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# Authentic Topics as Organizers for Instruction

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Authentic Topics as Organizers for Instruction

by

Cassandra Moulton

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A project submitted to the  
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Master of Science in Education

Authentic Topics as Organizers for Instruction

by

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## Table of Contents

Chapter One: Introduction .....	4
Chapter Two: Review of Literature .....	7
Context-Based Approaches to Promote Content Knowledge.....	8
Context-Based Approaches to Promote Nature of Science Understanding.....	15
Context-Based Approaches to Promote Argumentation Skills.....	20
Context-Based Approaches to Promote Student Motivation and Interest .....	27
Barriers and Considerations for Implementation.....	31
Conclusion .....	33
Chapter Three: Application.....	34
Use of Animals in Research.....	36
Taxation of Beverages .....	39
Cell Phones and Cancer .....	42
Sports Drinks .....	46
Implantation of Eggs Using In-Vitro Fertilization.....	49
Insurance Coverage for Assistive Reproductive Technology.....	53
Fetal Abuse .....	57
Legalization of Abortion.....	60
Separation of Conjoined Twins .....	63
Sex Verification of Olympic Athletes.....	66
Selective Breeding of Dogs .....	69
Human-Animal Hybrid Organisms.....	72
Mandatory DNA Fingerprinting in New York State .....	76
Genetically Modified Crops.....	79
Early Maternal Blood Tests for Gender Selection in Utero.....	82
Designing New Life Forms.....	85
Commercial Cloning of Cats and Dogs .....	88
Therapeutic Cloning in Animals.....	90
Use of rBHT in Cows to Stimulate Milk Production.....	93
Human Evolution .....	96
Antibiotic Use in the Poultry Industry .....	99
Growth Hormones in Meat .....	102
Mandatory HIV Testing.....	105
Use of BPA in Plastics.....	108
Food Allergies.....	112
Traumatic Brain Injuries.....	114
Vaccine Safety and Effectiveness.....	116
Synthetically Manufactured Artificial Sweeteners .....	119
Liver Transplants for Alcoholics .....	123
Pesticide Use on Agricultural Crops.....	126
Hunting of White-Tailed Deer .....	130
Global Warming.....	133
Offshore Drilling.....	135

## Table of Contents

Bottled Water .....	138
Exotic Animals as Pets.....	141
Reusable Shopping Bags.....	145
Nuclear Power.....	148
Hydrofracking in New York State .....	151
Donation of Cadavers to Forensic Research .....	154
Euthanasia of Domestic Animals.....	156
Chapter Four: Conclusions and Recommendations.....	159
References.....	160
Appendix	

## **Abstract**

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Context based approaches including STS, STSE, and SSI instruction have the potential to promote student content knowledge, deepen student understanding of the nature of science tenants, strengthen student argumentation skills, and promote student motivation and interest in science. This capstone project is a compilation of forty meaningful, curriculum generated science topics, which can be used as a foundation for designing lessons that incorporate strategies to promote written or verbal argumentation in living environment courses. The topics were selected such that their implementation would not significantly disrupt the existing organization of science content within a district curriculum. The project demonstrates the potential for context based approaches including STS, STSE, and SSI to be used in courses where science content to be taught is dictated by state standards and a major reorganization of the curriculum is not possible.

## **Chapter 1: Introduction**

Scientific literacy is a longstanding goal of science education (NRC, 1996; AAAS, 1990, 1993). While there is no universal definition for scientific literacy, scientifically literate citizens should be able to analyze, synthesize, and evaluate information, make personal informed decisions, think creatively, recognize the relevance of science-based issues in their everyday lives, actively participate in argumentative discourse, and understand that scientific endeavors are governed by moral, ethical, and social values (NRC, 1996; AAAS, 1990).

Unfortunately, scientific literacy for all has not been achieved. Students in the United States continue to show a lack of interest in school science (Britt et al., 2011), the number of students pursuing scientific careers is declining (NRC, 2012) and U.S. students have fallen behind their peers on international science assessments (Fensham, 2009).

Researchers have suggested that educators use personally meaningful and socially relevant topics that require students to use evidenced-based reasoning and engage in dialogue, discussion and debate as an instructional approach to increase motivation (Lee & Erdogan, 2007) and promote scientific and technological literacy for all students (Akçay & R. Yager, 2010; Zeidler & Nichols, 2009). Unlike traditional instruction, which uses scientific topics as illustrative ideas, this type of context-based approach uses authentic topics as organizers for the science curriculum (Dori, Tal, & Tsashu, 2003) and encourages students to make informed decisions or solve problems regarding issues related to the topics (Heath, 1992). These skills,

along with an understanding of science and technology, are essential for the discourse and debate required to contend with the rapidly increasing scientific, technological, and economic demands and challenges of the 21<sup>st</sup> century (NSTA, 2011).

In context-based approaches, which are rooted in the constructivist-learning model, students define the problems, generate their own questions, use resources and social interactions to explore, expand, and refine their previous understandings, suggest possible explanations or solutions, and evaluate others points of view (Yager & Akcay, 2008). These practices are consistent with characteristics of a scientifically literate individual described above implying that context based approaches have the potential to increase scientific literacy.

The idea of embedding science teaching and learning in contexts emerged in the mid- to late 1980's as a response to reform documents including the 1982 National Science Teachers Association position statement entitled *Science-Technology-Society: Science Education for the 1980's*. This document claimed the goal of education was “to develop scientifically literate individuals who understand how science, technology, and society influence one another and who are able to use this knowledge in their everyday decision making” (NSTA, 1982). In a 1990 NSTA position statement science-technology-society education was described as “essential” for science reform and expected to “create a scientifically literate citizenry for the 21<sup>st</sup> century” (NSTA, 1990). However, the teaching and learning of science in contexts received little attention through the 1990's due to curriculum projects, including Project 2061 (AAAS, 1993), defining science to be learnt in terms of long lists of



concepts in science disciplinary strands (Fensham, 2009). Recently, due to growing concerns over the state of science education, increasing demands of the 21<sup>st</sup> century, and the release of the National Research Council's framework for K-12 education (NRC, 2012), which calls for the next generation science standards to place a greater emphasis on the applications of science, technology, engineering, and society, the teaching and learning of science in contexts has regained attention (Driver, Newton, & Osborne, 2000).

Several different but overlapping pedagogical terms have been used in science education literature to describe the deliberate use of authentic topics as contexts for learning. These include "science, technology, and society (STS)", "science, technology, society, and environment (STSE)" and more recently "socioscientific issues (SSI)". STS and STSE education use science topics such as energy conservation, pollution, or preservation of rare species as contexts for learning science content. Both frameworks emphasize the interrelationships between science, technology, and society with respect to scientific developments however STSE places a greater emphasis on the environmental consequences of the developments. SSI education, which has emerged in the literature within the last decade, goes 'above and beyond' past STS frameworks (Zeidler, Walker, Ackett, & Simmons, 2002). SSI incorporates all of the previous STS components but it uses controversial, socially relevant issues such as cloning, genetically modified foods, and animal rights as the contexts for learning. SSI therefore places a greater emphasis on the moral and ethical aspects of science (Zeidler, Sadler, Simmons & Howes, 2005) as well as

informal reasoning and discourse related to argumentation (Sadler & Donnelly, 2006).

### **Significance**

Despite the recent attention given to context-based approaches including STS, STSE, and SSI, very few teachers are implementing this type of instruction in their classrooms. In living environment courses this is likely due in part to rigid state standards, which dictate the science content to be taught as lists of concepts and an inability to enact the major curriculum reorganization that researchers have described in long-term studies of context-based approaches. The aim of this capstone project is to demonstrate the potential for context based approaches incorporating written or verbal argumentation to be used in living environment courses where a major reorganization of the curriculum is not possible.

### **Terms**

*Authentic Topic* – A personally meaningful and socially relevant topic, controversial or non-controversial topic, that relates science to technology, society, and/or the environment.

*Context-Based* – Instructional method or approach that uses authentic topics as organizers for instruction.

## **Chapter 2: Review of the Literature**

Context-based instructional approaches including STS, STSE, and SSI, which use authentic topics as organizers for instruction, have been described in the literature for the last three decades. The purpose of the following literature review is to present

a synthesis of research articles related to context-based instructional approaches in science education. This literature review will evaluate research related to the impact of context based learning on students 1) content knowledge, 2) understanding of the nature of science 3) development of argumentation skills and 4) motivation and interest in science in order to establish the potential for context based approaches to promote scientific literacy.

### **Context-Based Approaches to Promote Content Knowledge**

A number of studies have directly investigated the effects of context-based approaches on student content knowledge. One study (Zohar & Nemet, 2002) employed a post-test only design intended to measure student content knowledge after the implementation of a context-based intervention while five studies (R. Yager et al., 2009; Yager & Akcay, 2008, S. Yager, Lim, & R. Yager, 2008; Dori et al, 2003; Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007) have used a pre- and post- test design to measure increases in student content knowledge as a result of context-based interventions. Two studies (Dori et al, 2003; Barab, et al., 2007) investigated the relationship between context-based instruction and student achievement on external measures of general content knowledge.

Several groups of researchers (R. Yager, et al., 2009; Yager and Akcay, 2008; Yager, Lim, Yager, 2008) have investigated a number of student learning outcomes, including content knowledge, in quasi-experimental studies involving teachers from the Iowa Chautauqua Program. This longstanding program, which is endorsed by NSTA, emphasizes context based instruction using constructivist teaching and

learning practices and has served as a model for science teachers and researchers interested in context based instruction for the last three decades (Daas & Yager, 2009).

R. Yager and colleagues (2009) investigated a number of student learning outcomes, including content knowledge, in a study involving fifteen experienced teachers who were part of the Iowa Chautauqua Program and selected for their dedication to the program reforms. The researchers used a pre- and post- test design to compare content learning gains among students receiving instruction with socioscientific emphases and students receiving more traditional directed inquiry instruction. Students from grades six through nine participated in the study and each teacher taught one directed inquiry and one STS section. The assessments consisted of weekly quizzes as well as unit and semester exams specifically designed for the Iowa Chautauqua Program. The content assessments were different for each teacher and grade level. Student assessment scores were not statistically significantly different among students in the STS and directed inquiry sections. The authors concluded that context-based instructional approaches are equally as effective as directed inquiry at promoting student learning of science content

In a similarly designed study, Yager and R. Akcay (2008) used a pre- and post- test design to examine the impact of a nine-week STS intervention on student learning outcomes, including content knowledge gains. The study involved two experienced teachers and fifty-two students in grades six through eight. One of the teachers centered instruction around an STS context relating to the building of a local

landfill while the other teacher used the traditional textbook dominated curriculum. At the beginning and end of the semester the authors administered ten curriculum aligned locally developed quizzes to measure concept mastery and a comprehensive locally developed assessment to measure general science achievement. A significant difference was found between pre- and post- test scores for concept mastery ( $t=42.46$   $p<0.01$ ) and pre- and post- test scores for general achievement ( $t = 39.47$   $p<0.01$ ) in the STS sections indicating that context-based instruction can serve as a framework for learning science content. However, there was no significant difference between the post-test scores for students enrolled in the STS and traditional sections indicating that students engaged in STS curriculum learn equally as much science content as students taught with traditional textbook instruction. These findings have been published a second time in a nearly identical study by a different group of authors (S. Yager et al., 2008).

In an unrelated study, Zohar and Nemet (2002) investigated the impact of a genetics unit featuring SSI and argumentation on student content knowledge and argumentation. The study involved nearly 200 ninth grade biology students from two Israeli junior high schools. A twenty item multiple choice test, developed independently of the specific genetics curriculum, was used to measure student content knowledge. Students engaged in the SSI curriculum scored significantly higher ( $X= 72.9$   $SD = 6.0$ ) than students who received genetics instruction without a socioscientific emphasis ( $X=59.4$   $SD=4.1$ ). This study demonstrated positive results

in terms of student content knowledge with SSI based instruction relative to traditional instruction.

In another study, Akcay and R. Yager (2010) investigated student learning outcomes, including content knowledge, for students taught with a student-centered STS approach and more teacher-centered STS approach. The study involved twelve teachers and a total of 724 students in grades six through nine. Each teacher taught one section in which they guided instruction, prepared daily lessons, and structured the STS modules for students and one section in which they used student-centered teaching and learning methods to guide the students through the STS modules. Like the previous study, the assessments used in this study were specifically designed for the Iowa Chautauqua Program and different for each teacher and grade level. Analysis of the students pre- and post- test scores showed no significant difference between students in the student-centered and teacher-centered STS sections. The authors concluded that both student centered and teacher centered context-based instructional approaches are equally as effective at promoting student learning of science content.

These four studies demonstrate the potential for context-based instructional approaches to uphold or improve student learning relative to traditional or directed inquiry instructional approaches. In addition, Akcay and R. Yager (2010) demonstrated that student gains in content knowledge were comparable when teachers took an active and passive role in the organization and teaching of the context-based instruction. This demonstrates the potential for authentic contexts to be

used as organizers for instruction in classrooms where teachers are hesitant to implement student-centered instructional practices.

Three additional investigations have looked at the effect of context-based approaches on student content knowledge with a specific focus on student ability level (Dori, et al., 2003) and performance on external measures of general science content (Barab et al., 2007; Klosterman & Sadler, 2010). Dori et al. (2003) studied the implementation of a series of SSI biotechnology case studies derived from primary literature with approximately 200 students in eight Israeli high schools. The researchers used a pre- and post- test design and locally developed tests to measure student content gains from SSI instruction. For data analysis the students were grouped according to their academic abilities (high, intermediate, and low). Students overall scores showed a significant improvement ( $t = 22.8$   $p < 0.0001$ ) from the pre-test ( $x=28$ ) to the post-test ( $x=70.7$ ) with an effect size of 2.7. However, the percentage gain was far more pronounced for the low academic ability group ( $t=17.7$   $p < 0.0001$ ) than the intermediate ability ( $t=11.81$   $p < 0.0001$ ) and high ability ( $t=10.52$   $p < 0.0001$ ) groups. The difference between the mean, raw scores, for the high and low ability groups in the pre-test was 26.9 points while the difference in post-test scores for the two groups was only 3.7 points. These results indicate the potential for context-based instruction to not only promote student learning but also act as a means to effectively reduce achievement gaps for students who have previously not performed well on traditional learning experiences.

Barab et al. (2007) investigated student learning outcomes, including content knowledge, in the course of a two week intervention designed around a multi-user virtual environment situated in an SSI topic. During this time, students used avatars to navigate a virtual park, which was experiencing steep declines in riverine fish populations. The students collected data from streams and conducted interviews with characters within the virtual environment and other players in order to identify the cause of the problem and propose possible solutions. Student content gains were measured using both a curriculum aligned (proximal) and standards-aligned (distal) assessment. The curriculum aligned assessment consisted of two open-ended items directly related to the aquatic SSI topic. Student responses were scored on a scale of 0 to 3 such that the total score on both items ranged from 0 to 6. Students mean raw scores on the pre- ( $x=1.7$ ) and post- ( $x=4.0$ ) tests increased by 2.3 points ( $p < 0.001$ ) indicating that virtual SSI environment was an effective context for learning science content. The standards-aligned assessment consisted of eighteen items randomly selected from publically released state standardized tests. The questions were aligned to targeted learning standards without regard for the virtual SSI curricula design. Students mean scores on the pre- (13.5) and post- (14.2) tests increased 0.67 points however these results were not statistically significant ( $p=0.122$ ). The researchers noted high scores on the pre-test (13.7 out of 18) and proposed a ceiling effect as a potential explanation for the apparent lack of student gains on the post-test.

In a more recent study, Klosterman & Sadler (2010) used a multi-level assessment framework to explore the effects of SSI-based instruction on student



learning of science content in secondary level chemistry and environmental science courses. Student content gains were measured using both a curriculum-aligned (proximal) and standards-aligned (distal) assessments before and after the implementation of a three-week SSI unit on global warming. The curriculum-aligned assessment consisted of five open ended items directly related to the global warming SSI unit. Student responses on the pre- and post- tests were coded according to their scientific accuracy and qualitatively analyzed to identify student content gains. In the SSI classroom, students on average expressed more accurate, more detailed, and more sophisticated understandings of global warming, the greenhouse effect, and the controversy and challenges associated with these issues. The standards-aligned assessment consisted of twenty items selected from publically released state, national, and international (NAEP and TIMSS) standardized tests. The questions were taken from four general areas of science related to the SSI unit and aligned with the state standards in each of the courses. Analysis of student post-test scores were statistically significantly different from their pre-test scores ( $F=15.31$   $p<0.001$ ) indicating that context-based instructional approaches can support student success on external measures of general content knowledge.

Taken together these eight studies offer evidence that context-based instruction can support student learning of science content, increase student learning relative to traditional and directed inquiry instruction, close achievement gaps for traditionally lower achieving students, and support student success on external measures of general content knowledge such as the New York State Regents exam.

The work by Klosterman and Sadler (2010) which suggested context-based approaches can support student success on external measures of content knowledge is particularly important in the current age of accountability where school and teacher performance is largely measured by student success on state and national exams. However, additional research is needed not only to support these findings but also compare student performance on external measures of success among students taught with traditional and context based approaches.

### **Context Based Approaches to Promote Nature of Science Understandings**

Several researchers have investigated the impact of context-based instruction on different aspects of student understanding of the nature of science (NOS) (Laius & Rannikäme, 2005; Akcay & R. Yager, 2010; R. Yager & Akcay, 2008; R. Yager et. al., 2009; Khishfe & Lederman, 2006; Walker & Zeidler, 2007). Like scientific literacy, the nature of science is not clearly defined (Khishfe & Lederman, 2006) however researchers have described some aspects or characteristics of the scientific enterprise that are accessible and relevant to students' everyday lives (Abd-El-Khalick, Bell, & Lederman, 1998) . These aspects include an understanding that scientific knowledge is: tentative (subject to change); empirically based (based on and/or derived from observations of the natural world); subjective (influenced by scientists' background, experiences, and biases); partly the product of human imagination and creativity; and socially and culturally embedded (AAAS,1993; NRC,1996).

Research on context-based learning and NOS has employed two different strategies for teaching and learning NOS tenets. These strategies include an implicit approach in which it is assumed that students will automatically understand NOS as a result of using authentic topics as organizers for instruction and an explicit approach in which NOS is specifically planned for and taught as a learning outcome embedded in or alongside context-based instruction (Khishfe & Lederman, 2006). Numerous research studies have utilized an implicit approach to investigate the impact of context-based instruction on the development of students' creativity (Laius & Rannikäme, 2005; Akcay & R. Yager, 2010; R. Yager & Akcay, 2008; R. Yager et al., 2009) which is an aspect of NOS understanding.

Laius and Rannikäme (2005) conducted a quantitative study to investigate the impact of an eight-week SSI intervention on the development of students' creative thinking skills. Eighty students in eight different Estonian schools participated in the study. The researchers used a discrepant event test before and after implementation of the SSI intervention to measure students' creative thinking abilities in three areas: asking questions, suggesting causes, and predicting consequences. Each area was scored for fluency, flexibility, and originality. Analysis of the pre- and post-test results indicated that students scored higher with respect to fluency in all three areas of creative thinking after the SSI intervention with significant improvements in the areas of asking questions ( $p < 0.001$ ) and predicting consequences ( $p < 0.01$ ). Hierarchical cluster analysis of the data for flexibility and originality indicated that 32.5% of students increased their hierarchical level within at least one of the three

categories of creative thinking after the SSI intervention with the most significant improvement in the area of asking questions ( $p < 0.01$ ). These results demonstrate that context-based instruction can effectively promote creative thinking skills, particularly in the area of asking questions.

Akçay and R. Yager (2010), R. Yager and Akçay (2008), and R. Yager et al. (2009) also looked at the effect of context-based instruction on the development of students' creative thinking skills; a central element of NOS. As previously described all three studies used similar quantitative methodologies to evaluate student outcomes. The researchers defined creativity as a student's ability to ask questions, propose answers for possible explanations, provide evidence for the validity of the explanations and conceptualize consequences for their predictions. R. Yager et al. (2009) found that students who received instruction with a socioscientific emphasis significantly outperformed students receiving more traditional directed inquiry instruction with respect to creativity. R. Yager and Akçay (2008) found that students who received STS instruction significantly outperformed students receiving traditional textbook instruction with respect to creativity. Akçay and R. Yager (2010) found that students at all grade levels, in the student-centered STS sections, demonstrated significantly more creativity in their post-test responses than students in the teacher-centered STS sections.

