfortable with the prefixes and suffixes and responses are (nearly) automatic, pass out an index card to each student with another class of organic compounds: ester, ethers, ketones, carboxylic acids, amides, amides, or aldehydes.

Students will use their textbooks or the internet to find and teach themselves the rule for naming that class of organic compound. They will then write a short explanation and an example for their ticket-out-the-door. The TODs will be compiled with their classmates work to provide notes for the class on how to name other functional groups.

EVALUATION

1. Sorting hydrocarbons group work
2. Sharing out findings from group work
3. Shout out
4. Whip around
5. Ticket-out-the-door

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Relevance of Content-This lesson grabs student's attention by focusing on something that is important to most of them: names. By latching on to their own frustrations with how people mispronounce their name or "don't know me" it gives students an opportunity to explore why names are important, the power they have, and how those same ideas of power and importance are relevant in science.
2. Raise a Righteous Hand-This protocol explicitly practices turn-taking, thus giving students the opportunity to actively practice a skill/behavior that is often expected in the traditional classroom but with which many students from other cultures lack practice. It also provides students with the opportunity to voice personal experiences and reinforces the value of those personal experiences as students are given their particular turn to speak their thoughts.
3. Group Work- Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition.
4. Hands-on-This investigation is structured around tangible objects and experiences on which students can fix their reasoning. This provides a conceptual bridge from a known object to a discoverable scientific concept.
5. Auditory Cues-These are simple classroom management cues that can be taught and used throughout the entire school year to facilitate transitions in the classroom. These auditory cues draw on the cultural backgrounds that emphasize sound and rhythm
6. Pick-a-stick-This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message that while working in groups every individual is still responsible for participating and understanding the content.
7. Shout out-This protocol serves to check whole class understanding by engaging students through a form of cultural discourse that is closer to their home cultures as it mirrors the call-and-response discourse styles of African traditions. This also provides code switching practice as

students must be cognizant of when it is appropriate to shout out and when they must listen to a specific individual.

8. Whip Around-This protocol allows students to practice explicit turn taking, but does so at a rapid pace. It maintains accountability for every student in the room, checks for overall understanding, but does so while validating every student's response.

9. Silent Appointment-This protocol helps students to practice situationally appropriate behavior by following a specific silent protocol that also allows student choice in partners and meaningful movement.

Extension and Additional Resources:

1. Challenge students to create a rap to help remember the prefixes and suffixes used in naming organic compounds. Make a class hydrocarbon music video.
2. Have students make a children's book on naming organic compounds (or on the importance of names- this could cover personal names, naming in biology, and IUPAC names) and actually share them at an elementary school.
3. Give students extremely complicated organic compounds and see what connections they can make between its name and its structure.

CRT Lesson #6: Skin Deep

Subject/ grade level: Living Environment (but could be revised and implemented for any science course) 7-12

Topic: Controlled Experiments

Materials:

- Smart board (or other projection device)
- Poster paper
- Sticky Notes
- Crayons/Markers/Etc.
- At least 1 computer for student use
- Copies of Controlled Experiment Notes

NYS Standards:

Standard 1- Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Key Idea 2: Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

Performance Indicator 2.3 Develop and present proposals including formal hypotheses to test explanations; i.e., predict what should be observed under specific conditions if the explanation is true.

Major Understandings

2.3a Hypotheses are predictions based upon both research and observation.

2.3b Hypotheses are widely used in science for determining what data to collect and as a guide for interpreting the data.

2.3c Development of a research plan for testing a hypothesis requires planning to avoid bias (e.g., repeated trials, large sample size, and objective data-collection techniques).

Performance Indicator 2.4 Carry out a research plan for testing explanations, including selecting and developing techniques, acquiring and building apparatus, and recording observations as necessary.

Key Idea 3: The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into natural phenomena.

Performance Indicator 3.4 Based on the results of the test and through public discussion, revise the explanation and contemplate additional research.

Major Understandings

- 3.4a Hypotheses are valuable, even if they turn out not to be true, because they may lead to further investigation.
- 3.4b Claims should be questioned if the data are based on samples that are very small, biased, or inadequately controlled or if the conclusions are based on the faulty, incomplete, or misleading use of numbers.
- 3.4c Claims should be questioned if fact and opinion are intermingled, if adequate evidence is not cited, or if the conclusions do not follow logically from the evidence given.

Performance Indicator 3.5 Develop a written report for public scrutiny that describes the proposed explanation, including a literature review, the research carried out, its result, and suggestions for further research.

Major Understandings

- 3.5a One assumption of science is that other individuals could arrive at the same explanation if they had access to similar evidence. Scientists make the results of their investigations public; they should describe the investigations in ways that enable others to repeat the investigations.
- 3.5b Scientists use peer review to evaluate the results of scientific investigations and the explanations proposed by other scientists. They analyze the experimental procedures, examine the evidence, identify faulty reasoning, point out statements that go beyond the evidence, and suggest alternative explanations for the same observations.

Lesson objective(s):

Students will be able to...

- Critique experimental design
- Design and implement a controlled experiment
- Evaluate the impact that skin color has on their lives and communities and propose reasons for these impacts

ENGAGEMENT

Students will be placed in groups of 4 students (pre-determined by teacher to create a range of skin pigmentation within each group)⁴. They will then rank the darkness of their skin color as well as the skin color of their group mates on a scale from 1 to 10 (1 being lightest, 10 being darkest) on a piece of scrap paper¹.

Within their groups, students will share out their rankings of themselves and each other. Students should look for similarities and discrepancies in their group's rankings of each other.

(5 minutes) Groups will then share out with the entire class. Pick-a-stick will be used to elicit random non-volunteer participation⁵. Questions to pose include:

1. Did others tend to rank you as lighter or darker than you ranked yourself?
2. Did students of different “races” tend to rank other “races” as lighter or darker?
3. Is our ranking of us/other a reflection of how we feel about us/other?

EXPLORATION

While still in groups, students will brainstorm/identify a list of all of the ways that they see their skin color affecting them positively and negatively in their daily lives². They can write these responses in either academic language or home language. Using Roll ‘Em, students will be selected to share out until groups have no more unique responses⁶. Teacher will record student responses and the comprehensive list will be posted.

At this point, it should be clear that skin color impacts our daily lives and the way people treat us, although some students may be more or less aware of this than others. Along with the questions of how and why skin color impacts our treatment in society, the teacher should introduce a third question: Can science help to make society fairer?

To help students consider this question, the class will watch a YouTube video clip of classic experiment: the [Barbie Doll Test](http://www.youtube.com/watch?v=YOHbtM9463c) (<http://www.youtube.com/watch?v=YOHbtM9463c>)

While watching this clip, students will be asked to consider the following questions and record their thoughts on a separate sheet of paper:

- What did the researchers probably expect to happen in this experiment?
- What was kept the same about the dolls and what was different about them?
- Who was questioned in this experiment?
- How do you think the experiment could have been improved?
- What did the researchers find out from the results?

At this point, a student helper can be asked to pass out note sheets (a possible example of the notes format is attached although every teacher may have their own ideas about the elements that they would like their students to focus on regarding experimental design) to each student. The teacher should explicitly state to the students that the questions that they thought about while watching the video were asked in non-academic language and that now they are going to learn/use the academic language for these questions³.

The teacher will continue to use pick-a-stick to elicit answers to the questions for completing the notes on designing controlled experiments. Students will be asked to volunteer if they have synonyms or more familiar words that mean the same thing as the academic words that might be helpful for their classmates.

When students answer the question “How could this experiment have been improved?” they may

very well offer suggestions that are improvements in their mind but are not improvement as measured by a scientific controlled experiment. It is important in such instances that science has specific criteria that it uses to measure the quality of an experiment but that their concepts of improvement may still be valid, if non-scientific⁶.

EXPLANATION

Student groups will then be assigned one of four “experiments” that continue to analyze how skin color is related to other variables (jail time, pay, general treatment, reaction to teenage vandalism). Groups may have to be redesigned by teacher in order to take into account literacy levels. Students will read/watch their assigned study and then will create a poster targeted towards their classmates that summarizes and critiques the experimental design and findings of the study.

1. Skin color and teenage vandalism- <http://www.everydaysociologyblog.com/2009/04/field-experiments-and-racism.html>
2. Skin color and pay- <http://news.vanderbilt.edu/2007/01/skin-color-and-salary-lighter-and-taller-equals-a-bigger-paycheck-for-immigrants-58754/>
3. Skin color and jail time- http://www.nasw.org/users/mslong/2011/2011_05/Prison.htm
4. Skin color and general treatment- <http://www.youtube.com/watch?v=YyL5EcAwB9c>

Completed posters will then be subject to a carousel walk in which each student will write either a question or critical feedback for each poster⁷. Sticky notes will be provided to students.

ELABORATION

Now that students have been exposed to a number of sociological studies on skin color, students will be challenged to return to our engage activity (ranking each other’s skin color) and considering whether our school community demonstrates attitudes, assumptions, and patterns of behavior that are consistent with these other skin color studies.

Continuing with their groups, students will use the framework provided by their notes to propose and design a study that could be conducted in the school community. The teacher will consult with each group to help them in isolating a possible research question, determining the necessary data for collection, variables, etc.

EVALUATION

1. Informal assessment via dialogue and conversation regarding the Barbie Doll test

2. Peer review of posters during Carousel
3. Submission of experimental design

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Relevance of content- The instruction on scientific method/experimental design is typically conducted using experiments that have little significance or familiarity to students. By focusing on a subject that is immediately important to them and impacts them every day of their life, the students immediately have a stronger reason to engage with the content.
2. Focus on societal implications, social justice, and power structures- For students with minority backgrounds and non-mainstream cultures, teachers need to prove the necessity for students to receive an education. The rationale that education is needed to obtain meaningful employment is often ineffective. A more effective argument can be made for the relationship between education and power. By choosing topics that explicitly explore social inequities and power structures, students gain a greater authentic understanding of their own need to be educated in order to combat, confront, and change these structures within their own lives and communities.
3. Explicit distinction and instruction in both home language and academic language- Instruction on the design of controlled experiments initially begins using language that is more familiar to the students. The scientific vocabulary is only introduced after students have grappled with the concepts of experimental design in more familiar terms and they are first encouraged to talk with each other and the teacher in this more familiar language. The students and the teacher engage in a collaborative endeavor to find the synonyms and connections that will help students retain and apply the academic language more effectively.
4. Group Work- Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition.
5. Pick-a-stick- This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message that while working in groups every individual is still responsible for participating and understanding the content.
6. Roll 'Em- This strategy helps to ensure that every individual is participating in group work. It particularly obligates group members to be cognizant of engaging every other member in the group and ensuring that every individual has an understanding of the group's thoughts, findings, and questions. To implement, each group is assigned a number (1-6) and each individual within each group is also assigned a number (1-6). The teacher rolls a pair of dice. The two numbers identify the group # and the # of the individual in the group who must share.
7. Carousel- This strategy draws on students' cultural connections with movement. It authentically incorporates movement into instruction by giving a meaningful reason for students

to move about the room while also engaging in critical thinking and evaluation of their peers' work. Thus it also brings back a sense of communal accountability. By failing to provide thoughtful feedback to their peers, not only do they lose out on gaining understanding of issues that are significant to them but they also impair their peers' growth and understanding of the content.

8. Acknowledgment of Student Home Culture- When asking for feedback on how to improve experimental designs, the legitimacy of non-scientific improvements are acknowledged but not devalued. Instead of dismissing them as wrong, they are met with the acknowledgement that, while it may be an improvement from one person's perspective, it does not work to improve the reliability or validity of the experimental results and therefore would not be appropriate for a scientific critique.

Extensions and Additional Resources:

Depending on time, resources, and student interest, teachers may wish to actually have their students conduct the experiments/studies that they designed. Ultimately, such research within the students' own community could be the basis for challenging and transforming a school's climate. Students could continuously refine their experiments, collect more data, and share findings with the school as a whole to begin opening up authentic dialogue about how race, ethnicity, and other factors are positively or negatively impacting their school community and what can be done about it.

Skin (2008)- movie based on the true story of a black girl born to two white Afrikaners in South America. This movie has received positive reviews from many middle school students and provides an excellent way to connect students with cultural roots while also looking at the sociopolitical role of skin color in countries other than the United States.

"Desiree's Baby" by Kate Chopin, *Vogue Magazine*, January 4, 1893- tells the story of a married couple in Louisiana whose marriage is torn apart with the discovery of the wife's African heritage that manifests in their son's skin color. This story begins to hint at the genetics behind skin color and raises a question that often puzzles students: can you be white but have black parents or vice versa.

CRT Lesson #7: Colorful Selections

Subject/ grade level: Living Environment (but could be revised and implemented for intermediate science 7-8)

Topic: Natural Selection

Materials:

- Dixie Cups (numbered on bottom to put students into partners)
- Jelly Beans (jelly bellies work best)
- Laptops
- Jelly Bean Simulation Handouts
- Natural Selection Notes
- Poster Paper

NYS Standards:

Standard 4 Living Environment: Students will understand and apply scientific concepts, principles, and theories pertaining to the living environment and recognize the historical development of ideas in science.

Key Idea 3- Individual organisms and species change over time.

Performance Indicator 3.1- Explain the mechanisms and patterns of evolution

Major Understandings:

- 3.1f Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.
- 3.1g Some characteristics give individuals an advantage over others in surviving and reproducing, and the advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase.
- 3.1h The variation of organisms within a species increases the likelihood that at least some members of the species will survive under changed environmental conditions.

Lesson objective(s):

Students will be able to...

- Predict the role of variations in the survival of a species
- Explain the survival value of different variations

- Model the impact of variations according to the framework of natural selection

ENGAGEMENT

As students come in to the classroom, they will pick up a “Jelly Bean Variation” handout¹ along with a cup full of jelly beans. Students will begin to work independently on identifying the different color variations in their jellybeans, classifying them into groups, and counting up their frequency. Students may choose to classify jelly beans in different ways. For example: one student may lump all green jelly beans into one group while others may divide them into light green and dark green. Students should also independently answer the two questions on the front of the work sheet. Students who finish this early may begin to work on the predictions on the back of the worksheet. No one should eat their jelly beans until they are told they can.

EXPLORATION

When all students are finished, tell them that they need to get into groups of two and that their partner has already been determined by the number on the bottom of their cup of jelly beans. Students should partner up with the individual who has the same number on the bottom of their cup. With their partners, they will compare their results in jelly bean classification and variation². This is an opportunity for them to clarify their understanding of the term variation by discussing it with a peer as they consider whether their jelly bean “populations” had high or low levels of variation. They will also work with their partners to complete the predictions on the back of their work sheet. The reasoning for the first prediction question on the back should be modeled so that students understand the type of thinking they will need to go through and the quality of response that is expected. When everyone is clear on directions, give them 30 seconds to find their partners, get seated, and get started. It may be appropriate to play music while they move to meet their partners³.

After each partnership has had time to address the prediction questions, use pick-a-stick⁴ to select students to share out their responses to each question respectively. After each response, ask their peers to clap once if they agree with the reasoning they heard⁵. Ask for volunteers to express why they agree or disagree with the responses offered.

After reviewing all student predictions with regard to the jelly bean simulation, ask students to write a short gist statement on their paper that summarizes the impact of variation on a population. Give students 1-2 minutes to write this down, then select several students using pick-a-stick to share their gist statements. Keep eliciting gist statements until it has been established that higher levels of variation are generally good for helping a population survive.

EXPLANATION

Next, explain to students that they will have the opportunity to choose between 1 of 4 areas of variation in organisms whose survival value they want to investigate. These 4 areas are: human skin color, sexual dimorphism, aposematism, or camouflage in organisms⁶.

Provide a brief explanation of aposematism (the use of colors, smells, etc. as warnings for other organisms) and sexual dimorphism (physical differences between males and females in a species).

Inform students that they will be researching this topic and will be presenting their findings to their classmates. In their research, they will be providing examples of the observable variants, the survival value of these variants, and ultimately will be trying to explain how these variants developed. However, in their first round of research, they will be focusing primarily on the first two areas (examples and survival value).

Designate one topic for each corner of the room (Corners Protocol⁷) and give students one minute to choose their topic and move to that corner of the room. Again, moving music may be appropriate. After students have sorted themselves in to corners, any corner that has more than 6 people will be divided into two smaller groups⁹.

Give the students 15-20 minutes (adjusted as needed) to begin their research and find adequate examples of their topic as well as reasonable, accurate, and thorough explanations of its survival value. When students have reached this point, distribute the “Natural Selection Notes” handout and recall students attention to the front of the room (auditory cues such as clap patterns or “When I say class, you say yes” are useful for managing this transition⁸).

Concisely walk students through the natural selection notes and illustrate the concept using an organism of your choice (peppered moths, finches, bacteria, rabbits, etc.).

ELABORATION

Armed with these notes, students will revisit their topic and will work to fit its survival value into the framework of natural selection that has just been provided. They may continue to use internet research to support their thinking.

Students are to summarize their research and reasoning by creating a final group product (poster, PowerPoint, skit, comic, etc.) that defines their topic, provides examples, explains its survival value, and proposes how these variants (or one example of these variants) developed using the natural selection framework.

To share out findings with their peers, the class will participate in a gallery walk¹⁰ to survey each other’s work. At each final product, individuals will write 3 things they learned from their peers’ products and these reflections will be turned in as a ticket-out-the-door.

EVALUATION

1. Responses to Questions through Pick-A-Stick
2. Informal Group Assessment- using claps for agreement with peers
3. Sharing of Gist Statements

4. Groups Products
5. Ticket-Out-the-Door

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Simulation- Although the jelly bean simulation is not as concrete or accurate as a simulation using actual organisms, it provides an accessible entry point for all students while reinforcing basic skills of classification and tabulation. It provides a nonthreatening introduction to a topic while also being concrete and tactile.
2. Partner Conferencing- This group work protocol allows students to compare the information that they gleaned from an activity and to clarify their understandings with their peers before having to submit their work to the critique of the teacher or the whole class.
3. Move to Music- This management/transition strategy pairs time constraints with auditory cues and provides a meaningful way to incorporate music, rhythm, and motion into the classroom with a flare of fun.
4. Pick-a-Stick- This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message that while working in groups every individual is still responsible for participating and understanding the content.
5. Claps and Snaps- asking for student concurrence with a clap/snap/stomp/whatever creates whole class participation while listening to one student's response and gives the teacher a chance to assess all students while incorporating African traditions of rhythm.
6. Relevance of Content- For students at the high school level, questions about race and gender are often at the forefront of their thinking as they are beginning to gain awareness of the implications of these two constructs. By placing these constructs within the framework of variation and natural selection, it gives students one possible framework through which to investigate them and to compare their findings with their personal and cultural experiences/beliefs.
7. Corners- This protocol allows students to choose the topic/issue that is most important/relevant to them. It develops student-choice interest groups and sets students with the task of finding evidence to support their opinions and positions.
8. Auditory Cues (Clap patterns, "Class, Yes") - These are simple classroom management cues that can be taught and used throughout the entire school year to facilitate transitions in the classroom. These auditory cues draw on the cultural backgrounds that emphasize sound and rhythm.
9. Group Work- Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to

talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition.

10. Gallery Walk- The gallery walk is an authentic way to incorporate movement into the classroom. Students have a structured path and task that they need to complete as they move to each groups' product. This also promotes cooperative learning as each group is responsible for the learning of their peers from their respective products.

**11. Focus on societal implications, social justice, and power structures- This is an optional extension for further investigation into skin color. For students with minority backgrounds and non-mainstream cultures, teachers need to prove the necessity for students to receive an education. The rationale that education is needed to obtain meaningful employment is often ineffective. A more effective argument can be made for the relationship between education and power. By choosing topics that explicitly explore social inequities and power structures, students gain a greater authentic understanding of their own need to be educated in order to combat, confront, and change these structures within their own lives and communities.

Extension and Additional Resources:

<http://humanorigins.si.edu/evidence/genetics/skin-color> - The Smithsonian provides extensive background on the genetics, origins, and diversity of human skin color. This may serve as a jumping off point for students to examine the origins of humans and why/how skin color has changed over time. Looking at the science behind skin color provides the framework for students to examine the basis for the concept of race and how this concept has led (or resulted from) political, societal, and economic inequity¹¹.

CRT Lesson #8: Water, Water Everywhere

Subject/ grade level: Living Environment (but could be revised and implemented for intermediate science 7-8)

Topic: Human Impacts on Environment, Conservation

Materials:

- 5 gallon jugs filled with water
- Poster paper
- Index cards labeled with the Great Lakes (to divide students into groups)
- Global Water Shortage Graphic Organizer
- Pennies- two per student
- Fake water samples: the ocean, Lake Ontario, water from pipes running through a slum, water from a mountain stream, creek water running through the woods (should be reddish from tannins), muddy water
- Copies of the UN Fresh Water Fact Sheet

NYS Standards:

Standard 4 Living Environment: Students will understand and apply scientific concepts, principles, and theories pertaining to the living environment and recognize the historical development of ideas in science.

Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

Performance Indicator 7.1: Describe the range of interrelationships of humans with the living and nonliving environment.

Major Understandings:

- 7.1a: The Earth has finite resources; increasing human consumption of resources places stress on the natural processes that renew some resources and deplete those resources that cannot be renewed.
- 7.1b: Natural ecosystems provide an array of basic processes that affect humans. Those processes include but are not limited to: maintenance of the quality of the atmosphere, generation of soils, control of the water cycle, removal of wasters, energy flow, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental.

Performance Indicator 7.2 Explain the impact of technological development and growth in the human population on the living and nonliving environment.

Major Understandings:

- 7.2a Human activities that degrade ecosystems result in a loss of diversity of the living

and nonliving environment. For example, the influence of humans on other organisms occurs through land use and pollution. Land use decreases the space and resources available to other species, and pollution changes the chemical composition of air, soil, and water.

Performance Indicator 7.3 Explain how individual choices and societal actions can contribute to improving the environment.

Major Understandings

7.3a Societies must decide on proposals which involve the introduction of new technologies. Individuals need to make decisions which will assess risks, costs, benefits, and trade-offs.

7.3b The decisions of one generation both provide and limit the range of possibilities open to the next generation.

Lesson objective(s):

Students will be able to...

- Explain the limitations of the global water supply in terms of available fresh water resources
- Argue whether water is a renewable or nonrenewable resource
- Refute or defend the idea that access to fresh water is a basic human right

ENGAGEMENT

As students come into the room, they should be placed into groups of 5 students¹. Given the topic, it may be appropriate to hand them an index card with one of the names of the 5 great lakes and to have groups of desks set up and clearly labeled with each of the great lakes' names.

When students are seated in their groups, inform them that they will be engaging in the Roundtable² protocol in response to the following question:

Imagine you have access to only one gallon of water per day. What daily actions or routines would you not be able to do? How would your life be different?

It may be helpful to have a gallon jug filled with water³ at each group to help students understand the quantity of water they are considering. Each team will have a single sheet of paper and pencil. They will pass the paper and pencil around the group as each individual state and writes their responses to the question on the paper. Students may pass if they cannot think of anything at the moment. The paper continues to get passed until time is up. When time is called, ask for one volunteer from each group to transfer the group responses onto a poster paper to be posted in the room.

EXPLORATION

While students are transferring responses to posters, hand out the “Global Water Shortage” graphic organizer. Tell students that they are going to watch a short video on water shortages around the world. While they are watching the video, they should be completing their graphic organizer which asks them to consider: where water shortages are occurring, why water shortages are occurring, who is being impacted⁴ most by water shortages, and how it can be fixed. After watching the video, students will be able to confer³ with their group. Depending on auditory processing skills, students may need to see the video a second time after conferencing with their group.

Global Water Shortage Video: <http://www.youtube.com/watch?v=Gg-ac0EaYDQ>

EXPLANATION

Following the video, distribute a glass of water⁶ to each group. Each glass should be labeled as coming from a particular source. Ideas for sources include, but are not limited to: the ocean, Lake Ontario, water from pipes running through a slum, water from a mountain stream, creek water running through the woods (should be reddish from tannins), muddy water. Water samples should look as if they actually came from their sources (add mud/sand to the muddy water sample, food coloring to the tannin-rich sample).

Each group must reach a consensus as to whether they would drink the water in front of them. They have 10-15 minutes to conduct individual research. When time is up, they will use the Put Your Two Cents⁵ In protocol to share their results. Each student will have two pennies. When they place their first penny in the center of the table, they share their research findings and their resultant opinions. After everyone has shared once, they put in their second penny and respond to someone else in the group either by stating “I agree with...” or “I disagree with...” The group must then reach consensus.

Once all groups have reached consensus, discussion will return to whole class. Each group will share out its verdict and their reasoning. The teacher will then dramatically either pour out the water and celebrate the group’s cogent reasoning, or will dramatically pretend to drink the water and suffer from any subsequent side effects:

Ocean water- induced vomiting

Lake Ontario- might taste and smell strange, but largely safe

Water from pipes in slums- parasites, diseases due to excrement contamination

Water from a mountain stream- largely safe, could be harboring parasites/diseases

Creek water through woods- funny color and might taste strange, but largely safe

Muddy water- tastes gross, but probably safe

Of the water samples that students were presented with, ask them which sample should be classified separately from the others. Students should be able to identify ocean water as the only salt water sample while the others are all freshwater. This segues into looking at the availability and use of freshwater on the planet.

Distribute copies of the UN Fresh Water Fact Sheet. Tell students that they will be doing a Train Reading⁷ of the fact sheet. Explain that you the teacher will start by reading the first paragraph out loud and that each student will then read one paragraph and/or bullet. Let students know which direction the Train Reading will flow so that students can identify their section and pre-read it. Allow 3-5 minutes for students to pre-read.

After completion of the train reading, students are to work in their groups to high light the text⁸ according to the following guidelines:

1. Yellow = THE main idea/big idea of the document
2. Pink = unknown vocabulary
3. Blue = examples of social inequity or imbalance in power⁴

As groups finish high lighting their texts, they should designate people to record their responses on classroom posters hung around the room.

Recall students to a whole group debriefing and quickly run through the responses on the classroom posters just completed. Summarize the main ideas presented and define unknown vocabulary.

This is now the opportunity to call students attention to the fact that they live near the Great lakes which constitute one of the largest sources of freshwater on the planet. Given how rare fresh water is in many places, these are an immensely valuable resource. However, this resource is being compromised through pollution.

Ask students to consider what happens to our global water supply if it becomes polluted. Are we able to replenish our water?

ELABORATION

Inform students that their final assessment for this topic will be conducted in the form of a fish bowl^{9, 10}. Students will be responsible for addressing two questions within the fishbowl: Is water a renewable or a nonrenewable resource? Is access to fresh water a basic human right? They will have additional time (at teacher's discretion) to conduction research. The definitions of renewable, nonrenewable, and human right will be as follows:

Renewable Resource- a natural resource that can replenish itself through biological or natural processes

Nonrenewable Resource- a finite resource that does not replenish rapidly enough for economic use at a rate that is meaningful for a human life span

Human Right-universal, equal, and fundamental rights that one is entitled to simply by being human

Each question will be addressed individually. Every student must participate at least twice in the fish bowl for each question (total of 4 times). Student responses must illustrate opinions that are supported by evidence. Students may take notes into the fish bowl with them, but highest quality responses will address other peers' comments and will express agreement, disagreement, or elaboration on previous points.

The fishbowl will consist of an inner circle of 7 chairs and an outer circle with sufficient chairs for remaining students. Students can move freely from inner to outer circle and if a seat is not open, they can ask a peer to move out of the circle by tapping them on the shoulder.