These four studies demonstrate that context-based instruction with an implicit approach to NOS is effective in promoting students development of creative thinking skills particularly when a student-centered approach is used. Two additional studies

have directly investigated the impact of context-based instructional practices on students' development of NOS understandings. Unlike the previous studies which used implicit approaches to NOS, these studies use explicit approaches to NOS.

Khishfe and Lederman (2006) investigated the role of context-based instruction in developing student understanding of NOS constructs, specifically that science is subjective, tentative, creative, empirical, and influenced by social factors. The researchers compared gains in NOS understandings among forty-eight secondary environmental science students receiving SSI instruction coupled with two different explicit NOS approaches. One intervention used an integrated approach wherein NOS instruction was embedded within the context-based instruction. The other intervention used a non-integrated approach wherein the five aspects of NOS were taught throughout the unit using activities and instruction that addressed NOS without relating it to the authentic context. Open ended questionnaires and semi structured interviews were used to assess students' views before and after instruction. Students who received the integrated NOS instruction showed improvements in NOS understandings that were comparable to the gains achieved by students in the non-integrated NOS intervention. These results demonstrate that explicit NOS instruction is effective in promoting students understanding of NOS regardless of whether an integrated or non-integrated instructional approach is used.

Walker and Zeidler (2007) also demonstrated that explicit NOS instruction embedded in context-based instructional practices can promote student understanding of NOS. Walker and Zeidler (2007) conducted an experimental case study to

investigate student development of NOS understandings as they negotiated a SSI related intervention involving genetically modified foods. Thirty six students from two high school science classes participated in the study. The WISE (Web-based Inquiry Science Environment: Bell, 2000) instructional framework was used to create a series of web-based activities which explicitly incorporated NOS based questions and teaching with activities aimed at promoting student learning of issues surrounding genetically modified foods. Students were then engaged in a culminating debate regarding the issue. Student conceptualizations of NOS were assessed using questions embedded in the web-based learning activities, data collected with an open-ended questionnaire, and semi-structured individual interviews. The authors concluded that students developed and articulated ideas related to the tentative, subjective, creative, and social aspects of the NOS as they responded to questions related to NOS in the web-based activities. Student gains were particularly noticeable for the tentative and creative aspects of science. However student NOS understandings were not robust enough to serve as conceptual resources during the culminating debate.

Together these six studies demonstrate that student-centered context-based instruction with or without explicit NOS instruction can effectively promote aspects of students NOS understandings and thus scientific literacy. However, science reform aims to move students beyond a basic level of understanding to a level of NOS understanding that enables them to apply NOS tenets to their everyday lives. The difficulty in accomplishing this was demonstrated in the study by Walker and Zeidler

(2007). Although this study used explicit instruction, which has been recognized as necessary in order to move students beyond naïve understandings (Abd-El-Khalic & Lederman, 2000), the students did not apply NOS tenants in the culminating debate. The researchers suggested that the use of a scaffolded approach to guided students in applying NOS understandings would encourage students to use NOS knowledge in scientific debates.

### **Context-Based Approaches to Promote Argumentation Skills**

A significant amount of research on argumentative discourse related to context-based instruction in science education has emerged within the last two decades. Most of this research has focused on the impact of context-based interventions incorporating explicit instruction in argumentation on the development of students reflective judgment (Zeidler, Sadler, Applebaum, & Callahan, 2009) and argumentation skills (Dori et al., 2003; Zohar & Nemet, 2002; Venville & Dawson, 2010; Osborne, Erduran, Simon, 2004). Reflective judgment is a term used to describe a student's ability to evaluate claims, analyze evidence, and assess multiple viewpoints regarding an ethical or moral scientific issues. These skills are necessary for argumentative discourse, essential aspects of scientific literacy, and necessary to participate in discourse and debate in the 21<sup>st</sup> century. Other research has investigated the impact of students' level of understanding on the quality and complexity of their arguments (Sadler & Donnelly, 2006; Sadler & Zeidler, 2005).

Zeidler and colleagues (2009) used a mixed methods study to describe the effects of a year-long SSI based intervention on the development of students'

reflective judgment in two anatomy and physiology classes. Two additional anatomy and physiology classes were studied for comparative purposes. These classes were instructed with a traditional textbook driven curriculum. A Prototypical Reflective Judgment Interview (PRJI) was used at the beginning and end of the year in all classes to assess students' reflective judgment. Qualitative analysis of student interview responses demonstrated a general trend toward higher stages of reflective judgment after exposure to the SSI curriculum. In order to represent students' reflective judgment as a continuum rather than quantitative analysis employed a three stage coding system for student responses and then converted the stages into a number between one and seven using a weighted average. Students in the comparison classes demonstrated virtually no changes in reflective judgment throughout the course of the year while student scores in the SSI treatment group increased from the pre-test ( $X=3.62$   $SD=1.18$ ) to the post-test ( $X=4.48$   $SD=1.34$ ). This demonstrates that SSI instruction can improve students' reflective judgment and therefore a students' ability to evaluate claims, analyze evidence, and assess multiple viewpoints and ultimately participate in argumentation.

Dori and colleagues (2003) evaluated Israeli students' ability to use three higher order thinking skills including argumentation in analyzing environmental and moral conflicts presented through a series of SSI related case studies in a biotechnology module. The researchers used pre- and post- tests consisting of open ended questions to evaluate the effect of context-based instruction on the development of argumentation skills. In order to analyze data the students were



grouped according to their academic abilities. Analysis showed that both high- and low- academic-level students achieved gains in argumentation skills after the context-based intervention. However, analysis of net gains showed significant improvements in argumentation for low academic level students relative to their high academic level peers ( $t=4.23$   $p<0.0001$ ). The authors concluded that SSI-based interventions have the potential to effectively promote higher-order thinking practices associated with argumentation. They also noted the potential for context-based instruction to help reduce achievement gaps among students.

Zohar and Nemet (2002) investigated the impact of an SSI-based intervention on student content knowledge and the development of students' argumentation skills. As previously described, the study involved nearly 200 Israeli ninth-grade students from nine different sections of biology. Five of the sections were instructed with an context-based curriculum designed by the authors while the other sections were instructed with a traditional textbook approach. To evaluate the development of argumentation skills the researchers collected and analyzed data from a series of written artifacts, transcribed discussions and a pre- and post- test. The test was developed to assess students' ability to formulate arguments, alternative arguments, and rebuttals using justifications. The test consisted of three sets, or dilemmas. These included opportunities for students to demonstrate argumentation practices relative to two genetics based contexts as well as an unrelated transfer task. The pre- and post- tests were evaluated using a scoring scheme based on the number of justifications provided and the structure of students' arguments, counter-arguments

and rebuttals. Analysis of the pre- and post- test scores indicated that students who received context-based instruction performed statistically significantly better on the post- test than the pre-test for all three sets of tests including the transfer task. The authors described these results as having a large effect size and practically significant. In contrast, students who received traditional instruction did not show any gains. These results demonstrate that context-based instruction can serve as an effective context for improving the quality of students written argumentation skills.

In a supporting quasi-experimental case study, Venville and Dawson (2010) examined the effect of explicit instruction in argumentation on the development of students' argumentation and informal reasoning skills in two SSI-based interventions related to genetics. A total of ninety-two students in four Australian classes participated in the study. Students in two of the four classes were given explicit instruction in argumentation which included fifty minutes of instruction on argumentation skills followed by two fifty minute whole class debates on scenarios about cystic fibrosis and genetically modified tomatoes. Students in the other two classes formed the comparison group and were not given any planned instruction or practice with argumentation. A written student survey made up of genetics-based socioscientific issues, and based on original work by Lewis (2000), was used before and after explicit instruction to assess the development of students' argumentation skills. The survey was evaluated using an analytic classification scheme based on Toulmin's (1958) argumentation pattern. A significant difference was found between pre- and post- test levels of argumentation for students who received explicit

instruction in argumentation ( $T=73.50$   $z=-0.68$ ) while no difference was found for students in the comparison group. Student responses improved significantly in complexity and quality after the SSI-related intervention. These results demonstrate that explicit instruction in argumentation and socioscientific debate over a short period of time can improve the structure and complexity of students' written argumentation skills.

In a contradictory study, Osborne and colleagues (2004) described a case study in which they studied the impact of a SSI-related genetics intervention incorporating argumentation on the progression of students' capabilities with argumentation. Six teachers, who had previously demonstrated an ability to facilitate and incorporate argumentation into their pedagogical practice, taught a minimum of nine lessons which involved socioscientific or scientific argumentation to classes of eighth-grade students. Similar lessons were taught to comparison groups at the beginning and end of the year. Data was collected from thirty-three lessons by video-taping two groups of four students in each class. The researchers used a framework based on Toulmin's (1958) argumentation pattern to assess the nature and quality of the students' arguments. The results showed evidence of positive improvement in the quality of students' verbal argumentation but the change was not significant. These findings contradict those of Dawson and Venville (2010) and Zohar and Nemet (2002) who found significant improvements in students' argumentation skills after a relatively short period of time.

Venville and Dawson (2010) and Osborne et al. (2004) both used Toulmin's (1958) argumentation pattern as a guiding framework to explore the structure and complexity of students' argumentation however Venville and Dawson analyzed monologic, written arguments while Osborne et al. (2004) analyzed dialogic, oral, arguments. Written arguments were also evaluated by Zohar and Nemet (2002) who used a survey and Dori et al. (2003) who used an open ended test to assess student argumentation. Regardless of the type of argument these studies demonstrate that improvement in students argumentation skills is possible if argumentation is explicitly addressed and taught.

Researchers have also shown that the quality and complexity of the argumentation depends on students' level of understanding (Sadler & Donnelly, 2006; Sadler & Zeidler, 2005). Sadler and Zeidler (2005) conducted a mixed methods study to investigate the relationship between content knowledge and argumentation in the context of a socioscientific issue. The researchers administered a quantitative test of genetics knowledge to undergraduate students with various academic backgrounds. Based on the test results, two groups of fifteen students representing divergent levels of content knowledge were selected to participate in individual audio-taped interviews designed to assess argumentation in the context of genetic engineering issues. A rubric based on Toulman's (1958) argumentation pattern was developed and used to quantitatively assess the quality of students' argumentation. Analysis of the interview and rubric data indicated that students who exhibited a high-level of genetics understanding often applied content knowledge as

they discussed the genetic engineering issues while students who exhibited a low-level of understanding never applied content knowledge during argumentation.

In a contradictory mixed methods study, Sadler and Donnelly (2006) investigated the relationship between content knowledge and the quality of fifty six high school students argumentation in the context of socioscientific issues. The researchers used the Test of Basic Genetics Knowledge (Sadler, 2003) to measure students' content knowledge and audio-taped individual interviews, in which students had to consider and resolve controversial genetic engineering scenarios, evaluate students' argumentation. Analysis of the test scores and interview transcripts demonstrated that student applications of content knowledge were very infrequent throughout the interviews, even among individuals who presumably had strong genetics content knowledge.

The study by Sadler and Zeidler (2005) found significant differences in the quality of argumentation presented by groups with disparate content knowledge while the study by Sadler and Donnelly (2006) revealed no significant relationship between content knowledge and argumentation. Sadler and Donnelly (2006) proposed a threshold model, based on their work and the work by Sadler and Zeidler (2005), to account for the non-significant relationship between content knowledge and argumentation quality described by their work. This model suggests certain knowledge thresholds which confer noticeable increases in argumentation quality. Thus, if argumentation quality is to improve, students' understanding of science concepts must also improve. These two contradictory studies demonstrate that

student reasoning and argumentation is related to students' content knowledge and can potentially be enhanced by providing students with opportunities to engage in context-based learning using authentic topics. In addition, the work by Zohar and Nemet (2002) suggested that transfer of argumentation skills from one context to another, which is a fundamental aspect of scientific literacy, is a potential when argumentation is taught through context-based approaches.

### **Context Based Approaches to Promote Student Motivation and Interest**

A common claim and assumption of educators using authentic topics as organizers for instruction is that engaging students in personally meaningful and socially relevant issues increases students motivation to learn science. This motivation is believed to positively impact student engagement and the development of attitudes towards science. Several studies, many of which have been fully described in the previous sections, have provided anecdotal evidence of student interest in context-based learning and socioscientific issues (Zeidler et al, 2009; Albe, 2008; Dori et. al, 2003) while other studies have investigated the effect of context-based interventions on more general attitudes toward science (Lee & Erdogan, 2007; Akcay & R. Yager, 2010; R. Yager & Akcay, 2008; Yager et. al, 2009)

Zeidler et al. (2009) noted anecdotal evidence supporting SSI as a means to increase student motivation and interest. As previously described, the authors implemented a year-long SSI-driven curriculum involving a series of authentic topics ranging from the fluoridation of public water supplies, to the safety of vaccines, and the allocation of organs for transplant. The researchers compared student

performance in SSI classes to classes that followed a traditional textbook driven approach. The authors used a Prototypic Reflective Judgment Interview (PRJI) developed by King and Kitchener (1994) to assess the efficacy of SSI instruction on students reflective judgment. This technique requires students to answer a series of seven questions related to a SSI problem and assesses students reflective thought. Student responses to the PRJI indicated that students who experienced the SSI-driven curriculum learned more basic anatomy and physiology concepts than students who experienced the traditional textbook driven approach. The authors proposed that students who experienced the SSI-driven curriculum were more motivated to learn, more interested in the material, and more engaged with the learning activities.

Able (2008) who conducted an in-depth micro-ethnography to explore discursive practices and social roles students develop as they engage in small group debates involving a socioscientific issue also noted anecdotal evidence in support of SSI as a motivational strategy. Based on the discourse analysis, Albe concluded that students found the process of reviewing research and engaging in arguments to be very demanding but also extremely interesting and highly motivating.

Dori and colleagues (2003) also provided anecdotal evidence of student interest in context-based instruction involving controversial and ethical topics. As previously described the researchers implemented a series of case studies related to genetic engineering, the human genome project, and gene therapy with a group of two hundred Israeli students. As part of the larger work, Dori and colleagues collected student portfolios and elicited teacher feedback to evaluate student interest and

motivation with respect to the SSI modules. Evaluation of student portfolios showed that ninety-six percent of students found the biotechnology modules to be interesting and relevant to their lives. The follow-up interviews with teachers supported this finding.

Together these three studies provide anecdotal evidence that context based instruction can promote student engagement and motivation in science. However, other studies have directly investigated the effect of context-based interventions on more general attitudes toward science (Lee & Erdogan, 2007; Akcay & R. Yager, 2010; R. Yager & Akcay, 2008; Yager et. al, 2009). Lee and Erdogan (2007) examined the impact of a four-week context-based intervention on students' creativity and attitudes toward science. A total of five-hundred and ninety-one students in fourteen sections of middle and high school science participated in the study. Seven teachers, who had extensive professional development in designing and implementing context-based instruction each taught one section using traditional methods and one section using context-based approaches. The Attitudes Toward Science Inventory was used to evaluate student attitudes toward science before and after implementation of the context-based instruction. Students taught with the traditional approach scored lower on the post-test ( $X=2.80$   $SD=0.52$ ) than the pre-test ( $X=2.86$   $SD=0.54$ ) while students taught with the context-based approach scored higher on the post- test ( $X=2.97$   $SD=0.58$ ) than the pre-test ( $X=2.77$   $SD=0.56$ ). These results demonstrated that positive attitudes towards science decrease for students taught with traditional approaches and increase among students taught with context-based instruction



approaches. The researchers concluded that context-based approaches to instruction have the potential to improve student attitudes towards science.

Akçay and R. Yager (2010), R. Yager and Akçay (2008), and R. Yager et al. (2009) also looked at the effect of context-based instruction on the students' development of more positive attitudes toward science. As previously described all three studies used similar pre- and post- test methodologies to evaluate student outcomes quantitatively. All three studies used attitude questions developed from items of the Third Assessment of Science by the National Assessment of Educational Programs (NAEP). The questions consisted of questions about favorite classes and the degree to which students were positive about science classes, teachers, and careers. R. Yager et al. (2009) found that students who received instruction with a socioscientific emphasis demonstrated more positive attitudes towards science than students taught with more traditional directed inquiry instruction. R. Yager and Akçay (2008) found that students taught with a traditional approach scored lower on the post-test ( $X=7.00$   $SD=0.9$ ) than the pre-test ( $X=8.15$   $SD=0.1.0$ ) while students taught with the context-based approach scored higher on the post- test ( $X=8.88$   $SD=0.8$ ) than the pre-test ( $X=7.65$   $SD=1.0$ ). Thus, students taught with context-based instruction demonstrated more positive attitudes towards science than students taught with more traditional instructional approaches. Akçay and R. Yager (2010) also found that students at all grade levels, in the student-centered STS sections, demonstrated significantly more positive attitudes in their post- test responses than students in the teacher-centered STS sections.

These four studies demonstrate that students taught with context-based approaches develop more positive attitudes towards science classes, teachers and science careers than students taught with traditional or directed inquiry approaches. All four studies attributed this to the authentic topics and the active role that students in context-based instruction assume in their learning. The authors argued that when learning is meaningful, relevant, and developmentally appropriate, and students are responsible for asking questions, conducting research, and finding their own information sources, students' engagement and motivation to learn science content increases. This was supported in the work by Akcay and R. Yager (2010) which showed that students, in student-centered STS classrooms, demonstrated more positive attitudes than students in teacher-centered STS classrooms.

### **Barriers and Considerations for Implementation of Authentic Topics**

While research in science education has discussed the use of authentic topics as organizers for instruction for the last three decades, only a few teachers have actually implemented context-based instruction in their classrooms. Research has found that teachers are reluctant to implement these topics because they feel pressure to “cover the standards” and prepare students for standardized exams (Sadler, Amirshokoochi, Kazempour, Allspaw, 2006). In addition, most teachers did not experience authentic instruction as part of their own science preparation, were successful themselves, and are therefore unwilling and inadequately prepared to use authentic contexts in science instruction (R. Yager, Choi, S. Yager, & Akcay, 2009). Furthermore, many teachers are concerned that science content will be diluted if they

use authentic topics as organizers for instruction (R. Yager et al., 2009) and do not feel comfortable with the instructional changes that are required for implementation of student-centered context-based instruction (Mansour, 2009) with argumentation. Additional political and technical barriers include a lack of time, administrative support, and professional development, inadequate or insufficient instructional materials and difficulties assessing student understanding of content using context-based approaches (Johnson, 2006). Many of these challenges can be overcome, with individualized and regular professional development aimed at improving teachers understanding of science content and instructional practices associated with context-based learning (R. Yager et al., 2009). Other challenges can be overcome, with time for collaborative planning and reflection (Johnson, 2006). In districts with a lack of administrative support and funding teachers have the ability to implement change one classroom at a time (Johnson, 2007).

Despite the barriers, teachers interested in implementing context-based approaches should be involved in the development of both the curriculum and assessment tools (Dori et al., 2000) and work collaboratively with their colleagues to create materials, implement lessons, and reflect on the success and failures of the implementation (Johnson, 2006). When implementing context-based approaches, teachers should provide explicit instruction in argumentation and socioscientific debate (Venville & Dawson, 2010). However, teachers do not need to provide explicit NOS instruction as context based approaches naturally promote student understanding of nature of science constructs (Khishfe & Lederman, 2006; Laius &

Rannikame, 2005). In addition, when implementing context-based approaches, teachers should use student-centered instructional approaches, as they are more effective than teacher-centered approaches at promoting student NOS understandings (Akçay & Yager, 2010). Furthermore, when evaluating student learning gains, teachers should not assume that students who demonstrate poor argumentation skills lack content knowledge or that students who demonstrate complex argumentation skills have greater content knowledge as the relationship between content knowledge and argumentation is unclear (Sadler & Zeidler, 2005).