EVALUATION

1. Roundtable Posters
2. Water Shortage Graphic Organizer
3. Put Your Two Cents In
4. Posters from Marking the Text
5. Fish Bowl

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Group Work- Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition.
2. Roundtable- This particular group work protocol validates every student's contributions while also maintaining accountability for all group members. The protocol also is an opportunity to explicitly practice turn taking, a behavioral expectation that is not always explicitly taught in the classroom but which is nearly universally expected.
3. Peer Conferencing- This group work protocol allows students to compare the information that they gleaned from an activity and to clarify their understandings with their peers before having to submit their work to the teacher.
4. Focus on societal implications, social justice, and power structures- For students with minority backgrounds and non-mainstream cultures, teachers need to prove the necessity for students to receive an education. The rationale that education is needed to obtain meaningful employment is often ineffective. A more effective argument can be made for the relationship between education and power. By choosing topics that explicitly explore social inequities and power structures, students gain a greater authentic understanding of their own need to be educated in order to combat, confront, and change these structures within their own lives and communities. Furthermore, a focus on social justice is very much at the core of African American communities and thus draws on students' cultural backgrounds.

5. Put Your Two Cents In- This group work protocol practices explicit turn taking, encourages students to express their own opinions, and plays directly into the strong oral tradition of Latino and African American cultures.

6. Concrete Objects- Although providing gallon jugs of water and glasses with water samples is not essential to students working through this lesson, these concrete objects give students a real example of the issues that they are working with. In many instances, an understanding of volumes and/or cleanliness of water may be nowhere within the students' realm of experience. Providing these objects helps to provide this experience instead of leaving it up to their imaginations.

7. Pre-Reading and Train Reading- Train Reading maintains the expectation that all students participate in reading and reinforces the necessity of the skill. However, by allowing students to pre-read, it allows weaker readers to be comfortable with reading out loud as they can practice their fluency and pronunciation of unfamiliar words.

8. Marking the Text- This strategy gives students an opportunity to interact in a meaningful way with a text. It gives them the freedom to identify words that are unfamiliar to them and validates their home cultures by asking them to identify a main idea (whatever idea is most important to them) and to analyze those instances that suggest inequities in social justice and power structures.

9. Fishbowl- The fish bowl protocol provides a community forum experience while allowing students to argue with each other and express their opinions in a structured format. It allows students to enter the dialogue when they are comfortable and at points in the dialogue that are most important to them.

10. Acknowledgment/Affirmation of Home Culture- Often in the academic world, particularly in science, students are told what they are supposed to think and believe. These prescribed beliefs often conflict with the beliefs and morals of a student's home culture and can lead those students to approach the content with skepticism, anger, a refusal to engage, and often complete shutdown. By allowing students to express their overall judgment on an issue, students may still hold to their home culture while subjecting it to the critical lens of the understandings that they have gained on the topic.

Extension and Additional Resources:

1. Blue Gold- This documentary investigates the scarcity and distribution of water and the role/value it could end up having globally in the near future.

2. Water for Sudan- this is a local charity that seeks to raise money and resources to provide clean drinking water for Sudan while also making people aware of the political and social climate in Sudan. Students may wish to become involved with this charity and/or Salva could be invited in to the classroom to speak to students about his experience growing up in Sudan.

CRT Lesson #9: How to Feed 7 Billion

Subject/ grade level: Living Environment 9-12 (but could be revised and implemented for intermediate science 7-8)

Topic: Population Growth and Food Supply

Materials:

- Copies of “How to Feed 7 Billion” Handout
- Copies of “How to Feed 7 Billion” Rubrics
- Oreo (enough for one per student)
- 6 Paper plates
- 5 Continents (with map) posted around classroom
- Slips of paper with continent names in quantities as listed in below simulation
- Smart board (or projection device)
- Computers (one per student)

NYS Standards:

Standard 4 Living Environment: Students will understand and apply scientific concepts, principles, and theories pertaining to the living environment and recognize the historical development of ideas in science.

Key Idea 6: Plants and animals depend on each other and their physical environment.

Performance Indicator 6.1 Explain factors that limit growth of individuals and populations.

Major Understandings:

6.1d The number of organisms any habitat can support (carrying capacity) is limited by the available energy, water, oxygen, and minerals, and by the ability of ecosystems to recycle the residue of dead organisms through the activities of bacteria and fungi.

6.1f Living organisms have the capacity to produce populations of unlimited size, but environments and resources are finite. This has profound effects on the interactions among organisms.

Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

Performance Indicator 7.2 Explain the impact of technological development and growth in the human population on the living and nonliving environment.

Major Understandings:

7.2a Human activities that degrade ecosystems result in a loss of diversity of the living

and nonliving environment. For example, the influence of humans on other organisms occurs through land use and pollution. Land use decreases the space and resources available to other species, and pollution changes the chemical composition of air, soil, and water.

- 7.2b When humans alter ecosystems either by adding or removing specific organisms, serious consequences may result. For example, planting large expanses of one crop reduces the biodiversity of the area.

Performance Indicator 7.3 Explain how individual choices and societal actions can contribute to improving the environment.

Major Understandings

- 7.3a Societies must decide on proposals which involve the introduction of new technologies. Individuals need to make decisions which will assess risks, costs, benefits, and trade-offs.

- 7.3b The decisions of one generation both provide and limit the range of possibilities open to the next generation.

Lesson objective(s):

Students will be able to...

- Analyze the challenges behind feeding a world population of 7 billion
- Describe different solutions for maintaining a sustainable global food supply
- Evaluate the feasibility of implementing different solutions for maintaining a global food supply

ENGAGEMENT

Open the class with the following video. Inform students that this short YouTube video provides a model for population growth on Earth over time. After watching the video once, tell students that you are going to play the video a second time and after that second viewing, they will be reflecting on three questions:

1. What factors have decreased the death rate/mortality rate over time?
2. What factors have led to an increased birth rate?
3. What challenges does such population growth pose for the future?

Video Link: <http://youtu.be/VcSX4ytEfcE>

After students have had time to write down their thoughts on the 3 questions, use the “Stick and Roll”¹ protocol to elicit answers from students. As novel answers are offered, ask students to clap once (or other simple percussive gesture)² to show how many came up with that same response.

This exercise should enable students to share any number of their ideas and can be used to review the concept of limiting factors. If it does not come up naturally through sharing out responses, the teacher should use questioning to help students identify increased food supply and improved nutrition as one of the factors decreasing mortality rate while also raising the challenge of feeding 7 billion (or more) people.

EXPLORATION

To investigate the challenges of feeding 7 billion (or more) people, conduct the following simulation³. Provide each student with a slip of paper that designates them to one of the following 5 continents. The number of students per continent is scaled to current population statistics. If a class is larger than 20 students, these additional students can be distributed to maintain rough proportionality. Alternatively, they can be used for the final stage of the simulation. The 5 continents should also be labeled clearly around the room (preferably with a map image of each continent as well).

Asia- 12 students

Africa- 3 students

Europe- 2 students

North America- 1 student

South America- 1 student

Explain to students that the population of the world has been scaled down from 7 billion to the size of the class and the students are being distributed to each of the continent proportionally. You can even note that one student is the equivalent of about 400,000,000 people.

Give students exactly 30 seconds to move to their continent. It may be appropriate to play music¹⁰ as an auditory cue for movement. When the music stops, students should be at their continent. Next, reveal a plate of Oreo cookies (with enough cookies for each student in the class to have one) that represents the world food supply at present⁴. In this simulation, we can say that each Oreo cookie represents sufficient energy to ensure each student's survival.

Ask the students: "Based on the number of cookies and the number of students, what can we infer about the food supply on Earth?" Wait for multiple students to have hands raised before soliciting answers.

Next, inform students that you are going to distribute food to their continents and that they can only "eat" the food that is delivered to them. Oreo cookies should be delivered to the continents in the following approximate proportions:

Asia- 1 cookie

Africa- 2 cookies

Europe- 5 cookies

North America- 9 cookies

South America- 3 cookies

Ask students: “Based on the number of cookies delivered to your continent, what will be the impact on your continent’s population?” As before, wait for multiple students to have answers for sharing. After sharing out, ask students which they think is a more realistic distribution of food: raise a fist for the first scenario, an open hand for the second⁵.

For the final portion of this simulation, we will project into the future. If all students were not yet participating in the simulation, add any remaining students to the populations of Asia, Africa, and South America. Otherwise, you can ask students to imagine that additional students were added to those continents, and/or you can redistribute students from other continents to model the declining birth rate in North America and Europe. For this portion of the simulation, the number of Oreos remains the same as in the prior stage. Again, elicit responses from students: What does this distribution of food mean for these populations?

To wrap up the simulation, ask for a student to summarize the main idea of the simulation. To flesh out the general concepts, use pick-a-stick¹ to elicit responses to the following questions:

Who can elaborate on what was just said?

How did the three phases of the simulation compare with each other?

Do you concur with what was just said?

Who can break this down into the primary challenges of food supply?

EXPLANATION

Through the simulation, students should have been able to identify both food distribution and scarcity as the root challenges in maintaining a global food supply.

Students will then receive a graphic organizer (see the “How to Feed 7 Billion” handout) that lists 4 possible approaches to increasing the world’s food supply as well as the concept of food deserts (which begins to look at food distribution in the United States). Students will complete the first column of the graphic organizer (“What it sounds like to me”) independently. Students must be assured that there are no wrong answers in this first column as they are using their prior knowledge to predict what these different terms refer to⁶. Next, students will conduct independent research on the computer to complete the second column of the graphic organizer (“What I think it means now...”). Then have students find a partner⁷, discuss their findings, and complete the third column (“What we think it means”).

Once all partner pairs have completed the third column, the class will debrief as a whole group. The teacher will ask for volunteers to share out their understandings of each term and these will be shaped into responses to complete the final column of the graphic organizer (“What it means in the scientific community”). This final column is where the teacher provides formal definitions along with any pertinent details or examples⁸.

ELABORATION

Having completed their graphic organizers⁹ and having a basic idea of each of the 5 issues surrounding food supply and distribution, students will then select one of the 5 areas that they want to pursue further. They will be working with a small group to create an informational brochure, poster, multimedia PSA, or other artifact that summarizes the root challenges in feeding 7 billion people and which thoroughly explains and evaluates the potential solution they researched (in the case of Food Deserts, they will explain the causes and effects of Food Deserts and will identify and evaluate actual programs that have been implemented to remediate Food Deserts).

Using a modified version of the Corners¹¹ protocol (may need to use area other than corners depending on classroom set-up); space should be designated for each of the 5 topics. Tell students that they have exactly one minute to silently select the topic they want to study further and to move to that location. It may be appropriate to play music¹⁰ and have a timer visible as students make their choice and move.

Within their “Corners” students should work as a group to identify areas that they need to research, questions they need to answer, and other information that they want to uncover on their topic. Depending on the research skills, literacy levels, and time management skills of the students, the teacher may need to provide a greater scaffold for their research by providing guiding questions and/or pieces of information that they need to find and perhaps even providing initial websites and resources to use.

Students should be reminded that their final product is what will be presented to their peers and the group will have the responsibility of explaining their topic to their classmates. Presentations and final products will be evaluated using the “How to Feed 7 Billion” rubric.

EVALUATION

1. Video reflection using Stick and Roll protocol
2. Informal discussion during simulation
3. Graphic Organizer
4. Final Products and oral presentations

Student’s final product will either be a flier, informational brochure, or multimedia PSA that summarizes the root challenges in feeding 7 billion and which thoroughly explains and evaluates one of the potential solutions for developing a sustainable food supply. These documents may then be compiled and made available to the school as a whole to build social awareness

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Pick-A-Stick- This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message

that while working in groups every individual is still responsible for participating and understanding the content. In this lesson, a variant of the protocol is used wherein a dice is rolled to determine which question the student whose name has been selected will answer.

2. Claps and Snaps- Asking for student concurrence with a clap/snap/stomp/whatever creates whole class participation when listening to one student's response and gives the teacher a chance to assess all students while incorporating African traditions of rhythm.

3. Simulation- The simulation of food distribution is an easy way to engage every student while meaningfully incorporating movement into the lesson. The simulation also takes an issue that students are probably already aware of in their own lives and allows them to see it in the world as a whole. It physically places students into groups that appear to be receiving an unfair quantity of resources while others have nothing. This evokes authentic reactions and engagement from students when they become outraged at the inequity.

4. Relevance of content- Food and meals holds an important role in most cultures. The meal is a special symbol of community and family and most students readily respect the importance of this group tradition. At the same time, since so many of these students come from impoverished or nutritionally impoverished families, this lesson resonates with their perspectives and home life.

5. Focus on societal implications, social justice, and power structures- When students see the inequity both in their lives and globally (as related to food distribution and access) it generally sparks intense emotion and a call to action and change. This topic is one that can be carried into the students' communities and can be used to promote action for social equality which has deep roots in African American culture.

6. Acknowledgment/Affirmation of Student Home Culture- The graphic organizer that students complete begins with their prior knowledge, their interpretation of words, and the meaning they derive from academic terminology. This provides the first step in showing students how they can code switch between their own way of speaking and the way of speaking that is accepted in academic circles while still validating both.

7. Group Work-Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition. In this lesson, it also drives home the point that meaning and knowledge can be made by collaborating with one's peers and it illustrates the path in moving from prior knowledge and home language to academic language and understanding.

8. Teacher as Elder-After students have worked with their peers to build meaning, the teacher finally steps in, in the role of the elder that adults are often perceived as holding in African and Latino cultures. The teacher provides the final bridge from student understanding and language to the academic/scientific language. In this role, the teacher as elder should take student words and mold them into the more formal structures that are expected in the academic world.

9. **Explicit Bridging from Home Language to Academic Language-** The entire graphic organizer is an explicit way of illustrating how students can begin to move from their home language to academic language with or without the assistance of an adult. It should also illustrate how their home language may mean the same thing as academic language, but that each way of speaking should be used in appropriate situations. When working with their peers to make meaning, it is appropriate to use a mix of home language and academic language. By the end of the lesson when they present to their peers, however, they should have moved primarily to academic language and they should be teaching their peers to speak it.

10. **Move to Music-** This management/transition strategy pairs time constraints with auditory cues and provides a meaningful way to incorporate music, rhythm, and motion into the classroom with a flare of fun.

11. **Corners-** This protocol allows students to choose the topic/issue that is most important/relevant to them. It develops student-choice interest groups and sets students with the task of finding evidence to support their opinions and positions.

Extension and Additional Resources:

1. Student final products can be compiled into one larger document that can be distributed to the school community.
2. Classes may want to look further into world hunger and may work to organizer fundraisers for charities that provide food relief.
3. Students may identify with the concept of food deserts in their own city. While they may not live in complete food deserts, students may gain awareness of the lack of nutritional choices available to them and could pursue the establishment of a community garden at their school and/or could conduct further research and write letters to their elected representatives at different levels of government expressing concerns about lack of nutritional options within the city and articulating possible solutions.
4. Relevant documentaries on food supply and production include:
 - *King Corn* (2007)
 - *Super Size Me* (2004)
 - *Food Inc.* (2009)
 - *Food Fight* (2008)

CRT Lesson #10: Cell Culture Clash

Subject/ grade level: Living Environment 9-12 (could be revised and used at Middle School level as well)

Topic: Ethics and Biotechnology

Materials:

- Excerpt from *The Immortal Life of Henrietta Lacks*
- Copies of the predictions, questions, facts table
- Computers for each student

NYS Standards:

Standard 1: Students will use mathematical analysis, scientific inquiry and engineering design, as appropriate to pose questions, seek answers, and develop solutions.

Key Idea 1: The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing and creative process.

Performance Indicator 1.1: Elaborate on basic scientific and personal explanations of natural phenomena, and develop extended visual models and mathematical formulations to represent one's thinking.

Major Understandings:

- 1.1a Scientific explanations are built by combining evidence that can be observed with what people already know about the world.
- 1.1b Learning about the historical development of scientific concepts or about individuals who have contributed to scientific knowledge provides a better understanding of scientific inquiry and the relationship between science and society.
- 1.1c Science provides knowledge, but values are also essential to making effective and ethical decisions about the application of scientific knowledge.

Lesson objective(s):

Students will be able to...

- Identify and explain the contributions made to science through the use of HeLa cell
- Explain why individuals need to be scientifically literate in modern society
- Analyze the role that societal status may play in scientific/medical ethical violations
- Evaluate the ethical decisions made in the HeLa case considering historical facts, subsequent scientific developments, and social justify

ENGAGEMENT

Think-Pair-Share³: As students enter classroom, they will be presented with the following hypothetical scenario on the board (or on paper). They are to silently read the scenario to themselves and then reflect on the questions posed.

Hypothetical Scenario-Imagine you are a musician who has just produced your first EP. Before you manage to release your EP, a record company claims the digital content as their own and sells 74,000 copies of your record.

Questions:

1. If the EP is being sold for \$5, how much money did the record company make off of your work?
2. How would you feel if your work had been taken and sold without your permission? Have you ever had a similar experience?
3. Why is this scenario unlikely to happen in the recording industry and what actions could an artist take if it *did* happen?

After students have reflected silently, they will share their thinking with a partner. Using the “Raise a Righteous Hand”⁴ protocol, students will volunteer to share their thoughts and experiences.

The big idea which should emerge through teacher facilitation of discussion is that the music industry is largely protected by copyright laws which provide artists with legal protection for their work. These laws help to limit (or provide compensation) for individuals whose musical property is stolen and used by someone else for financial gain. This knowledge of copyright laws translates into power, protection, and financial gain for those who understand their legal rights.

The question that should then be posed to students is: “What happens when you don’t know your legal rights?”²

EXPLORATION

“What happens when you don’t know your legal rights?”

To begin exploring this question, students will be provided with an excerpt from *The Immortal Life of Henrietta Lacks*^{1,6}.

The exact approach for reading through the excerpt will depend on the reading level and confidence in oral reading of the class⁷.

For lowest level classes:

Teacher Read Aloud: The teacher reads the entire text aloud to students in chunks. After each chunk, students independently complete a predictions, questions, facts table.

For classes with mixed reading levels:

Train Reading: the teacher reads the first chunk of the text aloud, and then selects the next student to read, and so on. After each chunk of text, students complete the predictions, questions, facts table.

For classes with more independent readers:

Students are placed in groups of 4. Each student takes a turn reading a chunk of the text. After each chunk of the text, students complete the predictions, questions, facts table. The teacher should be moving between groups monitoring for participation and shared reading.

At the end of the reading. Students should write a 3-5 sentence gist statement summarizing the main ideas that they took away from the excerpt.

EXPLANATION

Using the whip around⁵ protocol, the teacher has every student share out one take away idea from their gist statement, an unanswered question they have from the reading, or a reaction that they have to the reading. Teacher should model a response and should have possible sentence starters posted on the board:

- One question I still have is...
- After reading this passage, I feel...
- One idea I took away from this reading was...

After completion of the whip around, a whole class discussion should occur around the following questions:

1. What is the significance of the fact that Henrietta Lacks has so long been ignored by science?
2. Why do you think the author's biology professor felt the need to point out that Henrietta Lacks was black?
3. Do you think this would have happened to someone who was richer, whiter, or better educated?
4. What are the ethics behind this story? Who actually has ownership rights to these cells? Why is this a big deal? Is it a big deal?

Some students may not grasp the actual subtleties and ethical concerns over ownership of cells without some more concrete information.

In the bellwork, students estimated the financial cost of 74,000 records sold at \$5 apiece to be

about \$375,000. The number 74,000 is not arbitrary but rather is an estimate of the number of science experiments that have made use of HeLa cells. In current science supply catalogs, a HeLa cell culture sells for \$350. This translates into a financial gain of \$25,900,000 that was denied to the Lacks family.

Share with the students the actual resolution to the Lacks' families concerns over HeLa cell property rights: <http://www.nbcnews.com/health/nih-finally-makes-good-henrietta-lacks-family-its-about-time-6C10867941>.

ELABORATION

So far, we have looked particularly at the financial end of HeLa cells and at the social injustice. But what about the scientific developments that emerged from the cultivation and use of HeLa cells? Do these in any way ameliorate the injustice or do they exacerbate it?

In order to fully understand the significance of the HeLa cells to scientific developments, students will conduct individual research on any one of the many areas identified in the article.

Jigsaw⁸- Students will be placed in groups of 5 and as a group they will decide what 5 areas they want to research and who will research each one. Each student will conduct individual research on the topic and will generate a 5-7 slide presentation. When presentations are completed, the groups will then reconvene and each student will teach their group about their respective topics.

EVALUATION

Informal assessment via Think-Pair-Share and Whip Around Protocols along with whole class discussion.

Biotechnology presentation from Jigsaw

Final Summative Assessment: Students will write a multi-paragraph composition addressing all of the following questions:

- 1) Has the Lacks family been fairly compensated for the HeLa cells?
- 2) How can such an instance be avoided in the future?
- 3) Could this still happen today?
- 4) Overall, was it right or wrong for doctors to cultivate Henrietta Lack's cells despite her explicit refusal to let them do so?⁹

Responses must use evidence and information from both the reading and students' presentations on biotechnological applications of HeLa cells.

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Relevance of Content- This lesson is structured entirely around an instance of a minority family with whom students from that same background can readily feel kinship. Because the subject of the lesson revolves around individuals who share the student's culture, there is a greater desire for students to engage with the lesson.
2. Focus on societal implications, social justice, and power structures-For students with minority backgrounds and non-mainstream cultures, teachers need to prove the necessity for students to receive an education. The rationale that education is needed to obtain meaningful employment is often ineffective. A more effective argument can be made for the relationship between education and power. By choosing topics that explicitly explore social inequities and power structures, students gain a greater authentic understanding of their own need to be educated in order to combat, confront, and change these structures within their own lives and communities. This lesson in particular provides a definite example of a family that was exploited partially due to their lack of medical/scientific knowledge thus providing a real urgency for students to achieve scientific literacy.
3. Think-Pair-Share- The TPS protocol forces students to draw on their prior knowledge and beliefs before looking to the teacher for answers. It also fosters group work and communication with peers and draws on the oral and communal traditions of many student cultures
4. Raise a Righteous Hand-This protocol explicitly practices turn-taking, thus giving students the opportunity to actively practice a skill/behavior that is often expected in the traditional classroom but with which many students from other cultures lack practice. It also provides students with the opportunity to voice personal experiences and reinforces the value of those personal experiences as students are given their particular turn to speak their thoughts.
5. Whip Around- This is protocol allows students to practice explicit turn taking, but it does so at a rapid pace. It maintains accountability for every student in the room, checks for overall understanding, but does so while validating every student's response.
6. Culturally Relevant Text- *The Immortal Life of Henrietta Lacks* is an excellent text that provides a nonfiction source with a cultural perspective that is more closely aligned with the students and therefore is likely more relevant to them.
7. Responsive Literacy Strategies- For students who are struggling readers from other cultural backgrounds, reading aloud often serves to draw on oral storytelling heritages which can serve as a cultural base for students to engage with text. Reading aloud, either as a whole class or in small groups also reinforces the communal nature of learning. If the teacher is the individual reading aloud it also highlights the teacher's role as the elder of the community.
8. Jigsaw- The jigsaw protocol is a method of implementing group work and reinforcing interdependency and accountability within a small group. Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage

while also giving students opportunities to talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition.

9. Acknowledgment/Affirmation of Home Culture- Often in the academic world, particularly in science, students are told what they are supposed to think and believe. These prescribed beliefs often conflict with the beliefs and morals of a student's home culture and can lead those students to approach the content with skepticism, anger, a refusal to engage, and often complete shutdown. By allowing students to express their overall judgment on an issue, students may still hold to their home culture while subjecting it to the critical lens of the understandings that they have gained on the topic.

Extension and Additional Resources:

Immortal Life of Henrietta Lacks by Rebecca Skloot- students may wish to continue reading the full book.

Teachers may also wish to challenge students by asking them to research and identify other instances, current or historical, in which minority populations have been exploited or manipulated due to ignorance in the areas of science (or mathematics).

CRT Lesson #11: In the Beginning

Subject/ grade level: Earth Science 9-12

Topic: Origin of the Universe

Materials:

- Computers
- Big History Project Question sheets
- poster paper
- Projector/DVD player
- Digital copy or DVD of How the Universe Works: The Big Bang

NYS Standards:

Standard 4 Physical Setting: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 1: the Earth and celestial phenomena can be described by principles of relative motion and perspective.

Performance Indicator 1.2: Describe current theories about the origin of the universe and solar system.

Major Understandings:

- 1.2a: The universe is vast and estimated to be over ten billion years old. The current theory is that the universe was created from an explosion called the Big Bang. Evidence for this theory includes: cosmic background radiation and red shift (Doppler effect) in light from very distant galaxies.
- 1.2c: Our solar system formed about five billion years ago from a giant cloud of gas and debris. Gravity caused Earth and the other planets to become layered according to density differences in their materials.

Lesson objective(s):

Students will be able to...

- describe current scientific theories about the origins of the universe/solar system
- articulate and assess their own preconceptions about the formation of the universe/solar system
- dialogue with and critique others' understandings about the origins of the universe

ENGAGEMENT

On a piece of notebook paper, have students respond to the following questions. Assure them that their answers will be private unless they wish to share them!:

1. How old are you?
2. How old do you think the Earth is?
3. How old do you think the universe is?
4. How do you think the universe was created?

EXPLORATION

Once students have reflected on what they already believe and know, ask for volunteers who are willing to share how they believe the universe was created^{1,4}. If no one wants to share, that's fine. Generally, some students are more than willing to proclaim that they believe in the Bible, or that God created the planet, or that they "believe" in the Big Bang.

Explain to students that everyone has their own personal beliefs about how the universe and everything in it was created^{1,4}. In this lesson, they are going to explore how scientists explore the origins of the universe and the evidence that scientists use to support their explanation.

They will begin by picking up a laptop and going to the Big History Project at the following url: <https://www.bighistoryproject.com/pages/syllabus#>

Students will independently watch the videos and will respond to the questions on the Big History Project handout. Students are welcome to watch the videos more than once and they are free to explore other parts of the website as well, but they must be done in 20 minutes.

When students have completed their questions, instruct them to get into groups of 3². The teacher will give each group a number, and each person in the group must claim a number 1-3. In their groups, they will have 8 minutes to check their answers from the website, brainstorm questions that they have about the Big Bang and origins of the universe, and discuss how they feel about a theory that scientists can't fully explain. Do they accept it or not and why?

When the 8 minutes are up, the teacher will use the Roll'Em³ protocol to select a group member to share out a summary of the group's discussion: how do they feel about the Big Bang theory and what questions do they have. Questions raised by groups should be recorded on a sheet of poster paper.

EXPLANATION

In addition to any questions raised by students, be sure to get on to the question list “What evidence exists to support the Big Bang theory?”

Be sure to explain to students that the Big Bang is an extremely sophisticated concept and the origin of the universe is a topic of interest to top scientists. While much of the science behind it might be challenging or beyond them at this point in time, that simply means that they need to continue to develop their scientific understanding to rise to that challenge. The difficulty of the content is not grounds for choosing to not believe in it.

To further their understanding and knowledge of the formation of the universe, student will watch episode 1 of *How the Universe Works: The Big Bang* (available through Netflix).

While watching the movie, students should be attempting to find answers to the questions that they posed and they should be making notes about the evidence used to support the Big Bang Theory (the episode distinctly talks about both the Doppler effect and cosmic background radiation). It may be appropriate to pause the movie throughout in order to simplify, summarize, and explain some of the content being presented.

ELABORATION

Once the movie is complete, have students complete the following ticket-out-the-door:

1. What is your understanding of the Big Bang Theory and the evidence supporting that theory?
2. What questions do you still have?
3. How does the scientific explanation for the origins of the universe align with your own explanation for the origins of the universe'?