### **Conclusion**

Context-based instructional approaches, which use authentic topics as organizers for instruction, support the goal of scientific literacy as described in the National Science Education Standards (NSES, 1996) and are expected to be a focus of the Next Generation Science Standards (NRC, 2012). Context-based approaches require students to explain and predict natural phenomena, explore, synthesize, and evaluate scientific information to make informed decisions, actively participate and evaluate argumentative discourse, and apply moral, ethical, and social values in making decisions. These skills are consistent with the skills that the National Research Council (1996) and the American Association for the Advancement of Science (1990) have outlined for scientifically literate individuals. They are also consistent with the skills that the National Science Teachers Association (2011) has identified as necessary for individuals to possess with the increasing scientific and technological advancements and challenges of 21<sup>st</sup> century.

Research in science education on context-based instruction demonstrates that context-based approaches can promote aspects of scientific literacy. The research has demonstrated that authentic topics can be used to promote student learning of science concepts, promote student understanding of the nature of science tenants and develop students' argumentation skills. Furthermore, the research demonstrated that context-based approaches using authentic topics as organizers can increase student interest and motivation in science. This could ultimately increase the number of students pursuing higher education as well as scientific careers leading to a more scientifically literate society.

### **Chapter 3: Application**

Context-based instruction requires teachers to rethink, restructure, reorganize, rewrite and review current science materials, realign goals and objectives, reallocate resources, and rethink teaching practices. While there are many approaches to implementing context-based instruction into the classroom, all of the approaches require students to explore, synthesize, and evaluate scientific information in order to make an informed decision regarding a meaningful and socially relevant issue. The approaches all stress the importance of social interactions in developing student understanding and require students to engage in written or verbal argumentative discourse.

The following project demonstrates the rethinking and restructuring required to implement context-based instruction incorporating written or verbal argumentation into a course in which the science content to be taught is dictated by state standards,

and the organization of the content within the year, is restricted by the use of non-negotiable common unit assessments, aligned to district curriculum. The project consists of a compilation of forty meaningful and controversial authentic topics that could be used as contexts for learning in a living environment course without significantly disrupting the existing organization of the content in a district curriculum. Each topic in the compilation includes a list of the New York state standards addressed by the topic, a problem statement that could be used to initiate verbal or written argumentative discourse related to the topic, a rational for selecting the topic, and suggestions for the implementation of the topic in a traditional living environment course. The rational for each topic includes, but is not limited to, a brief discussion of the pertinent science content, opposing viewpoints, and the relevance of the topic to high school students. In order to provide a clearer understanding of the application of the project a sample lesson, based on one of the forty authentic topics, is included in the appendix.

## Use of Animals in Research

**Authentic Topic:** Use of Animals in Research

**New York State Standards and Performance Indicators:**

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.

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.

1.1 – Hone ideas through reasoning, library research, and discussion with others, including experts.

1.2a – Inquiry involves asking questions and locating, interpreting, and processing information from a variety of sources.

1.2b – Inquiry involves making judgments about the reliability of the source and relevance of information.

**Traditional Unit:** Unit #1 – Scientific Method

**Problem Statement:**

Animals are used in biomedical research, drug and toxicology testing, cosmetic testing, defense research and studies of genetics and developmental biology

despite strong opposition from animal rights activists and animal welfare organizations. Should the use of animals in biomedical, pharmaceutical, and defense research continue to be allowed?

**Rationale for Topic:**

Animal research also known as, animal testing or animal experimentation, is a controversial subject that has been the center of debate among animal rights activists for hundreds of years. Animal research is conducted in medical schools, pharmaceutical companies, farms, defense facilities, universities, and commercial facilities throughout the United States. It is widely used in biomedical research, drug and toxicology testing, cosmetic testing, defense research, and studies of genetics and developmental biology. Invertebrate animals such as flies and vertebrate animals such as mice, rats, hamsters, gerbils, guinea pigs, birds, frogs, zebrafish, cats, dogs, pigs, horses and non-human primates are commonly subjects in research. While these animals may be obtained from the wild, most are purchased from special breeding facilities or dealers who get them from auctions and animal shelters. At the conclusion of a research study, the animals are usually euthanized.

Advocates of animal research argue that the research is necessary in order to make advances in science and has been used in virtually every medical advancement during the 20<sup>th</sup> century. They believe that animal research is necessary to study the interactions of molecules, cells, tissues, organs, and organ systems with the environment and that computers, while sophisticated, are unable to accurately model these interactions. Opponents of animal research, including animal rights activists



and animal welfare organizations, argue that it is cruel, unnecessary, poorly regulated, and violation of the intrinsic rights of animals. They are particularly opposed to research on vertebrate animals such as cats, dogs, pigs, horses, and non-human primates. Opponents argue that research on these animals usually has the potential to cause pain or distress and is therefore ethically unacceptable and morally wrong.

The use of animals in research as a controversial subject exposes students to current research and enables them to evaluate their own moral and ethical beliefs about the use of animals in experimental studies. The topic can be used to expand students' knowledge of scientific concepts and enhance their understanding of scientific design.

**Suggestions for Instruction:**

Students could read several articles describing experimental studies using animals. For instance, students could read about the use of primates in HIV research, the use of dogs in pharmaceutical research, the use of pigs in military research and the use of mice in behavioral studies. They could then read or watch controversial videos or articles arguing for and against animal testing and write a position paper or participate in a class debate on whether animals should continue to be subjects in scientific research.

## Taxation of Beverages

**Authentic Topic:** Taxation of Beverages

**New York State Standards and Performance Indicators:**

- 1.1 – Elaborate on basic scientific and personal explanations of natural phenomena, and develop extended models and mathematical formulations to represent one’s thinking.
  - 1.1c – Science provides knowledge, but values are also essential to making effective and ethical decisions about the application of scientific knowledge.
- 3.1 – Use various methods of representing and organizing observations (e.g., diagrams, tables, charts, graphs, equations, matrices) and insightfully interpret the organized data.
  - 3.1a – Interpretation of data leads to development of additional hypotheses, the formation of generalizations, or explanations of natural phenomena.
  - 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.

**Traditional Unit:** Unit #1 – Scientific Method

**Problem Statement:**

Obesity has become epidemic in the United States and obesity related diseases are costing taxpayers millions of dollars each year in medical expenses. Sugary

drinks are contributing to this obesity epidemic. Should cities impose taxation laws on soda and other sugar-loaded drinks in order to offset the costs of obesity related diseases?

**Rationale for Topic:**

The taxation of sugary beverages is one way to offset the enormous costs of medical care related to obesity and discourage the purchase and consumption of sugar-loaded beverages. Proponents of drink taxation argue that obesity is costing the United States millions of dollars in health related expenditures each year. They feel that taxation would not only discourage the sale of sugary beverages but also help to offset the related medical costs. Opponents of drink taxation argue that it will not prevent people from purchasing sugary beverages and therefore it will not help solve the nation's obesity epidemic.

Students, especially those who are overweight or obese, constantly bring sugary drinks to class. These students often drink multiple unhealthy beverages each day. Most of these students want to lose weight and some of them are conscious of what they eat but most do not realize that what they drink is contributing to their weight issues. The consumption of sugar-loaded drinks as an authentic topic could help these students understand how to eat healthier and therefore lose weight. It would also expose students to the dangers of obesity and enable students to evaluate their own beliefs about how to control obesity among the nation's youth. In addition, the consumption of sugar-loaded drinks as an authentic topic would enable students to practice lab skills and analyze data.

**Suggestions for Instruction:**

Students could read about New York City Mayor Bloomberg banning restaurants, movie theaters, and sports stadiums from selling soda and other sugar-loaded drinks larger than 16 ounces in an effort to reduce the obesity epidemic in NYC. They could then do a lab in which they measure out the amount of sugar in different size drinks and analyze obesity statistics and related medical costs from the local area. To summarize their knowledge students could write a position paper on the subject of whether cities like Rochester should tax sugary loaded drinks to offset the medial costs associated with the rising obesity rates. As an alternative, students could write a letter to Tom Richards, the mayor of the city of Rochester, encouraging or discouraging him to impose taxation laws similar to those enacted by that Mayor Bloomberg in New York City.

## Cell Phones and Cancer

**Authentic Topic:** Cell Phones and Cancer

**New York State Standards and Performance Indicators:**

- 1.1 – Hone ideas through reasoning, library research, and discussion with others, including experts.
- 1.2a – Inquiry involves asking questions and locating, interpreting, and processing information from a variety of sources.
- 1.2b – Inquiry involves making judgments about the reliability of the source and relevance of information.
- 1.3 – Work toward reconciling competing explanations; clarify points of agreement and disagreement.
- 1.3a – Scientific explanations are accepted when they are consistent with experimental and observational evidence and when they lead to accurate predictions.
- 1.3b – All scientific explanations are tentative and subject to change or improvement. Each new bit of evidence can create more questions than it answers. This leads to increasingly better understanding of how things work in the living world.
- 5.1 – Explain disease as a failure of homeostasis.
- 5.2i – Gene mutations in a cell can result in uncontrolled cell division, called cancer. Exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer.

**Traditional Unit:** Unit #1 – Scientific Method or Unit #3 - Reproduction

**Problem Statement:**

Cell phones are readily available and widely used throughout the world. Concerns over the potential for cell phones to cause cancer have sparked debate among scientists and individuals in the population. If cell phone radiation is linked to cancer, children and teenagers are the most susceptible. However, research on cell phone safety has not been conclusive. Should cell phone use be regulated in order to reduce the chance of developing cancers?

**Rationale for Topic:**

The use of cell phones has rapidly increased since the 1990's when they first became available in the United States. Recently, the safety of long term cell phone usage has been questioned, particularly because of the increase in the number of reported brain and neck tumors over the last two decades. When cell phones are used, they release a form of electromagnetic radiation similar to the radiation released from low-powered microwaves. In 2011, the World Health Organization classified cell phones as "possibly carcinogenic" placing them in the same category as lead and engine exhaust. However, research has not conclusively linked cell phone usage to brain and neck cancers. The difficulty with this type of research is that environmental factors, such as radiation exposure, require a few decades of exposure before any consequences can be identified and brain tumors are typically slow growing. Since cell phones have only been used for two decades, the research is just beginning. Two years ago, an international study showed that participants who used cell phones for at

least ten years had a fifty percent greater risk of developing brain tumors. However, there have been no long term studies on the risk of cell phone usage among children and teenagers. These individuals typically have thinner skulls and are therefore more susceptible to radiation than adults. Cell phone companies have recognized the risk and have published guidelines for how far away to hold phones in order to minimize exposure to cell phone radiation.

Students are constantly using their cell phones and many parents are now using the phrase “you are going to get cancer” as a way to discourage phone use. Therefore, students have many questions regarding the possibility of getting cancer from cell phones. Using cell phones as an authentic topic is not only engaging for students but also exposes them to research that is relevant to their lives. In addition, since many studies are not conclusive, and a number of contradictory studies exist, students will have to weigh the potential to develop brain tumors against the social need to constantly use their electronic devices in order to answer the question of whether cell phone usage should be regulated among teenagers.

**Suggestions for Instruction:**

Students could analyze data on the average number of reported brain tumors since the introduction of cell phones in the 1990's. This data is readily available, and because the incidence of brain tumors has increased, the data will lead students to believe that cell phones cause cancer. However, the increase could potentially be due to other environmental toxins. After analyzing the data, students could read about at least two conflicting studies on the potential for cell phones to cause cancer. They

could then write a position paper on whether or not cell phones usage should be regulated in the United States.



## **Sports Drinks**

**Authentic Topic:** Sports Drinks

**New York State Standards and Performance Indicators:**

1.2 – Describe and explain the structures and functions of the human body at different organizational levels (e.g., systems, tissues, cells, organelles)

1.2b – Humans are complex organisms. They require multiple systems for digestion, respiration, reproduction, circulation, excretion, movement, coordination, and immunity. The systems interact to perform life functions.

1.2e – The organs and systems of the body help to provide all the cells with their basic needs. The cells of the body are of different kinds and are grouped in ways that enhance how they function together.

1.2g – Each cell is covered by a membrane that performs a number of important functions for the cell. These include: separation from its outside environment, controlling which molecules enter and leave the cell, and recognition of chemical signals. The processes of diffusion and active transport are important in the movement of materials in and out of cells.

5.2 – Explain disease as a failure of homeostasis.

5.2a – Homeostasis in an organism is constantly threatened. Failure to respond effectively can result in disease or death.

**Traditional Unit:** Unit #2 – Cells and Biochemistry

**Problem Statement:**

Endurance athletes are at particular risk for developing hyponatremia during or after sporting events. Sports drink companies have marketed their products as a way to prevent this potentially fatal problem in all athletes. However, sports drinks are typically high in sugar and low in nutritional benefits. Are sports drinks beneficial for the average athlete?

**Rationale for Topic:**

Water intoxication, or hyponatremia, is a potentially fatal disturbance in brain function that results from disruption of the normal balance of electrolytes in the body. It is caused from drinking large amounts of plain water over a short time period. The water dilutes the blood causing the concentration of the solutes in the body cells to be much higher than the concentration of solutes in the blood. To compensate for the imbalance, and thus maintain homeostasis, water diffuses into the body cells causing them to swell. In the brain this causes intracranial pressure which leads to changes in behavior, confusion, fatigue and muscle weakness, cramping, vomiting, difficulty breathing and as the condition progresses changes in blood pressure and pulse rate.

Sports drink companies have marketed their products as being healthy and having the necessary ingredients to replenish the body during and after sporting events. While these products do contain various electrolytes, that may lower the risk of hyponatremia, the drink also contains large amounts of sugar, which contributes to obesity rates. Critics of sports drinks argue that the perception that sports drinks are healthy is contributing to the obesity epidemic among the nation's youth. They argue that the average athlete does not need a sports drink to compensate for water loss

because they do not lose a significant amount of water during exercise. For an average athlete plain water in small quantities is perfectly safe.

The use of sports drinks as an authentic topic allows students to examine fallacies in the marketing industry of the United States and introduces them to the concept of water intoxication, diffusion and osmosis. It could also enable them to learn about the nervous system and disruptions in homeostasis.

**Suggestions for Instruction:**

Students could read articles about water intoxication then complete part II of the NYS “Diffusion Through a Membrane” lab. As a summary to the topic students could write a position paper on whether sports drinks are beneficial for the average athlete.

## **Implantation of Eggs Using In vitro Fertilization**

**Authentic Topic:** Implantation of Eggs Using In vitro Fertilization

**New York State Standards and Performance Indicators:**

4.1 – Explain how organisms, including humans, reproduce their own kind.

4.1c – The process of meiosis and fertilization are key to sexual reproduction in a wide variety of organisms. The process of meiosis results in the production of eggs and sperm which each contain half of the genetic information. During fertilization, gametes unite to form a zygote, which contains the complete genetic information for the offspring.

4.1f – The structures and functions of the human female reproductive system, as in almost all other mammals, are designed to produce gametes in ovaries, allow for internal fertilization, support the internal development of the embryo and fetus in the uterus, and provide essential materials through the placenta, and nutrition through milk for the newborn.

4.1h – In humans, the embryonic development of essential organs occurs in early stages of pregnancy. The embryo may encounter risks from faults in its genes and from its mother's exposure to environmental factors such as inadequate diet, use of alcohol/drugs/tobacco, other toxins, or infections throughout her pregnancy.

5.2 – Explain disease as a failure of homeostasis

5.2j – Biological research generates knowledge used to design ways of diagnosing, preventing, treating, controlling, or curing diseases of plants and animals.

**Traditional Unit:** Unit #3 – Reproduction

**Problem Statement:**

In vitro fertilization (IVF) is a commonly used reproductive technology in which eggs are fertilized outside of the body and placed back into the uterus of a female in order to develop. Recently, clinics practicing IVF have been criticized for endangering the welfare of women by placing more than the desired number of embryos back into the uteri of women trying to become pregnant. Should the number of eggs placed into the uterus using IVF be regulated by laws in order to protect women's rights?

**Rationale for Topic:**

In vitro fertilization or the fertilization of an egg and sperm outside of the body is a commonly used reproductive technology when natural fertilization is not possible and/or other methods of fertilization have been unsuccessful. During in vitro fertilization eggs and sperm are combined in a petri dish. The resulting embryos are placed into the uterus of a female. Both the eggs and sperm can be from a donor, and typically the technique is combined with other fertility treatments to increase the likelihood of success. The procedure itself is widely accepted, however some religions are opposed to the procedure, and there are moral and ethical concerns over the destruction, indefinite freezing, or donation of left over embryos.

In addition, in recent years, the IVF industry has received considerable attention for making unscientific claims and distorting facts related to the prevalence of infertility. The distortion has led to an increase in the number of in vitro fertilization procedures performed creating what many consider a corrupt multimillion dollar industry. Within the industry, individual practitioners have been criticized for not using judgment regarding the number of embryos that can be safely placed back into a mother in order to make a profit. Currently, the United States recommends that no more than two embryos are placed back in the uterus but the actual number of embryos returned is left to the discretion of the health care provider. There are no laws regulating the number.

In vitro fertilization is often interesting to students because they know someone who has undergone the procedure. In addition, since in vitro fertilization was widely used 13 to 15 years ago, some students were conceived with IVF or know someone who was. The use of IVF as an authentic topic enables students to learn about an assistive reproductive technology and provides them with an opportunity to evaluate their moral and ethical beliefs about the disposal, donation, and indefinite freezing of left over embryos as well as their religious views on conception. Asking the question of whether there should be regulations on the number of embryos placed back in the uterus helps students learn about the risks associated with higher order multiple births.

**Suggestions for Instruction:**

Students could learn about fertilization, the implementation of an embryo, and basic information about IVF. They could then read about the highly publicized 2009 case of Angela Suleman, who was implanted with twelve embryos, and gave birth to a set of octuplets as well as cases where higher order multiple births have led to severe problems during pregnancy. Students could then write a position paper to answer the question of whether there should be regulations governing the number of eggs that can be placed back in a uterus during IVF treatments.

## **Insurance Coverage for Assistive Reproductive Technologies**

**Authentic Topic:** Insurance Coverage for Assistive Reproductive Technologies

### **New York State Standards and Performance Indicators:**

4.1 – Explain how organisms, including humans, reproduce their own kind.

4.1c – The process of meiosis and fertilization are key to sexual reproduction in a wide variety of organisms. The process of meiosis results in the production of eggs and sperm which each contain half of the genetic information. During fertilization, gametes unite to form a zygote, which contains the complete genetic information for the offspring.

4.1f – The structures and functions of the human female reproductive system, as in almost all other mammals, are designed to produce gametes in ovaries, allow for internal fertilization, support the internal development of the embryo and fetus in the uterus, and provide essential materials through the placenta, and nutrition through milk for the newborn.

4.1h – In humans, the embryonic development of essential organs occurs in early stages of pregnancy. The embryo may encounter risks from faults in its genes and from its mother's exposure to environmental factors such as inadequate diet, use of alcohol/drugs/tobacco, other toxins, or infections throughout her pregnancy.

5.2 – Explain disease as a failure of homeostasis



5.2j – Biological research generates knowledge used to design ways of diagnosing, preventing, treating, controlling, or curing diseases of plants and animals.

**Traditional Unit:** Unit #3 - Reproduction

**Problem Statement:**

In most states, insurance companies are not required to cover the costs associated with assistive reproductive technologies. In vitro fertilization is the safest and most regulated technology but it is far more costly than technologies such as fertility treatments and intrauterine insemination. However, these less expensive technologies often lead to higher order multiple births. Should insurance companies be required to cover the cost of assistive reproductive technologies such as IVF?

**Rationale for Topic:**

In most states, including New York, insurance companies are not required to cover the cost of reproductive technologies such as in vitro fertilization. In vitro fertilization (IVF) is one of the most sophisticated, controlled, and expensive reproductive technologies available today. One round of in vitro fertilization can cost anywhere from ten to thirty thousand dollars depending on whether the egg and sperm is from a donor or the future parents, genetic testing is done on the embryo, or other technologies and medications are used in conjunction with IVF in order to increase the likelihood of egg retrieval and implantation. The enormous costs associated with IVF are not possible for many middle and lower class families. Therefore, people trying to have children on a limited budget often resort to less

costly procedures including injections of fertility drugs and intrauterine insemination. Since it is impossible to control how many eggs will be fertilized, both of these procedures carry an increased risk of higher order multiple births. If insurance companies paid for IVF, more people would be able to afford it, thus reducing the number of higher order births and dangerous pregnancies caused by assistive reproductive technologies.