EVALUATION

1. Big History Project Questions
2. Sharing out from groups via Roll’Em
3. Ticket-Out-the-Door

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Affirmation/validation of student home culture- Studying this topic often has the unintended side effect of causing students to shut down if their beliefs are incompatible with the scientific knowledge. This lesson begins by having students reflect on what they know and believe and

simply offers the explanation and evidence that the scientific community adheres to. Students are given the opportunity to assess this explanation with their peers, challenge it, and raise questions. They are then given the opportunity to further explore it and end with a final reflection to see if this exploration has changed their thinking at all. At no point is their home culture labeled as wrong or ignorant. Instead students are given the freedom to evaluate different perspectives and choose the one that resonates most with them while also teaching them the scientific arguments.

2. Group work-Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition.

3. Roll 'Em-This strategy helps to ensure that every individual is participating in group work. It particularly obligates group members to be cognizant of engaging every other member in the group and ensuring that every individual has an understanding of the group's thoughts, findings, and questions. To implement, each group is assigned a number and each individual within each group is also assigned a number. The teacher rolls a pair of dice. The two numbers identify the group # and the # of the individual in the group who must share.

4. Relevance of content to students- Many teenagers have reached an age where they are beginning to make sense of their place in the world and are beginning to clarify their own beliefs about the universe. This lesson provides an outlet for students to raise some of those questions and concerns.

Extension and Additional Resources:

1. Students may want to continue exploring the Big History Project

2. It may be useful to model the concept of the Doppler effect for students using a slinky to show how wavelengths change when objects are moving towards each other or further away. May also want to play YouTube videos of the classic Doppler experiment with a car horn

3. Students could research creation stories from other cultures

CRT Lesson #12: A Universal Debate

Subject/ grade level: Earth Science 9-12

Topic: Geocentricity and Heliocentricity

Materials:

- Smart Boards
- Computers
- Library Access

NYS Standards:

Standard 1 Analysis, Inquiry, and Design: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Key Idea 1: The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

Standard 4 Physical Setting: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 1: the Earth and celestial phenomena can be described by principles of relative motion and perspective.

Performance Indicator 1.2: Describe current theories about the origin of the universe and solar system.

Major Understandings:

- 1.1b: Nine planets move around the sun in nearly circular orbits. The orbit of each planet is an ellipse with the sun located at one of the foci.

Lesson objective(s):

Students will be able to...

- compare the geocentric and heliocentric models of the solar system
- evaluate the evidence for both the heliocentric and geocentric models

ENGAGEMENT

Have students start by giving them 2-3 minutes to draw a quick sketch of the solar system. Then have them turn to a partner and share/compare their drawing for 1-2 minutes¹. Be sure to move around the room and make note of at least one student who has a heliocentric solar system with all of the planets in the correct order (or close to correct order).

EXPLORATION

Up on the Smart Board, bring up the first slide in the Solar System presentation (an image of the medieval conception of the solar system).

Bait students by asking: “So all of your drawings look like this, correct?” When students yell at you that it’s wrong, continue to bait them by asking “What’s the problem?” Let them shout out various flaws that they see². Then continue to bait saying something like: “Alright. Granted that layer of fire in the solar system might be bogus and whatever that firmament thing is might be a little strange. I’ll give you that. But certainly you’re not going to tell me that this one is wrong (changing to the next slide which depicts Ptolemy’s model of the solar system).

When students continue to object to it, select a student who you know has already drawn a heliocentric solar system to come up and draw their solar system on a sheet of poster paper.

After they draw their image, pretend to be shocked and ask “So you’re telling me the sun is at the center of the solar system? You’re telling me that we have a heliocentric (write it on the board) solar system? You’re telling me that the Earth isn’t at the center and that we are not in fact living in a geocentric (write it on the board) solar system?”

Students will probably hold their ground and say “yes” you are the crazy one and they are correct.

Call on the student who just drew their solar system on the poster paper (or call on a student who arguing most vehemently with you), and ask them to prove it.

Challenge them to prove that the earth isn’t in the center: “After all, we see the sun move across the sky each day. We see the stars and the moon move across the sky each night. How could the sun be in the center if it moves? How can the earth not be in the center if everything is moving around us?”

Continue this argument as long as it remains productive³. Unless there is an expert on the subject in the class, you should be able to out argue the students and maintain that the earth is at the center of the solar system⁶.

Hopefully, your students are frustrated and exasperated with you.

EXPLANATION

Inform your students that you aren't going to believe that the universe is heliocentric unless they can prove it to you using solid scientific evidence and that that is exactly what they will be working on for the next several class periods.

Tell students that they will be working in groups of 3-5 to build their case proving that the solar system is heliocentric and not geocentric^{3,4}. Assure them that the larger the group, the more material they should have to present. Their presentation may take the form of a PowerPoint, a skit, a rap, or any other format that they think can effectively communicate their argument. The groups will be presenting their findings to the class as a whole and they will have a maximum of 10 minutes.

Give students 60 seconds to get into their groups and then pass out the "Great Debate" group worksheet. Explain that this worksheet provides the starting point for students to begin their research. It provides a list of 6 scientists/philosophers who contributed to the solar system model debate as well as several questions to consider when trying to disprove the geocentric model.

Give students another 3 minutes to assign responsibilities within their groups. Once responsibilities are assigned, students may begin research on the computer, using books, etc. (2-3 45 minutes periods are generally needed to complete thorough research with another period needed to complete presentations).

ELABORATION

For student presentations, inform the groups that aren't presenting that they will be taking the role of the individuals who support the geocentric theory. As they listen to groups present, they should be writing down questions, challenges, and comments that they have about the material being presented. They will also score each group on a scale from 1-5 on how convincing a case they made (1=I still hold to the geocentric model, 5= I'm completely convinced the heliocentric model is correct).

After all of the groups have presented, have students write a short reflection that answer the following questions:

1. Why do you think it was so difficult get the heliocentric universally accepted?
2. Summarize the evidence that you think provides the most convincing argument for the heliocentric theory⁵.

EVALUATION

1. Think Pair Share- solar system drawings
2. Group Presentations
3. Personal Reflections

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Think-Pair-Share- The TPS protocol forces students to draw on their prior knowledge and beliefs before looking to the teacher for answers. It also fosters group work and communication with peers and draws on the oral and communal traditions of many student cultures
2. Shout Out-This protocol serves to check whole class understanding by engaging students through a form of cultural discourse that is closer to their home cultures as it mirrors the call-and-response discourse styles of African traditions. This also provides code switching practice as students must be cognizant of when it is appropriate to shout out and when they must listen to a specific individual.
3. Relevance to students- While the content of this lesson may or may not be relevant to students, the medium through which it is presented (argumentation and the goal of being right) is one that is extremely relevant to them and is an action in which they partake almost every day. It draws very heavily on oral argumentation traditions that tend to characterize students' home life.
4. Group Work-Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition. In this instance, the group work is almost the sole vector through which learning occurs. Groups are responsible for their members learning but also help to reinforce the learning of other groups by presenting their understanding and interpretations of the same subject. This helps the whole class to make greater sense of a very complicated topic.
5. Affirmation/Validation of Student Beliefs- Instead of dictating to students what the most important pieces of evidence are that they need to commit to memory and instead of telling them why this topic garnered so much controversy, this particular lesson shows a respect for the cultural knowledge of students and allows them to evaluate the evidence and interpret the situation according to their own beliefs and understandings. This kind of reflective thinking encourages them to consider how such a controversy could impact their own world and makes them sift through all of the evidence to find those pieces that resonate most strongly with their own beliefs.
6. Teacher as Elder- This lesson turns the "teacher as elder" idea upside down as the teacher assumes the role of the opposition and challenges students to disprove them. However, in doing so, the teacher is able to provide the arguments and phenomenon that students need to investigate in order to prove their point. In many ways, it is reflective of a coming of age scenario in which

students prove their adulthood by refuting the knowledge of the elder.

Extension and Additional Resources:

1. Students may wish to research other cultures cosmologies to see how aboriginal and traditional cultures made sense of the structure of the solar system. This would expose them to many non-Western and non-science based forms of explaining the solar system.

2. Link to the PBS movie: Galileo's Battle for the Heaven:

<http://www.pbs.org/wgbh/nova/ancient/galileo-battle-for-the-heavens.html>

CRT Lesson #13: Cartography and Culture**Subject/ grade level:** Earth Science 9-12**Topic:** Interpreting Maps, Latitude and Longitude**Materials:**

- globes
- wrapping paper, newspaper, or tissue paper
- tape
- scissors
- rulers
- transparencies with graph paper
- “Comparing Maps” handouts
- Smart board/projector
- computers

NYS Standards:

Standard 4 Physical Setting: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 1: the Earth and celestial phenomena can be described by principles of relative motion and perspective.

Performance Indicator 1.1: Explain complex phenomena such as tides, variations in day length, solar insolation, apparent motion of the planets, and annual traverse of constellations.

Major Understandings:

- 1.1c: Earth’s coordinate system of latitude and longitude, with the equator and prime meridian as reference lines, is based upon Earth’s rotation and our observation of the sun and stars.

Standard 6: Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Key Idea 2: Models are simplified representation of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Lesson objective(s):

Students will be able to...

- plot coordinates of latitude and longitude
- identify the coordinates of a given location on a map
- compare how different map projections depict landmasses on the planet
- assess the socio-political implications of common map projections

ENGAGEMENT

To begin, have students choose groups of 2-4 to work in. Each group will need a globe, scissors, tape, and a roll of wrapping paper, tissue paper, or newspaper^{1,2}.

Tell the groups that they have 5 minutes to find a way to wrap the globes with a single sheet of paper (size doesn't matter) without creating any creases or folds in the paper. The paper should be completely smooth when wrapped around the globe. If students try to tell you the task is impossible, encourage them to be more creative in their thinking. Have they tried cutting the paper in different ways? Make sure they try something.

Put a timer on the board and play some music (geographic rap might be appropriately puny) for the duration of the 5 minutes. At the end of the 5 minutes, groups will place their attempts in the center of the room so that all groups can see them. Applaud students for their efforts, but ultimately explain to them that this *was* an impossible task.

Model for them the opposite action. Using an inflatable globe (beach ball) cut the globe open and demonstrate how it is impossible to lay it flat. You can even cut down the lines of longitude (or latitude) and show that even when the globe is cut apart into pieces, it can't be made completely flat.

Ask students to consider why this inability to make a globe lie flat could be a challenge to scientists. Have them think for 30 seconds, then turn to a partner and share for 60 seconds (think-pair-share)³. Then use whip around to have each group share what they came up with⁴.

If none of the groups come up the challenge that translating a round surface into a flat surface poses for making maps, then help guide them to this. Students sometimes struggle to make the connection between globes and maps (especially since most students will never use a tangible map and rely exclusively on electronic GPS).

EXPLORATION

For the next activity, students will work in pairs (larger groups may be needed depending on available materials)⁵. Each pair will need two world maps created using different map projections. Preferably, one of the maps will have fidelity to distance but not area while the other

map will have fidelity to area and not distance. Any projections that allow for these discrepancies are acceptable. Both maps should have a map scale to enable students to calculate distances between points. Maps should also either have clearly marked cities (unlikely on a world map) or points placed by the teacher (A-F, points should be placed at the same coordinates on both maps). Students will also need a ruler, a graph paper transparency, and a “Comparing Maps” handout².

Tell students that they will have 15 minutes to complete the “Comparing Maps” handout which asks them to find the coordinates for sets of points on both maps, the distance between sets of point on both maps, and the areas of certain countries/continents on both maps.

**If not all students remember how to find coordinates using latitude and longitude, poll the class to find out who remembers how to use those coordinates. Have partners that need help seek out those individuals for a quick lesson in using latitude and longitude. (Revised Circle the Sage protocol)⁵

EXPLANATION

When students have completed the “Comparing Maps’ handout, return to a full class discussion. First ask very broadly: “What did you discover?”

Use pick-a-stick to choose respondents⁶. If students don’t know how to respond to such a broad question, ask them to share a specific result off of their handout (ex. How far away was A from B on map 1? How far away were those points on map 2? What were the coordinates of points C on map 1? How about on map 2?”)

Some students may stick to comparisons between specific points, coordinates, or areas. Other students may immediately begin to make generalizations between the two maps. These generalizations are the goal. To get to them, you may need to ask students to compare coordinates of locations on both maps and to make an observation (they are the same). Ultimately, the three following generalizations should emerge:

1. Coordinates of points are the same on both maps
2. Distances between the same points are different on the two maps
3. Areas of countries are different on the two maps

Depending on the map projections used, you may also be able to observe that these differences become more skewed as you go further east/west.

Challenge students to consider: Why are the two maps different? Isn’t a map a map?

Ask students to take a moment of silence to think about this (give 60-90 seconds)⁷. Then ask for volunteers to share. The first answer will probably be that one of the maps is wrong. Inform students that both maps are correct and that we need to try to think of an alternative reason why two maps could both be correct, but also be different. Having them reflect on their opening activity (wrapping the globe) may help them arrive at an answer as certainly not every group

took the same approach to the challenge.

As the class continues to talk the idea should emerge that there is more than one way to make a map and that different methods produce maps that are slightly different.

ELABORATION

Next, have students watch the following clip from Law and Order (up to the 2:43 mark):
<http://www.youtube.com/watch?v=vVX-PrBRtTY>

At this point in the video clip, have students take 3 minutes to quickly write a prediction as to why the individuals in the video are petitioning the government to have schools change the maps that they use in the classroom. Use whip around again to have students share their predictions⁴. Then finish playing the video clip.

After finishing the clip, open up a class discussion around the following points that were raised by the cartographers in the video⁸:

1. Do we consciously equate size with importance and power?
2. Does misrepresenting a country's size mean that people will perceive them as more or less important?
3. Is this a form of discrimination against third world (poor) countries?
4. Does a top and bottom orientation lead to "top and bottom attitudes"?

Once students have had enough time to discuss/argue, give students their final task for the lesson. They are to write an opinion piece responding to the following question^{8,9}:

"Do maps (and different map projections) lead to or perpetuate social inequality?"

To answer this question, students will need to conduct some research on map projections (how they are made, their uses, distortions and errors in different projections). They can talk and argue with their peers. They may discuss the question with their parents at home, their social studies teacher, etc.

The final product must be a composition presenting a cogent and well-substantiated opinion.

EVALUATION

1. Think-Pair-Share
2. Comparing Maps handout
3. Whole Class Discussion
4. Whip Around
5. Final Composition

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Group Work- Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition.
2. Hands-on-This investigation is structured around tangible objects and experiences on which students can fix their reasoning. This provides a conceptual bridge from a known object to a discoverable scientific concept.
3. Think-Pair-Share- The TPS protocol forces students to draw on their prior knowledge and beliefs before looking to the teacher for answers. It also fosters group work and communication with peers and draws on the oral and communal traditions of many student cultures
4. Whip Around-This protocol allows students to practice explicit turn taking, but it does so at a rapid pace. It maintains accountability for every student in the room, checks for overall understanding, but does so while validating every student's response.
5. Circle the Sage (modified) - This protocol promotes students learning from each other. Classroom experts identify themselves as being knowledgeable in a topic and serve as the teachers for their classmates. This promotes communal learning and also demonstrates that the teacher does not have to be the source of all knowledge.
6. Pick-a-Stick- This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message that while working in groups every individual is still responsible for participating and understanding the content.
7. Moment of Silence- This protocol draws on students' experiences at church and during other somber moments and connects this experience to the idea that this moment in the classroom is one of complete silence and reflection. It is another way of teaching situational appropriateness.
8. Focus on societal implications, social justice, and power structures- For students with minority backgrounds and non-mainstream cultures, teachers need to prove the necessity for students to receive an education. The rationale that education is needed to obtain meaningful employment is often ineffective. A more effective argument can be made for the relationship between education and power. By choosing topics that explicitly explore social inequities and power structures, students gain a greater authentic understanding of their own need to be educated in order to combat, confront, and change these structures within their own lives and communities.
9. Affirmation/Validation of Student Culture- While the topic that students are writing on should be informed by research, students are allowed to present their own opinions and beliefs (as learned from their friends, family, etc.). This helps them to see that science and academic knowledge are not trying to supplant their cultural understandings but rather can be used to

inform and support those beliefs that they already have.

Extension and Additional Resources:

1. Have students try to make their own maps of an area of the globe either using their own reasoning or trying to apply a specific type of map projection.
2. Have students research the history of the Peters projection controversy.
3. Have students complete further research into different map projections and identify which map projections are best for what purposes.
4. http://nationalatlas.gov/articles/mapping/a_projections.html Good introductory website to map projections

CRT Lesson #14: A Matter of Perspective I

Subject/ grade level: Earth Science 9-12

Topic: Constellations

Materials:

- Light sources (flashlights, etc.)
- globe
- poster paper
- Do You See What I See handouts

NYS Standards:

Standard 4 Physical Setting: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 1: the Earth and celestial phenomena can be described by principles of relative motion and perspective.

Performance Indicator 1.1: Explain complex phenomena, such as tides, variation in day length, solar insolation, apparent motion of planets, and annual traverse of constellations.

Major Understandings:

- 1.1d: The Earth rotates on an imaginary axis at a rate of 15 degrees per hour. To people on Earth, this turning of the planet makes it seem as though the Sun, the moon, and the stars are moving around Earth once a day. Rotation provides the basis for our system of local time; meridians of longitude are the basis for time zones.
- 1.1g: Seasonal changes in the apparent positions of constellations provide evidence of Earth's revolution.

Lesson objective(s):

Students will be able to...

- identify the variables that influence individual perceptions of visual patterns
- explain how planetary motions and relative location lead to changes in the apparent positions of the constellations
- suggest improvements for modeling planetary motion and constellations
- recognize the widespread cultural role of constellations

ENGAGEMENT

Have the “Ambiguous Images” presentation ready for viewing. Once students are seated and have read the directions (to be ready for a shout out), explain that you are going to show them a series of pictures. Each picture asks them a question. They should only shout out the answer to that question when the teacher cues them to “give me a shout out”. Give students 10-20 seconds to look at the images before asking for a shout out so that some have time to see both interpretations of the images.¹

After running through the shout out for each image, revisit each image and make sure that all students are aware that they all have two possible interpretations. Help them to see the different interpretations, however explain to them that if they can't see the other possibility, that's okay. Everyone's brain works a little differently.

Follow up by asking students why people saw different things.

Why might some people see a duck instead of a rabbit? (some people prefer one animal over the other, some people may be more familiar with one animal than the other)

Why do most people see 4 legs on the elephant? (that's what we expect to see)

How come some people can't find the hidden message? (because their brains don't work that way)

Why do some people see the old lady first instead of the girl or vice versa? (Could be based on experience. If you are young, you might be more likely to see a young person. If you have a grandmother that you have a strong connection with, you might be more likely to see the older woman).

Use pick-a-stick to see if students can summarize/generalize why people see different things when looking at the same thing². Continue to select students until the following points have been established and recorded on a poster paper:

1. Everyone's brain works differently
2. People see what they know/expect
3. People see things based on their experiences/what is familiar

EXPLORATION

For this next activity, the room should be set up with chairs/desks in a large circle with a large table in the center. On the table should be a collection of flashlights and other light sources set up in a random arrangement with lights at different heights, distances, etc. (or, if really ambitious, lights could be suspended from the ceiling).

Students should be sitting in the desks surrounding the lights and they should have a copy of the “Do you see what I see” handout. Explain to students that they are to imagine that they are staring at the night sky looking at the stars (flashlights). From their desk, they are going to draw the arrangement of “stars” as they see them. They will have 3 minutes to draw the star

arrangement.

You may want to model this activity with a separate set-up of lights at the front of the room as students often struggle with how to translate these points of light into a drawing.

After they have drawn the first star arrangement, everyone will get up and will rotate 6 seats to the right (assuming a class of 24). They will take their new seat and will again draw the pattern of stars from their new seat. This rotation will occur three more times (the last rotation should return them to their original seat)³.

EXPLANATION

When they are back in their original seat, they will answer the first two analysis questions on their handouts independently and silently. When they are done, they are to make a silent appointment with one of their peers⁴. With their partner, they should compare their responses to questions 1 and 2, answer question 3, and begin to discuss the last two questions⁵.

Once all groups have had time to discuss all analysis questions, give those 30 seconds to get back to their original seats. It may be appropriate to play music as an auditory cue⁶.

Briefly ask for volunteers to share out responses to questions 1-3. Most students grasp very readily that they saw different star patterns even though they were looking at the same stars because their position relative to the stars had changed so their perspective changed. However, their language is probably not this precise.

Ask for a student to write their response to question 2 on the board (confirm the gist of it is correct, first), then show students how to rewrite it into more precise language using terms such as “relative position”, “perspective”, “angle”, etc⁷. Question 3 connects directly back to the discussion of the ambiguous activities.

For question 4, ask students to clap if they thought the activity modeled the rotation of the earth. Ask them to snap if they thought it modeled the revolution of the earth⁸. Use pick-a-stick to select students to support their answer to number 4². Make sure that students are not confusing the two motions of the earth. In reality, both positions are defensible. Students may connect the 4 rotations with the 4 seasons which suggests movement over the course of the year (revolution). However, students may also have connected that the stars were the same for the whole activity which is more similar to the stars observed moving across the sky in a single night. The justification is most important⁷.

Question 5 is to get students thinking about what is really happening when we see stars move across the sky. It may be useful to have a globe to demonstrate the flaws and limitations of the activity that they engaged in. The activity really fails to accurately model either motion of the earth (revolution and rotation). With respect to revolution, as the earth moves around the sun, people on earth are looking outward (not inward as in our model) and so are actually seeing different stars. With respect to rotation, the students’ physical movement was more representative of revolution⁷.

Challenge students to redesign the activity they just engaged in to make it more accurate. What modifications would they make?

ELABORATION

Tell students that in our model, we were examining how physical position and movement led to changes in the stars that we see and those differences in individual perspectives and experiences leads to the differences in images that we see in the stars.

These two elements (physical position and personal perspective) are what have led to the identification of 88 common constellations (star patterns). Ask students to shout out any constellations that they are familiar with¹.

However, people have been looking up at the night sky for thousands of years and have seen countless different images based on their cultural experiences. The 88 constellations that are most familiar have largely been drawn from Western cultures. However, African, Native American, and other Eastern cultures also have constellations that draw from their own traditions.

Students are to select one of the 88 Western constellations and one non-Western constellation (though in many cases, it may be a Western constellation but with a different name and story)⁹.

They are to create a poster that provides the names of both constellations, images of both constellations, where on the globe the constellations can be seen, what seasons of the year they are observable, and the story/myth behind the constellations (Refer to constellation poster notes/checklist).

EVALUATION

1. Analysis Questions
2. Class Discussion
3. Constellation Poster

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Shout out-This protocol serves to check whole class understanding by engaging students in a form of cultural discourse that is closer to their home cultures as it mirrors the call-and-response discourse styles of African traditions. This also provides code switching practice as students must be cognizant of when it is appropriate to shout out and when they must listen to a specific individual.
2. Pick-a-Stick- This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message

that while working in groups every individual is still responsible for participating and understanding the content.

3. Rotation- This literal rotation incorporates meaningful and organized movement into the lesson.
4. Silent Appointment-This protocol helps students to practice situationally appropriate behavior by having to follow a specific silent protocol that also allows student choice in partners and meaningful movement.
5. Peer Conferencing/Partners- This group work protocol allows students to compare the information that they gleaned from an activity and to clarify their understandings with their peers before having to submit their work to the critique of the teacher or the whole class.
6. Move to Music- This management/transition strategy pairs time constraints with auditory cues and provides a meaningful way to incorporate music, rhythm, and motion into the classroom with a flare of fun.
7. Explicit Instruction from Home Language to Academic Language- Students first work to create explanations in their own language working with peers but then are guided by the teacher to apply more precise academic language to concepts that they already own. This process is modeled explicitly in front of the whole class with the home language and academic language side by side.
8. Claps and Snaps-asking for student concurrence with a clap/snap/stomp/whatever creates whole class participation when listening to one student's response and gives the teacher a chance to assess all students while incorporating African traditions of rhythm.
9. Multicultural Perspectives- Students are pushed to explore other cultures (either their own heritage or another) and to see how that culture viewed the same celestial objects as Western cultures. This also demonstrates to students that science and astronomy are not simply Western constructs but have played a role in cultures all over the globe.

Extension and Additional Resources:

1. <http://www.mesd.k12.or.us/os/starlab/African.html> Lists some African constellations
2. <http://www.rmg.co.uk/explore/astronomy-and-time/astronomy-facts/stars/south-african-star-myths> South African star myths
3. <http://www.native-languages.org/legends-star.htm> Native American star myths
4. <http://members.optusnet.com.au/virgothomas/space/abobeliefs2.html> Aboriginal star myths

CRT Lesson #15: A Matter of Perspective II

Subject/ grade level: Earth Science 9-12

Topic: Moon Phases

Materials:

- Envelopes of moon phases (using the moon phases flip book images: make sure the names of the phases have been cut off and/or whited out. The cards also need to have a clearly labeled top and bottom so students don't flip the cards upside down. Envelopes can contain as many or few phases as desired. This is a good way to build different levels of difficulty).
- Paper
- Tape/Glue
- Moon models (moon phase mats, ping pong ball with one hemisphere colored black, bottle cap, cardboard cutout)
- Moon lab handouts
- Send-a-Problem answer sheets

NYS Standards:

Standard 4 Physical Setting: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 1: the Earth and celestial phenomena can be described by principles of relative motion and perspective.

Performance Indicator 1.1: Explain complex phenomena, such as tides, variation in day length, solar insolation, apparent motion of planets, and annual traverse of constellations.

Major Understandings:

- 1.1a: Most objects in the solar system are in regular and predictable motion. These motions explain such phenomena as the day, the year, seasons, phases of the moon, eclipses, and tides.

Lesson objective(s):

Students will be able to...

- sequence moon phases
- draw and identify moon phases as observed from Earth
- explain why moon phases occur in terms of movements of celestial bodies

ENGAGEMENT

Have students pair up and distribute an envelope of moon phases to each pair. Instruct the pairs to sequence the moon phases that they have in order from new moon (complete darkness) to full moon (completely lit) back to new moon¹. Make sure that they know that the envelopes do not necessarily have all of the moon phases so they will have to be careful and realize that there will be “holes” in their sequence. They should also try to name the phases.

Have students tape or glue their final sequence (with label) onto a sheet of paper and post them around the room. The partners should remain standing in front of their moon phase sequence. Once all sequences are posted, place a sticky note with a number on each one.

Tell students that they are going to complete a quick carousel to review their peer’s work². On a count of 3, they will move to the next poster (next highest number, highest number moves to 1). There they will have 30 seconds to analyze and critique that group’s work. They will then move again on the count of 3. This will be repeated 3 times.

After all rotations have been completed, have students return to their seats and use pick-a-stick to get feedback³. What did students observe that was good about the posters? What did they observe that suggested confusion?

Other than phases being glaringly out of sequence, students may have noticed confusion with names (misuse of waxing and waning, no use of waxing/waning, confusing gibbous and crescent, failure to name phases). However the most subtle critique, which they may or may not notice, is that the waxing moon should be lit from the right and the waning moon should be lit from the left.

Show students a complete and fully labeled sequence on the Smart Board.

EXPLORATION

Before introducing students to the moon model that they are going to be using to simulate phases of the moon, review with them facts that they already know about the moon. Use pick-a-stick to elicit answers to the following questions³:

1. Why does the same side of the moon always face the Earth? (because the rate of rotation and the rate of revolution are the same)
2. How long does it take the moon to complete one revolution and one rotation? (27.3 days)
3. Why is only one side of the moon lit? (Because only one side is exposed to the sun’s rays).
4. How long does it take the moon to move from new moon to new moon? (Most students should be able to guess that it takes 30 days. Teacher can correct it to 29.5).