Students are familiar with the struggles of multiple births due in part to the reality television series *Jon & Kate Plus 8* restyled to *Kate Plus 8* which aired from 2007 to 2011 on the cable network TLC. The show chronicled the life of the dysfunctional Gosselin family and the challenges associated with raising eight children (twins and sextuplets), including the divorce of Jon and Kate. Students are interested in the topic and often want to know more about how someone becomes pregnant with “that many kids”.

The use of insurance coverage for assistive technologies as an authentic topic would require students to evaluate their moral and ethical beliefs about whose responsibility it is to pay for unnecessary procedures and the consequences of not providing coverage for these procedures. It would also introduce students to assistive reproductive technologies and the dangers of higher order multiple births.

**Suggestions for Instruction:**

Students could learn about fertilization, fetal development, and problems with infertility. They could then research assistive reproductive technologies and analyze data on the costs of these procedures. As a summary, students could write a position

paper to answer the question of whether insurance companies should be required to pay for reproductive technologies such as IVF.

## **Fetal Abuse**

**Authentic Topic:** Fetal Abuse

**New York State Standards and Performance Indicators:**

4.1 – Explain how organisms, including humans, reproduce their own kind.

4.1f – The structures and functions of the human female reproductive system, as in almost all other mammals, are designed to produce gametes in ovaries, allow for internal fertilization, support the internal development of the embryo and fetus in the uterus, and provide essential materials through the placenta, and nutrition through milk for the newborn.

4.1h – In humans, the embryonic development of essential organs occurs in early stages of pregnancy. The embryo may encounter risks from faults in its genes and from its mother’s exposure to environmental factors such as inadequate diet, use of alcohol/drugs/tobacco, other toxins, or infections throughout her pregnancy.

5.2 – Explain disease as a failure of homeostasis

5.2j – Biological research generates knowledge used to design ways of diagnosing, preventing, treating, controlling, or curing diseases of plants and animals.

**Traditional Unit:** Unit #3 - Reproduction

**Problem Statement:**

Drugs and alcohol readily diffuse across the placenta from a mother to her fetus causing severe and sometimes fatal birth defects. Should pregnant mothers who drink alcohol and use illegal drugs during pregnancy be charged with fetal abuse?

**Rationale for Topic:**

Drug and alcohol use during pregnancy can cause death or significant long-term damage to a developing fetus. Alcohol consumption, particularly during the first trimester, causes Fetal Alcohol Syndrome while drug use can result in miscarriage, fetal addiction, and profound birth defects including learning disabilities and physical deformities. Proponents of holding mothers accountable for drug and alcohol use during pregnancy argue that it is equivalent to forcing children to use drugs and alcohol and should be punished as such. They strongly believe that providing consequences would reduce the number of people who use drugs and alcohol during pregnancy. Opponents argue that taking legal action against women who use drugs and alcohol during pregnancy would cause pregnant women to stay away from healthcare providers thus preventing the unborn child from receiving critical prenatal care. They also argue that it would result in a number of women having late term abortions to avoid legal consequences.

The use of drugs and alcohol during pregnancy enables students to evaluate their own moral and ethical beliefs about the role of the legal system in protecting unborn children. It also teaches students about the exchange of materials across the placenta and the risks associated with drug and alcohol use during pregnancy.

**Suggestions for Instruction:**

Students could learn about the exchange of materials across the placenta and research the effects of drug and alcohol use during pregnancy from scaffolded work and the dissection of a placenta. They could then write a position paper or participate in a class debate on whether pregnant mothers, who drink alcohol or use drugs during pregnancy, should be charged with abuse of the unborn fetus.

## Legalization of Abortion

**Authentic Topic:** Legalization of Abortion

**New York State Standards and Performance Indicators:**

4.1 – Explain how organisms, including humans, reproduce their own kind.

4.1c – The process of meiosis and fertilization are key to sexual reproduction in a wide variety of organism. The process of meiosis results in the production of eggs and sperm which each contain half of the genetic information. During fertilization, gametes unite to form a zygote, which contains the complete genetic information for the offspring.

4.1d – The zygote may divide by mitosis and differentiate to form the specialized cells, tissues, and organs of multicellular organisms.

**Traditional Unit:** Unit #3 - Reproduction

**Problem Statement:**

Induced abortion or the intentional termination of pregnancy is one of the most controversial subjects in health care today. While it is illegal in some countries, the United States does not place any regulations on who can have abortions and only loosely regulates when abortions can be performed. Should abortion be legal, and if so, for what reasons and up until what gestational age during pregnancy?

**Rationale for Topic:**

The right to terminate pregnancy has been a controversial subject for many years. Induced abortion has been legal in the United States since 1973 however the practice remains illegal in many developing countries. When done in accordance

with local legislation abortion is one of the safest procedures in medicine. However, in countries with restrictive laws, abortions are often self-induced or performed in improper facilities by people without formal medical training. Self-induced abortions often use illegally obtained drugs or herbal medications and are performed with sharpened objects such as knitting needles and clothes hangers. They are also done by causing physical trauma to the abdomen. These unsafe abortions, which account for slightly under half of the abortions performed globally, result in thousands of material deaths and millions of disabilities each year.

Some countries limit abortions to situations where the life or death of the mother is threatened, the fetus is seriously deformed, or the pregnancy was the result of a rape, the United States does not currently place any regulations on who can have abortions. In the United States women, including teenagers, have the legal right to obtain an abortion anytime during pregnancy, for any reason at all, up until twenty-four weeks of pregnancy, and later if there are health complications. As a result abortions are being performed as a result of societal pressures including disapproval of single or early motherhood, stigmatization of people with disabilities, pressure to have children of a specific sex, insufficient economic resources, and a lack of access to contraceptive methods.

The use of abortion as an authentic topic would enable students to evaluate their own moral, ethical and religious beliefs about the reproductive rights of a woman and the pro-life, pro-choice, argument. This argument has been a mainstay in politics for many years and is therefore a relevant topic for students. The use of



abortion would also require students to carefully examine the developmental changes that occur during each trimester of pregnancy in order to create a valid biologically based argument which addresses both sides of the pro-life, pro-choice, argument.

**Suggestions for Instruction:**

Students could learn about fertilization, the implantation of a zygote into the uterus, mitosis, differentiation or cleavage, and the developmental changes that occur during the three trimesters of pregnancy through individual research using scaffolded questions aimed at teaching the science concepts. Students could then write a position paper, addressing the question of whether abortion should be legal, and if so, for what reasons and at what gestational stage during pregnancy. As an alternative, students could write a newspaper article for an opinion section presenting their case. Due to the extremely controversial nature of the topic, and the religious beliefs that may enter a debate, a whole class debate may be difficult to have for this particular subject.

## Separation of Conjoined Twins

**Authentic Topic:** Separation of Conjoined Twins

**New York State Standards and Performance Indicators:**

1.2 – Describe and explain the structures and functions of the human body at different organizational levels (e.g., systems, tissues, cells, organelles)

1.2d – If there is a disruption in any human system, there may be a corresponding imbalance in homeostasis.

4.1 – Explain how organisms, including humans, reproduce their own kind.

4.1d – The zygote may divide by mitosis and differentiate to form the specialized cells, tissues, and organs of multicellular organisms.

5.2 – Explain disease as a failure of homeostasis

5.2a – Homeostasis in an organism is constantly threatened. Failure to respond effectively can result in disease or death.

5.2g – Some allergic reactions are caused by the body's immune responses to usually harmless environmental substances. Sometimes the immune system may attack some of the body's own cells or transplanted organs.

5.2j – Biological research generates knowledge used to design ways of diagnosing, preventing, treating, controlling, or curing diseases of plants and animals.

**Traditional Unit:** Unit #3 – Reproduction

**Problem Statement:**

Medical advances within the last century have made the successful separation of conjoined twins a possibility. However, the surgery often poses a significant life-threatening risk to one or both of the twins. If two conjoined twins can survive without being separated should they undergo surgery in order to be separated?

**Rationale for Topic:**

The incidence of conjoined twins is a rare phenomenon estimated to occur in less than 0.002 percent of births. It has historically been believed to be the result of the partial splitting of a fertilized egg. However, recent research suggests that it is due to the fusion of stem cells from two previously separated fertilized eggs. While many conjoined twins are stillborn, and some are born alive with abnormalities that cause death shortly after birth, a small percentage of conjoined twins survive. These twins are often separated through surgery. The difficulty of the surgery depends on how the twins are attached and what internal organs are shared. Most cases of separation are life-threatening to one or both of the twins. As a result, the separation of conjoined twins who would otherwise survive is very contentious.

Due to the release of multiple films portraying conjoined twins and the media publicity that conjoined twins receive, most students are familiar with the topic and interested in learning more about it. The use of conjoined twins as an authentic topic would enable students to evaluate their own beliefs on whether it would be better to live in a society where you would be stigmatized for being different or separated at the risk of dying. The topic could be used to reinforce the ideas of mitosis and

differentiation or discuss organ transplants, as most separation surgeries require some organ transplant.

**Suggestions for Instruction:**

This topic could be used as a way for students to learn about mitosis and differentiation or it could be used in the homeostasis unit as part of a lesson on organ transplant. There are multiple case studies that describe both successful and unsuccessful separations of conjoined twins. These cases could be used to introduce or learn about conjoined twins and the risks associated with their separation. Students could then write a position paper or participate in a debate on whether conjoined twins who can survive without separation should be surgically separated.

## Sex Verification of Olympic Athletes

**Authentic Topic:** Sex Verification of Olympic Athletes

**New York State Standards and Performance Indicators:**

4.1 – Explain how organisms, including humans, reproduce their own kind.

4.1e – Human reproduction and development are influenced by factors such as gene expression, hormones, and the environment. The reproductive cycle in both males and females is regulated by hormones such as testosterone, estrogen, and progesterone.

**Traditional Unit:** Unit #3 – Reproduction

**Problem Statement:**

Sex testing using DNA in Olympic sports has been done for many years in order to prevent males from participating in female competitions. It is based on the premise that males, who have higher testosterone levels, have a biological advantage over females. Recently, the International Olympic Committee drafted guidelines, which mandate the testing of testosterone levels in female athletes if questions are raised about their performance. However, females who have a medical condition known as hyperandrogenism, have naturally occurring high levels of testosterone. Should the hormone, testosterone, be used in the sex testing of Olympic athletes?

**Rationale for Topic:**

Hyperandrogenism is a medical condition occurring in females and characterized by an excessive production of androgens including testosterone. In females, increased testosterone causes personality changes, irregular menstrual

cycles, excessive facial and body hair, increased muscle mass, and masculinization of the overall physical appearance. Some have argued that this gives female athletes an unfair advantage in competitive sports.

Recently, the International Olympic Committee drafted guidelines that mandate new sex testing procedures in female athletes if questions are raised about a female's performance. These new procedures use blood tests to measure the amount of testosterone in the body. The guidelines were applied in the London 2012 Summer Olympics and are expected to serve as recommendations for other international groups at future competitions. While sex testing is done to prevent male athletes from participating in female competitions, and is therefore not new to competitive sports, the use of testosterone levels as a way to determine sex has not been practiced before. Traditionally, sex testing has been performed using DNA. Proponents of the new testing procedures argue that it is necessary in order to promote equality in female sports. They believe that women with high testosterone levels have an increased advantage due to testosterone promoting muscle mass and aggressive behavior. Opponents of the new regulations argue that female athletes who have higher testosterone levels are not necessarily more successful than female athletes with normal testosterone levels. They also argue that suspending females who have high testosterone levels is a violation of their medical confidentiality. In addition, opponents argue that the self-identification of one's gender is a fundamental right, which should not be questioned in sports.

The use of sex testing as an authentic topic enables students to look at the role of hormones in regulating secondary sex characteristics. It is an engaging topic for students, particularly females or those who enjoy watching or participating in sports, and it enables students to evaluate the definition of female and male from an abstract perspective. In addition, it allows students to evaluate their own beliefs about fairness in sporting competitions and an athlete's right to privacy.

**Suggestions for Instruction:**

Students could research male and female hormones and their interactions with target cells as well as hyperandrogenism. They could then read news articles about the release of the new Olympic regulations and write a position paper or participate in a class debate on the issue of whether the new regulations are fair and should be implemented in female sports.

## Selective Breeding of Dogs

**Authentic Topic:** Selective Breeding of Dogs

**New York State Standards and Performance Indicators:**

2.1 – Explain how the structure and replication of genetic material result in offspring that resemble their parents.

2.1b – Every organism requires a set of coded instructions for specifying its traits. For offspring to resemble their parents, there must be a reliable way to transfer information from one generation to the next. Heredity is the passage of these instructions from one generation to another.

2.1c – Hereditary information is contained in genes, located in the chromosomes of each cell. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes in its nucleus.

2.1e – In sexually reproducing organisms, the new individual receives half of the genetic information from its mother (via the egg) and half from its father (via the sperm). Sexually produced offspring often resemble, but are not identical to, either of their parents.

2.1j – Offspring resemble their parents because they inherit similar genes that code for the production of proteins that form similar structures and perform similar functions.

2.2 – Explain how the technology of genetic engineering allows humans to alter genetic makeup of organisms.



2.2a – For thousands of years new varieties of cultivated plants and domestic animals have resulted from selective breeding for particular traits.

**Traditional Unit:** Unit #4 - Genetics

**Problem Statement:**

Purebred dogs have been treasured for their looks and temperament for many centuries. However, due to selective breeding they are far more likely to develop genetic diseases than mixed breed dogs. In addition, in order to obtain purebred dogs breeders often cull, or kill, dogs with undesirable characteristics. Should people looking to adopt a dog, adopt a purebred dog from a reputable breeder, or a mixed breed dog from an animal shelter?

**Rationale for Topic:**

Selective breeding, or the intentional breeding of genetically similar individuals in order to obtain specific characteristics, has been practiced for thousands of years. Today, purebred dogs, cost hundreds to thousands of dollars and are typically preferred to mixed breed dogs which can easily be adopted at local animal shelters. Unfortunately, selective breeding to create and emphasize desirable physical characteristics has caused purebred dogs to be more prone to physical and genetic disabilities such as respiratory issues, eye and heart disease, orthopedic problems, neurological diseases, cancer, and reproductive problems. Since many of these diseases are genetic, and most are polygenic and recessive, mixed breed dogs are typically less likely to have these problems. In addition, in order to create dogs with desirable characteristics, breeders of purebred dogs often cull, or kill, puppies that do

not meet breed standards. For many, this raises ethical questions about the practice of selective breeding.

The use of selective breeding as an authentic topic enables students to weigh the value of having a purebred dog against the increased risk for the dog to develop a physical or genetic disability. It also allows students to learn about the transmission of genetically inherited diseases and selective breeding.

**Suggestions for Instruction:**

Students could participate in a class discussion about animal shelters and selective breeding or visit an animal shelter and talk to a breeder about his or her practices. They could then learn about selective breeding through activities that examine the transmission of genes from one generation to the next and research a breed of dog in order to identify any genetic conditions that commonly affect the breed. To summarize their understanding they could write a position paper outlining and supporting their position on whether adopting a purebred dog from a breeder or mixed breed dog from an animal shelter is better alternative. As an alternative, students could write a newspaper article persuading the public to either adopt purebred or mixed-breed dogs.

## **Human-Animal Hybrid Organisms**

**Authentic Topic:** Human-Animal Hybrids

**New York State Standards and Performance Indicators:**

2.1 – Explain how the structure and replication of genetic material result in offspring that resemble their parents.

2.1e – In sexually reproducing organisms, the new individual receives half of the genetic information from its mother (via the egg) and half from its father (via the sperm). Sexually produced offspring often resemble, but are not identical to, either of their parents.

2.2 – Explain how the technology of genetic engineering allows humans to alter genetic makeup of organisms.

2.2a – For thousands of years new varieties of cultivated plants and domestic animals have resulted from selective breeding for particular traits.

2.2d – Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it.

2.2e – Knowledge of genetics is making possible new fields of health care; for example, finding genes which may have mutations that can cause disease will aid in the development of preventive measures to fight disease. Substances, such as hormones and enzymes, from genetically engineered organisms may reduce the cost and side effects of replacing missing body chemicals.

**Traditional Unit:** Unit #4 – Genetics

**Problem Statement:**

Human-animal hybrids have been portrayed in science fiction books and films for decades. Recently, scientists have started genetically engineering human-animal hybrid organisms for use in medical and pharmaceutical research. While these organisms do not look like the human-animal hybrids portrayed in science fiction, many people are concerned about the blurring of the line between humans and animals. They are also concerned about how far research will go. Should research that uses, or creates human-animal hybrid organisms, be banned in the United States?

**Rationale for Topic:**

Hybrid animals such as ligers and leopons have been produced in zoos since the late 1800's and early 1900's and some organisms, such as polar and grizzly bears have been known to mate naturally in the wild. The production of certain hybrid organisms including mules (horses and donkeys) and beefalo (cow and buffalo) is common practice in the United States. However, animal-human hybrids, known as chimeras, are relatively new and are extremely controversial.

Throughout the last decade, many chimeras have been created, and used, in science. Scientists have created sheep with human livers and pancreas cells, pigs with human blood flowing through their veins, mice with human liver and brain cells, cats with human proteins known to suppress allergies, and hundreds of different human-animal embryos. Scientists argue that animals with human-like characteristics make better models for testing drugs and therefore human-animal hybrids are

beneficial to science. They also believe human-hybrid organisms could be used to grow spare organs from human tissue. These organs could be used in organ transplants to reduce the deficit of available organs and, if the original tissue is taken from the person in need, prevent the immune response and thus reduce the chance of rejection and eliminate the need to take anti-rejection drugs following surgery.

Opponents of human-animal hybrid organisms often acknowledge the benefits but are concerned over the blurring of the lines between humans and animals. They are also concerned about how far the research could potential go in the future. The research is controversial, and morally and ethically questionable, due to the use of animals, the destruction of human-hybrid embryos, and the potential for the production of human-animal hybrids with human memories and feelings. However, even opponents acknowledge that human-animal hybrids have the potential to lead to major advances in the medical and pharmaceutical fields. Currently, in the United States there are no laws restricting the production of human-animal hybrids. This topic is being debated in legislation.

The use of human-hybrid organisms as an authentic topic would be highly engaging for students and expose them to another technological advance in the field of genetic engineering. A discussion of hybrid organisms could also be used to reinforce reproductive ideas such as meiosis and fertilization and introduce the idea of genetic manipulation.

**Suggestions for Instruction:**

Students could read about hybrid organisms such as ligers, leopons, mules, and beefalo. They could then research hybrid-humans to learn about the different human-hybrids and the purpose for creating each of these organisms. Students could complete a lab in which they design a hybrid organism from two imaginary organisms in order to evaluate the role of meiosis and fertilization in the creation of hybrid organisms. As a summary, students could write a position paper on whether or not research using human-hybrid organisms should continue to be permitted in the United States.

## **Mandatory DNA Fingerprinting in New York State**

**Authentic Topic:** Mandatory DNA Fingerprinting in New York State

**New York State Standards and Performance Indicators:**

2.1 – Explain how the structure and replication of genetic material result in offspring that resemble their parents.

2.1f – In all organisms, the coded instructions for specifying the characteristics of the organism are carried in DNA, a large molecule formed from subunits arranged in a sequence with bases of four kinds (represented by A, G, C, and T). The chemical and structural properties of DNA are the basis for how the genetic information that underlies heredity is both encoded in genes (as a string of molecular bases) and replicated by means of a template.

Laboratory Checklist - Uses chromatography and/or electrophoresis to separate molecules

**Traditional Unit:** Unit #4 - Genetics

**Problem Statement:**

DNA fingerprinting is a reliable and accurate way to match suspected criminals to crime scenes. In New York State DNA fingerprinting is only mandatory for people who are convicted of felony crimes. However, current legislation is being presented to push a bill that would make DNA fingerprinting mandatory for anyone arrested in conjunction with a felony crime. Should DNA fingerprinting be mandatory for people arrested for felony crimes in New York State?

**Rationale for Topic:**

DNA profiling, also called DNA testing or DNA fingerprinting, is a technique used by forensic scientists to assist in the identification and conviction of criminals. It produces reliable data, and with the exception of identical twins, each individual has a unique DNA fingerprint. In New York State DNA fingerprinting is only mandatory if a person is convicted of a felony, however a number of other states currently mandate DNA fingerprinting for individuals arrested for violent crimes. To encourage DNA fingerprinting as a form of identification, the federal government provides monetary incentives, equivalent to the costs associated with the technology for the first year of use, to states that mandate DNA fingerprinting upon arrest.

Proponents of mandatory DNA fingerprinting believe that it would significantly aid in solving crimes, exculpate individuals who are wrongly convicted, and reduce the number of repeat offenders therefore reducing the number of crimes. Opponents argue that DNA fingerprinting upon arrest, rather than conviction, is a violation of a person's fourth amendment rights and ignores the presumption of innocence until proven guilty. They also believe that police may abuse the system by arresting people who they are interested in on pre-textual charges in order to collect a DNA sample. Furthermore, opponents are skeptical of the costs associated with the process and concerned about the privacy issues associated with placing personal information in a database. They worry that a DNA database, if wrongly used, could lead to the denial of employment and health care coverage for those who are



predisposed to genetic conditions as well as racial and sex discrimination in the workplace.

The use of DNA fingerprinting as an authentic topic enables students to evaluate their own moral and ethical beliefs about the security and maintenance of DNA fingerprints in a national database while learning about the technology. Using mandatory testing for criminals adds an ethical and moral dimension to the dilemma because it requires students to evaluate their beliefs about the rights of individuals arrested and convicted of crimes. This topic is extremely controversial to students, particularly those who have been arrested or know someone who has been arrested.

**Suggestions for Instruction:**

Students could complete a real or simulated experiment in which they use gel electrophoresis to look at a number of DNA samples in order to identify a pretend criminal and learn the basic science behind the technique. They could then read articles related to DNA fingerprinting in order to identify the pros and cons of mandatory testing for criminals and write a position paper or participate in a class debate on whether the testing upon arrest should be mandatory. Alternately, students could write a letter to a local legislator presenting their case.

## **Genetically Modified Crops**

**Authentic Topic:** Genetically Modified Crops

**New York State Standards and Performance Indicators:**

2.2 – Explain how the technology of genetic engineering allows humans to alter genetic makeup of organisms.

2.2b – In recent years new varieties of farm plants and animals have been engineered by manipulating their genetic instructions to produce new characteristics.

2.2c – Different enzymes can be used to cut, copy, and move segments of DNA. Characteristics produced by the segments of DNA may be expressed when these segments are inserted into new organisms, such as bacteria.

2.2d – Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it.

2.2e – Knowledge of genetics is making possible new fields of health care; for example, finding genes which may have mutations that can cause disease will aid in the development of preventive measures to fight disease. Substances, such as hormones and enzymes, from genetically engineered organisms may reduce the cost and side effects of replacing missing body chemicals.

**Traditional Unit:** Unit #4 – Genetics

**Problem Statement:**

Over half of the agricultural crops produced in the United States have been genetically modified, for one purpose or another. In many countries, the labeling of

genetically engineered food is mandatory. However, in the United States labeling is currently not required. Should the labeling of genetically modified food be mandatory in the United States?

**Rationale for Topic:**

The United States is the leading producer of genetically modified food such as corn, soybeans, cotton, potatoes, tomatoes, cantaloupes, and sugarbeets. These crops have been genetically modified by inserting genes to make them more aesthetically appealing, insecticide resistant, herbicide tolerant, disease resistant, cold tolerant, more nutritious, better tasting, and able to grow in non-ideal conditions.

Proponents of genetically engineered food argue that it enhances the appearance, taste, and quality of food, and improves the resistance of plants to disease, insects, and herbicides thus reducing the amount of chemical spraying required. They also argue that it allows for larger yields thus providing increased food security for the growing population. Opponents of genetically modified foods argue that the proteins produced from the modified genes may lead to potential negative health effects on humans and other organisms. They fear that genetically engineered foods may be responsible for the recent increase in the number of people with allergies and may be contributing to the problem of antibiotic resistance in the population. Opponents also argue that there could be an unintended transfer of genes from modified organisms to non-target species resulting in disruptions to the food chain and a loss of biodiversity. In addition, opponents argue that it is dangerous to

allow the world food population to be controlled by a small number of companies and that tampering with the genes of an organism is ethically wrong.

The use of genetically modified crops as an authentic topic will enable students to evaluate their own beliefs about the safety and environmental consequences of altering the genes in organisms. It could be used to teach students about genetic engineering and the production of proteins from genes. Many students do not know that the food they purchase at the grocery store has been genetically modified and therefore this topic not only introduces them to technological advances but also allows them to make informed choices as young adults.

**Suggestions for Instruction:**

Students could learn about technique of genetic engineering, how specific organisms that have been genetically modified, and the potential safety and environmental consequences of modification. This could be accomplished through individual research using scaffolded activities and activities designed to enable students to genetically modify DNA to create a resistant crop. Students could then be divided into two groups for a whole class debate on the issue of whether genetically modified crops should be labeled in the United States. As an alternative, students could create a commercial arguing for, or against, the use of genetically modified crops.

## **Early Maternal Blood Tests for Gender Selection in Utero**

**Authentic Topic:** Early Maternal Blood Tests for Gender Selection in Utero

**New York State Standards and Performance Indicators:**

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

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.

2.2 – Explain how the technology of genetic engineering allows humans to alter genetic makeup of organisms.

2.2e – Knowledge of genetics is making possible new fields of health care; for example, finding genes which may have mutations that can cause disease will aid in the development of preventive measures to fight disease. Substances, such as hormones and enzymes, from genetically engineered organisms may reduce the cost and side effects of replacing missing body chemicals.

**Traditional Unit:** Unit #4 – Genetics

**Problem Statement:**

Gender selection in utero has been practiced around the world for decades. However, due to a lack of technology women have not been able to know the sex of a child until the 16<sup>th</sup> to 20<sup>th</sup> week of pregnancy. At this point in pregnancy, abortions

are very controversial, and relatively dangerous. Recently, scientists have created a maternal blood test, which is safe for the fetus, and can be used to identify gender as early as the seventh week of pregnancy. Abortions at seven weeks are minimally invasive and routinely performed in the United States where women do not need a reason to have an abortion. Should the use of maternal blood tests to identify gender be regulated in order to prevent the tests from being used for non-medical sex selection?

**Rationale for Topic:**

Sex selection in utero, or the intentional abortion of a fetus due to its sex, is practiced around the world. In China and India, boys are preferred to girls. As a result of sex related abortions in these countries the ratio of males to females has been profoundly altered. Currently, most women who are having sex-related abortions, are having them around the 16<sup>th</sup> to 20<sup>th</sup> week of pregnancy.

Recently, researchers have created a blood test to determine gender, with accuracy, as early as the seventh week of pregnancy without posing a risk to the embryo. The test examines fragments of fetal DNA found in the maternal blood for genes found on the Y chromosome. Proponents of the test argue that it enables parents who are concerned about sex-linked diseases to select for gender at an earlier stage in pregnancy making the abortion of the fetus safer and less controversial. Opponents argue that sex selection is unethical and that earlier tests will lead to more women having abortions in order to have a child of a desired sex. They also point out that sex selection could create a significant imbalance in the ratio of males to females

in a population, particularly in countries like China where one sex is valued more than another. Currently, the United States does not keep track of the number of women having sex related abortions but scientists estimate that it is relatively low.

The use of maternal blood tests for sex selection in utero as an authentic topic is very controversial because it involves abortion. However, opponents of abortion may support early blood tests because in a country like the United States, where abortion is legal for any reason, early blood tests would encourage women who may have a sex-related abortion after amniocenteses or an ultrasound at the 16<sup>th</sup> to 20<sup>th</sup> week to have it done at an earlier stage in pregnancy. Opponents of abortion may also support early blood testing due to the tradeoff of enabling women concerned about sex-linked genetic diseases to know the sex of the fetus earlier. The use of maternal blood tests as a way of identifying gender exposes students to reproductive technology, sex linked diseases, and the developmental stages of pregnancy.

**Suggestions for Instruction:**

Students could research the technique, accuracy, and safety of amniocentesis and the newly developed early maternal blood test. They could then write a position paper, or be divided into two groups for a whole class debate, on whether the use of material blood tests to identify gender should be regulated in order to prevent the tests from being used for non-medical sex selection.

## Designing New Life Forms

**Authentic Topic:** Designing New Life Forms

**New York State Standards and Performance Indicators:**

2.2 – Explain how the technology of genetic engineering allows humans to alter genetic makeup of organisms.

2.2e – Knowledge of genetics is making possible new fields of health care; for example, finding genes which may have mutations that can cause disease will aid in the development of preventive measures to fight disease. Substances, such as hormones and enzymes, from genetically engineered organisms may reduce the cost and side effects of replacing missing body chemicals.

**Traditional Unit:** Unit #4 – Genetics

**Problem Statement:**

Synthetic Genomics is a private biotechnology company founded by Craig Venter focused on creating and modifying organisms in order to solve the growing global demand for critical resources. The company recently designed and created the first synthetically manufactured bacterial cell. While this cell is genetically similar to a bacterium commonly found in sheep, this genetically manufactured cell is groundbreaking research that demonstrates the potential to create a multitude of new organisms. Should the government place restrictions on the creation of synthetic life forms?

**Rationale for Topic:**



Two years ago, Craig Venter, best known for his work in sequencing the human genome, created the first synthetic life form: a bacterial cell named *Mycoplasma mycoides*. The genome for the bacteria was designed on a computer, synthesized in a lab, and transferred to the cytoplasm of a recipient cell. The new bacteria, which is genetically similar to a bacteria found in the intestines of goats, is currently alive and self-replicating. While this particular bacterium does not do anything unique, Venter hopes that in the near future he will be able to use the technology to synthesize bacteria that can produce biofuels and medicines and break down pollutants. He currently has a contract with Exxon Mobil to create an algae which can excrete crude oil.

Proponents of Venturs' work believe that the creation of a synthetic life forms is a remarkable step towards creating bacteria capable solving many of the world's problems. Opponents argue that the technique is financially impractical in the industrial world and that the knowledge of the technology makes it possible for terrorists to create biological weapons capable of destroying large segments of the population. In addition, many argue that the creation of new life forms has no bounds, is "playing God", and is therefore morally and ethically wrong.

The use of synthetic life forms as an authentic topic enables students to evaluate their own moral and ethical beliefs about the creation of new organisms using biotechnology. It also exposes them to advances in biotechnology and genomics, which are two fields that are expected advance during their lifetime. This topic could be used to teach DNA structure and function.

**Suggestions for Instruction:**

Students could learn about DNA, the genome project and various DNA technologies. They could then read multiple news articles related to the synthetically produced bacteria and complete an activity in which they simulate the creation of a new organism. To demonstrate their knowledge students could participate in a whole class debate on whether the government should place restrictions on the creation of synthetic life forms.

## Commercial Cloning of Cats and Dogs

**Authentic Topic:** Commercial Cloning of Cats and Dogs

**New York State Standards and Performance Indicators:**

4.1 – Explain how organisms, including humans, reproduce their own kind.

4.1b – Some organisms reproduce asexually with all the genetic information coming from one parent. Other organisms reproduce sexually with half the genetic information typically contributed by each parent. Cloning is the production of identical genetic copies.

**Traditional Unit:** Unit #4 - Genetics

**Problem Statement:**

Due to recent advances in biotechnology the cloning of aging and deceased pets is now possible and rapidly becoming an industry in the United States. Critics of the technology argue that the practice is unethical and should be banned. Should the cloning of cats and dogs be legal in the United States?

**Rationale for Topic:**

Since the mid-nineties scientists have cloned a number of organisms including plants, flies, frogs, cats, dogs, sheep, cows, deer, horses, pigs, and wolves. As technology has advanced to make the successful cloning of any organism a possibility, consumers have search for ways to have their aging and deceased pets cloned. While extraordinarily expensive, there are a number of companies in the United States and overseas that are cloning pets for profit.

Proponents of cloning pets argue that the technique would enable owners to get another pet with characteristics that they have enjoyed. Critics of cloning argue that until the success rate, which is currently very low, improves, the practice of cloning pets is unethical. They also argue that the environment influences gene expression and therefore cloned pets will not necessarily behave in the way that the owners expect the pet to behave. Opponents believe that if the technology becomes available and affordable it will create dissatisfaction among owners and contribute to the current animal overpopulation problem in the United States.

The use of pet cloning as an authentic topic is engaging for students and it enables them to evaluate their own moral and ethical beliefs about the practice of cloning organisms. In addition it introduces them to the techniques of cloning organisms.

**Suggestions for Instruction:**

Students could learn about cloning through individual research using scaffolded activities that guide them to learn about the required science concepts. Students could be divided, into two groups, for a whole class debate on the issue of whether the cloning of cats and dogs should be legal in the United States.

## Therapeutic Cloning in Animals

**Authentic Topic:** Therapeutic Cloning in Animals

**New York State Standards and Performance Indicators:**

4.1 – Explain how organisms, including humans, reproduce their own kind.

4.1b – Some organisms reproduce asexually with all the genetic information coming from one parent. Other organisms reproduce sexually with half the genetic information typically contributed by each parent. Cloning is the production of identical genetic copies.

5.2 – Explain disease as a failure of homeostasis.

5.2j – Biological research generates knowledge used to design ways of diagnosing, preventing, treating, controlling, or curing diseases of plants and animals.

**Traditional Unit:** Unit #4 - Genetics

**Problem Statement:**

Due to recent advances in biotechnology, reproductive and therapeutic cloning of humans is possible. While the scientific community opposes the reproductive cloning of humans, therapeutic cloning of human organs is much more controversial. Should therapeutic cloning be banned in the United States?

**Rationale for Topic:**

Scientists have successfully cloned a number of organisms and now have the ability to clone humans. However, reproductive cloning, or the creation of an identical copy of a human, is illegal in most countries including the United States. In

addition, for ethical and moral reasons most people strongly oppose human cloning. However, even those opposed to reproductive cloning can see a benefit and use for therapeutic cloning of humans.

Therapeutic cloning is similar to reproductive cloning but it produces stem cells rather than a living organism. In therapeutic cloning, the nucleus of an egg is removed, and a complete set of DNA, ideally from a patient in need of a body part, is placed into the empty egg. The egg undergoes mitosis to form a blastocyst containing multiple layers of cells. The inner layer of the blastocyst is rich in stem cells. These cells are harvested and implanted back into the donor of the DNA where they differentiate into specialized cells and tissues imparting structure and function as needed. This type of therapy has the potential to treat and cure diseases by replacing damaged or dysfunctional cells, and because a patient's own DNA is used, it reduces the risk of immunological rejection that typically results from implantation of foreign organs and tissues.

Like abortion, therapeutic cloning is controversial for both moral and ethical reasons, the largest of which being that in order to harvest the stem cells necessary to create an organ and embryo is destroyed. While therapeutic cloning has the potential to cure a person of a wide range of degenerative diseases such as diabetes, Parkinson's, multiple sclerosis, spinal cord injuries, and Alzheimer's the research is in the early stages and therefore a number of embryos are destroyed for each successful clone. In addition, there is skepticism as to where the eggs would come from and ethical concerns about the destruction of viable eggs.

The use of therapeutic cloning as an authentic topic exposes students to human cloning and the potential medical benefits of cloning human cells. It also encourages students to examine their own moral, ethical, and religious beliefs on whether the benefits of therapeutic cloning compensate for the destruction of an embryo.

**Suggestions for Instruction:**

Students could engage in a discussion of human cloning and the reasons why it is illegal in the United States followed by a brief introduction to stem cells. They could then research therapeutic cloning to learn about the process, the potential benefits, and the ethical concerns surrounding the destruction of the embryo to harvest the stem cells. As a summary, students could then write a position paper arguing for or against the use of therapeutic cloning for humans in the United States.

## **Use of rBHT in Cows to Stimulate Milk Production**

**Authentic Topic:** Use of rBHT in Cows to Stimulate Milk Production

**New York State Standards and Performance Indicators:**

3.1 – Explain the mechanisms and patterns of evolution.

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.

**Traditional Unit:** Unit #5 - Evolution

**Problem Statement:**

The United States dairy industry has been scrutinized for corrupt practices including the use of the synthetic hormone rBGH to stimulate milk production in cows. Opponents of its use argue that it is unhealthy for cows and will increase the number of antibiotic resistant strains of bacteria. Proponents argue that it increases



milk production and income for farmers. Should the United States ban the use of rBGH in the dairy industry?

**Rationale for Topic:**

The United States dairy industry has been criticized for the use of synthetic recombinant bovine growth hormone, or rBGH, to increase milk production in dairy cattle. Milk from cows treated with rBGH contains higher levels of Insulin Growth Factor-I, a protein which has been linked to both colon and breast cancer. Despite concern from scientists, elevated levels of Insulin Growth Factor-I in milk have not been linked to the development of cancer in humans.

While these concerns are legitimate, a greater problem with using rBGH to stimulate milk production in cows is that its use causes a reduction in fertility, an increased risk of lameness and a dramatic increase in incidence a bacterial infection called mastitis, which causes inflammation and swelling of utters. Not only is this painful for cows but it requires treatment with antibiotics. Many farmers who use rBGH routinely treat the whole heard with antibiotics, mixed into feed or water, in order to prevent and eliminate any cases of the contagious bacterial infection.

Opponents of rBGH use argue that it is not healthy for the cows and want it to be banned. They also worry that the increased use of antibiotics will lead to an increase in strains of antibiotic resistant bacteria. Antibiotic resistant strains of salmonella have been identified in animal products and foods. Proponents of allowing farmers to use rBGH argue that the increase in milk production outweighs the negative health effects and potential risks of rBGH use.

The use of growth hormones in dairy products as an authentic topic would enable students to evaluate their own moral and ethical beliefs about the treatment and welfare of animals in the food industry. It would also enable students to learn about antibiotics and antibiotic resistance.

**Suggestions for Instruction:**

Students could watch the video Food Ink as an introduction to the corrupt practices of the food industry and complete a lab that demonstrates antibiotic resistance. They could then read contradictory articles about the benefits and risks associated with rBHT use and research the idea of antibiotic resistance. To summarize their understanding they could write a position paper on whether the United States should ban the use of rBHT in the dairy industry.

## Human Evolution

**Authentic Topic:** Human Evolution

**New York State Standards and Performance Indicators:**

3.1 – Explain the mechanisms and patterns of evolution.

3.1a – The basic theory of biological evolution states that the Earth’s present-day species developed from earlier, distinctly different species.

3.1e – Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life-forms, as well as for the molecular and structural similarities observed among the diverse species of living organisms.

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.

3.1j – Billions of years ago, life on Earth is thought by many scientists to have begun as simple, single-celled organisms. About a billion years ago, increasingly complex multicellular organisms began to evolve.

3.11 – Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on Earth no longer exist.

**Traditional Unit:** Unit #5 – Evolution

**Problem Statement:**

The origin of humans has been a debate between creationists and scientists for hundreds of years. Scientists rely on the theory of natural selection and evidence from the fossil record to explain the existence while creationists rely on biblical accounts. Based on your understanding of science and creationism which theory is a more accurate or valid account of human evolution?

**Rationale for Topic:**

The origin of humans has been a longstanding debate between creationists and scientists. Creationists and other religious groups believe that a higher power created humans in their present form at one time within the last 10,000 years. Creationists reject modern studies of paleontology, evolutionary biology, and geology, which suggest that present day humans have evolved over thousands of years from primates that are no longer alive today. While scientists rely on evidence from studies of fossils that have accumulated throughout the geologic history of the earth and Darwin's theory of natural selection, creationists rely on biblical accounts to explain the existence of humans.