The moon models that students are using consist: of a mat showing the relative positions of the sun, moon, and earth, a ping pong ball (one hemisphere colored black) to represent the moon, a bottle cap (to keep the moon from rolling away), and a piece of cardboard cut so that it can fit over the ping pong ball to show the profile of the moon as seen from earth.

Students will follow the directions on the moon phases lab and will fill in the data sheet. They will need about 10 minutes to complete the lab in groups of no more than 3^{4,5}.

EXPLANATION

Once all groups have put their models away and have completed the data sheet, have students return to their seats and pose the following question:

Why do we have moon phases if half of the moon is always dark and half of the moon is always lit? Shouldn't it always look like a first or last quarter moon?

Tell students they need to give a moment of silence (60 seconds) to think before anyone responds⁶.

After 60 seconds is up, ask for volunteers to share their thinking. This concept is fairly challenging for students to internalize and apply. In the subsequent dialogue, the following concepts should be teased out⁷:

1. If we were observing the sun, earth and moon from above (imagine a point in outer space above all three celestial bodies), from that perspective we would always see a moon that is half lit and half dark.
2. The moon revolves around earth.
3. As the moon revolves around earth, the lit portion that is observable from Earth changes
4. It is this changing amount of the lit portion that is viewable FROM EARTH that leads to our observation of moon phases.

Play the following video clip to summarize: <http://www.youtube.com/watch?v=nXseTWTZlks>

ELABORATION

Pass out the "moon phase send-a-problem" answer sheets. On the Smart Board, draw a quick sketch of the sun, earth, and the moon at any position around the earth. In the center square of the answer sheets, have students write the teacher's name and then draw the moon phases that would be observed from a person standing on Earth.

Then have students draw their own moon phase question on their paper. Tell students that they are going to get up and send-a-problem to 8 other students in the class⁸. In exchange, they must complete 8 send-a-problems posed by their peers. For each problem they complete, they must write the creator's name and draw the moon phase represented in the problem.

EVALUATION

1. Moon phase sequencing
2. Pick-a-stick questions
3. Moon phases lab
4. Class discussion
5. Send-a-Problem answer sheet

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Partner Conferencing-This group work protocol allows students to compare the information that they gleaned from an activity and to clarify their understandings with their peers before having to submit their work to the critique of the teacher or the whole class.
2. Carousel-This strategy draws on students' cultural connections with movement. It authentically incorporates movement into instruction by giving a meaningful reason for students to move about the room while also engaging in critical thinking and evaluation of their peers' work. Thus it also brings back a sense of communal accountability.
3. Pick-a-stick-This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message that while working in groups every individual is still responsible for participating and understanding the content.
4. Group Work-Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition.
5. Hands-On-This investigation is structured around tangible objects and experiences on which students can fix their reasoning. This provides a conceptual bridge from a known object to a discoverable scientific concept. This particular model was chosen because it enables students to achieve both perspectives for viewing the moon (both outside the Earth and from Earth).
6. Moment of Silence-This protocol draws on students' experiences at church and during other somber moments and connects this experience to the idea that this moment in the classroom is one of complete silence and reflection. It is another way of teaching situational appropriateness and draws attention to the importance and complexity of the question at hand.
7. Teacher as Elder- After students have worked with their peers to build meaning, the teacher finally steps in, in the role of the elder that adults are often perceived as holding in African and Latino cultures, and provides the final bridge from student understandings and language to the academic/scientific language. In this role, the teacher as elder should take student words and mold them into the more formal structures that are expected in the academic world. In this lesson, the teacher assumes the role as expert to help students grasp on to a concept that is fairly

subtle and difficult to grasp. As such, the teacher is needed in that expert role to help students navigate the jumps they need to make in perspective.

8. Send-a-Problem-This protocol maintains the expectation that students not only are responsible for their own learning but are able to help quiz and assess their peers as well thereby fostering a communal sense of learning in the classroom.

Extension and Additional Resources:

1. The following link provides an online simulation for moon phases that simultaneously shows perspectives from outer space and from Earth.

http://highered.mcgraw-hill.com/olcweb/cgi/pluginpop.cgi?it=swf::800::600::/sites/dl/free/0072482621/78778/Lunar_Nav.swf:Lunar%20Phases%20Interactive

CRT Lesson #16: Pressure, Pushing Down on Me

Subject/ grade level: Middle School Science 7-8

Topic: Air Pressure

Materials:

- Poster Paper
- Markers
- Cups
- Paper Towels
- A clear bowl or aquarium filled with water
- Yardstick
- 2 balloons
- Hanger
- Tape
- String
- Mysterious Egg in The Bottle Handouts for each student

- 2 Set-ups for each of the following stations and directions for each station:
- Glass with straw and water
- Glasses with cardboard, water, and a basin
- Soda bottle with holes poked in the bottom and filled with water, a basin

- Hard-boiled eggs
- A flask or other bottle with a wider mouth
- Paper
- Candles
- Matches

NYS Standards:

Standard 4: The Physical Setting- Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and recognize the historical development of ideas in science.

Key Idea 2: Many of the phenomena that we observe on Earth involve the interactions among components of air, water, and land.

Performance Indicator 2.1: Explain how the atmosphere (air), hydrosphere (water), and lithosphere (land) interact, evolve, and change. .

Major Understandings:

2.1b: As altitude increases, air pressure decreases.

***Although this standard does not explicitly demand an understanding of the physics behind pressure, the term pressure is frequently used in intermediate science content in different contexts (rock formation, weather, climate, etc.). A concrete exploration and understanding of this concept is essential for students to attain mastery of these major understandings that are dictated in the standards.

Lesson objective(s):

Students will be able to...

- Explain observable phenomena in the context of air pressure
- Propose ways to apply principles of air pressure to novel problems

ENGAGEMENT

Begin the lesson by giving students 3 minutes to respond to the following prompt independently:

“Consider the word ‘pressure’. Write a definition for pressure in your own words. Then think of as many synonyms and examples for the word as possible.”¹

At the end of three minutes, have students get up and record their responses on sheets on poster paper posted around the room and clearly labeled “Definitions”, “Synonyms”, “Examples”. Depending on the size of the class, you may need two of each poster. Give students 3-5 minutes to get all of their responses recorded. Use both a visible timer and play music so they have both visual and auditory cues². When students have returned to their seats, run through their responses. Many of them will probably consider pressure in a nonscientific sense. Others may have no idea. This is fine and simply helps to assess the students’ starting point. As the lesson continues, tell students they are welcome to add new ideas to these Pressure “parking lots”¹.

Next, show students the following SickScience video clip:

http://www.youtube.com/watch?v=M_eScIAI8Dg

Students will probably ask to see the video a second time and will try to insist that it’s fake. Inform them that their goal by the end of the lesson is to be able to explain how the egg is slipping into the bottle and to offer a possible method for removing the egg without breaking the container.

EXPLORATION

Before tackling the egg in the bottle challenge, the class needs to agree on a few facts. Pose the following two questions to the class:

“Does air take up space? Give me a clap if you say yes (pause for claps). Give me a stomp if you say no (pause)”⁴

“Does air have weight? Give me a clap if you say yes (pause for claps). Give me a stomp if you say no (pause)”⁴

There will almost always be a student who disagrees with both statements. If not, challenge students to prove both of the statements. When they struggle to do so, use the following two demos to verify these facts.

Air Taking Up Space³

You will need a paper cup, a few paper towels, and a clear bowl or aquarium filled with water. Crumple the paper towel and press into the bottom of the cup. Tell students that you are going to submerge the cup in the water with the lip pointing up. Ask students to predict what will happen to the paper towel with a shout out: wet or dry. Of course, the towel gets wet.

Replace the paper towel with a dry one and repeat the experiment, but tell students you are going to submerge the cup in the water with the lip pointing down. Again, ask for shout out predictions. This time the towel stays dry.

Ask students to talk with a partner for 60 seconds to try to explain what they observed. After time is up, use pick-a-stick to elicit responses. If students can't reach an explanation on their own, guide them to it by questioning:

What was in the cup when we started? (towel and air)

When the cup was facing lip up, could the air leave the cup? (yes, so water could enter)

When the cup was facing lip down, could the air leave the cup? (no, so the water could not enter)

Therefore, it demonstrates that air takes up space and prevents water from filling the space.

Air Has Weight³

For this demonstration, you will construct a scale to measure the mass of two empty balloons out of a yardstick, string, a hanger, and tape. Make sure you tape the balloons such that the scale is balanced when they are not inflated.

Make certain students not the balanced scale. Remove one of the balloons, inflate it, and tape it back into place. Students will observe that the yard stick is no longer balanced meaning that the addition of air changed the weight of the balloon.

EXPLANATION

Having confirmed that air both takes up space and has weight and pass out The Mysterious Egg

in the Bottle Handouts to each student. Explain to the students that they will be cycling through 3 stations³. At each station are all of the materials they will need as well as directions. They will have 8 minutes at each station to read their procedure, make a prediction, carry out the experiment, record observations, and then talk as a group to arrive at an explanation for what they observed.

Explain that students will be working in groups of 3-4⁵ and give students 60 seconds to make silent appointments⁶ (made through eye contact and a confirmatory nod) with their group mates and then 15 seconds to get in their groups and choose their starting station.

Put 8 minutes up on the timer and instruct students to begin. Reset the timer after each 8 minute span.

When all stations have been completed, instruct students to make a silent appointment⁶ with one partner NOT currently in their group. They are to meet with that partner and compare the observations and explanations of their two groups⁷.

Recall students to their original seats and use pick-a-stick⁸ to have one student summarize each station and share the explanation they arrived at.

ELABORATION

After hearing student explanations, begin to help them see the real story of what's happening⁹. Students should take notes on what's happening on the back of the Mysterious Egg in the Bottle Handout.

- 1) We already know air takes up space and has weight
- 2) We also know that air is made up of molecules that are constantly in motion. These molecules are what take up space and have weight.
- 3) These air molecules are always moving and running into object. The total force of all of the molecules running into an object results in air pressure. The more molecules that are pushing on an object, the greater the air pressure.
- 4) In the case of the straw and the glass experiment and the leaky bottle experiment, when the straw and bottle were open, air pressure was pushing down on the water forcing it out of the straw and the bottle. When the openings were closed off with one's finger or the cap, air pressure was pushing up from the bottom of the straw/bottle preventing the water from leaving.
- 5) The Levitating cardboard station is similar in concept except that in this case, the air pressure pushing up was greater than the pressure of the water pushing down (this can help students think about the small amount of water versus the giant amount of air involved).

Now, actually perform the egg in the bottle trick for the students. It can be conducted the same way as in the video using burning paper or it can be done using by pouring hot water in the container, placing the egg over the mouth, and waiting for the water to cool.

Armed with their understanding of air pressure, ask students to work with their group to complete their ticket-out-the-door which poses two questions:

1. Explain the egg in the bottle trick using the concept of air pressure.
2. Pose a possible method to remove the egg from the container without breaking it. Discuss the changes in air pressure that would need to occur.

EVALUATION

1. Parking lots
2. Claps and Snaps
3. Questioning
4. Mysterious Egg in the Bottle Handout
5. Partner conversations
6. Ticket-out-the-door

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Home Language to academic language-Similar to the manner in which this lesson validates student beliefs, it also starts students by talking with peers in their own home language. The scientific language and vocabulary is not introduced until students have already grappled with concepts in their home language. Explicit practice in using the academic language is provided in responding to the ticket-out-the-door.
2. Move to Music- This is a means of incorporating rhythm and music, which play significant roles in African American cultural backgrounds, into the classroom in a meaningful way by using it as an auditory cue.
3. Hands On-This investigation is structured around motion and action while giving students tangible objects on which to fix their reasoning. This provides a conceptual bridge from a known object to a discoverable scientific concept.
4. Claps and Snaps-asking for student concurrence with a clap/snap/stomp/whatever creates whole class participation when listening to one student's response and gives the teacher a chance to assess all students while incorporating African traditions of rhythm.
5. Group Work-Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to

talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition

6. Silent Appointment-This protocol helps students to practice situationally appropriate behavior by having to follow a specific silent protocol that also allows student choice in partners and meaningful movement.

7. Partners-Having students work with partners promotes collaboration and communal learning in the classroom.

8. Pick-a-Stick-This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message that while working in groups every individual is still responsible for participating and understanding the content.

9. Teacher as Elder-After students have explored and grappled to make meaning with their peers, the teacher assumes the authority role that is designated to them in Latino and African cultures and provides the guidance and knowledge of the “elder”.

Extension and Additional Resources:

1. Test student methods for removing the egg from the bottle.

2. Students can build their own barometers and then use them to make daily measurements while also making observations about weather patterns, temperature, etc. to look for connections between pressure and weather.

CRT Lesson #17: The Weight of the World

Subject/ grade level: Middle School Science 7-8 *** This lesson was originally written for a 12:1:1 self-contained 7th grade science class

Topic: Gravity

Materials:

- paper
- textbook
- Smart board/projector
- “Gravity or Not” survey handouts
- poster paper
- Gravity Notes handouts
- Comprehension questions handouts
- Assortment of objects to model differences in gravitational forces

NYS Standards:

Standard 4: The Physical Setting- Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and recognize the historical development of ideas in science.

Key Idea 5: Energy and matter interact through forces that result in changes in motion.

Performance Indicator 5.2: Observe, describe, and compare effects of forces (gravity, electric current, and magnetism) on the motion of objects.

Major Understandings:

- 5.2a: Every object exerts gravitational force on every other object. Gravitational force depends on how much mass the objects have and on how far apart they are. Gravity is one of the forces acting on orbiting objects and projectiles.

Lesson objective(s):

Students will be able to...

- identify phenomena that are caused/controlled by gravity
- hypothesize what a world without gravity would be like
- compare the gravitational force between two systems and justify their reasoning

ENGAGEMENT

Begin by standing on a desk, holding a book and an open piece of paper. Ask "which will hit the ground first if I drop them from the same height?" Ask for a shout out response: book or paper.

Then ask students to clap² once if they believe the book will hit first. Then ask for students to clap twice if they think the paper will hit first. Ask for volunteers to support their answers. Typically, students will answer the book with the justification that it is heavier. Further ask students to predict how much faster the book will reach the ground: by a lot or by a little. Again ask for a shout out, and then use claps to show how much of the class subscribes to each prediction.

Then, crumple up the paper (usually to remarks such as "cheater") and drop them. Ask students what they observed. Some students will maintain that the book hit the floor before the paper because that is their preconception. However, most students who believed the book would hit the floor first will be surprised at how close the two are. Repeat the demonstration several times to model repeatability of results.

Some follow up questions might be...

1. Does crumpling the paper add mass to it?
2. When the paper is not crumpled does its *mass* make it fall faster?
3. What makes the paper fall more slowly when it is not crumpled? (Note here you are leading students thought toward air resistance)
4. What force makes things fall toward the ground?

EXPLORATION

It is this final question that identified the topic of interest for the day. Most students are familiar with the concept of gravity as the force the “pulls everything down to the earth”. To challenge students’ misconception about gravity being exclusive to the earth, ask them to predict what the results of this experiment would be on the moon.

Have them complete a Think-Pair-Share³ with a partner next to them. Give them 1 minute to think and 2 minutes to share with a partner. Ask for volunteers to share their thinking and look for class consensus by asking students to stomp once if they agree with the predictions and reasoning. Probe for divergent predictions and justifications. Frequently, students will predict that the book and feather will simply float in mid-air.

To test their predictions (and conceptions), play the following video of the feather and hammer drop on the moon:

Video clip- http://www.youtube.com/watch?v=5C5_dOEyAfk

To further probe students understandings and conceptions about gravity, have them complete the “Gravity or Not” survey. Have them complete it independently first, then have them compare and discuss with a partner.

EXPLANATION

Select one student to be the record keeper for a poll of student beliefs^{5,6} on gravity. This student will keep tally on a poster paper the number of students who believed each phenomenon was caused by gravity or not. For each item on the survey, tell students to stand⁴ if they said it was influenced by gravity. Call on one of the students who are standing to explain why they believed it was influenced or caused by gravity. Continue this protocol for all of the items on the survey.

After hearing student explanations and justifications, ask for 3-4 volunteers to provide their own definitions of gravity. Students may choose to elaborate on other students' definitions or they may disagree with them.

At this point, pass out the "Gravity Notes" to students. Concisely complete these Cloze notes on gravity. When looking at the definition of gravity, differences in gravitational attraction between objects and people in the room should be used to reinforce the idea that gravity is a force that exists between *everything* with mass but in most cases the force is so weak because the masses are so small.

Ways to model this include:

- explaining (and then asking) how the force of gravity changes as you walk towards a student
- explaining/comparing (and then asking them to compare) the difference in gravitational force between a textbook and a pencil vs. two human bodies

It is also important to emphasize that mass and weight *are not* the same thing. It may be useful to refer back to the moon video to illustrate that while the objects weighed different amounts on the moon compared to earth (in fact they weighed less because gravity is weaker on the moon), the amount of mass in the objects remains the same. From this, we can infer a smaller acceleration due to gravity on the moon.

To check for understanding of this material, have students work in their partnerships⁷ to answer the gravity comprehension questions⁶.

ELABORATION

As partners complete the gravity comprehension questions, have them move on to "Life Without Gravity"⁸ where they imagine and describe how their own lives would be different without gravity. To help students imagine life in zero gravity, show them video clips from different space missions:

After watching these videos and re-evaluating the role of gravity in their lives, ask students to reconsider the "Gravity or Not" survey. Quickly survey the class again by asking them to stand if they think gravity influences those different phenomena. Record student's new beliefs and understandings.

Finally, as a ticket-out-the-door, have students write a gravity comparison question for their peers⁹ (to be used at the start of the next class) modeled from questions 4 and 5 on their worksheets. Remind them that gravity is influenced by both mass and distance so both must be considered in their comparison questions.

EVALUATION

1. Shout out predictions
2. Claps and Stomps
3. Questioning and dialogue
4. Think Pair Share
5. Standing Polls (“Gravity or Not”)
6. Comprehension Questions
7. Life Without Gravity descriptions
8. TOD-Gravity comparison questions for peers

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Shout out-This protocol serves to check whole class understanding by engaging students in a form of cultural discourse that is closer to their home cultures as it mirrors the call-and-response discourse styles of African traditions. It also provides practice in code switching as students begin by using a discourse style that is more culturally relevant and transition into the listening/turn-based discourse style of Western cultures.
2. Claps and snaps (stomps in this case) - Asking for student concurrence with a clap/snap/stomp/whatever creates whole class participation when listening to one student’s response and gives the teacher a chance to assess all students while incorporating African traditions of rhythm.
3. Think Pair Share- The TPS protocol forces students to draw on their prior knowledge and beliefs before looking to the teacher for answers. It also fosters group work and communication with peers and draws on the oral and communal traditions of many student cultures
4. Standing Polls-This strategy incorporates authentic movement into a lesson while assessing students and demanding participation and engagement from all individuals.
5. Affirmation/validation of student beliefs- In this lesson, students begin by exploring their own preconceptions about gravity and try to fit their understanding into a framework of phenomena. As they try to articulate their own understanding, they engage in a dialogue with peers from similar cultural backgrounds who may have different understandings. This allows students to evaluate their understanding and compare it to observable events in a way that is open to their prior beliefs. When students are finally provided with “the science” they are not forced to fit it into their framework, but instead are simply assessed to see if there have been changes in understandings. This approach affirms and validates the beliefs and knowledge that students

bring with them while also providing them with experiences and knowledge to adjust their understandings. This approach encourages students to engage with a topic as it is less threatening to their home culture.

6. Bridging from home language to academic language- Similar to the manner in which this lesson validates student beliefs, it also begins with students talking to peers in their own home language. The scientific language and vocabulary is not introduced until students have already grappled with concepts in their home language. Explicit practice in using the academic language is provided in responding to the comprehension questions.

7. Partnerships- Having students work with partners promotes collaboration and communal learning in the classroom.

8. Relevance of content- By connecting gravity to everyday activities and illustrating how dramatically transformed these activities become without gravity, it students are given a universal entry point that ties directly into their own lives and experiences. This familiarity with the experiences under analysis encourages students to engage more readily with the topic and inspires curiosity.

9. Send a problem- This protocol maintains the expectation that students are not only responsible for their own learning but are able to help quiz and assess their peers as well thereby fostering a communal sense of learning in the classroom.

Extension and Additional Resources:

1. Students may want to further explore what life is like in outer space, especially on the International Space Station. This could be extended to developing/designing systems, furniture, and protocols that make life in zero gravity functional.

2. Depending on students' mathematical competencies, they could apply Newton's universal law of gravitation and calculate the actual force of gravity in different systems to begin thinking about gravity in a more quantifiable form.

3. <http://ed.ted.com/lessons/jon-bergmann-how-to-think-about-gravity>- this TEDtalk lesson allows students to independently explore more nuanced concepts around gravity

4. If you have some truly ambitious middle school students (or high school students), they could begin to investigate how scientific thinking about gravity changed after Einstein.

CRT Lesson #18: More Than Meets the Eye

Subject/ grade level: Middle School Science 7-8

Topic: Light

Materials:

- glasses filled with water (one per student station)
- straws
- color wheel templates or pre-made color wheels
- prisms
- flashlights (different colored bulbs are a plus)
- EMS note handouts
- slinky
- computers

NYS Standards:

Standard 4: The Physical Setting- Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 4: Energy exists in many forms, and when these forms change energy is conserved.

Performance Indicator 4.4: Observe and describe the properties of sound, light, magnetism, and electricity.

Major Understandings:

- 4.4a: Different forms of electromagnetic energy have different wavelengths. Some examples of electromagnetic energy are microwaves, infrared light, visible light, ultraviolet light, X-rays, and gamma rays
- 4.4b: Light passes through some materials, sometimes refracting in the process. Materials absorb and reflect light, and may transmit light. To see an object, light from that object, emitted by or reflected from it, must enter the eye.

Lesson objective(s):

Students will be able to...

- differentiate between different types of electromagnetic radiation by comparing wavelength and energy
- identify uses for different types of electromagnetic energy
- explain how a prism splits “white” light into a rainbow

ENGAGEMENT

At each student station, place a clear glass filled half way with water and with a straw placed in it².

Students will engage in Think-Pair-Share^{1,3}. First they will silently observe the glass and straw without touching it and will be asked to come up with an explanation for what they observe. After thinking independently for 2-3 minutes, they will discuss with a partner what they observed and their explanation for it. At this point, students may touch the glass and the straw as manipulating the materials may help them clarify their own reasoning. After a few more minutes, the teacher will ask for volunteers to share their partnerships observations and explanations.

It should be evident to all groups that the straw appears to be disjointed or offset where water and air meet. Some groups may even know (or be able to speculate) that the light is being bent.

The teacher should challenge groups to take that thinking further:

- Why is the image of the straw bent when the straw itself clearly isn't?
- What does this mean about the nature of light?
- What causes the light to bend?

EXPLORATION

While students continue to ponder these questions, they will engage in two additional activities that also explore the nature of the color white.

In their partnerships, designate each partner as either Partner A or Partner B⁴. Partner A will begin by building a color wheel and observing what happens when it is spun². Partner B will begin by exploring the properties of prisms². When each individual is done with their respective task, they will reconvene with their partners and model/share their findings^{3,4}.

Partner A will receive a template from which to make their color wheel (alternatively, pre-made color wheels can be used). Incomplete colors wheels or color wheels with different combinations of colors may also be used for comparison.

Partner B will receive a prism and can use a flashlight, sunlight, or classroom lighting. It could also be interesting to provide different colored lights to use as a comparison. Objects that look like prisms but lack the same optical properties should also be provided so students can observe that a rainbow only appears when light passes through the prism.

After partners have shared their findings with each other, ask for volunteers to share out. Again, in general they should have observed that when white light passed through a prism, it split into a rainbow (whereas colored light would not have split). Conversely, when the complete color is spun, it appears white instead of a rainbow. Incomplete color wheels tend to be dominated by

other colors.

EXPLANATION

At this point, the teacher should help facilitate a discussion that begins to combine the observations made of the straw with the observations made about the prism and the color wheel.

Students should be prompted with the clue that there is a similarity between the appearance of the straw in the glass and the appearance of a rainbow through a prism.

How did students account for the appearance of the straw? How can we extend this explanation to the emergence of a rainbow from white light passed through a prism? Why don't all objects that allow light to pass through turn white light into rainbow? And why does a color wheel look white when it is spun?

Clearly, somehow the light is bending to create the bent image of the straw. Since it is only the image and not the straw itself, this suggests that light travels from the object to our eyes in order for us to perceive an image. (At this point, a slinky could be introduced as a visual aid for imagining light as a wave). When light passes from water into air, it bends only slightly because its speed is only changed slightly by the substances it is passing through. However, when light passes through a prism, the speed of the light changes much more.

The color wheel demonstration shows us that when all colors are mixed and blended together, our eyes/brain perceive the color as white. This means that white light is really a mixture of all colors. When white light passes through a prism, each different color of light is affected differently so when the light passes out the opposite side of the prism, all of the colors have been bent and split apart.

At this point, the formal vocabulary refraction and wavelength may be introduced to the discussion of light.

To summarize their understanding of the discussion, Partner A will talk to Partner B for 1 minute explaining their gist understanding of the topic. Partner B will then have 60 seconds to talk back to Partner A and either agree, disagree, or elaborate^{4,3}.

ELABORATION

Students will then receive the electromagnetic energy notes handout. The teacher should explain that not all wavelengths of light are visible and that, in fact, the visible portion of the spectrum is very small. Electromagnetic energy refers to all wavelengths of light and they are often referred to as the electromagnetic spectrum (EMS) because they exist over a continuous range of wavelengths. As each type of electromagnetic energy is introduced, the teacher and a student helper will model that wavelength using a slinky. As this model continues to be developed,

students will record some generalizations on their note sheets including labeling the arrows increasing energy and longer wavelength on their handouts along with labeling the sequence of the visible light spectrum (ROYGBIV).

Using the slinky and the shout-out protocol mixed with cold call, the teacher can conduct immediate informal assessment of student understanding of types of electromagnetic energy, wavelength, and energy.

Examples: Are infrared waves more or less energetic than red light?

How should I change the wavelength to move from infrared to red light?

Did my wave become more or less energetic? What two types of electromagnetic radiation could I have changed from?

Simpler questions about relationships (increase, decrease, more, less) or that identifying only one type of electromagnetic radiation are more appropriate for shout-outs. Cold call questions can be more sophisticated and probe for deeper understanding⁵.

Students will complete their survey of the EMS by going to

http://missionscience.nasa.gov/ems/01_intro.html and using the website to complete half of the EMS grid on their notes. The remainder of the grid will be completed through the Give one, get one protocol⁶ (although students may also simply choose to complete it independently using the website).

EVALUATION

1. Think-Pair-Share
2. Questioning
3. Partners
4. Discussion
5. Gist Statements Peer Review
6. Shout Out/Cold Call
7. Give One, Get One Grids

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Think-Pair-Share-The TPS protocol forces students to draw on their prior knowledge and beliefs before looking to the teacher for answers. It also fosters group work and communication with peers and draws on the oral and communal traditions of many student cultures
2. Hands On Experiences- This investigation is structured around tangible objects and experiences upon which students can fix their reasoning. This provides a conceptual bridge from a known object to a discoverable scientific concept.
3. Explicit bridging from home language to academic language-This lesson starts with students

talking to peers in their home language about science concepts and provides activities/experiences to grapple with the concept and begin to build their understanding. The scientific language and vocabulary is not introduced until students have already grappled with concepts in their home language and have achieved some understanding of the concept.