The use of human evolution as an authentic topic is highly controversial. Public education cannot teach creationism due to the religious affiliation and some public schools do not teach human evolution. Therefore, in New York State, where evolution taught, and questions about human evolution are likely to arise, it is important to present both sides of the debate. Students who come from religious backgrounds may reject the theories of evolution while those who believe in science may reject the theories of creationism. Exposure to both sides would enable students to have a more informed opinion and reinforce the concept of natural selection and the use of fossils in determining evolutionary relationships.

**Suggestions for Instruction:**

Students could learn about fossil evidence and natural selection then have the option of watching the video *Walking with Caveman*. Students could also watch the PBS Dover trial documentary. Since some students are already familiar with creationism, and as a result disagree with the theories of evolution, students could be given the choice of which side of the argument to take. Students could be divided for a class debate on the theory of evolution. Both sides would be expected to present evidence, in the form of science or biblical references, that support their beliefs. By teaching these two opposing arguments in this manner neither side is forced to learn about, or present, the opposite viewpoint.

## Antibiotic Use in the Poultry Industry

**Authentic Topic:** Antibiotic Use in the Poultry Industry

**New York State Standards and Performance Indicators:**

3.1 – Explain the mechanisms and patterns of evolution.

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.

**Traditional Unit:** Unit #5 – Evolution

**Problem Statement:**

Antibiotics are used in the poultry industry to prevent the spread of disease and promote the rapid growth of chickens. As a result, antibiotic resistant bacteria thrive on poultry farms throughout the United States. Within the last decade the number of resistant bacteria, which are genetically similar to those found on poultry

farms, has been increasing in humans. The FDA has banned the use of some antibiotics, and suggested that farmers voluntarily refrain from using others, but antibiotic residues are still present in a large amount of chicken sold for human consumption. Should the FDA place stricter regulations on the use of antibiotics in the poultry industry?

**Rationale for Topic:**

Antibiotic resistant strains of bacteria such as the “superbug” *Staphylococcus aureus* (MRSA) have been emerging rapidly within the last decade and resistant strains of phenomena, tuberculosis, and malaria have been identified throughout the world. The emergence of these strains is largely due to the overuse and misuse of antibiotics in the medical and food industries but has also been attributed to the meat industry. In the poultry industry, antibiotics are added to animal fed in order to prevent the spread of bacteria and promote the rapid growth of chickens. The overuse of antibiotics such as fluroquinolone and ciprofloxacin in the poultry industry has enabled resistant strains of bacterial such as *E. coli* to thrive on poultry farms. These resistant strains are genetically similar to the resistant *E. coli* known to affect humans and therefore believed to be the result of antibiotic use in the chicken industry. Researchers speculate that when conditions are right, humans have the potential to become infected with the resistant strains by handling meat or cross-contaminated foods containing the bacteria. The FDA has issued guidelines, which call for the voluntary reduction in the use of antibiotics such as ciprofloxacin, and has banned the

use of fluroquinoline, but recent research indicates that these antibiotics are still being used regularly in the poultry industry.

Opponents of using antibiotics in the food industry argue that it creates antibiotic resistant strains of bacteria that could be spread to humans. Proponents, including the leaders in the poultry industry, argue that the use of antibiotics increases farmers profits and does not necessarily contribute to antibiotic resistance in humans. They argue that while resistant strains of bacteria in the poultry industry are genetically similar to those found in humans, there is no conclusive evidence linking the resistance to the use of antibiotics in chickens. This data is difficult to obtain due to the nature of the research.

The use of antibiotics in poultry industry as an authentic topic allows students to learn about the evolution of bacteria, natural selection, and antibiotic resistance. It also enables them to evaluate their own beliefs about the treatment of animals in the food industry and the risk of spreading resistant bacteria from poultry farms to humans.

**Suggestions for Instruction:**

Students could watch the video Food Ink as an introduction to the corrupt practices of the food industry and complete an inquiry lab on antibiotic resistance. They could then research antibiotic resistance and the use of antibiotics in the poultry industry. After researching students could write a position paper on whether the FDA should place stricter regulations on the use of antibiotics in the poultry industry.



## **Growth Hormones in Meat**

**Authentic Topic:** Growth Hormones in Meat

**New York State Standards and Performance Indicators:**

1.2 – Describe and explain the structures and functions of the human body at different organizational levels (e.g., systems, tissues, cells, organelles)

1.2b - Humans are complex organisms. They require multiple systems for digestion, respiration, reproduction, circulation, excretion, movement, coordination, and immunity. The systems interact to perform the life functions.

1.2d – If there is a disruption in any human system, there may be a corresponding imbalance in hormones.

5.2 – Explain disease as a failure of homeostasis

5.2a – Homeostasis in an organism is constantly threatened. Failure to respond effectively can result in disease or death.

**Traditional Unit:** Unit #6 – Energy, Matter and Organization

**Problem Statement:**

The United States meat industry has been scrutinized for corrupt practices including the use of growth hormones in beef cattle. While the use of hormones enables farmers to produce larger cattle in a shorter time period, thus increasing their profits, residues of injected hormones can be found in the meat from slaughtered animals. There is growing concern that increased exposure to growth hormones will have long-term negative health consequences on the population. Should the United

States ban the use of growth hormones in the cattle industry, require the labeling of meat from cows treated with hormones, or take no action at this time?

**Rationale for Topic:**

The United States meat industry is a multimillion dollar enterprise that has come under scrutiny within the last decade for what many call corrupt and unethical practices. Today, approximately two-thirds of US beef cattle are given natural and/or synthetic hormones to help them grow faster. Residues of hormones including Oestradiol, Progesterone, Testosterone, Zeranol, Trenbolone, and Melengestrol are often present in the meat from slaughtered animals. There is concern that the consumption of these hormones can cause developmental problems in children, interfere with the reproductive cycles in women, and lead to the development of breast, prostate or colon cancer. However, research studies regarding these concerns have been largely inconclusive or funded by agencies that profit from the sale of beef products. Therefore, with the exception of elevated hormone levels contributing to early onset puberty in teenage girls, most of the concerns, particularly about cancer, have no grounding in research. While the United States allows the use of growth hormones in beef cattle, the European Union has prohibited the use of hormones in cattle, prohibited the import of all hormone-treated beef, and banned the import of all meat from the United States.

The use of hormones in beef cattle exposes students to the corruption that exists in the United States food industry and enables them to make their own decisions as to whether hormone-treated beef is safe to consume. The subject is

particularly controversial for students whose families depend on the sale of beef as their primary source of income. The use of the topic would enable students to learn about the endocrine system including various hormones and the function of hormones in the body.

**Suggestions for Instruction:**

Students could watch the video Food Ink as an introduction to the corrupt practices of the food industry and use scaffolded activities to learn about hormones and the endocrine system. They could then read contradictory articles about the use of growth hormones in meat and the effect that these hormones have on people. To summarize their understanding they could write a position paper on whether the United States should ban the use of growth hormones in the cattle industry, require the labeling of meat from cows treated with hormones, or take no action at this time.

## **Mandatory HIV Testing**

**Authentic Topic:** Mandatory HIV Testing

**New York State Standards and Performance Indicators:**

5.2 – Explain disease as a failure of homeostasis

5.2a – Homeostasis in an organism is constantly threatened. Failure to respond effectively can result in disease or death.

5.2b – Viruses, bacteria, fungi, and other parasites may infect plants and animals and interfere with normal life functions.

5.2f – Some viral diseases, such as AIDS, damage the immune system, leaving the body unable to deal with multiple infectious agents and cancerous cells.

5.2j – Biological research generates knowledge used to design ways of diagnosing, preventing, treating, controlling, or curing diseases of plants and animals.

**Traditional Unit:** Unit #7 - Maintaining a Dynamic Equilibrium

**Problem Statement:**

Students medical records contain information about allergies, asthma, vaccinations, learning disabilities and physical disabilities but HIV infection does not need to be reported on these records. The percentage of teenagers with HIV or AIDS is rapidly increasing. Since HIV may not present any symptoms for years after the initial exposure, it is likely that many students do not know they are infected, and are unknowingly spreading the disease to their peers through high risk behaviors. Should HIV testing and reporting be mandatory in schools?

**Rationale for Topic:**

Human Immunodeficiency Virus, or HIV, is a retrovirus that causes AIDS, or Acquired Immunodeficiency Virus. AIDS leads to progressive failure of the immune system thereby allowing other infectious diseases and cancers to invade the body. HIV is typically transmitted through unprotected sex or the sharing of needles during drug use but can also transmit through contact with body fluids. The Center for Disease Control and Prevention (CDC) estimates that nearly a million people are living with HIV infection and nearly twenty percent these infected people are unaware of their infection, because the clinical symptoms of HIV may not be present for over ten years after the initial infection. This poses a large risk to teenagers who the CDC estimates accounted for nearly forty percent of the new HIV infections in 2009.

Students engage in risky behaviors without considering the potential consequences. The use of mandatory HIV testing as an authentic topic would enable students to consider their own beliefs about whether mandatory HIV testing is an invasion of privacy or a way to help prevent the spread of the infection among teenagers. It would also enable students to learn about AIDS, the spread of HIV, and the mechanism by which the HIV virus attacks the immune system.

**Suggestions for Instruction:**

Students could complete a lab to demonstrate the spread of infectious diseases through a population. They could then research HIV and analyze data on the prevalence of HIV infections in the world, United States, and local community. To

demonstrate their knowledge, students could write a position paper or participate in a class debate on whether HIV testing should be mandatory in schools.

## Use of BPA in Plastics

**Authentic Topic:** Use of BPA in Plastics

**New York State Standards and Performance Indicators:**

1.2 – Describe and explain the structures and functions of the human body at different organizational levels (e.g., systems, tissues, cells, organelles)

1.2b – Humans are complex organisms. They require multiple systems for digestion, reproduction, circulation, excretion, movement, coordination, and immunity. The systems interact to perform life functions.

1.2d – If there is a disruption in any human system, there may be a corresponding imbalance in homeostasis.

1.2j – Receptor molecules play an important role in the interactions between cells. Two primary agents of cellular communication are hormones and chemicals produced by nerve cells. If nerve or hormone signals are blocked, cellular communication is disrupted and the organisms stability is affected.

5.1 – Explain the basic biochemical processes in living organisms and their importance in maintaining dynamic equilibrium.

5.1g – Enzymes and other molecules, such as hormones, receptor molecules, and antibodies, have specific shapes that influence both how they function and how they interact maintaining dynamic equilibrium

5.2 – Explain disease as a failure of homeostasis.

5.2a - Homeostasis in an organism is constantly threatened. Failure to respond effectively can result in disease or death.

5.2j – Biological research generates knowledge used to design ways of diagnosing, preventing, treating, controlling, or curing diseases of plants and animals.

**Traditional Unit:** Unit #7 - Maintaining a Dynamic Equilibrium

**Problem Statement:**

In 1978 the United States Environmental Protection Agency (EPA) banned the use of lead in paints in order to reduce the risk of lead poisoning in children. In 1989 the EPA issued a ban on the production of all asbestos containing products after asbestos exposure was linked to serious respiratory problems including cancer. However, in 1991 this regulation was overturned, ultimately allowing the use of asbestos in a handful of products that are marketed today. Recently, bisphenol A (BPA), a synthetically manufactured compound commonly used in plastics, has been scrutinized for potential health effects, particularly in pregnant women, infants, and young children. In July 2012, the United States Food and Drug Administration (FDA) banned the use of BPA in baby bottles and sippy cups but claimed that the ban was to “boost consumer confidence” and not due to safety concerns. Despite concerns about potential health effects, there are currently no BPA labeling requirements in the United States. Should the FDA ban, regulate, or require BPA labeling on plastics and other products containing BPA?

**Rationale for Topic:**

Bisphenol A is an organic compound that has been used to manufacture polycarbonate plastics and epoxy resins since 1958. It is commonly found in baby



bottles, water bottles, sports equipment, the lining of beverage containers, medical and dental devices, industrial furniture, CD's and DVD's, toys and the lining of many canned foods. BPA acts as an endocrine disruptor mimicking estrogen in both animals and humans. Recent studies have shown that low doses of BPA can increase the risk of various cancers, heart disease, obesity, and diabetes in adults; accelerate the onset of puberty in females; and have negative effects on the brain development and behavior of fetuses, infants and children.

Despite hundreds of studies that describe the potential negative health effects of BPA exposure, the FDA had only banned the use of BPA in baby bottles and sippy cups. The FDA however acknowledges that there is “some concern” related the effect of BPA on the brain development and behavior of fetuses, infants, and children and “minimal concern” for the effects of BPA on the onset of puberty and mammary gland development in adolescent females.

The use of BPA as an authentic topic would enable students to evaluate their own beliefs about federal regulations and the safety of BPA in products that they use daily. It would also provide them with an understanding of the role of the endocrine system in regulating homeostasis within organisms. In addition, the use of BPA as an authentic topic would enable students to review the concepts of cancer, fetal development, and reproductive hormones.

**Suggestions for Instruction:**

Students could engage in a class discussion about banned and regulated substances such as lead and asbestoses. This would provide students with an

understanding of the role of the EPA and FDA in monitoring the safety of consumed products. Students could collect data on the prevalence of BPA by examining plastics at home. Students could then engage in individual scaffolded research to learn about BPA, the effect of BPA on the endocrine system, health concerns related to BPA exposure, and the current federal regulations surrounding BPA in consumer products. To summarize their understanding students could write a position paper on whether the FDA should ban, regulate, or require BPA labeling on products produced using BPA.

## Food Allergies

**Authentic Topic:** Food Allergies

**New York State Standards and Performance Indicators:**

5.2 - Explain disease as a failure of homeostasis

5.2a – Homeostasis in an organism is constantly threatened. Failure to respond effectively can result in disease or death.

5.2g – Some allergic reactions are caused by the body’s immune responses to usually harmless environmental substances. Sometimes the immune system may attack some of the body’s own cells or transplanted organs.

**Traditional Unit:** Unit #7 - Maintaining a Dynamic Equilibrium

**Problem Statement:**

In recent years the number of students diagnosed with allergies to food such as peanuts, soybeans, tree nuts, eggs, milk, wheat, natural and synthetic coloring, and chemical additives has been increasing. Schools have responded by removing some of these substances from school lunches and regulating what substances students can bring into the building. Obviously, in a large school it is impossible to eliminate all of the known allergens from school lunches. Should schools be responsible for minimizing the risk of exposure to food allergens?

**Rationale for Topic:**

Students typically know that people are allergic to foods, can identify common food allergens, and can describe the symptoms of mild allergic reactions (hives, stomach pain, diarrhea, sneezing, etc.). However, they are often naïve with

respect to the severity of some allergic reactions and as a result frequently bring prohibited foods into the building. If students are made aware of the risks associated with particular foods, they may be less likely to risk exposing others to them.

The use of food allergens as an authentic topic would not only help to address faculty and staff concerns about food brought into the building but also enable students to learn about allergies and the role of the immune system in allergic responses. In addition, it would enable students to evaluate how the choices that they make affect the lives of others.

### **Suggestions for Instruction:**

Students could learn about the immune system, the immune response pathway, and allergic reactions through individual research using scaffolded activities aimed at developing science understandings. They could also complete a lab that models the immune response to allergens and enables them to evaluate data on the number of students with food allergies and the type of allergies. Students could then write a position paper on whether or not schools should be responsible for minimizing the risk of exposure to food allergens. Some students will argue to prohibit foods that cause anaphylactic shock and other serious reactions in classmates while some will argue that preventing allergic reactions in schools is the sole responsibility of the individual who has the allergy and not the responsibility of other students and adults. As an alternative, students could create a video, to increase school-wide awareness of food allergies and encourage students to follow the current guidelines for food in the building.

## **Traumatic Brain Injuries**

**Authentic Topic:** Traumatic Brain Injuries

**New York State Standards and Performance Indicators:**

1.2 – Describe and explain the structures and functions of the human body at different organizational levels (e.g., systems, tissues, cells, organelles)

1.2b – Humans are complex organisms. They require multiple systems for digestion, reproduction, circulation, excretion, movement, coordination, and immunity. The systems interact to perform life functions.

1.2d – If there is a disruption in any human system, there may be a corresponding imbalance in homeostasis.

**Traditional Unit:** Unit #7 - Maintaining a Dynamic Equilibrium

**Problem Statement:**

Concussions are common among high school athletes who participate in contact sports such as wrestling, lacrosse, ice hockey, and football. Unfortunately, multiple incidents can contribute to the development of mild cognitive impairments (MCIs), chronic traumatic encephalopathy (CTE), or post-concussion syndrome (PCS). Because high school students brains are still developing, they are particularly susceptible to the long-term medical and psychological damage. Should the rules of high school contact sports be more restricted in order to minimize the risk of head injuries?

**Rationale for Topic:**

Students are expected to know that the brain, spinal cords, and nerves comprise the nervous system. They are also expected to understand that the major role of the nervous system is to control and coordinate all life functions. While most students have heard of concussions, and many have had them, or know someone who has had at least one, the majority of students do not know what a concussion or why concussions lead to symptoms such as headaches, loss of consciousness, vomiting, fatigue, light sensitivity, and dizziness. They also do not know the debilitating and sometimes life-threatening risks associated with sustaining repeated concussions and thus many of them do not follow medical advice and refrain from activity after receiving a concussion. Educating students on concussions would not only teach them the parts and functions of the nervous system but also enable them to make informed choices if, and when, they receive a concussion.

**Suggestions for Instruction:**

Students could use the internet and guided questions to research the causes, symptoms, and long term consequences of concussions. They could then look at local or school statistics on the number of head injuries obtained from high school sports. After researching and analyzing the data students could write a position paper or participate in a class debate on the issue of whether the rules of high school contact sports should be more restricted in order to minimize the risk of head injury.

## **Vaccine Safety and Effectiveness**

**Authentic Topic:** Vaccine Safety and Effectiveness

**New York State Standards and Performance Indicators:**

5.2 – Explain disease as a failure of homeostasis

5.2a – Homeostasis in an organism is constantly threatened. Failure to respond effectively can result in disease or death.

5.2b – Viruses, bacteria, fungi, and other parasites may infect plants and animals and interfere with normal life functions.

5.2c – The immune system protects against antigens associated with pathogenic organisms or foreign substances and some cancer cells.

5.2d – Some white blood cells engulf invaders. Others produce antibodies that attack them or mark them for killing. Some specialized white blood cells will remain, able to fight off subsequent invaders of the same kind.

5.2e – Vaccinations use weakened microbes (or parts of them) to stimulate the immune system to react. This reaction prepares the body to fight subsequent invasions by the same microbes.

5.2j – Biological research generates knowledge used to design ways of diagnosing, preventing, treating, controlling, or curing diseases of plants and animals.

**Traditional Unit:** Unit #7 - Maintaining a Dynamic Equilibrium

**Problem Statement:**

Vaccinations are one of the most controversial issues in medicine today. In the United States immunizations are not mandated by the government. However, in New York State vaccines are required to attend public school. Should vaccines such as the HPV or MMR vaccine be mandatory for all students?

**Rationale for Topic:**

The safety and effectiveness of vaccines has been a controversial subject for many years. Recently, HPV vaccines have been introduced in order to prevent infection with several strains of sexually transmitted human papillomavirus associated with cervical cancer and genital warts. The human papillomavirus is a pervasive problem in the United States. While the HPV vaccine is not currently mandatory for students in public schools, it is highly recommended before any sexual activity. In contrast, the MMR vaccine, which prevents infection with measles, mumps, and rubella, is currently mandatory for all students in public schools. However, unlike human papilloma virus these diseases are no longer considered endemic in the United States. In addition, the MMR vaccine is widely believed to be associated with autism as a result of a fraudulent paper published in the late 1990's.

The use of vaccinations as an authentic topic would enable students to evaluate their own moral and ethical beliefs about the safety, effectiveness, and need for vaccines. It would also introduce students to various diseases, the function of the immune system, the role of vaccinations in preventing disease, and the immune response pathway. In addition, it would enable students to identify causes and risk



factors of disease as well as ways of diagnosing, preventing, treating, and controlling or curing diseases.

**Suggestions for Instruction:**

Students could learn about the immune system, immune response, role of vaccinations in preventing disease, and safety and effectiveness of vaccines through individual research using scaffolded activities that guide students to learn about the science concepts. Students could be divided into two groups for a whole class debate on the issue of whether vaccines such as the HPV and MMR should be mandatory for all students in public schools. As an alternative, students could write a position paper on the subject.

## Synthetically Manufactured Artificial Sweeteners

**Authentic Topic:** Synthetically Manufactured Artificial Sweeteners

**New York State Standards and Performance Indicators:**

5.2 – Explain disease as a failure of homeostasis

5.2a – Homeostasis in an organism is constantly threatened. Failure to respond effectively can result in disease or death.

5.3 – Relate processes at the system level to the cellular level in order to explain dynamic equilibrium in multicelled organisms.

5.3a – Dynamic equilibrium results from detection of and response to stimuli.

Organisms detect and respond to change in a variety of ways both at the cellular level and at the organismal level.

5.3b – Feedback mechanisms have evolved that maintain homeostasis.

Examples include the changes in heart rate or respiratory rate in response to increased activity in muscle cells, the maintenance of blood sugar levels by insulin from the pancreas, and the changes in openings in the leaves of plants by guard cells to regulate water loss and gas exchange.

**Traditional Unit:** Unit #7 - Maintaining a Dynamic Equilibrium

**Problem Statement:**

Synthetically manufactured artificial sweeteners such as aspartame, saccharin and sucralose, have been criticized for contributing to a variety of health concerns including cancer while natural sweeteners such as sugar and high fructose corn syrup are known to cause weight gain and increase the risk of diabetes and heart disease. Is

the consumption of synthetically manufactured sugars such as aspartame, saccharin and sucralose more or less dangerous than the consumption of sugar and high fructose corn syrup?

**Rationale for Topic:**

Sugar and high fructose corn syrup naturally occurring sugars used in the food industry. Sugar, or sucrose, contains approximately 50% fructose and 50% glucose and is derived from sugar cane or beets while high fructose corn syrup contains approximately 55% fructose and 45% glucose and is derived from corn. In the body, glucose is metabolized by insulin released from the pancreas and used by cells to produce energy. Fructose on the other hand is metabolized by enzymes released from the liver and undergoes a process similar to glycolysis ultimately producing fatty acids and triglycerides. While the safety of high fructose corn syrup has been questioned, largely due to the increased amount of fructose, and therefore fat production, the metabolism of both sugar and high fructose corn syrup occur through natural processes in the body. The major concern with both of these sugars is weight gain, tooth decay, and an increased risk of diabetes and heart disease.

Artificial sweeteners such as such as aspartame (Equal and Nutrasweet), saccharin (Sweet N' Low) and sucralose (Splenda) are attractive alternatives to sugar because they are virtually calorie free and do not contribute to tooth decay however they are synthetically made. In the body aspartame, which is derived from two amino acids, breaks down into aspartic acid, phenylalanine, and methanol. High levels of the naturally occurring phenylalanine are dangerous to people born with PKU but

otherwise the FDA maintains that aspartame is safe at current levels of consumption. Saccharin, another artificial sweetener, was discovered in 1878 and is currently derived from various acids, sulfur dioxide, chlorine and ammonia. In the body, saccharin is not metabolized. Instead, it is absorbed and excreted, unchanged, through the kidneys. Since its introduction in the food industry, it has received considerable attention, and has been banned, at least once, after studies demonstrated that saccharin caused bladder cancer in rats. However, subsequent studies have not provided any clear evidence of an association between saccharin and cancer in humans. Currently, the FDA maintains that saccharin is safe at the current level of consumption but there are unsupported claims that it may cause headaches, breathing difficulties, and diarrhea in people with allergies to sulfa drugs. Sucralose, the third artificial sweetener, is also not metabolized by the body. Sucralose is predominantly excreted through the feces but excreted in small amounts through the kidneys. Hundreds of studies have demonstrated the safety of sucralose in both laboratory animals and humans.

Artificial sweeteners have received considerable criticism as a result of the publication of numerous laboratory studies on animals. Today, many people believe that artificial sweeteners such as aspartame, saccharin and sucralose are not good for you. While this may be true to some extent, particularly at high levels of consumption, sugar and high fructose corn syrup are also dangerous as they contribute to obesity, tooth decay, and the development of diabetes and heart disease. The use of artificial sweeteners as an authentic topic enables students to evaluate their

own beliefs about the safety of artificial sweeteners. It also enables them to learn about the insulin feedback mechanisms and the excretory system.

**Suggestions for Instruction:**

This topic could be used in the maintaining a dynamic equilibrium unit as part of a lesson on the insulin feedback mechanisms or as part of a lesson on the excretory system. Within the unit these topics can be taught in either order. The topic of artificial sweeteners could be used as a review of the first topic and a reinforcement of the second topic. Students complete a lab that demonstrates insulin feedback mechanisms. They could then research synthetically manufactured sugars and write a position paper on whether synthetically manufactured sweeteners are more or less dangerous than sugar and high fructose corn syrup.

## **Liver Transplants for Alcoholics**

**Authentic Topic:** Liver Transplants for Alcoholics

**New York State Standards and Performance Indicators:**

5.2 – Explain disease as a failure of homeostasis

5.2g – Some allergic reactions are caused by the body's immune responses to usually harmless environmental substances. Sometimes the immune system may attack some of the body's own cells or transplanted organs.

5.2h – Disease may also be caused by inheritance, toxic substances, poor nutrition, organ malfunction, and some personal behavior. Some effects show up right away; others may not show up for many years.

**Traditional Unit:** Unit #7 - Maintaining a Dynamic Equilibrium

**Problem Statement:**

Alcohol is the major cause of liver disease in the United States and one of the primary reasons that people receive liver transplants. While alcoholics must be sober for six to eighteen months before they can be considered for an organ donation there are no other restrictions preventing them from receiving a transplant. Unfortunately, there is a shortage of organs in the United States and as a result many people, including those who never abused their organs, die while waiting for an organ to become available. Should people who have abused their liver by drinking alcohol be allowed to receive a liver transplant when organs are in short supply?

**Rationale for Topic:**

Organ donation is a common practice in the United States. Donated organs are allocated based on how sick recipients are, how long they have been waiting, and how closely the blood and tissue of the donor matches the recipient. Most transplanted organs come from deceased donors but a small number of organs, including livers, are taken from healthy living people. When organs become available, they are dispersed locally, then regionally, then nationally. Unfortunately, in the United States the number of people in need of organ transplants is far greater than the number of available organs. As a result, many people die before receiving a potentially life-saving transplant.

The reason for needing an organ donation is not taken into account in the allocation of organs. Therefore, people who abuse their bodies by using drugs and alcohol may receive a transplant before someone who has lived a healthy life and developed cancer or a genetic condition necessitating a transplant. Alcohol consumption is known to cause long term liver damage. However, as long as an alcoholic is sober for six to eighteen months they can be put on a waiting list for a liver transplant. This is very controversial particularly with those who are awaiting transplant or know someone who is awaiting transplant.

The use of organ transplants for alcoholics as an authentic topic enables students to evaluate their own moral and ethical beliefs about the fair dispersal of available organs and teaches them about organ transplant and rejection. Some students are likely to be opposed to liver transplants for recovered alcoholics while

others are likely to support it, particularly if the liver is donated from a donor who knows and wants to donate his or her organ to the recipient.

**Suggestions for Instruction:**

Students could learn about the effect of alcohol on the liver, the immune system, the immune response, the enzymes involved in liver detoxification, and liver transplants through individual research using scaffolded activities. Students could then participate in a whole class debate on the issue of whether people who have abused their organs should be allowed to receive an organ transplant.



## **Pesticide Use on Agricultural Crops**

**Authentic Topic:** Pesticide Use on Agricultural Crops

**New York State Standards and Performance Indicators:**

3.1 – Explain the mechanisms and patterns of evolution.

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.

7.1 – Describe the range of interrelationships of humans with the living and nonliving environment.

7.1c – Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

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

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.

**Traditional Unit:** Unit #8 – Ecology

**Problem Statement:**

Pesticides, including herbicides, insecticides, and fungicides, are an effective and inexpensive way of controlling harmful organisms in agricultural crops. However, pesticide use has been linked to a range of diseases and disorders in humans and other organisms. Equally as effective environmentally friendly alternatives exist but they are typically more expensive and often difficult implement in large scale agricultural practices. Should farmers use pesticides or pesticide alternatives to control harmful organisms in agricultural crops?

**Rationale for Topic:**

The use of pesticides, including herbicides, insecticides, and fungicides on agricultural crops is a controversial subject. Pesticides have been linked to a range of diseases and disorders. They are known to cause poisoning, infertility, reproductive problems, birth defects, nervous system damage and cancer in humans and other organisms. Today, pesticides are one of the major causes of water and soil pollution in the United States. The use of pesticides reduces biodiversity, contributes to a reduction in the number of pollinating species, and threatens endangered species. It

also creates pesticide resistant organisms. However, pesticides are an effective and inexpensive way to control harmful insect and worm infestations, prevent weed growth, and treat fungal infections. Therefore, pesticide use ensures a diverse food supply and an economically sound agricultural economy.

Alternatives to pesticides include the use of biological pesticides, or organisms that eat pest organisms, the genetic engineering of pest-resistant crop varieties, the use of mechanical pest traps, crop rotation, the planting of crops in areas where pests do not live, and the thermal treatment of soil through steam. Studies have shown that these natural methods are equally as effective as pesticides, particularly because organisms have become more resistant to traditional pesticides. However, many of them are not economically feasible on a large scale and those that are, namely genetic engineering, are controversial.

The use of pesticides on agricultural crops is an ethically and environmentally controversial subject, which requires students to evaluate the impact that humans have on the environment. Many students are concerned with their health and would therefore be interested in learning about the topic in order to better understanding the safety risks associated with pesticide use.

**Suggestions for Instruction:**

Students could learn about the environmental and health concerns, economic benefits, and effectiveness of pesticides and pesticide alternatives through individual research using scaffolded activities that guide students to learn about the science concepts. As part of their research, students could read about specific pesticides and

their environmental consequences. For example, students could read about the use of atrazine, an organic herbicide, which causes amphibians to become hermaphrodites. They could also complete a lab that simulates the use of pesticides on plants. After researching and completing the lab students could be divided into two groups for a whole class debate on the issue of whether farmers should use pesticides or pesticide alternatives to control harmful organisms in agricultural crops.

## **Hunting of White-Tailed Deer**

**Authentic Topic:** Hunting of White-Tailed Deer

### **New York State Standards and Performance Indicators:**

1.1 – Explain how diversity of populations within ecosystems relates to the stability of ecosystems.

1.1d – The interdependence of organisms in an established ecosystem often results in approximate stability over hundreds and thousands of years. For example, as one population increases, it is held in check by one or more environmental factors or another species.

1.1e – Ecosystems, like many other complex systems, tend to show cyclic changes around a state of approximate equilibrium.

6.1 – Explain factors that limit growth of individuals and populations.

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.

6.1e – In any particular environment, the growth and survival of organisms depend on the physical conditions including light intensity, temperature range, mineral availability, soil/rock type, and relative acidity (pH).

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.

7.1 – Describe the range of interrelationships of humans with the living and nonliving environment.

7.1c – Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

**Traditional Unit:** Unit #8 – Ecology

**Problem Statement:**

The safety, effectiveness, costs, and ethics of hunting have been debated for many years. Proponents and opponents both present strong cases for and against the sport. Should the hunting of white-tailed deer continue to be allowed in New York State?

**Rationale for Topic:**

Hunting is a controversial subject largely because it has evolved into a sport. In New York State, white-tailed deer flourish due to the lack of natural predators. As a result, they cause significant damage to cars and properties each year. In New York, deer hunting is regulated but legal from the beginning of October through the middle to end of December. Proponents of hunting argue that it is necessary in order to control the deer population, a relatively safe sport, and economically beneficial to state wildlife agencies which are partially, or fully supported, by the sale of permits.

They also argue that hunting is ethically superior to the killing of cows or chickens because deer are able to live a free life before being killed and have a chance to escape. Opponents of hunting argue that hunting is not necessary to control the deer population, results in a number of fatalities each year, and is a burden to taxpayers who provide the funding for land maintained specifically for hunting. Certain practices, such as trophy hunting, canned hunting, baiting, using scents, and hunting of stocked animals are objectionable to people on both sides of the argument.

The use of deer hunting as an authentic topic enables students to learn about the idea of carrying capacity, overpopulation, and the human impact on the environment. It also enables them to evaluate their own moral and ethical beliefs about the killing of wild animals for food.

**Suggestions for Instruction:**

Students could complete a lab activity that requires them to evaluate changes in a deer population that result from the introduction and elimination of predators. They could then read articles and analyze data about the costs and dangers of hunting and write a position paper on whether hunting should continue to be allowed in New York State. As an alternative, students could write a newspaper article, or letter to the state wildlife agencies, stating their case.

## **Global Warming**

**Authentic Topic:** Global Warming

**New York State Standards and Performance Indicators:**

7.1 – Describe the range of interrelationships of humans with the living and nonliving environment.

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 wastes, energy flow, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental.

7.1c – Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

**Traditional Unit:** Unit #8 – Ecology

**Problem Statement:**

The existence, causes, effects, and seriousness of global warming have been debated for the last few decades. While science has demonstrated that global warming is occurring and human activities are contributing to the problem many people still deny its occurrence. Current debate exists around the seriousness of the



issue and the most economical way to reduce the emission of greenhouse gasses due to human activities. Is global warming an urgent issue in the world?

**Rationale for Topic:**

Global warming has been a controversial subject for the last few decades. Scientific literature provides strong evidence that the average temperature of the Earth has increased due in large part to the emission of greenhouse gasses from human activities but the effects, seriousness, and remedies for global warming are still strongly debated. Inaccurate media, and politically driven statements on the issue, fuel much of the debate.

The use of global warming as an authentic topic would enable students to learn about the causes, effects and seriousness of global warming. It would also enable students to examine scientific research and data in an objective and analytical view. In addition, the use of global warming as a topic would also expose students to fallacies in social media as well as political campaigns and enable them to evaluate their own beliefs about whether global warming is an urgent issue in the world.

**Suggestions for Instruction:**

Students could research the existence, causes, and effects of global warming using scaffolded activities that guide students to learn the science concepts. They could then be divided into two groups for a whole class debate on the seriousness of global warming and whether urgent measures are needed to prevent further destruction of the ozone layer. As an alternative to a debate, students could create a political advertisement or prepare a political speech on the topic.

## Offshore Drilling

**Authentic Topic:** Offshore Drilling

**New York State Standards and Performance Indicators:**

7.1 – Describe the range of interrelationships of humans with the living and nonliving environment.

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.

7.1c – Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

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

7.2c – Industrialization brings an increased demand for and use of energy and other resources including fossil and nuclear fuels. This usage can have positive and negative effects on humans and ecosystems.

**Traditional Unit:** Unit #8 – Ecology

**Problem Statement:**

The increasing demand for fossil fuels has forced the United States to consider offshore drilling as a way to reduce dependence on foreign oil. Unfortunately, offshore drilling poses a significant environmental risk to organisms and ecosystems. Should offshore drilling be allowed in the United States?

**Rationale for Topic:**

Offshore drilling, or the extraction of crude oil from the ocean floor, is a controversial issue, which has received a significant amount of attention, particularly since the 2010 BP spill off the Gulf of Mexico. Due to increased demand, and the drying of previously drilled reservoirs, US energy companies such as BP are searching for potential offshore wells in deep water. The controversy surrounding the drilling debate focuses on the environmental impacts of oil spills and the need for US energy independence. Proponents of offshore oil drilling argue that it would help the US reduce our reliance on foreign oil, prevent major spikes in the cost of gasoline, and reduce our trade deficit with other countries. Opponents of offshore drilling argue that deep-water wells are highly susceptible to damage from hurricanes and thus more prone to spills, which create environmental problems in ecosystems.

The use of offshore drilling as an authentic topic enables students to evaluate their own moral and ethical beliefs about the trade-off between the ability to reduce our dependence on foreign oil the environmental risks of deep water drilling. It also teaches students about fossil fuels and the impact that humans can have on the environment.

**Suggestions for Instruction:**

Students could read about offshore drilling, the 2010 BP oil spill, and analyze data on the number of spills from deep water drilling. They could then participate in a whole class debate on whether offshore drilling should be allowed in the United States.

## **Bottled Water**

**Authentic Topic:** Bottled Water

**New York State Standards and Performance Indicators:**

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

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.

7.1 – Describe the range of interrelationships of humans with the living and nonliving environment.

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 wastes, energy flow, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental.

7.1c – Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution,

atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

**Traditional Unit:** Unit #8 – Ecology

**Problem Statement:**

The debate regarding the safety of tap and bottle water has been ongoing for decades. Both tap and bottled water have been shown to have potentially negative health and environmental consequences. Is bottled water safer than tap water for human consumption?

**Rationale for Topic:**

The debate of whether bottled water is safer than tap water is a matter of personal preference. The Environmental Protection Agency (EPA) monitors the quality of tap water while the Food and Drug Administration (FDA) regulate the quality of bottled water. The EPA has specific guidelines outlining acceptable quantities of contaminants while the FDA monitors the manufacturing practices and requires sampling and testing of the final product for contaminants. However, the FDA regulations do not apply to bottled water sold within the same state.

Bottled water comes from lakes, springs, and aquifers however over a quarter of all bottled water is treated or purified in municipal facilities. Studies of bottled water, including a notorious 1999 study by the Natural Resources Defense Council have found that many brands of bottled water are contaminated with bacterial or chemical contaminants, including phthalates, a class of known carcinogens used to make the plastic containers that bottle water is typically marketed in. In addition to

the immediate health risks; the use of bottles made from petroleum-derived PET increases our dependence on crude oil and contributes to the carbon footprint by filling landfills.

Tap water comes from streams, rivers, or lakes and is purified by municipal facilities, which add chemical compounds to the water in order to kill any biological toxins and adjust the pH. However, studies have found that tap water contains traces of a vast array of pharmaceuticals including antibiotics, steroids, hormones and antidepressants. While there are currently no studies showing evidence of adverse effects of these pharmaceuticals on humans it is an area of concern for many people particularly because the presence of these pharmaceuticals in water has been linked to changes in the reproductive behaviors of fish.

The use of bottled water as an authentic topic enables students learn about the potential for human products to enter and accumulate in water systems. It also allows students to review the ideas of antibiotics, hormones, bacteria and cancer. The use of bottled water as a topic enables students to make their own decisions regarding the health risks and environmental impacts the different waters.

**Suggestions for Instruction:**

Students could research pharmaceuticals in tap water in order to explain how these products build up in water systems. They could then read about the production of bottled and tap water and write a position paper addressing the question of whether bottled water is safer for human consumption than tap water. As an alternative, students could create a public service announcement addressing the topic.

## Exotic Animals as Pets

**Authentic Topic:** Exotic Animals as Pets

### **New York State Standards and Performance Indicators:**

1.1 – Explain how diversity of populations within ecosystems relates to the stability of ecosystems.

1.1a – Populations can be categorized by the function they serve. Food webs identify the relationships among producers, consumers, and decomposers carrying out either autotrophic or heterotrophic nutrition.

1.1c – In all environments, organisms compete for vital resources. The linked and changing interactions of populations and the environment compose the total ecosystem.

1.1f – Every population is linked, directly or indirectly, with many others in an ecosystem. Disruptions in the numbers and types of species and environmental changes can upset ecosystem stability.

6.1 – Explain factors that limit growth of individuals and populations.

6.1a – Energy flows through ecosystems in one direction, typically from the Sun, through photosynthetic organisms including green plants and algae, to herbivores to carnivores and decomposers.

6.1e – In any particular environment, the growth and survival of organisms depend on the physical conditions including light intensity, temperature range, mineral availability, soil/rock type, and relative acidity (pH).

7.1 – Describe the range of interrelationships of humans with the living and nonliving



environment.

7.1c – Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

**Traditional Unit:** Unit #8 – Ecology

**Problem Statement:**

Exotic species such as cichlids, plecos, snakes, and iguanas are commonly sold in pet stores throughout the United States. While these organisms are harmless when kept in captivity, the accidental or intentional release of these species into the wild can cause significant damage to existing ecosystems. Should exotic species such as cichlids, plecos, snakes, and iguanas be sold in pet stores?