4. Partners- This protocol promotes communal learning and mutual accountability for the partner's learning. Not only do partners compare their experiences and reasoning in an effort to make sense of what they are observing, but they also check their understanding with their partner and help to refine their partner's understandings.

5. Shout out/Cold Call-This protocol serves to check whole class understanding by engaging students in a form of cultural discourse that is closer to their home cultures as it mirrors the call-and-response discourse styles of African traditions. This also provides code switching practice as students must be cognizant of when it is appropriate to shout out and when they must listen to a specific individual.

6. Give One; Get One- This protocol provides students with significant opportunities for movement in an authentic context. Students are provided with the choice of who they would like to share and interact with while understanding that their contributions must be meaningful as their peers are relying on them for their own learning. Thus this strategy also promotes communal learning.

Extension and Additional Resources:

1. Students could further explore refraction of light by investigating properties of lenses.

2. Have students examine the math of the electromagnetic spectrum by introducing the speed of light and calculating the frequencies for different wavelengths of light. This can then be reconnected with the slinky model.

CRT Lesson #19: The Many Faces of Energy I
Subject/ grade level: Middle School Science 7-8
Topic: Energy
<p>Materials:</p> <ul style="list-style-type: none"> • bouncy ball • poster paper • tennis balls, golf balls, ping pong balls • ruler • meter sticks • dice • Types of Energy handouts • Diagram of Bouncing Ball handouts
<p>NYS Standards:</p> <p>Standard 4: The Physical Setting- Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and recognize the historical development of ideas in science.</p> <p><u>Key Idea 4:</u> Energy exists in many forms, and when these forms change energy is conserved.</p> <p>Performance Indicator 4.1: Describe the sources and identify the transformations of energy observed in everyday life.</p> <p><i>Major Understandings:</i></p> <p>4.1e: Energy can be considered to be either kinetic energy, which is the energy of motion, or potential energy, which depends on relative position.</p>
<p>Lesson objective(s):</p> <p>Students will be able to...</p> <ul style="list-style-type: none"> - discern between kinetic and potential energy - describe the changes in energy that occur throughout the path of a bouncing ball (in terms of kinetic and potential energy) - compare the relative amounts of potential and kinetic energy between points on the path of a falling object
<p>ENGAGEMENT</p> <p>Open the class with a quick demonstration. At the front of the room, so all students can see, drop a bouncy ball from a predetermined height. Let it bounce multiple times before catching it. Drop the ball again from the same height. At this point, pose the following questions to your students:</p>

“Where does the ball have the most energy?”

“Where does the ball have the least energy?”

Give students 1-2 minutes to think about their answers, then have them turn to a partner and discuss what they think¹. Allow another 2-3 minutes for students to talk with each other and argue over where the ball has the most and least energy.

Call the students' attention back to the front of the class with an auditory cue² (Clap patterns, “Class, Yes”, etc.).

On the board, draw the path of the ball for two to three bounces. Draw a series of points along the path of the ball making sure that there are points at the beginning, middle, and end of the first bounce (5-8 points is sufficient). Ask students to stand³ if they think the ball has the most energy at point #1 and record the number above the point. Continue for each point on the path of the ball. Repeat for the point that has the least amount of energy and record the number below the point.

Ask for volunteers to explain their thinking. Pick-a-stick⁴ may be mixed in with asking for volunteers to ensure all students are engaged. Work to summarize student thinking and record these different explanations/reasoning on a piece of poster paper.

EXPLORATION

Tell students that they will be working in groups⁵ to further investigate the idea of energy in a bouncing ball. They will work in groups of no more than 4 to see if it is possible to get a ball to rebound to the height from which it was dropped⁶. They will have 3 different types of balls to work with: a tennis ball, a golf ball, and a ping pong ball. They will also have rulers and meter sticks available for use.

In their exploration, they must create a hypothesis, procedure, collect data, and arrive at a conclusion to be presented in a poster. However the exact details of how they conduct the investigation is up to them. At the end of the investigation, all group members must be prepared to share out.

Students may choose their own groups (or the teacher may group if it is deemed necessary), however once they have chosen their groups the teacher will assign each group member a number between 1 and 4 and each group will be given a number as well. Set a timer to give the students 10 minutes of planning time for their hypothesis and procedure. By the end of those 10 minutes, they must have checked in with the teacher and received approval to conduct their investigation.

Provide another 15-20 minutes for students to conduct their investigation and complete posters.

EXPLANATION

Use an auditory cue to bring everyone's attention to the front of the room. Then use the Roll 'Em protocol' (roll two dice: the first die indicates the group #, the second die designates the individual in the group who has to report out) to choose the first group and the individual who will present their group's findings.

Most groups should have found that it is impossible for the ball to return to the height that it was dropped from. Any group that *did* conclude it could return to the height it was dropped from probably threw the ball to the floor. Groups may have made other observations about which type of ball got the closest to its original height. Challenge students to consider, in terms of energy, why this is. This discussion depends on the background experiences of the students with energy concepts and if they are struggling to make meaning of their observations, it is time to forward load their knowledge.

At this point, the handout for "Types of Energy" should be passed out.

This handout provides three brief definitions. It introduces energy as the ability to do work, kinetic energy as the energy of movement, and potential energy as stored energy. It also introduces the Law of Conservation of Energy. Use the ball to model these two forms of energy.

To make sure students are comfortable with these terms, use the shout out protocol to check for understanding of PE and KE based on the images on the handout. For each image ask students to "shout out"^s potential energy, kinetic energy, or both, and confirm the correct answer by repeating it back to them. When all images have been correctly labeled, use pick-a-stick to ask students to explain why those labels apply.

Equipped with this knowledge, have student groups returned to the questions that they started class with: where does the ball have the least and the most energy? Have them consider ONLY the first bounce of the ball. Give students 5 minutes to discuss.

Use Roll 'Em again to have the first group share out their new thinking. Then use Roll'Em to identify subsequent groups to agree and elaborate or disagree and justify with previous groups' explanations.

By the end of this discussion, the class should have reached agreement on the following points:

1. The ball has the greatest potential energy at the beginning of its path before it is dropped because it is at its highest point above the ground.
2. As the ball falls, its kinetic energy increases while its potential energy increases.
3. The ball has the greatest amount of kinetic energy just before it hits the ground.

If students do not believe or accept their classmate's explanations/reasoning, it becomes the teacher's role to step in and make these points explicit^o. These notations should be made on the diagram of the bounce of a ball that has remained on the board.

ELABORATION

Pass out diagrams of the bounce of a ball. Within their groups, students are to work collaboratively on providing a narration/explanation for the changes in kinetic and potential energy during the successive bounces of the ball. This can be completed as a paragraph or as an annotated image (based on the annotations modeled by the teacher in the previous group discussion).

They will also work as a group to complete the accompanying questions. Only one narration needs to be turned in for the group but every individual needs to submit the questions as these link in the concept of the Law of Conservation of Energy and transformations between forms of energy which will be explored in the next lesson.

EVALUATION

1. Informal assessment via Think-Pair-Share and Pick-a-stick
2. Students check investigation procedures with teacher
3. Shout out understanding check for KE/PE
4. Class Discussion
5. Annotated Diagrams and Questions

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Think Pair Share-The TPS protocol forces students to draw on their prior knowledge and beliefs before looking to the teacher for answers. It also fosters group work and communication with peers and draws on the oral and communal traditions of many student cultures

2. Auditory Cues-These are simple classroom management cues that can be taught and used throughout the entire school year to facilitate transitions in the classroom. These auditory cues draw on the cultural backgrounds that emphasize sound and rhythm.

3. Standing Polls- This strategy for incorporates authentic movement into a lesson while assessing students and demanding participation and engagement from all individuals.

4. Pick-a-stick- This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message that while working in groups every individual is still responsible for participating and understanding the content.

5. Group Work- Students with Latino and/or African American cultural heritages are often raised with a greater cultural focus on cooperation and working together. Building in significant opportunities for group work draws on this heritage while also giving students opportunities to talk with each other. Thus group work reinforces two cultural strengths: cooperation and oral tradition

6. Hands on Investigation-This investigation is structured around motion and action while giving students tangible objects on which to fix their reasoning. This provides a conceptual bridge from a known object to a discoverable scientific concept.

7. Roll 'Em- This strategy helps to ensure that every individual is participating in group work. It particularly obligates group members to be cognizant of engaging every other member in the group and ensuring that every individual has an understanding of the group's thoughts, findings, and questions.

8. Shout Out- This protocol serves to check whole class understanding by engaging students in a form of cultural discourse that is closer to their home cultures as it mirrors the call-and-response discourse styles of African traditions. This provides a code switching opportunity in which they transition from school code (listening/lecture) to home code (shout out) and back to school code (pick-a-stick explicit turn taking).

9. Teacher as Elder- While this lesson relies heavily on the group achieving consensus of understandings around potential and kinetic energy, it also reserves a place for the teacher to step in, if need be, and serve at *the* authority on the topic at hand. This directly mirrors the way Latino and African cultures often perceive the role of the adult/elder authority in the community.

Extension and Additional Resources:

1. While this lesson is largely pursued and extended in a subsequent lesson, students could pursue further investigations regarding the impacts of different variables on the rebound heights of a bouncing ball which can then be used to generalize relationships between other variables and their effects on kinetic and potential energy.

2. The below link was the original source for the ball drop investigation and provides an inquiry wheel approach for further investigations.

http://www.asee.org/conferences-and-events/conferences/k-12-workshop/2012/Ball_Drop_activity.pdf

CRT Lesson #20: The Many Faces of Energy II

Subject/ grade level: Middle School Science 7-8

Topic: Energy

Materials:

- computers
- ball
- The Energy Story Chapter 1 Guides
- Silent Appointment record sheets

NYS Standards:

Standard 4: The Physical Setting- Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and recognize the historical development of ideas in science.

Key Idea 4: Energy exists in many forms, and when these forms change energy is conserved.

Performance Indicator 4.1: Describe the sources and identify the transformations of energy observed in everyday life. .

Major Understandings:

4.1d: Different forms of energy include heat, light, electrical, mechanical, sound, nuclear, and chemical. Energy is transformed in many ways.

Lesson objective(s):

Students will be able to...

- identify different forms of energy
- describe the energy transformations occur within different processes (kinetic to potential, transformations between different forms of energy)

ENGAGEMENT

Ask for a volunteer to summarize what the class has already learned about energy. Continue to ask for volunteers or use pick-a-stick to select students to elaborate on previous comments by students or to share something new that hasn't yet been mentioned. Push to get responses summarizing the two main types of energy (PE and KE), the relationship between these two types of energy in the path of a bouncing ball, and the law of conservation of energy.

Inform students that, while we can classify energy into the two types of PE and KE, energy (especially PE) can exist in many different forms and the law of conservation of energy tells that energy can be readily changed between these forms.

Have students take out a scrap piece of paper and number it 1-10. Tell them that they are going to watch a video clip that gives examples of 10 different forms of energy. As they watch the video, they are going to try to identify what those 10 forms are. Provide the hint that one of the forms of energy that is included will be kinetic energy.

Video clip- <http://www.youtube.com/watch?v=kbQc-XUrWvo>

Pause the video clip before it reaches the end where it reveals the 10 types of energy.

EXPLORATION

Throw a ball to a student and ask them to name one form of energy they saw in the video. Record their response and then have them throw the ball to another student while asking them “What form of energy did you find?” If the recipient of the ball has a form of energy that has not been shared already, they share it. If not they respond with “I also had _____ energy”. Keep passing the ball around until as many forms of energy have been identified as possible.

With the responses that have been recorded, ask students to identify the video clips that went with them. Then provide the remaining forms of energy to the students and for volunteers to match up the form of energy with the video clip. They match as follows:

1. Magnetic- junkyard electromagnet
2. Kinetic- ATVs in the desert
3. Heat- the sun
4. Light- light bulbs
5. Gravitational- amusement park ride drop
- 6 .Chemical- burning materials (a chemical reaction)
7. Sound- man repeating himself over and over
8. Elastic- trebuchet
9. Electrical- arcing on electric lines
10. Nuclear- bomb drop

EXPLANATION

Assure students that, while they don't need to memorize all 10 forms of energy, they should be familiar with 5 main ones: kinetic, heat, light, chemical, electrical, and nuclear.

Tell students that they will be conducting independent research on energy and its different forms.

Primarily, they will be focusing on how energy is transformed between different forms and how those different forms can be harnessed by humans.

To do so, they will begin by completing a reading guide for the following website:

<http://energyquest.ca.gov/story/chapter01.html>

Although the website looks extremely dense, reassure students that they will only be responsible for investigating parts of Chapter 1 and one other chapter that will be assigned to them randomly. For their second chapter, students will be responsible for creating a short PowerPoint presentation that will be shared with their peers to teach them about the topic in that chapter. The PowerPoint should include the following features:

- A title identifying the energy topic
- A written and visual description of how this type of energy production works.
- Examples of how humans utilize this form of energy production
- Identification of all of the energy transformations (how the energy moves from form to form) that occur when energy is produced in this way

Pass out “The Energy Story: Chapter 1 Guides” while students pick up laptops.

Students should work independently to complete this guide. When they are finished, they can turn it in to the teacher and can draw a number at random. The number represents the second chapter on The Energy Story that they are responsible for.

The chapters under investigation will be:

- Chapter 2: Electricity
- Chapter 5: Stored Energy
- Chapter 12: Hydro Energy
- Chapter 13: Nuclear Energy
- Chapter 14: Ocean Energy
- Chapter 15: Solar Energy
- Chapter 16: Wind Energy

Students who finish their presentations early may act as expert helpers to assist other students in developing presentations and making sense of the information they are processing. Presentations should be shared with the teacher either via email, saving to a flash drive, or other method.

ELABORATION

When all presentations are finished, students will engage in 4 silent appointments with their peers. Each appointment will last 5 minutes. Within their appointments, each partner will take a turn sharing the findings from their research while the other takes notes on their silent appointment record sheet.

To make their first silent appointment, students set up appointments with a partner silently by making eye contact and nodding. After their first appointment has ended, they set up their second appointment the same way.

After their final silent appointment, students will complete their final reflection question:

“Based on what you learned today, why can a ball never bounce back to the height it was dropped from? What happens to the energy?”

Final reflection responses and silent appointment record sheets should be turned in to the teacher.

EVALUATION

1. Pick-a-stick questioning
2. Pass the ball
3. Chapter 1 Guides
4. PowerPoint presentations
5. Silent Appointment Record sheets
6. Final Reflection Question

Culturally Responsive Strategies and Pedagogical Practices Implemented:

1. Pick-a-Stick- This strategy is an equitable way of eliciting non-volunteered answers from students. As sticks with each student name are drawn at random, it communicates the message that while working in groups every individual is still responsible for participating and understanding the content.
2. Pass the Ball- This is an explicit turn taking strategy that teaches situational appropriateness while incorporating meaningful movement and activity into the lesson. The ball is a tangible cue that indicates the only individual who should be talking. The strategy also makes it safe for everyone to participate as students can repeat a previous answer if they have no new answers to contribute.
3. Peer Tutors- This strategy draws on student expertise to maintain engagement while also fostering a sense of communal responsibility for each other’s learning.
4. Silent Appointment- This protocol helps students to practice situationally appropriate behavior by having students follow a specific silent protocol that also allows student choice in partners and meaningful movement.
5. Team-Pair-Solo- Although this scaffolded approach is slightly modified between these two lessons (Many Faces of Energy Parts I and II), this protocol has students work on a question/problem first with partners and in the context of a group before asking them to address

it by themselves. This protocol uses a gradual transition away from cooperative learning to help students tackle a problem that may have originally been too difficult for them.

Extension and Additional Resources:

1. Students can investigate how these different energy sources impact them locally: Which forms of energy are in fact relevant to their communities? How are these forms of energy changing? What are future proposals to meet energy demands and are they effective/efficient?

Discussion and Summary of Process

In this project, a comprehensive survey was conducted on the theoretical principles of culturally responsive teaching as described in the body of educational literature. These theoretical principles were then transformed and synthesized into a comprehensive framework describing the application of CRT at all levels of education. Having outlined this macrostructure for CRT, attention was then shifted to CRT at the classroom level. Six elements of classroom practices were identified as being essential to establishing a culturally responsive classroom. These 6 elements were then analyzed to provide concrete principles for classroom implementation. In particular, consideration was given to modifying the 6 elements of responsive classroom practices for urban populations (primarily of African American and Latino composition). Exemplar lessons were then designed around the New State Regents science standards to model application of these principles in both the middle school and the high school science classrooms.

Each lesson followed the same format and includes the following components: title, grade level, topic, materials, NYS standards, learning objectives, full lesson plan following the 5-E learning model, a list of culturally responsive strategies and pedagogical practices used, and extensions and additional resources. The title, grade level, and topic all function to provide teachers with a general overview of the content covered in the lesson plan and the grade levels for which the lesson may be applicable. If the lesson has potential for multiple grade levels, that possibility is noted. Similarly, if the lesson was designed for a particular setting (eg. Self-contained classrooms) it is also noted. The comprehensive materials list allows teachers to quickly identify whether they have the necessary supplies available to implement the lesson.

Provision of New York state science standards is not only significant in assisting teachers in identifying how the lesson fits into their mandated curriculum, but also demonstrates that culturally responsive teaching *can* occur within the current curricula provided to teachers. The student learning objectives identify particular student outcomes that should be achieved by the end of the lesson and further reinforce the fact that *authentic* and *rigorous* science instruction can occur while applying culturally responsive teaching practices.

The 5-E model was adopted for the general lesson plan template given its alignment with constructivist principles which are central to culturally responsive teaching. The engage component of the model encourages teachers to find culturally compatible entry points and experiences that can be used to hook students while the exploration component aligns with students working collaboratively and discussing and grappling with science concepts in their home language. The transition into the explanation and elaboration components provides a direct scaffold for students to begin transitioning from home language to academic language with teacher guidance.

At the core of this project is the identification of the culturally responsive strategies and pedagogies used to transform the lesson. While these lessons largely subscribe to best-practices in science instruction, this section enumerates and justifies the strategies while providing the reasoning that transforms a high-quality science lesson into one that is a high-quality *and* culturally responsive lesson. This section also provides teachers with simple strategies that they can implement to begin infusing their own instruction with culturally responsive practices. Perhaps most significantly, it demonstrates that CRT in the science classroom does not have to be time consuming for the teacher nor does it require vast revisions of the curriculum.

Finally, a list of extensions and additional resources are provided for teachers who wish to have their students continue to explore a topic beyond the scope of the lesson. Many of these extensions demonstrate further alignments with CRT and/or provide links to resources that can be used to further infuse the classroom with multicultural and responsive practices.

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Appendix A:

Ancillary documents for:

A framework for culturally responsive teaching:

Effectively implementing culturally responsive
instruction in the science classroom

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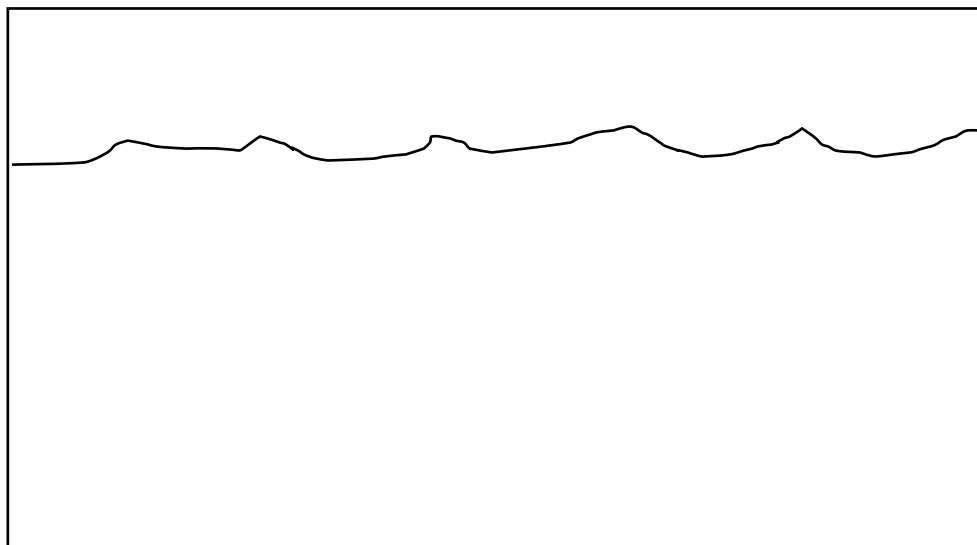
DIVING INTO DENSITY: INVESTIGATION

DIRECTIONS: In the table below, record the mass and volume that you measured for each block.

Block	Mass	Volume	???
A			
B			
C			
D			
E			
F			
G			
H			

DIRECTIONS: In the table below, predict whether you think each block will sink or float. After you watch the actual experiment, record the actual results and draw a picture showing the results.

Block	A	B	C	D	E	F	G	H
Predict								
Actual								



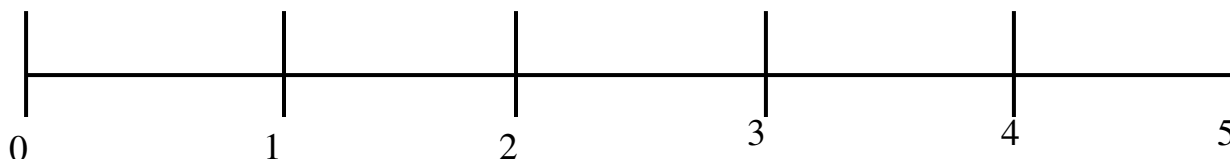
Exploring the Atom: Investigation Record

Hypothesis: I think my nucleus has _____ protons and _____ neutrons.

Procedure/Results: In the space below, list any steps or strategies you used to determine the number of protons and neutrons in your nucleus. Also, describe how you knew when you found a proton/neutron. You may want to draw pictures.

Conclusion: Based on my results, I believe that I encountered _____ protons and _____ neutrons in my nucleus making it a(n) _____ atom.

Uncertainty: On a scale of 0-5 (5 being the most), rank how confident you are in the accuracy of your results by placing an X on the line below.

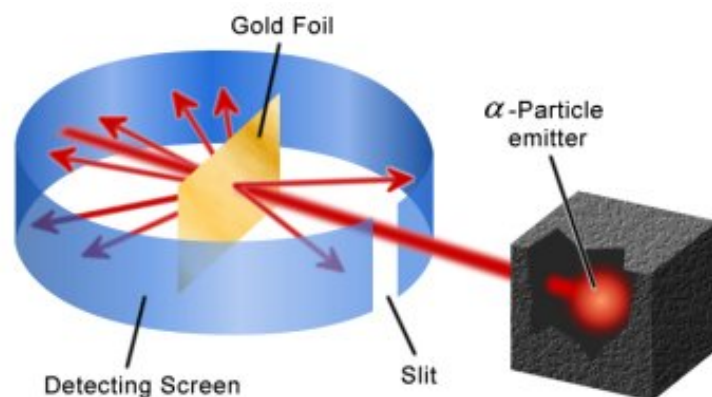


DIRECTIONS: Read the following passage and answer the following questions using information from the reading, your knowledge of science, and your experiences from today's lab.

Uncovering the Atom: Rutherford's Gold Foil Experiment

The idea that matter is made up of particles called atoms has existed for over 2500 years. However, it is only in the last 100 years that scientists have started to understand what the atom really looks like. Atoms are too small to be seen. In order to draw a picture of what they look like, scientists must carry out experiments and use the results to infer (or guess) what they are like.

In 1911, Ernest Rutherford set out to study the structure of the atom. In Rutherford's experiment, tiny particles were fired at a sheet of gold foil. At the time, scientists thought the atom was a solid mass made of electrons placed among protons (like raisins in a loaf of bread). If that model were correct, Rutherford's experiment should have shown the particles bouncing off of the gold foil. Instead, most of the particles passed straight through the foil. Some of the particles, however, bounced off of the sheet.



The results of the gold foil experiment led to a new theory for the model of the atom. Rutherford proposed that the atom was mostly empty space and that most of the mass was located in a dense center which he called the nucleus.

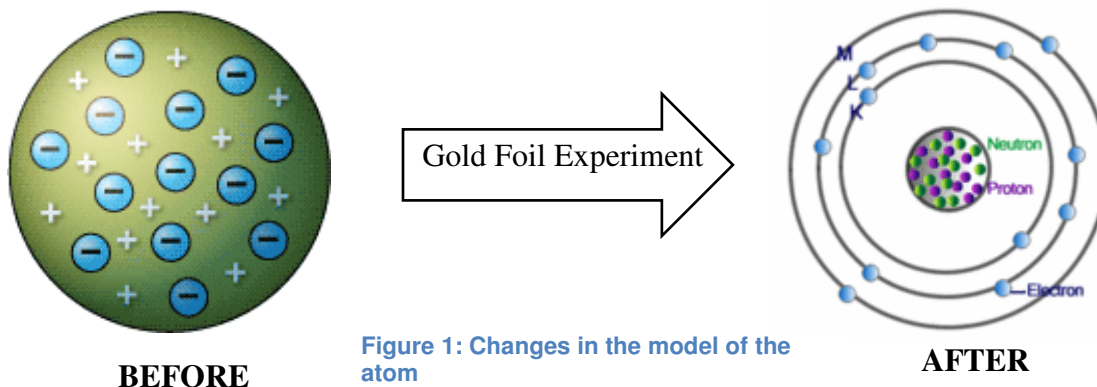


Figure 1: Changes in the model of the atom

QUESTIONS:

1. What part(s) of the atom were Rutherford's particles bouncing off of?
2. Why were most of the particles able to pass straight through the foil?
3. What did Rutherford's experiment prove/demonstrate and how did it change the theory of the atomic model?

Uncovering the Atom

***Replace **bold** words with blanks to generate Cloze notes

- The idea of atoms as the smallest part of matter dates back 2500 years but the original model was not based on **science**
- The original model of the atom was **wrong** because it said atoms were **unbreakable**
- Experiments over the past 100 years have shown the atom is actually made of 3 different **subatomic** particles.
 - **Electrons** are extremely small negatively charged particles. They are so small that they have a mass of zero.
 - Protons are positively charged particles with a mass of one. Because it is nearly **impossible** for an atom to gain or lose protons, the number of protons is used to identify the **kind** of atom.
 - The number of protons in an atom is known as its **atomic** number.
 - Neutrons are particles with the same mass as protons, but with a charge of zero. (**neutral**)
 - By adding the number of **protons** and **neutrons**, you can calculate atomic mass.
- Scientists continue to carry out experiments to develop a better **model** of the atom.

Directions: Teach someone at home (mom, dad, brother, sister, grandma, grandpa, friend) about atoms. Then have them take this quiz.

Atoms Quiz

Decide whether the following statements are true or false then write T or F on the line to the left of the statement.

- _____ 1. Atoms are the smallest unit of matter.
- _____ 2. Electrons are positively charged particles.
- _____ 3. Adding up the number of protons and neutrons gives an atom's mass.
- _____ 4. Atoms easily lose or gain protons.
- _____ 5. Scientists know everything there is to know about the atom.

Directions: Teach someone at home (mom, dad, brother, sister, grandma, grandpa, friend) about atoms. Then have them take this quiz.

Atoms Quiz

Decide whether the following statements are true or false then write T or F on the line to the left of the statement.

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- _____ 4. Atoms easily lose or gain protons.
- _____ 5. Scientists know everything there is to know about the atom.

EXPLORING MATTER

Definition of Matter: _____.

DIRECTIONS: You will be proving (or disproving) that solids, liquids, and gases fit our definition of matter. Complete the challenges/questions below to demonstrate the properties of these substances.

You will need the following materials:

- A wooden block
- A beaker of water
- A triple beam balance
- A calculator
- A graduated cylinder
- A ruler
- A balloon

	Solid	Liquid	Gas
1. What is the mass of this substance?			
2. Does this substance have volume?			

	Solid	Liquid	Gas
3. Calculate the volume. Show your work.			
4. Without taking away any of the substance, is it possible to change its volume? How?			
5. What is the shape of the substance right now?			
6. Without taking away any of the substance's mass, is it possible to change its shape? How?			

Conclusion Questions:

1. Can we say that solids, liquids, and gases are all matter? Why or why not?
2. How are the properties of solids, liquids, and gases the same? How are they different?
3. Would fire be considered matter? Why or why not?

Concept Map Words and Phrases:

SOLID	LIQUID	GAS	Particles are moderately attracted to each other
Particles move slowly	Takes the shape of its container	Volume spreads to fill any container	Particles are moving at a medium rate
Particles have low energy	Takes the shape of its container	Particles have medium energy	Particles are weakly attracted to each other
Particles attract each other strongly	Has a fixed volume	Particles have high energy	Particles are moderately attracted to each other
The particles have a loose pattern	The particles have no pattern	The particles are moderately close together	The particles are spread far apart
Has a fixed volume	Has a fixed shape	Particles are moving rapidly	The particles are packed close together

SAMPLE PERIODIC TABLE ANALOGY CARDS



Answer key is available at: <http://www.purdue.edu/discoverypark/gk12/downloads/Hands-on-Chemistry.pdf> (page 37)

Getting to Know the Periodic Table

Objective: To be able to use the periodic table to identify elements and classify them and to use the periodic table to predict the behavior of elements.

Procedure: Follow the directions carefully. Read all directions before you start and use your textbook or the internet to complete the following:

1. Number the groups (columns) one through eighteen.
2. Number the periods (rows) one through seven.
3. Draw a heavy black line between the metals and nonmetals.
4. Write the name of each of the following groups above the number:

Group 1
Group 2
Group 3 – 12 (collectively)
Group 16
Group 17
Group 18

5. Write the names of the two rows at the bottom of the chart.
6. Write the symbol of each element that exists as a gas at room temperature in red.
7. Write the symbol of each element that is a solid at room temperature in black.
8. Write the symbol of each element that is a liquid at room temperature in blue.
9. Write the symbol of elements considered man-made in outline form.
10. Place the atomic number for each element above the symbol.
11. Use the following chart to color the periodic table:

Halogens	blue
Noble gasses	yellow
Alkali metals	purple
Alkaline earth metals	red
Transition elements	green
Chalcogens	brown
Lanthanoids	orange
Actinoids	light blue

12. Outline the symbol's box in dark green if it is radioactive in its most common form.

Blank Periodic Table of the Elements

<http://chemistry.about.com>

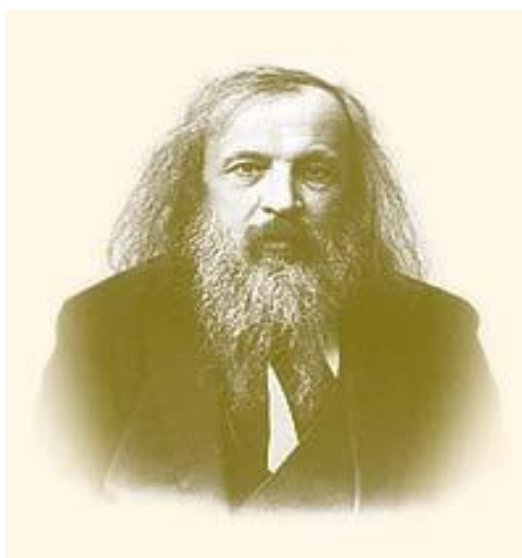
©2008 Todd Helmenstine

The image shows a blank periodic table grid. It consists of a main body of 7 rows and 18 columns. The first row has 2 cells, the second row has 2 cells, the third row has 2 cells, the fourth row has 18 cells, the fifth row has 18 cells, the sixth row has 18 cells, and the seventh row has 18 cells. Below the main body, there are two rows of 14 cells each, representing the lanthanide and actinide series. The grid is empty, with no elements or symbols present.

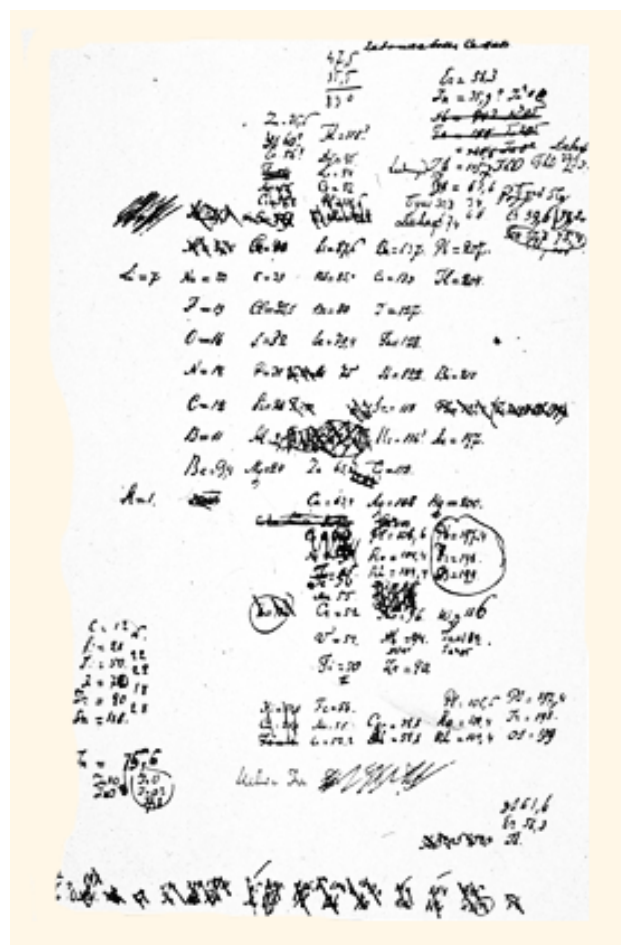
The Periodic Table of Elements

➤ Dmitri Ivanovich Mendeleev (1834-1907)

WHO ORGANIZED THE ALPHABET? We will never be able to attribute to a single individual the development of the basic building blocks of writing. Yet we do know the name of the man who devised the method of classifying the basic building blocks of matter. Dmitri Ivanovich Mendeleev was born in Siberia in 1834. When Mendeleev became a professor of general chemistry at the University of St. Petersburg, he was unable to find an appropriate textbook and thus began writing his own. That textbook, written between 1868 and 1870, would provide a framework for modern chemical and physical theory.



Mendeleev first trained as a teacher in the Pedagogic Institute of St. Petersburg before earning an advanced degree in chemistry in 1856.



Mendeleev's first sketch of a periodic table of the elements

➤ Elements and Their Properties

COMBINATIONS OF 26 LETTERS make up every word in the English language.

Similarly, all material things in the world are composed of different combinations of about 100 different elements. An element is a substance that cannot be broken down into simpler substances through ordinary chemistry--it is not destroyed by acids, for example, nor changed by electricity, light, or heat. Although philosophers in the ancient world had a rudimentary concept of elements, they were incorrect in identifying water, for example, as one. Today it is common knowledge that water is a compound, whose smallest unit is a molecule. Passing electricity through a molecule of water can separate it into two atoms of hydrogen and one atom of oxygen, each a separate element.

The ancient concept of elements jibed with today's in noting that elements had characteristic properties. Just as people not only look different from each other but also interact differently with others, so elements have both physical and chemical properties. Some elements form shiny solids, for example, that react readily and sometimes violently with oxygen and water. The atoms of other elements form gases that scarcely interact with other elements.

			Ti = 50	Zr = 90	? = 180
			V = 51	Nb = 94	Ta = 182
			Cr = 52	Mo = 96	W = 186
			Mn = 55	Rh = 104,4	Pt = 197,4
			Fe = 56	Ru = 104,4	Ir = 198
		Ni =	Co = 59	Pd = 106,6	Os = 199
			Cu = 63,4	Ag = 108	Hg = 200
H = 1			Zn = 65,2	Cd = 112	
	Be = 9,4	Mg = 24	? = 68	Ur = 116	Au = 197?
	B = 11	Al = 27,4	? = 70	Sn = 118	
	C = 12	Si = 28	As = 75	Sb = 122	Bi = 210?
	N = 14	P = 31	Sc = 79,4	Te = 128?	
	O = 16	S = 32	Br = 80	J = 127	
	F = 19	Cl = 35,5	Rb = 85,4	Cs = 133	Tl = 204
Li = 7	Na = 23	K = 39	Sr = 87,6	Ba = 137	Pb = 207
		Ca = 40	Ce = 92		
		? = 45	La = 94		
		?Er = 56	Di = 95		
		?Yt = 60	Th = 118?		
		?In = 75,6			

Mendeleev's table as published in 1869, with many gaps and uncertainties

Below: The table, rotated ninety degrees, as shown in textbooks in 1898 when Marie Curie discovered Radium. Mendeleev and others promptly added the new element to their textbooks. Its place is in column II below Ba, Barium. (From W. Ostwald, *Grundriss der Allgemeine Chemie*.)

0	I	II	III	IV	V	VI	VII	
He 4	Li 7	Be 9-1	B 11	C 12	N 14	O 16	F 19	—
Ne 20	Na 23	Mg 24-4	Al 27-1	Si 28-4	P 31-0	S 32-1	Cl 35-5	—
Ar 40	K 39-1	Ca 40	Sc 44-1	Ti 48-1	V 51-2	Cr 52-1	Mn 55-0	Fe 56, Ni 58-7, Co 59
Kr >45	Cu 63-6	Zn 65-4	Ga 70	Ge 72	As 75	Se 79-1	Br 80-0	—
X > 65	Rb 85-4	Sr 87-6	Y 89	Zr 90-6	Nb 94	Mo 96-0	—	Ru 102, Rh 103, Pd 106
—	Ag 107-9	Cd 112	In 114	Sn 118-5	Sb 120	Te 127	J 126-9	—
—	Cs 133	Ba 137-4	La 138 etc.	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	Yb 173	—	Ta 183	W 184	—	Os 191, Ir 193, Pt 195
—	Au 197-2	Hg 200-3	Tl 204-1	Pb 206-9	Bi 208	—	—	—
—	—	—	—	Th 232	—	U 240	—	—

SCIENTISTS HAD IDENTIFIED over 60 elements by Mendeleev's time. (Today over 110 elements are known.) In Mendeleev's day the atom was considered the most basic particle of matter. The building blocks of atoms (electrons, protons, and neutrons) were discovered only later. What Mendeleev and chemists of his time could determine, however, was the atomic weight of each element: how heavy its atoms were in comparison to an atom of hydrogen, the lightest element.

“I began to look about and write down the elements with their atomic weights and typical properties, analogous elements and like atomic weights on separate cards, and this soon convinced me that the properties of elements are in periodic dependence upon their atomic weights.”

--Mendeleev, Principles of Chemistry, 1905, Vol. II

A modern periodic table.

1A	Periodic Table of the Elements																0						
1 H	2 He																						
3 Li	4 Be	5 B	6 C	7 N	8 O	9 F	10 Ne																
11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar																
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr						
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe						
55 Cs	56 Ba	57 *La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn						
87 Fr	88 Ra	89 +Ac	104 Rf	105 Ha	106 Sg	107 Ns	108 Hs	109 Mt	110 110	111 111	112 112	113 113											
* Lanthanide Series		58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu								
* Actinide Series		90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr								

Classifying the Elements

AN OVERALL UNDERSTANDING of how the elements are related to each other and why they exhibit their particular chemical and physical properties was slow in coming. Between 1868 and 1870, in the process of writing his book, *The Principles of Chemistry*, Mendeleev created a table or chart that listed the known elements according to increasing order of atomic weights. When he organized the table into horizontal rows, a pattern became apparent—but only if he left blanks in the table. If he did so, elements with similar chemical properties appeared at regular intervals—periodically—in vertical columns on the table.

Mendeleev was bold enough to suggest that new elements not yet discovered would be found to fill the blank places. He even went so far as to predict the properties of the missing elements. Although many scientists greeted Mendeleev's first table with skepticism, its predictive value soon became clear. The discovery of gallium in 1875, of scandium in 1879, and of germanium in 1886 supported the idea underlying Mendeleev's table. Each of the new elements displayed properties that accorded with those Mendeleev had predicted, based on his realization that elements in the same column have similar chemical properties. The three new elements were respectively discovered by a French, a Scandinavian, and a German scientist, each of whom named the element in honor of his country or region. (Gallia is Latin for France.) Discovery of a new element had become a matter of national pride—the rare kind of science that people could read about in newspapers, and that even politicians would mention.

Claiming a new element now meant not only identifying its unique chemical properties, but finding the atom's atomic weight so the element could be fitted into the right slot in the periodic table. For radioactive atoms that was a tough challenge. At first these atoms were isolated only in microscopic quantities. The straightforward way to identify them was not by their chemical properties at all, but by their radiations. Until the radioactive atoms could be sorted out with traditional chemistry, some scientists were reluctant to call them new elements.

WHAT MADE THE TABLE PERIODIC? The value of the table gradually became clear, but not its meaning. Scientists soon recognized that the table's arrangement of elements in order of atomic weight was problematic. The atomic weight of the gas argon, which does not react readily with other elements, would place it in the same group as the chemically very active solids lithium and sodium. In 1913 British physicist Henry Moseley confirmed earlier suggestions that an element's chemical properties are only roughly related to its atomic weight (now known to be roughly equal to the number of protons plus neutrons in the nucleus). What really matters is the element's atomic number—the number of protons its atom carries, which Moseley could determine with X-rays. Ever since, elements have been arranged on the periodic table according to their atomic numbers. The structure of the table reflects the particular arrangement of the electrons in each type of atom. Only with the development of quantum mechanics in the 1920s did scientists work out how the electrons arrange themselves to give the element its properties.

[On learning about the table] “For the first time I saw a medley of haphazard facts fall into line and order. All the jumbles and recipes and hotchpotch of the inorganic chemistry of my boyhood seemed to fit themselves into the scheme before my eyes — as though one were standing beside a jungle and it suddenly transformed itself into a Dutch garden.”

— *C.P. Snow*

NAMING HYDROCARBONS: Prefixes and Suffixes

Prefix	Number of Carbon Atoms

Suffix	Kind of Bond	Saturated or Unsaturated?
-ane		
	double	
		unsaturated

EXPERIMENTAL DESIGN NOTES

What did the researchers think was going to happen?	Hypothesis: In my words:
Who participated in the experiment?	Sample: In my words:
How were the dolls the same? What was different about the dolls?	Controlled Variables: In my words: Independent Variable: In my words:

<p>What did the researchers find out from the results?</p>	<p>Dependent Variable:</p> <p>In my words:</p> <p>Conclusion:</p> <p>In my words:</p>
<p>How do you think the experiment could have been improved?</p>	<p>Sources of Error:</p> <p>Sample Size:</p> <p>Representative Sample:</p> <p>Repeatability:</p>

Imagine that in addition to having different colors, the following is also true about jelly bean traits:

- A. Dark colored jelly beans are able to survive lower temperatures while light colored jelly beans are better able to survive in warmer temperatures.
- B. Jelly Beans have many predators
- C. Jelly Beans with sports are more likely to get sick
- D. All jelly beans have a gene that requires them to eat a certain protein that can only be gotten from the jelly plant. Without it, they die.

DIRECTIONS: Use the information above to predict what would happen to variations in the jelly bean population in the following scenarios. Be sure to support your prediction. An example has been provided for you.

1. The jelly beans' habitat is usually a field of colorful flowers. However, all of the colorful flowers are mowed down to produce a park with short cut grass.

The green jelly beans will probably survive because they are camouflaged and blend in with the grass. However, colors that stand out will probably die because predators will be able to see them more easily.

2. Global warming causes the average temperature of the jelly beans' habitat to increase by 5 degrees.

3. The influenza virus (which jelly beans can get) is brought into their habitat.

4. All of the jelly plants die.

5. Over many years, the jelly beans' field suffers from erosion and eventually turns into a white sand desert. Fortunately, some jelly plants are still able to grow.

NATURAL SELECTION

***Teacher's Note: The underlined words should be deleted to create Cloze notes

5 Components of Natural Selection	Description	Illustration/Example
1. Overproduction	Organisms produce more <u>offspring</u> than can survive. Most of these offspring will die or be killed before they mature and are able to <u>reproduce</u> .	
2. Limited Resources	There are not enough <u>resources</u> in the environment to support all organisms. Members of the same species <u>compete</u> with each other and with other species for <u>food</u> , living space, hunting grounds, water, nutrients, <u>mates</u> , etc.	
3. Variation Within Species	Within any single species there are many differences in <u>genes</u> and characteristics. <u>Variations</u> can be visible (color, size, etc) or they can involve an organism's behaviors (hunting, running, hiding).	
4. Competition	Because there are <u>limited resources</u> , and <u>overproduction</u> , not all organisms will survive. Organisms with <u>variations</u> that help them survive will <u>outcompete</u> members of the same species that don't have that variation.	
5. Passing on Traits	The organisms that outcompete other members of their species are the ones that survive and <u>reproduce</u> . By surviving to have their own offspring, those organisms pass on their <u>traits</u> to their children. While these individual variations may be <u>small</u> , over time the changes can accumulate to make completely new <u>species</u> .	



United Nations

International Year of Freshwater 2003



WaterYear2003

Fact Sheet

Water: A Matter of Life and Death

There are more than one billion people who lack access to a steady supply of clean water. There are 2.4 billion people — more than a third of the world's population — who do not have access to proper sanitation. The results are devastating:

- ◆ More than 2.2 million people, mostly in developing countries, die each year from diseases associated with poor water and sanitary conditions.
- ◆ 6,000 children die every day from diseases that can be prevented by improved water and sanitation.
- ◆ Over 250 million people suffer from such diseases every year.

Access to water and sanitation, so crucial for human well-being and development, has now become a priority for the international community. To underscore the need for immediate action, the United Nations has designated 2003 as the International Year of Freshwater.

Although essential, freshwater is unevenly distributed: while 70 per cent of the world's surface is covered by water, 97.5 per cent of that is salt water. And of the remaining 2.5 per cent that is freshwater, almost three quarters of that is frozen in ice caps.

While in most regions there is still enough water to meet everyone's needs, it needs to be properly managed and used. In today's world, much water is wasted or used inefficiently, and often demand is growing faster than the supply can be replenished by nature. While competition over water resources can be a source of conflict, history has shown that shared water can also be a catalyst for cooperation.

Key Statistics

- ◆ About 70 per cent of all available freshwater is used for agriculture. Yet because of inefficient irrigation systems, particularly in developing countries, 60 per cent of this water is lost to evaporation or is returned to rivers and groundwater aquifers.
- ◆ Water withdrawals for irrigation have increased by over 60 per cent since 1960.
- ◆ About 40 per cent of the world's population currently lives in areas with moderate-to-high water stress. By 2025, it is estimated that about two thirds of the world's population — about 5.5 billion people — will live in areas facing such water stress.
- ◆ More and more of the world is facing water shortages, particularly in North Africa and Western and South Asia.
- ◆ Water use increased six-fold during the last century, more than twice the rate of population growth.
- ◆ Water losses due to leakage, illegal water hook-ups and waste total about 50 per cent of the amount of water used for drinking in developing countries.
- ◆ About 90 per cent of sewage and 70 per cent of industrial wastes in developing countries are discharged without treatment, often polluting the usable water supply.
- ◆ Freshwater ecosystems have been severely degraded: about half the world's wetlands have been lost and more than 20 per cent of the world's 10,000 known freshwater species are extinct.

- ◆ In areas such as the United States, China and India, groundwater is being consumed faster than it is being replenished, and groundwater tables are steadily falling. Some rivers, such as the Colorado River in the western United States and the Yellow River in China, often run dry before they reach the sea.
- ◆ The task of carrying water in many rural areas falls to women and children, who often must walk miles each day to get water for their family. Women and girls also tend to suffer the most as a result of the lack of sanitation facilities.
- ◆ At any one time, half of the world's hospital beds are occupied by patients suffering from water-borne diseases.
- ◆ During the 1990s, about 835 million people in developing countries gained access to safe drinking water, and about 784 million gained access to sanitation facilities.

Meeting the Global Targets

The 147 world leaders who attended the UN Millennium Summit in 2000 adopted the target of 2015 for halving the proportion of people who are unable to reach or to afford safe drinking water. At the 2002 World Summit on Sustainable Development in Johannesburg, countries agreed to a parallel goal to halve by 2015 the proportion of people without proper sanitation.

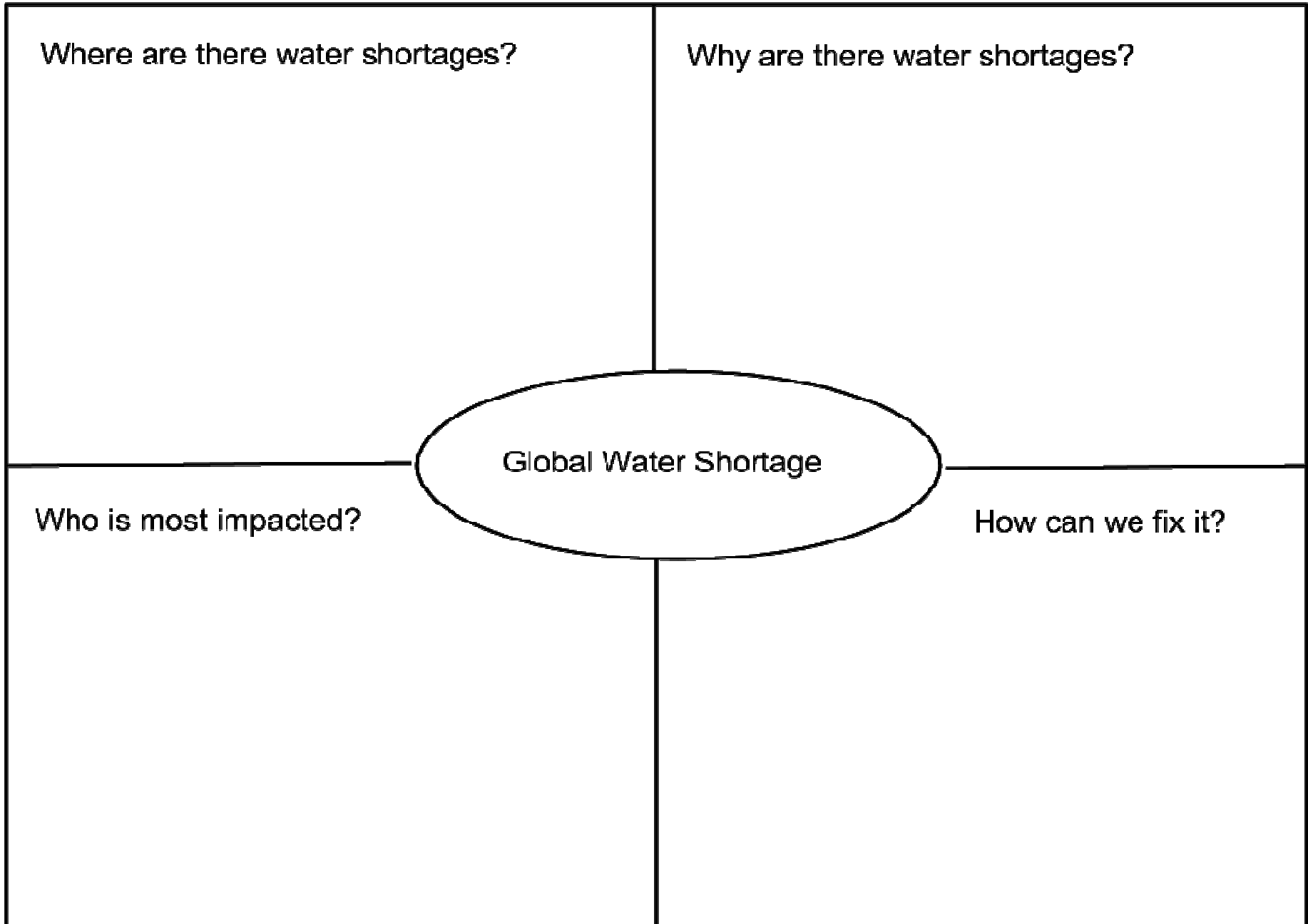
The cost of upgrading water supply and sanitation to meet basic human needs in developing countries is

estimated to run about \$20 billion a year — current spending in those countries totals about \$10 billion each year.

Estimates for the level of global investment required in all forms of water-related infrastructure vary widely, although there is wide agreement that the present investment level of \$70-80 billion a year needs to be substantially increased. According to some estimates, up to \$180 billion is required annually.

While there is agreement on the urgent need to improve water management, there are policy differences regarding how best to do this. Some contend that access to clean drinking water and sanitation is a human right for which governments are obligated to provide services. Others maintain that water is an economic good that should be provided in the most cost-effective way, including market-driven schemes and privatization of certain components of water delivery as options. Many governments have pursued a hybrid approach.

Countries that have concentrated efforts on improving access to water and sanitation have made progress. In South Africa, for example, 14 million people out of a total population of 42 million lacked access to clean drinking water in 1994. But in seven years, South Africa has halved the number of people who lack access to safe water — ahead of schedule. If the present targets are met, South Africa aims to provide everyone with clean drinking water and sanitation by 2008.



	What it sounds like to me...	What I think it means now...	What we think it means...	What it means in the scientific community...
Vertical Farming				
Genetically Modified Organisms				
Sustainable Agriculture				

Lab Grown Meat				
Food Deserts in the United States				

ORAL PRESENTATION RUBRIC

	3	2	1
Collaboration (X2)	All group members participate equally in presentation.	All group members participate, but presentation is dominated by 1 or 2 individuals.	All group members do not participate in presentation.
Clarity (X2)	Explanations of material are delivered concisely and clearly using appropriate science vocabulary and including relevant facts and details.	Explanations of material are supported by relevant facts and detail but are meandering and use minimal science vocabulary.	Explanations are confusing and lack support from relevant facts and details.
Delivery (X1)	Presenters are audible and speak with fluency and expression.	Presenters are audible but lack fluency and expression.	Presenters are not audible and do not demonstrate fluency or expression.
Poise (X1)	All presenters stand, demonstrate good posture, and make eye contact with audience.	Some presenters remain seated, are hunched/slumped, and have eyes cast down.	No presenters stand, demonstrate good posture, or make eye contact.

TOTAL _____/18

PRODUCT RUBRIC

	3	2	1
Content (X2)	Thoroughly describes the subject using vivid detail. All content is accurate. Illustrates depth of understanding.	Describes subject incorporating relevant details.. Most content is accurate. Demonstrates emerging understanding	No evidence of further research on subject and/or largely inaccurate content. Shallow understanding.
Real World Application (X2)	Identifies and describes examples and instances of this solution being implemented. Identifies successes and challenges that need to be overcome.	Identifies and describes examples and instances of this solution being implemented	Fails to identify any implementation of this solution.
Feasibility/ Evaluation (X3)	Thoroughly identifies pros and cons of approach. Uses evidence and data to support the subject's actual potential in sustaining a global food supply.	Identifies the pros and cons of this approach towards attaining a sustainable global food supply.	Fails to address pros and cons of approach. Overall judgment lacks supporting evidence/data.
Creativity and Organization (X1)	Flow of information is logical. Final product is neat, visually pleasing, and demonstrates careful planning.	Information is organized in related chunks. Final product is neat and visually pleasing.	Information is disorganized. Final product is messy and haphazard.

TOTAL_____/24

Excerpt From:
The Immortal Life of Henrietta Lacks
by Rebecca Skloot

There's a photo on my wall of a woman I've never met, its left corner torn and patched together with tape. She looks straight into the camera and smiles, hands on hips, dress suit neatly pressed, lips painted deep red. It's the late 1940s and she hasn't yet reached the age of thirty. Her light brown skin is smooth, her eyes still young and playful, oblivious to the tumor growing inside her—a tumor that would leave her five children motherless and change the future of medicine. Beneath the photo, a caption says her name is “Henrietta Lacks, Helen Lane or Helen Larson.”

No one knows who took that picture, but it's appeared hundreds of times in magazines and science textbooks, on blogs and laboratory walls. She's usually identified as Helen Lane, but often she has no name at all. She's simply called HeLa, the code name given to the world's first immortal human cells—*her* cells, cut from her cervix just months before she died.

Her real name is Henrietta Lacks.

I've spent years staring at that photo, wondering what kind of life she led, what happened to her children, and what she'd think about cells from her cervix living on forever—bought, sold, packaged, and shipped by the trillions to laboratories around the world. I've tried to imagine how she'd feel knowing that her cells went up in the first space missions to see what would happen to human cells in zero gravity, or that they helped with some of the most important advances in medicine: the polio vaccine, chemotherapy, cloning, gene mapping, in vitro fertilization. I'm pretty sure that she—like most of us—would be shocked to hear that there are trillions more of her cells growing in laboratories now than there ever were in her body.

There's no way of knowing exactly how many of Henrietta's cells are alive today. One scientist estimates that if you could pile all HeLa cells ever grown onto a scale, they'd weigh more than 50 million metric tons—an inconceivable number, given that an individual cell weighs almost nothing. Another scientist calculated that if you could lay all HeLa cells ever grown end-to-end, they'd wrap around the Earth at least three times, spanning more than 350 million feet. In her prime, Henrietta herself stood only a bit over five feet tall.

I first learned about HeLa cells and the woman behind them in 1988, thirty-seven years after her death, when I was sixteen and sitting in a community college biology class. My instructor, Donald Defler, a gnomic balding man, paced at the front of the lecture hall and flipped on an overhead projector. He pointed to two diagrams that appeared on the wall behind him. They were schematics of the cell reproduction cycle, but to me they just looked like a neon-colored mess of arrows, squares, and circles with words I didn't understand, like “MPF Triggering a Chain Reaction of Protein Activations.”

I was a kid who'd failed freshman year at the regular public high school because she never showed up. I'd transferred to an alternative school that offered dream studies instead of biology, so I was taking Defler's class for high-school credit, which meant that I was sitting in a college lecture hall at sixteen with words like *mitosis* and *kinase inhibitors* flying around. I was completely lost.

“Do we have to memorize everything on those diagrams?” one student yelled.

Yes, Defler said, we had to memorize the diagrams, and yes, they'd be on the test, but that didn't matter right then. What he wanted us to understand was that cells are amazing things: There are about one hundred trillion

of them in our bodies, each so small that several thousand could fit on the period at the end of this sentence. They make up all our tissues—muscle, bone, blood—which in turn make up our organs.

Under the microscope, a cell looks a lot like a fried egg: It has a white (the *cytoplasm*) that's full of water and proteins to keep it fed, and a yolk (the *nucleus*) that holds all the genetic information that makes you you. The cytoplasm buzzes like a New York City street. It's crammed full of molecules and vessels endlessly shuttling enzymes and sugars from one part of the cell to another, pumping water, nutrients, and oxygen in and out of the cell. All the while, little cytoplasmic factories work 24/7, cranking out sugars, fats, proteins, and energy to keep the whole thing running and feed the nucleus—the brains of the operation. Inside every nucleus within each cell in your body, there's an identical copy of your entire genome. That genome tells cells when to grow and divide and makes sure they do their jobs, whether that's controlling your heartbeat or helping your brain understand the words on this page.

Defler paced the front of the classroom telling us how mitosis—the process of cell division—makes it possible for embryos to grow into babies, and for our bodies to create new cells for healing wounds or replenishing blood we've lost. It was beautiful, he said, like a perfectly choreographed dance.

All it takes is one small mistake anywhere in the division process for cells to start growing out of control, he told us. Just *one* enzyme misfiring, just one wrong protein activation, and you could have cancer. Mitosis goes haywire, which is how it spreads.

“We learned that by studying cancer cells in culture,” Defler said. He grinned and spun to face the board, where he wrote two words in enormous print: HENRIETTA LACKS.

Henrietta died in 1951 from a vicious case of cervical cancer, he told us. But before she died, a surgeon took samples of her tumor and put them in a petri dish. Scientists had been trying to keep human cells alive in culture for decades, but they all eventually died. Henrietta's were different: they reproduced an entire generation every twenty-four hours, and they never stopped. They became the first immortal human cells ever grown in a laboratory.

“Henrietta's cells have now been living outside her body far longer than they ever lived inside it,” Defler said. If we went to almost any cell culture lab in the world and opened its freezers, he told us, we'd probably find millions—if not billions—of Henrietta's cells in small vials on ice.

Her cells were part of research into the genes that cause cancer and those that suppress it; they helped develop drugs for treating herpes, leukemia, influenza, hemophilia, and Parkinson's disease; and they've been used to study lactose digestion, sexually transmitted diseases, appendicitis, human longevity, mosquito mating, and the negative cellular effects of working in sewers. Their chromosomes and proteins have been studied with such detail and precision that scientists know their every quirk. Like guinea pigs and mice, Henrietta's cells have become the standard laboratory workhorse.

“HeLa cells were one of the most important things that happened to medicine in the last hundred years,” Defler said.

Then, matter-of-factly, almost as an afterthought, he said, “She was a black woman.” He erased her name in one fast swipe and blew the chalk from his hands. Class was over.

As the other students filed out of the room, I sat thinking, *That's it? That's all we get? There has to be more to the story.*

I followed DeFler to his office.

“Where was she from?” I asked. “Did she know how important her cells were? Did she have any children?”

“I wish I could tell you,” he said, “but no one knows anything about her.”

After class, I ran home and threw myself onto my bed with my biology textbook. I looked up “cell culture” in the index, and there she was, a small parenthetical:

In culture, cancer cells can go on dividing indefinitely, if they have a continual supply of nutrients, and thus are said to be “immortal.” A striking example is a cell line that has been reproducing in culture since 1951. (Cells of this line are called HeLa cells because their original source was a tumor removed from a woman named Henrietta Lacks.)

That was it. I looked up HeLa in my parents’ encyclopedia, then my dictionary: No Henrietta. As I graduated from high school and worked my way through college toward a biology degree, HeLa cells were omnipresent. I heard about them in histology, neurology, pathology; I used them in experiments on how neighboring cells communicate. But after Mr. DeFler, no one mentioned Henrietta.

When I got my first computer in the mid-nineties and started using the Internet, I searched for information about her, but found only confused snippets: most sites said her name was Helen Lane; some said she died in the thirties; others said the forties, fifties, or even sixties. Some said ovarian cancer killed her, others said breast or cervical cancer.

Eventually I tracked down a few magazine articles about her from the seventies. *Ebony* quoted Henrietta’s husband saying, “All I remember is that she had this disease, and right after she died they called me in the office wanting to get my permission to take a sample of some kind. I decided not to let them.” Jet said the family was angry—angry that Henrietta’s cells were being sold for twenty-five dollars a vial, and angry that articles had been published about the cells without their knowledge. It said, “Pounding in the back of their heads was a gnawing feeling that science and the press had taken advantage of them.”

The articles all ran photos of Henrietta’s family: her oldest son sitting at his dining room table in Baltimore, looking at a genetics textbook. Her middle son in military uniform, smiling and holding a baby. But one picture stood out more than any other: in it, Henrietta’s daughter, Deborah Lacks, is surrounded by family, everyone smiling, arms around each other, eyes bright and excited. Except Deborah. She stands in the foreground looking alone, almost as if someone pasted her into the photo after the fact. She’s twenty-six years old and beautiful, with short brown hair and catlike eyes. But those eyes glare at the camera, hard and serious. The caption said the family had found out just a few months earlier that Henrietta’s cells were still alive, yet at that point she’d been dead for twenty-five years

Section of Text	Predictions	Questions	Facts
1			
2			
3			
4			
5			

BIG HISTORY PROJECT

DIRECTIONS: On your laptops, go to <https://www.bighistoryproject.com/pages/syllabus#>. On the timeline, click on the red segment (the Big Bang) and watch the video clip. As you watch the clip, answer the questions below. When you finish the clip, move on to the next segment of the timeline, and continue to do this until you have watched through the Earth and Solar System.

The Big Bang

1. When did the Big Bang occur?
2. What made the Big Bang possible?
3. Why did the Big Bang happen?
4. What 4 things came into existence after the Big Bang?

How Did Stars Form?

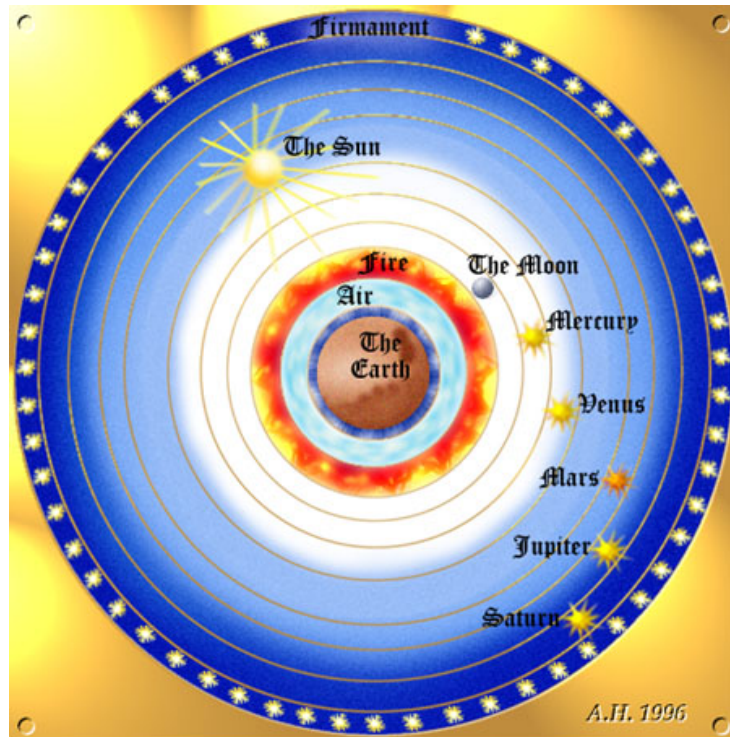
5. What was the universe made of right after the Big Bang?
6. What happened 380,000 years after the Big Bang?
7. Describe how stars form.
8. How long do stars produce energy?
9. What are galaxies?

New Chemical Elements

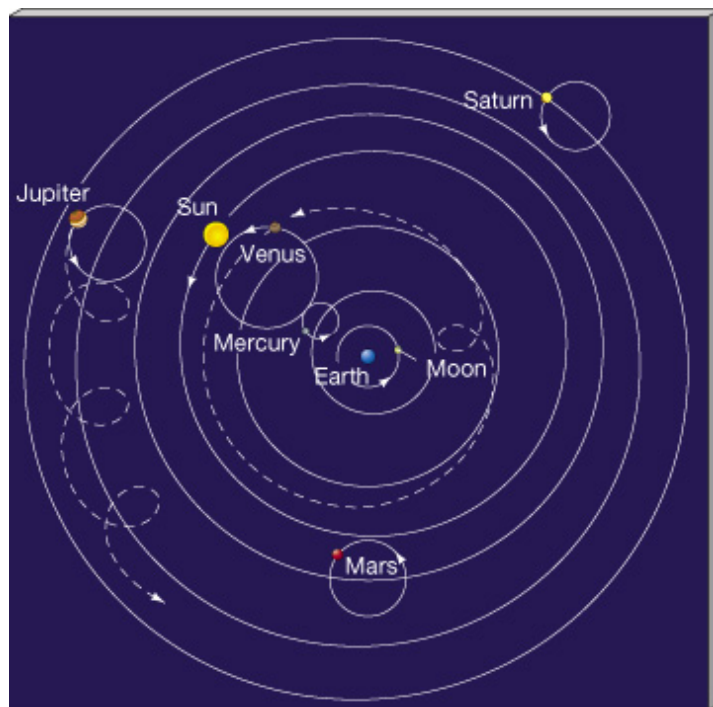
10. Describe space after the formation of stars.
11. What two elements existed?
12. How/where were new elements made?
13. What is a supernova and why is it important in making elements?

Earth and the Solar System

14. What percentage of matter in the universe consists of hydrogen and helium?
15. What is accretion and how does it lead to planets?
16. How do solid/terrestrial planets form?
17. How many years ago did the Earth form?



Medieval Conception of the Solar System



Geocentric Model

A UNIVERSAL DEBATE: Group Responsibilities

DIRECTIONS: Decide who will be responsible for researching the individuals below and their contributions to the geocentric/heliocentric debate.

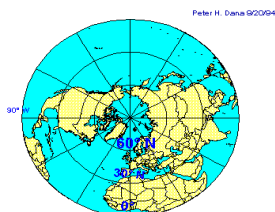
HISTORICAL FIGURE	GROUP MEMBER RESPONSIBLE
Aristotle	
Ptolemy	
Copernicus	
Galileo	
Tycho Brahe	
Kepler	
Others (many more individuals and institutions played a role in this debate)	

Questions to consider:

How can we explain the observed movements of the planets in the night sky if the Earth isn't in the center of the solar system? (Associated terms: retrograde motion, epicycles)

If the Earth is moving around the sun, why doesn't it feel like it's moving? And why isn't there any wind from its movement?

If the Earth is moving, why don't we observe stellar parallax?



How did the invention of the telescope contribute to this debate?

COMPARING MAPS

DIRECTIONS: Find the coordinates (latitude, longitude) of the following points on both maps 1 and 2. Record them in the table below.

Table 1. COORDINATES

	Map 1	Map 2
A		
B		
C		
D		
E		
F		

DIRECTIONS: Using a ruler and the map scales of your respective maps, find the actual distance between the following points on both maps 1 and 2. Be sure to show your work and record your answer in the table below.

Table 2. DISTANCES

	Map 1	Map 2
A to B		
C to D		
E to F		

DIRECTION: Using transparent grids, estimate the areas of the following continents (in # of grid squares) and record in the table below.

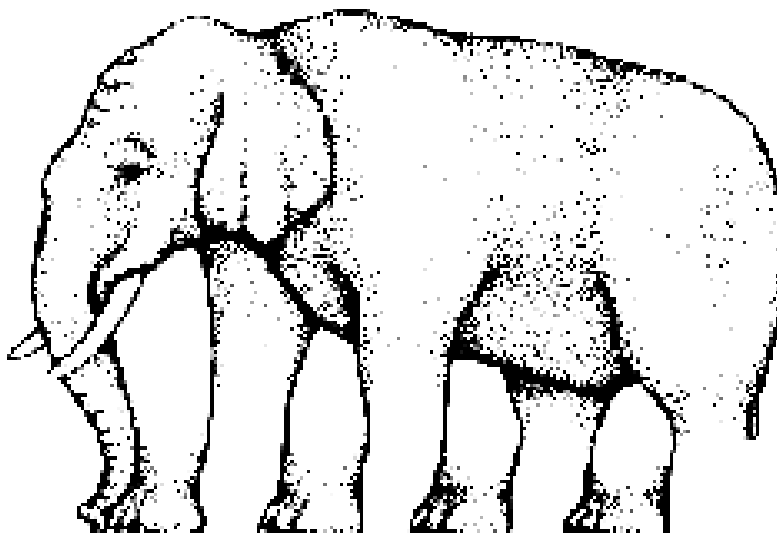
Table 3. AREAS

	Map 1	Map 2
Europe		
North America		
South America		
Africa		

What animal is this?



How many legs does the elephant have?



What does the message say?



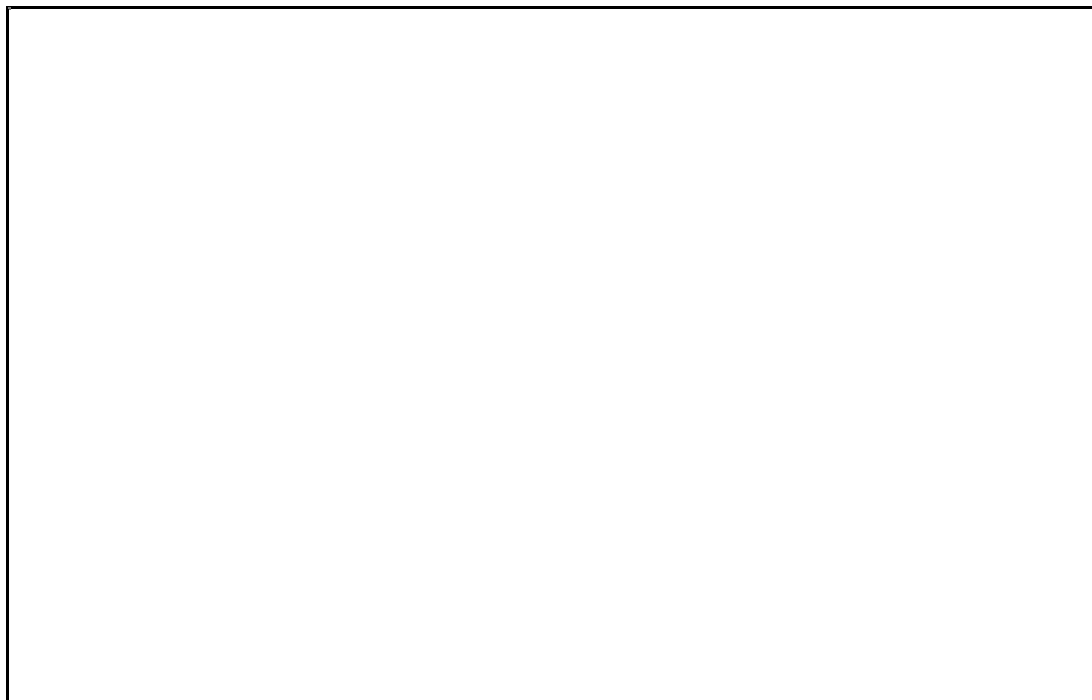
How old is the woman?



DO YOU SEE WHAT I SEE?

DIRECTIONS: As you move around the room, observe the star patterns from your relative position. Draw the patterns you see at each position in each of the four boxes below.

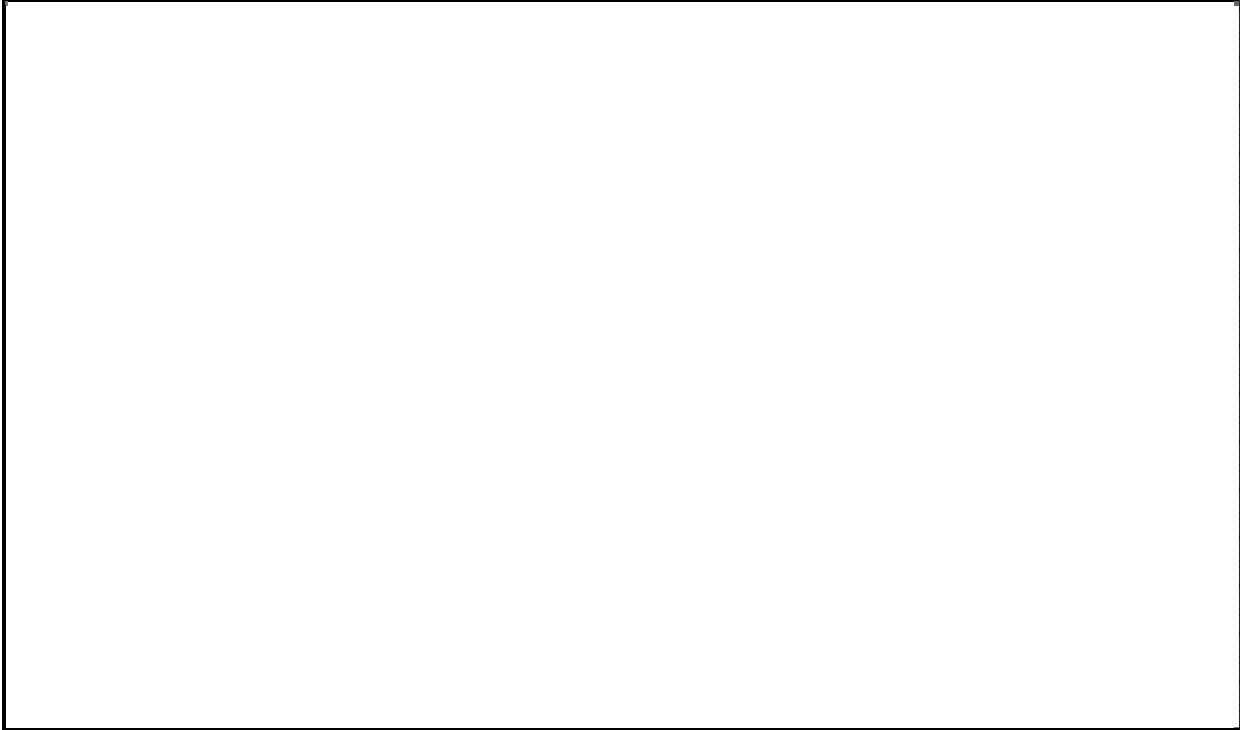
Rotation 1:



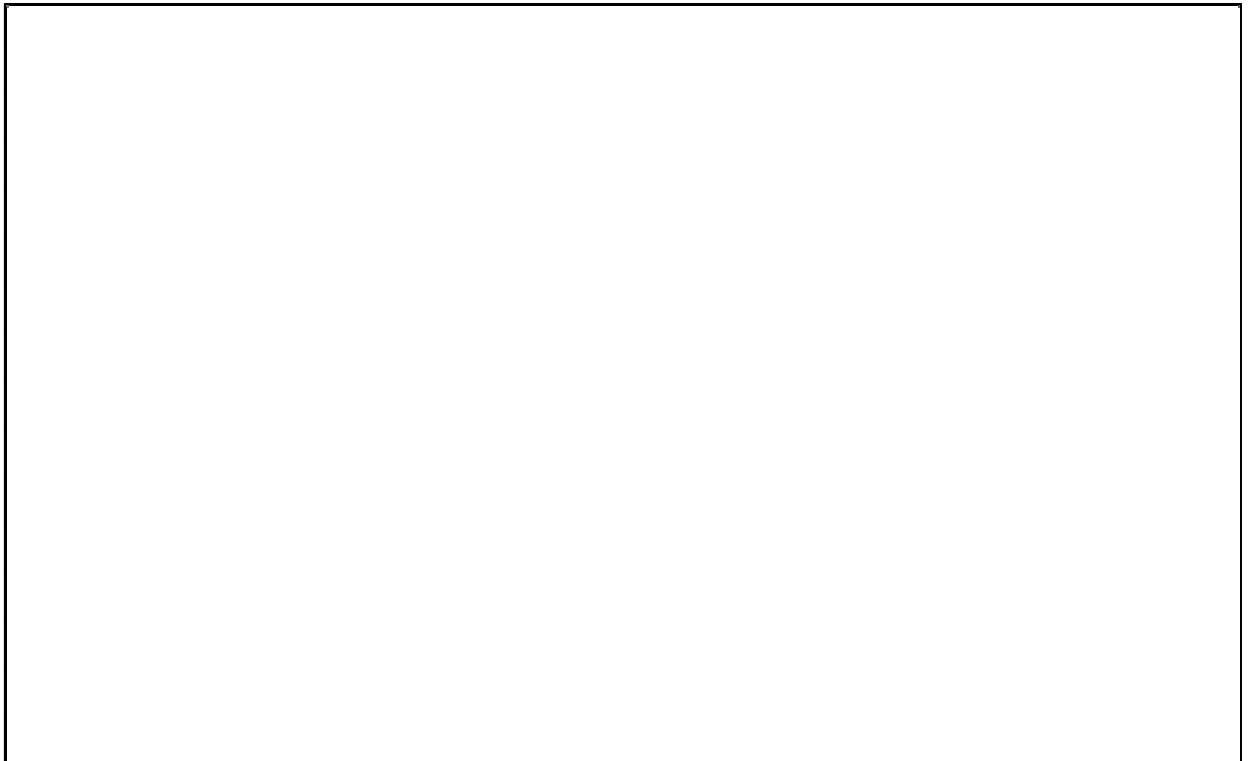
Rotation 2:



Rotation 3:



Rotation 4:



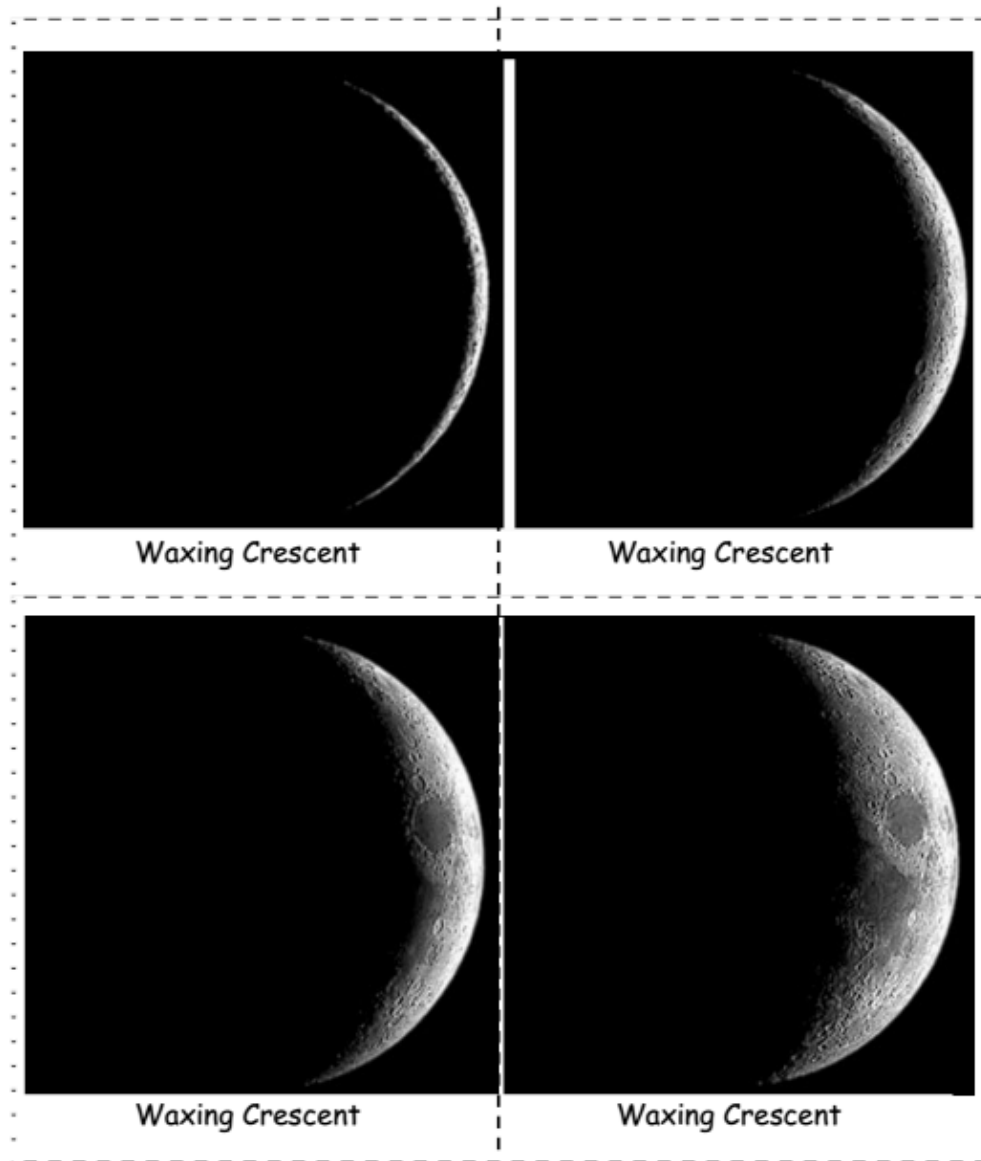
Analysis Questions:

1. Go back to the star patterns that you drew in rotations 1-4. Do you see any patterns that suggest a picture (or a constellation)? Find at least one and draw it in by connecting the stars. Below, name the object/picture that you found.
2. Did you see the exact same pattern of stars after each rotation? Explain why this is the case.
3. Compare your star drawings with your partner's. Did you see the same star patterns? Did you find the same constellations? Why or why not?
4. What planetary motion (rotation or revolution) did we model in this activity? Justify your answer.
5. Why was this **not** a perfect model of planetary motions?

CONSTELLATION POSTER NOTES/CHECKLIST

	Western Constellation	Non-Western Constellation
Name		
Image		
Where on the globe it is viewable		
What seasons it is viewable		
Constellation Myth/Story		

MOON PHASES





Waxing Crescent



First Quarter



Waxing Gibbous



Waxing Gibbous



Waxing Gibbous



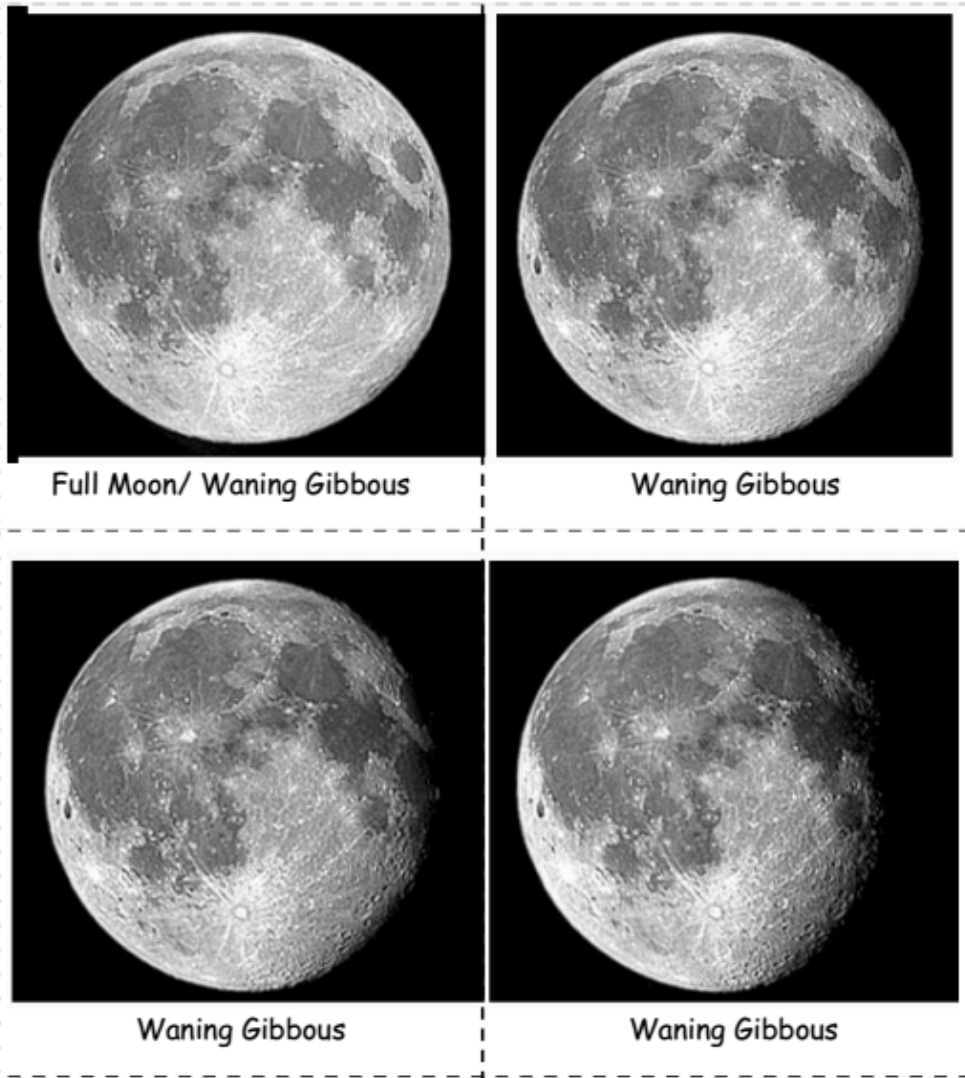
Waxing Gibbous



Waxing Gibbous



Waxing Gibbous/ Full





Waning Gibbous



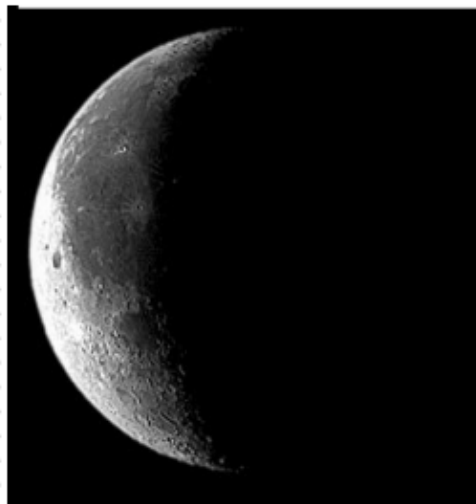
Waning Gibbous



Third Quarter



Waning Crescent



Waning Crescent



Waning Crescent



Waning Crescent



**Moon
Phases
Flip Book**

New Moon

Modeling Moon Phases Lab

Directions:

1. On the moon phase mats, label the moon position 1-8, starting with the circle directly between the sun and the earth and moving counterclockwise.
2. Place the “moon” (ping pong ball) on the bottle cap and place the bottle cap at position 1. Make sure the lit side of the moon is facing the sun.
3. On your data sheet, in Figure 1, sketch the moon and show which side of the moon was dark and which side was lit. In figure 2, show the moon phase that would have been observable from Earth and name the moon phase (It may help to place the cardboard cut out over the moon along the orbital path and then observe the moon at desk-level).
4. Move the moon to position 2 and repeat step 3.
5. Move the moon to position 3 and so on, continuously repeating step 3 until you are back at position 1.

Figure 1.

Dark and Light Side of the Moon

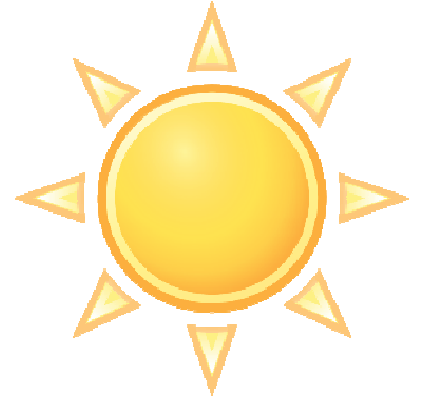
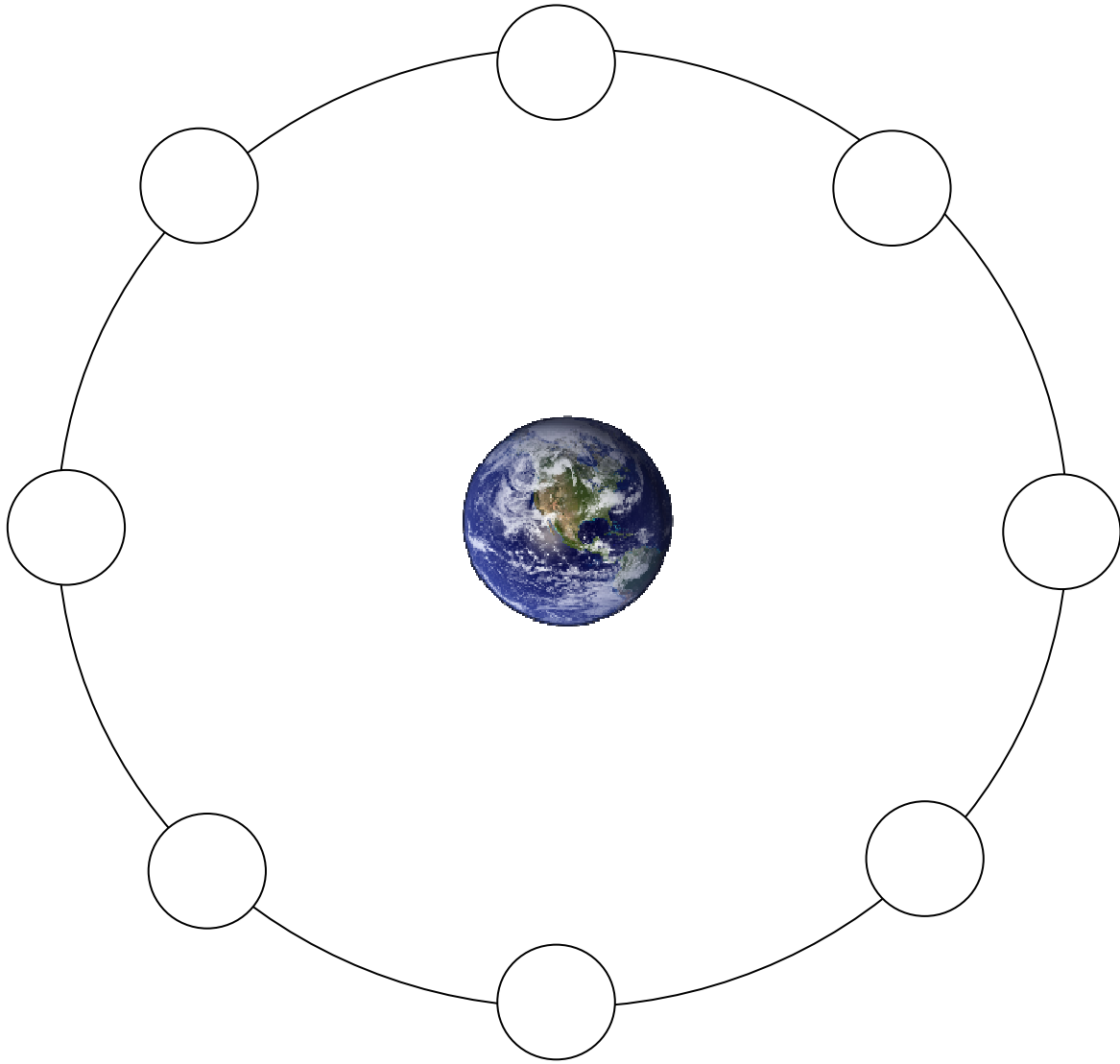
Position 1	Position 2	Position 3	Position 4
Position 5	Position 6	Position 7	Position 8

Figure 2.

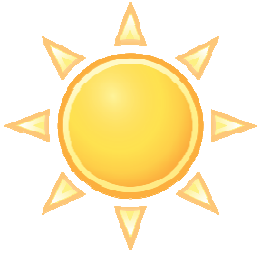
Moon Phases

Position 1	Position 2	Position 3	Position 4
Position 5	Position 6	Position 7	Position 8

Moon Phase Mat



Send-A-Problem: Moon Phases



THE MYSTERIOUS EGG IN THE BOTTLE

	Station 1: Straw and Glass	Station 2: Levitating Cardboard?	Station 3: The Leaky Bottle
Predict			
Observe			
Explain			

Station 1: The Straw and the Glass

DIRECTIONS: Place the straw in the glass filled with water. Place your finger across the top of the straw sealing the end and lift the straw out of the glass of water. Place the straw over the glass and lift your finger from the top of the straw.

Station 2: Levitating Cardboard

DIRECTIONS: Place the cardboard over the drinking glass which you should have filled to the brim. Make sure there are no air bubbles. Turn the glass upside down over the basin then take away the hand holding the cardboard.

Station 3: The Leaky Bottle

DIRECTIONS: Place the bottle in the basin of water. Pour water into the bottle to make sure it is filled to the top. Screw the cap onto the bottle. Lift the bottle above the basin and observe what happens. Next, while still holding the bottle over the basin, unscrew the cap and observe what happens

Gravity or Not Survey

DIRECTIONS: So many things on our planet are influenced by or controlled by gravity. Place a checkmark next to those events and phenomena below that are directly controlled by gravity.

___ Weather

___ Seasons

___ Length of the year

___ Erosion

___ Food moving through the digestive system

___ Wind

___ Tides

___ Directions (up and down)

___ Weight

___ Plant growth

___ Falling objects

___ Formation of the planets/galaxies/stars

Life Without Gravity

DIRECTIONS: We take gravity for granted, but what if we lived in a world without gravity? Consider the following everyday activities below. Describe how you think they would be different without gravity?

A. Drinking soda



B. Doing the dishes

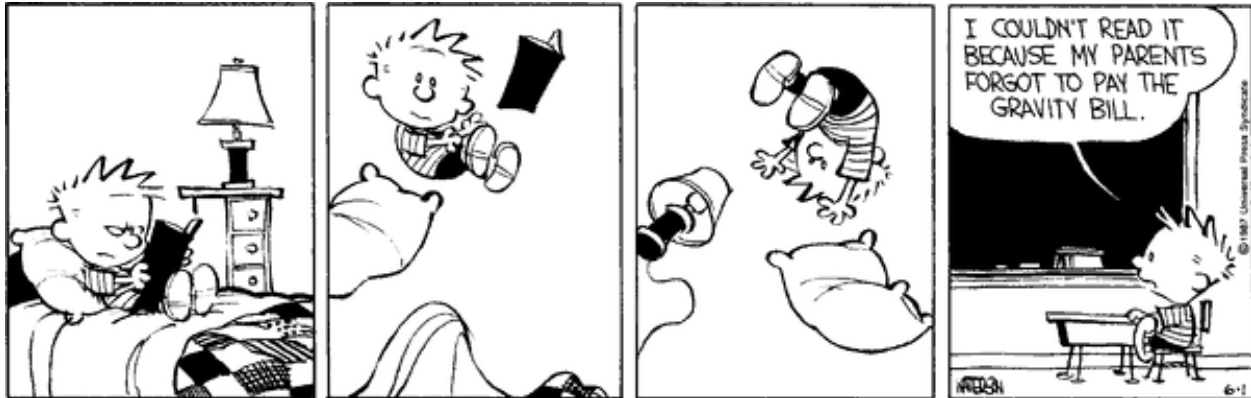


C. Taking a shower



D. Brainstorm as many other daily activities that would be different without gravity

GRAVITY NOTES



- The theory of **gravity** was discovered (or at least explained) by **Isaac Newton** in the late 1600s
- Despite over 300 years of study and research, scientists still do not completely understand what **causes** gravity.
- Gravity is the force of **attraction** between any two objects with **mass**. (Remember, mass is how much **matter** is in an object). While we usually think of gravity as the force that pulls us down to **Earth**, this is simply because the Earth is so much more **massive** than anything else around us that it has the **greatest** attraction.
 - More **massive** objects have a **greater** force of attraction (**more** gravity)
 - Objects that are **farther** away have a **lesser** force of attraction (**less** gravity)
 - This force of attraction exists between **everything** that has mass
 - There is still gravity in **outer space**. People appear to float because they are in a state of **free fall** but they are not close enough to **Earth** to have gravity act in a “downward” direction.

- So why don't more massive objects fall faster than less massive objects?
 - Differences in mass aren't big enough
 - Gravity acts on the smallest pieces of **matter** individually. So even if there are 5000 pieces of matter in an object, each piece feels the same "**pull**" from gravity and each piece falls at the same **rate**. This **constant** rate of falling in gravity (on Earth) is called **Acceleration due to gravity**.
- **Weight**, however, exists because of gravity.
 - Weight = **Mass** x Acceleration Due to **Gravity**
 - **Acceleration** is the same for everyone, so when an object's **mass** increases, its weight **increases**.

Gravity Comprehension Questions

DIRECTIONS: Read and answer the following questions in your own words and using complete sentences. *****Be sure to use your notes.**

1. What is gravity?
2. What scientist came up with the Theory of Gravity?
3. What **2** variables affect the force of gravity?
4. Which has a stronger gravitational force: two cars parked next to each other on the street or two houses that are next to each other? Explain your answer.
5. Which has a stronger gravitational force: two planets of the exact same size in the same solar system or two planets of the exact same size that are in different solar systems? Explain your answer.

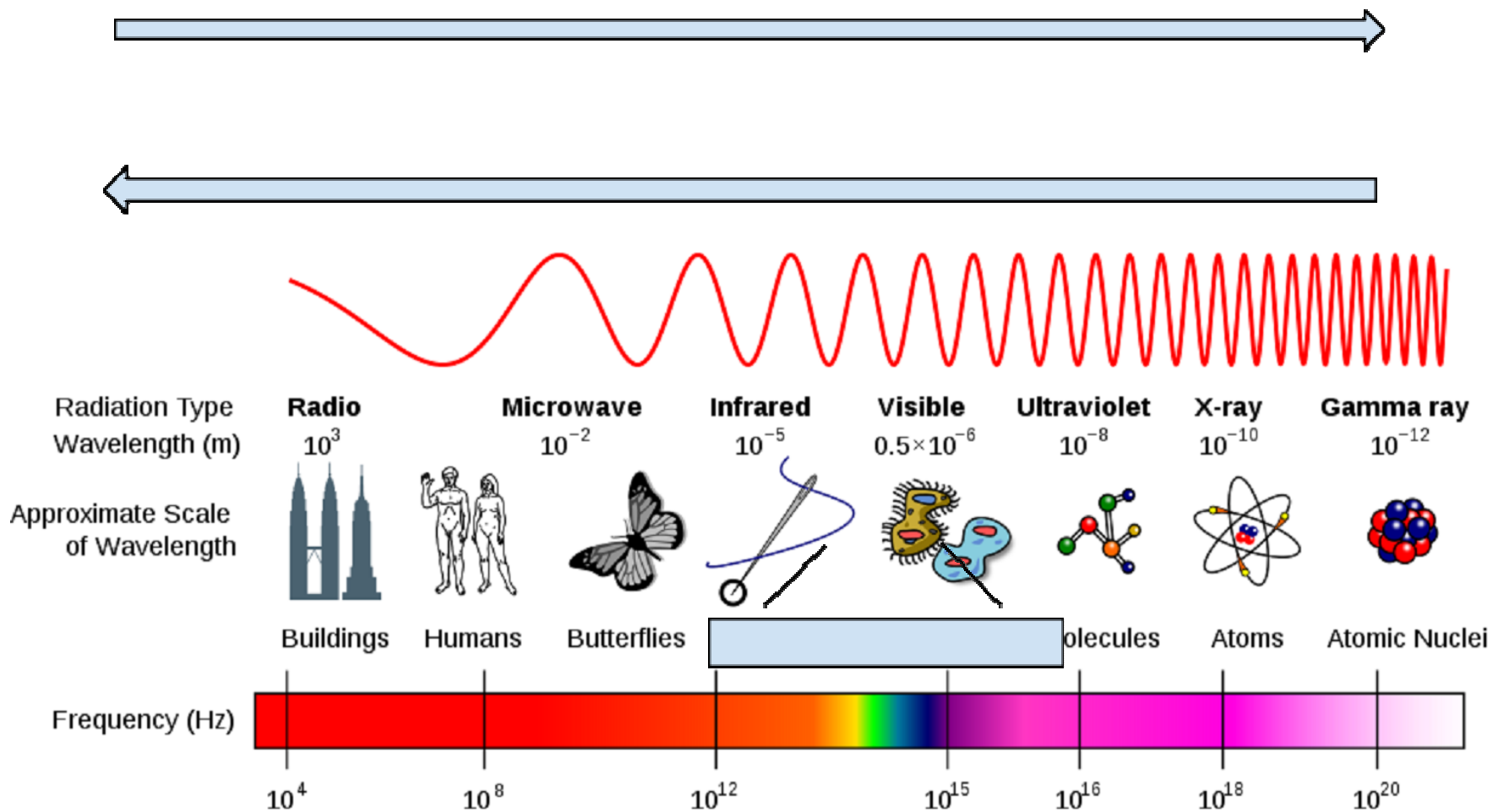


6. Why don't humans fall off the Southern Hemisphere of the planet?

7. How are weight and gravity related?

8. On Earth, Miss Dunne weighs 140lbs. On the moon, she would weigh 23lbs but on Jupiter she would weigh 330lbs. What does this tell us about the force of gravity on the moon and on Jupiter?

The Electromagnetic Spectrum



DIRECTIONS: Go to the following website http://missionscience.nasa.gov/ems/01_intro.html. Use the website to come up with examples/uses for 4 different kinds of electromagnetic energy. Record these 4 examples in the grid below. After you have completed your 4, complete the rest of the grid by following the Give 1, Get 1 protocol with your peers.

RADIO WAVES:	VISIBLE LIGHT:	GAMMA RAYS:
INFRARED WAVES:	ELECTROMAGNETIC ENERGY	X-RAYS:
ULTRAVIOLET WAVES:	MICROWAVES:	REFLECTED NEAR INFRARED WAVES:

TYPES OF ENERGY

Definitions:

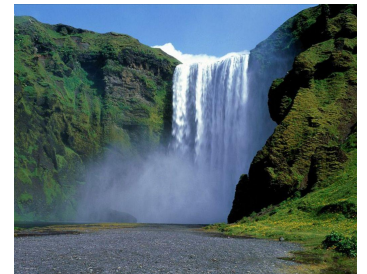
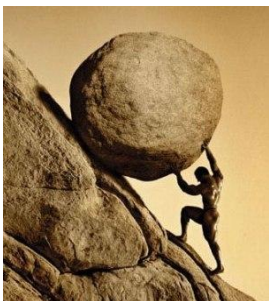
Energy-

Kinetic Energy-

Potential Energy-

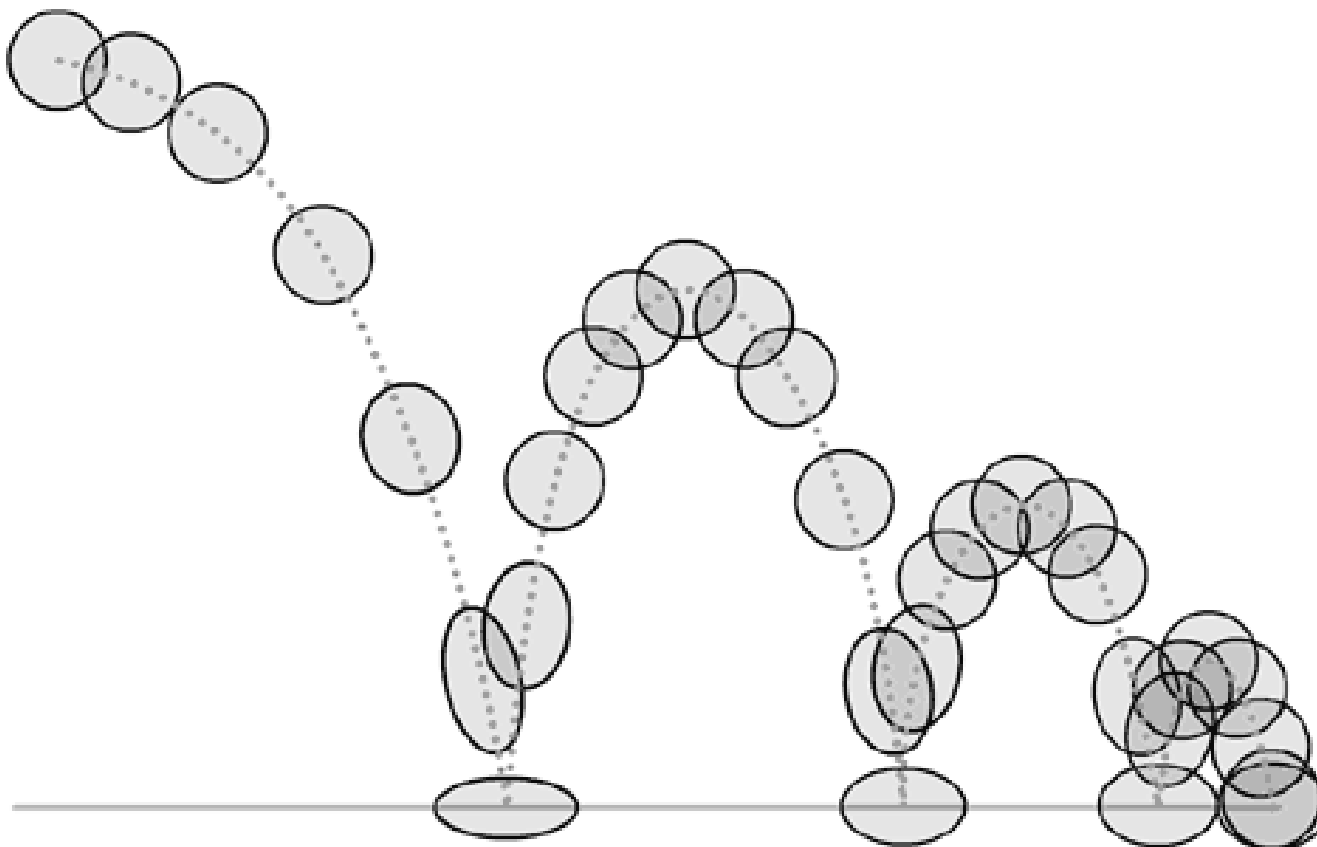
Law of Conservation of Energy-

Directions: Decide whether the following pictures depict kinetic energy, potential energy, or both. Label them KE, PE, or both.



ENERGY OF A BOUNCING BALL

DIRECTIONS: In your groups, compose a complete narration/description of the changes in kinetic and potential energy through the entire path of the bouncing ball pictured below. Be sure to note how potential and kinetic energy change both as the ball falls and bounces back up. Your response may be written in paragraph form or as annotations to the image below.



Questions:

1. Write a mathematical equation showing how kinetic and potential energy relate to the total energy in an object.
2. According to the law of conservation of energy, energy can be neither created nor destroyed. It can only be transformed. How can we apply this to the bouncing of a ball? (Hint: What can't the ball ever reach its original height?)
3. How does the total energy of the ball at the beginning of its path compare with the total energy of the ball at the end of its second bounce?
4. How does the potential energy of the ball at the beginning of its second fall compare with the potential energy of the ball just before its final fall?
5. How does the kinetic energy of the ball just before its first bounce compare with the kinetic energy of the ball just before its third bounce?

DIFFERENT FORMS OF ENERGY

DIRECTIONS: Go to the following website:

<http://energyquest.ca.gov/story/chapter01.html> Read the information and use it to answer the following questions.

CHAPTER 1: ENERGY-WHAT IS IT?

1. Why is energy important?
2. What is the definition of energy?
3. According to this website, what are the different forms of energy?

STORED AND MOVING ENERGY

4. Explain how a pencil can model potential and kinetic energy.
5. Describe another example (not a bouncing ball or pencil) that can serve as a model of potential and kinetic energy. Be sure to explain or illustrate how.

CHANGING ENERGY

6. In each of the following scenarios, identify all of the energy transformations that occur:
 - a. Turning on a flashlight-
 - b. Eating food-
 - c. Talking on the phone-

d. Driving a car-

e. Using a toaster-

f. Watching television-

7. Think about what happens when you touch a light bulb that has been on for a while or the screen of a television that is turned on. What other energy transformation occurs in these (and in fact all) instances?

SILENT APPOINTMENT RECORD SHEET

Appointment #	Partner	What I learned...
1		
2		
3		
4		

Final Reflection Question: Based on what you learned today, why can a ball never bounce back to the height it was dropped from? What happens to the energy?