**Rationale for Topic:**

Exotic animals such as iguanas and snakes purchased as pets frequently escape or are released into the wild when they become too large or burdensome for their owners. While the vast majority of these organisms die due to predation, starvation, and an inability to adapt to new environments, a few survive and are able to reproduce. These organisms often become invasive causing damage to ecosystems by preying on native species, competing for resources, and introducing parasites and diseases not typically found in the area. In Florida, wild boars, Burmese pythons,

parakeets, Nile monitors, plecos, and cichlids have been released into the Everglades. These species are now causing significant damage to the native plant and animal populations, including some populations at risk of becoming extinct.

Every state has different exotic pet laws. Some states are specific about what animals are restricted while other states allow virtually any animal to be kept as a pet. In New York State, it is illegal to keep a wild cat, wolf, fox, bear, venomous reptile, or crocodile without a license but exotic organisms such as iguanas, snakes, cichlids, and plecos are commonly sold at pet stores.

The use of exotic pets as an authentic topic enables students to evaluate the ecological dangers of keeping exotic organisms as pets. It also teaches them about the interdependence of organisms in a food web, invasive species, and the impact that human choices can have on the environment. The topic could be used to teach vocabulary related to ecosystems (producer, consumer, herbivore, carnivore, scavenger, decomposer, abiotic, biotic, food chain, food web, invasive species, autotroph and biodiversity) as well as the human impact on ecosystems. By researching the organisms in an ecosystem, while simultaneously learning the ecology vocabulary, student interest and motivation would be improved.

**Suggestions for Instruction:**

Students could be divided into groups. Each group could research one exotic species, which has been released into the wild and has become invasive. Students could research their organisms' niche in the environment and create a food web to demonstrate the impact that the invasive organism has on the native populations.

They could also research and describe the effect that the species has on the environment (erosion, destruction of property, etc.) and the reasons for the success of the species. To increase the relevancy, students could research local cases where arrests have occurred for the possession or release of exotic animals. Students could then share their findings with each other and write a position paper on whether organisms that are non-native to an area should be sold in pet stores in the United States.

## Reusable Shopping Bags

**Authentic Topic:** Reusable Shopping Bags

**New York State Standards and Performance Indicators:**

7.1 – Describe the range of interrelationships of humans with the living and nonliving environment.

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 wastes, energy flow, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental.

7.1c – Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

**Traditional Unit:** Unit #8 – Ecology

**Problem Statement:**

Some people believe that reusable shopping bags are the solution to the ongoing debate between plastic and paper bags. However, all three types of bags have negative environmental consequences. Should the local grocery store offer paper, plastic or reusable grocery bags to consumers?

**Rationale for Topic:**

The debate between plastic, paper and more recently “reusable” shopping bags is a longstanding dispute among environmentalists. Plastic bags are made of products derived from petroleum and natural gas in a process that contributes a significant quantity of various greenhouse gases to the environment. They are also widely known to entangle or be ingested by animals ultimately causing thousands of deaths each year. In addition, over time plastic bags go through a process known as photodegradation in which they are broken down into smaller and smaller molecules. Many of these small molecules are toxic and as a result they contaminate soil and water and ultimately affect food chains.

Like plastic bags, paper bags contribute to greenhouse gas emissions but they do not degrade into toxic products. However, trees are used in the manufacturing of paper bags and therefore forests are destroyed for the raw materials. The destruction of forests leads to a loss of habitats for organisms ultimately resulting in a disruption of the food chain and a potential loss of species. In adding, the manufacturing of paper bags releases a number of toxic chemicals, including sulphurous acid, which contributes to acid rain and water pollution.

Reusable bags are the only alternative to paper and plastic and they are often made of canvas or cotton using recycled material and ecologically friendly manufacturing techniques. However, because of the energy costs associated with the manufacturing process and the sheer volume that reusable bags take in landfills a consumer would have to reuse the bag multiple times in order for it to be more environmentally friendly. Unfortunately, many consumers do not reuse these bags. In addition, most bags are not properly washed after each use and therefore contain a large amount of dangerous bacteria.

The use of paper, plastic, or reusable bags as an authentic topic would enable students to learn about the ecological impacts of all three choices and evaluate their own preferences so that they can make informed choices as consumers. It would enable students to learn about deforestation, the water cycle, and the growth of bacteria as well as the impact that human decisions can have on the environment. As it is a broad topic, it could be used to teach many different areas of the curriculum.

**Suggestions for Instruction:**

Students could be divided into three groups. Each group could research the environmental impact of the manufacturing, use, and disposal of one of the three types, namely paper, plastic or reusable grocery bags. The groups could then present their findings to each other, ask questions of the opposing groups, and draw a conclusion as to which type is the most environmentally friendly. As a summary each student could write a position paper on which type of grocery bag the local grocery store should offer to consumers.

## **Nuclear Power**

**Authentic Topic:** Nuclear Power

**New York State Standards and Performance Indicators:**

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

7.2c – Industrialization brings an increased demand for and use of energy and other resources including fossil and nuclear fuels. This usage can have positive and negative effects on humans and ecosystems.

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

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.

**Traditional Unit:** Unit #8 – Ecology

**Problem Statement:**

Nuclear power has been controversial for many decades. However, the production of nuclear energy is currently at an all-time high. The United States is home to a large number of nuclear power plants, including the Ginna Nuclear Power Plant, located in Ontario New York. These power plants carry an inherent environmental risk. Should nuclear power plants, which produce tremendous

amounts of energy, continue to operate in the United States despite the environmental risks associated with their operation?

**Rationale for Topic:**

Nuclear power, or the use of nuclear fission reactors, to generate electricity, has been controversial for decades. Proponents of nuclear power argue it is sustainable energy, which produces significantly less greenhouse gas than fossil fuels, and can decrease our reliance on foreign oil. Opponents of nuclear power argue that it poses many threats to people and the environment including the production of small amounts of radioactive nuclear waste, the risk of increased nuclear weapon usage as the technology becomes more available, and environmental damage from uranium mining. Critics often cite incidents such as the 1986 Chernobyl or 2011 Fukushima disasters in their opposition to nuclear power.

The use of nuclear power as an authentic topic teaches students about a contested alternative to fossil fuels and allows them to evaluate their own moral and ethical beliefs about the use of nuclear power to reduce our reliance on foreign oil. The proximity of the Ginna power plant in Ontario New York makes this topic particularly relevant to students, particularly those who have families that depend on the power plant as a source of income.

**Suggestions for Instruction:**

Students could read about nuclear power, the incidents at Chernobyl and Fukushima, and the environmental benefits of nuclear power. They could then participate in a class debate on whether nuclear power plants should continue to



operate in the United States despite the environmental risks associated with their operation. As an alternative students could create and video-tape a public service announcement encouraging or discouraging the use of nuclear power.

## **Hydrofracking in New York State**

**Authentic Topic:** Hydrofracking in New York State

**New York State Standards and Performance Indicators:**

7.1 – Describe the range of interrelationships of humans with the living and nonliving environment.

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 wastes, energy flow, and recycling of nutrients. Humans are changing many of these basic processes and the changes may be detrimental.

7.1c – Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly affected.

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

7.2c – Industrialization brings an increased demand for and use of energy and other resources including fossil and nuclear fuels. This usage can have positive and negative effects on humans and ecosystems.

**Traditional Unit:** Unit #8 – Ecology

**Problem Statement:**

Hydrofracking is a controversial topic, which has regularly appeared in the media and political campaigns throughout the last few years. Opinions about the safety and benefits of hydrofracking are largely divided. Should hydrofracking be permitted in New York State?

**Rationale for Topic:**

Hydrofracking, otherwise known as fracking or hydraulic fracturing, is a widely debated and highly controversial topic. For the last few years, it has appeared regularly on the news and in political campaigns. Hydrofracking involves injecting large amounts of sand, water, and chemicals underground at high pressures to extract natural gas from existing rock formations.

Proponents of hydrofracking argue that natural gas burns cleaner than coal or oil, and that hydrofracking would increase the amount of available natural gas in the United States thereby reducing greenhouse gas emissions. They also argue that hydrofracking would reduce our dependence on foreign oil and create more US industry thus providing economic benefits, including jobs, to the United States. Opponents of hydrofracking argue that the toxic chemicals used and produced in the hydrofracking process could contaminate groundwater ultimately have large

environmental consequences. Opponents also argue that while natural gas burns cleaner than other fossil fuels, the process of hydrofracking releases methane, a major greenhouse gas.

Students often have unfounded opinions about safety and benefits of hydrofracking. The use of hydrofracking as an authentic topic would enable students to evaluate their own moral and ethical beliefs about the potential environmental consequences of drilling and releasing toxic chemicals into the ground versus the economic benefits of creating more industry in the United States. It would also teach students about fossil fuels, greenhouse gasses, industrialization and the impact that human activities can have on ecosystems.

**Suggestions for Instruction:**

Students could learn about the process of hydrofracking, the different types of fossil fuels, and greenhouse gas emissions through individual research using scaffolded activities that guide students to learn the science concepts. Students could then be divided into two groups for a whole class debate on whether hydrofracking should be permitted in New York State. As an alternative, students could write a position paper, create and video tape a public message, or write a political advertisement on the topic.

## **Donation of Cadavers to Forensic Research**

**Authentic Topic:** Donation of Cadavers to Forensic Research

**New York State Standards and Performance Indicators:**

6.1 – Explain factors that limit the growth of individuals and populations.

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.

**Traditional Unit:** Unit #8 - Ecology

**Problem Statement:**

Organ and body donation has been commonly practiced in the United States for many years. However, under current laws, a person is not able to make the decision to donate all or part of their body to research until they are considered a legal adult. At what age should you be allowed to make your own decision regarding the donation of your body to forensic science?

**Rationale for Topic:**

The donation of organs upon death to individuals awaiting organ transplant is a common practice in the United States. According to the current laws, at eighteen individuals can request to be an organ donor and specifying which organs they would like to be donated. If an unfortunate circumstance leads to death before eighteen their next of kin, usually their parents are asked whether they would like to donate any or all of the organs. However, organ donation is not the only option. Entire bodies may

be donated to science for use in medical schools or research including forensic studies. These forensic studies look at human decomposition, human skeletal variation, and osteological remains to help law enforcement agencies and the medical community analyze and convict criminals.

The use of body donation for forensic research as an authentic topic would expose students to options that they have available when they turn eighteen. It would also allow the students to evaluate their own beliefs about life after death. Students are very interested in the topic, specifically body donation for forensic research. Most students have seen a television show that analyzes forensic evidence and wondered how investigators know all of the information that they seem to know. The topic is engaging for students, and also, informative with respect to the idea of decomposition, the stages of decomposition, and the need for nutrient cycling in an ecosystem.

**Suggestions for Instruction:**

Students already know that organisms decompose after death but they do not know how or why the decomposition occurs. Students could complete a lab in which they observe the decomposition of a mouse. Students could also watch a brief segment of a forensic television show, research the stages of decomposition, read about body farms and their use in forensic studies. Students could then write a position paper addressing their position with respect to what age people should be allowed to make a decision regarding the donation of their body to forensic science.

## **Euthanasia of Domestic Animals**

**Authentic Topic:** Euthanasia of Domestic Animals

**New York State Standards and Performance Indicators:**

6.1 – Explain factors that limit growth of individuals and populations.

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.

**Traditional Unit:** Unit #8 – Ecology

**Problem Statement:**

Each year five to seven million animals enter animal shelters across the country. Sadly, due to sickness, overcrowding in shelters, behavioral problems, or a lack of available homes, three to four million of these animals are euthanized. Is the euthanasia of cats and dogs in animal shelters necessary to prevent overpopulation?

**Rationale for Topic:**

The euthanasia of animals in shelters is a controversial subject that evokes a great deal of emotion in most students. Students are familiar with both large “kill” shelters such as Lollypop Farm and smaller “no kill” shelters such as Scottsville Pet Adoptions, GRASP, Another Chance Pet Rescue, and the Pet Adoption Network.

Unfortunately, due to a lack of national regulation, and inconsistent use of language, most notably the term “adoptable animal”, comparison of statistics between organizations is difficult, if not impossible. Shelters that proclaim to be “no kill” shelters often apply the term “adoptable animal” loosely or have a “limited admission” policy thereby only accepting particular animals. On the other hand, “kill” shelters typically have an “open admission” policy in which they accept any animal, including those that are denied by “no kill” shelters.

Currently, in the United States, the number of cats and dogs in search of homes far exceeds the number of available homes. Euthanasia is one way to control the population. However, it may also be possible to control the population through low cost spaying and neutering programs thereby reducing future populations and minimizing the current need to euthanize cats and dogs in shelters.

The use of euthanasia of domestic animals as an authentic topic would enable students to evaluate their own moral and ethical beliefs about euthanasia and the principles under which animal shelters operate. It would also reinforce the ideas of overpopulation, limiting resources, and carrying capacity. Students typically understand these concepts however due to their limited exposure to nature they have difficulty applying them to natural situations such as wolf and rabbit populations. A lesson on overpopulation among domestic animals is much more relevant to students who have not grown up in the country.

**Suggestions for Instruction:**



There are many heartbreaking visuals from animal shelters available on the internet. These could be used to evoke initial uninformed responses from students. Students could then analyze and compare statistics from local animal shelters and rescue groups as well as statistics on spaying and neutering. Students could use this data as well as their knowledge of overpopulation and carrying capacity to support a paper addressing the question of whether euthanasia is necessary in animal shelters in order to prevent overpopulation.

## **Chapter 4: Conclusions and Recommendations**

The use of personally meaningful and socially relevant topics that require students to use evidence-based reasoning and engage in dialogue, discussion and debate has appeared in science education literature for the last three decades under the umbrella of STS, STSE, and SSI instruction. Researchers have suggested that the use of STS, STSE, and SSI context-based instruction can promote student content knowledge, deepen student understanding of the nature of science, strengthen student argumentation skills, and promote student motivation and interest in science and scientific careers thereby creating a more scientifically literate society. However, the teaching and learning of science in contexts has not been widely implemented by teachers for a number of reasons including current state standards and the difficulty associated with enacting major curriculum changes equivalent to those described by researchers in long-term studies of context-based instructional approaches.

This culminating project demonstrated the potential to implement context-based instruction incorporating written or verbal argumentation into a course in which the science content to be taught is dictated by state standards, and the organization of the content within the year, is restricted by the use of non-negotiable common unit assessments, aligned to district curriculum. It also demonstrates the ability to rethink curriculum to better align with the Next Generation Science Standards, which place a greater emphasis on the applications of science, technology, engineering, and society as well as the explicit teaching and learning of argumentation. These standards may be adopted by New York State in coming years. This culminating project can serve

as a foundation for designing living environment lessons, which incorporate context-based instruction with argumentation and are therefore aligned to these new standards.

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## Lesson Plan: Exotic Species as Pets 9<sup>th</sup> Grade

<b>Topic:</b> Exotic Species as Pets	<b>Subject/Course:</b> Living Environment
<b>Time:</b> Approximately 320 min	<b>Unit:</b> Ecology
<b>Desired Results</b>	
<p><b>Measurable Objective(s):</b></p> <ul style="list-style-type: none"> <li>- Students will create a food web to demonstrate the effect of invasive species on an ecosystem</li> <li>- Students will support their response to a controversial question with evidence from research</li> <li>- Students will define key vocabulary terms</li> </ul>	
<p><b>Standard(s) and Performance Indicators:</b></p> <p>1.1 – Explain how diversity of populations within ecosystems relates to the stability of ecosystems.</p> <p>1.1a – Populations can be categorized by the function they serve. Food webs identify the relationships among producers, consumers, and decomposers carrying out either autotrophic or heterotrophic nutrition.</p> <p>1.1c – In all environments, organisms compete for vital resources. The linked and changing interactions of populations and the environment compose the total ecosystem.</p> <p>1.1f – Every population is linked, directly or indirectly, with many others in an ecosystem. Disruptions in the numbers and types of species and environmental changes can upset ecosystem stability.</p> <p>6.1 – Explain factors that limit growth of individuals and populations.</p> <p>6.1a – Energy flows through ecosystems in one direction, typically from the Sun, through photosynthetic organisms including green plants and algae, to herbivores to carnivores and decomposers.</p> <p>6.1e – In any particular environment, the growth and survival of organisms depend on the physical conditions including light intensity, temperature range, mineral availability, soil/rock type, and relative acidity (pH).</p> <p>7.1 – Describe the range of interrelationships of humans with the living and nonliving environment.</p> <p>7.1c – Human beings are part of the Earth’s ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems may be irreversibly.</p>	
<p><b>Essential Question(s):</b></p> <p>Should exotic species such as cichlids, plecos, snakes, and iguanas be sold in pet stores?</p>	

<b>Assessment Evidence</b>	
<b>Evidence of Learning:</b>	
<ul style="list-style-type: none"> <li>- Observations of student participation and ability to answer questions</li> <li>- Successful completion of research project and essay</li> </ul>	
<b>Learning Plan</b>	
<b>Teaching/Learning Activities:</b>	
<b>TEACHER</b>	<b>STUDENT</b>
<ul style="list-style-type: none"> <li>- Teacher facilitates discussion about invasive species that are present in New York State (Zebra Mussels, Purple Loosestrife, Ash Borer, etc.)</li> <li>- Teacher provides students with a list of potential species and guides their selections.</li> <li>- Teacher walks around and asks questions and monitors research.</li> <li>- Teacher guides students as they have questions and monitors learning by asking questions such as “how does the alcohol get from the stomach to the blood?” and “how does the message get from one cell to another?” to individual students.</li> <li>- Teacher monitors students as students move group to group sharing their findings.</li> <li>- Teacher monitors writing.</li> </ul>	<ul style="list-style-type: none"> <li>- Students discuss invasive species that are present in New York State. Students should be familiar with these as they were taught in previous years.</li> <li>- Student select an invasive species that was intentionally or accidentally released from captivity into the wild. The species could be selected from the list or by researching.</li> <li>- Students use computers to research the ecosystem that the invasive species was introduced to. As students research they complete the research placement and associated questions.</li> <li>- Students create a food web that contains the invasive species, producers, herbivores, carnivores, and omnivores in the ecosystem .</li> <li>- Students present their findings to other groups</li> <li>- Students individually write a response to the essential question. Student responses should be supported with evidence from student research.</li> </ul>

# Invasive Species Project

In this activity you will create a landscape picture of an ecosystem. The ecosystem you select must contain at least one species that has been released from captivity and has since become a pest in the ecosystem.

Ecosystem: \_\_\_\_\_

Invasive Species: \_\_\_\_\_



In your landscape picture you must represent each of these topics below.

**biodiversity**

**biotic factors**

**abiotic factors**

**population**

**community**

**producer**

**autotroph**

**primary consumer**

**secondary consumer**

**carnivore**

**herbivore**

**decomposer**

**scavenger**

**omnivore**

**food chain**

**food web**

**limiting factors**

**renewable resource**

**O<sub>2</sub> and CO<sub>2</sub> cycle**

**invasive specie**

You will demonstrate your knowledge of these topics by creating a landscape picture, a food web for the ecosystem, and presenting your picture to the class. You must include all of the terms

# **Invasive Species Project Research Organization**

What **invasive species** did you select?

How has the **invasive species disrupted the ecosystem**? You must show this in your landscape picture.

How will you represent **biodiversity** in your landscape picture?

How will you represent the idea of a **population** in your landscape picture?

How will you represent the idea of **limiting factors** in your landscape picture?

How will you represent **renewable resources** in your landscape picture? You must have a minimum of two.

How will you represent the **O<sub>2</sub> and CO<sub>2</sub> cycle** in your landscape picture?

In the space below, draw a **food web** that includes the names of the invasive species you selected, and at least three producers, three herbivores, three omnivores, and three carnivores that you will show in your landscape picture. This will be graded as part of your project.





# Invasive Species Project Research Placemat

<p><b>Abiotic Factors</b> (minimum of <u>3</u>)</p>	<p><b>Biotic Factors</b> (Minimum of <u>3</u> – One must be unique to this category)</p>
<p><b>Scavenger</b> (Minimum of <u>1</u>)</p>	<p><b>Decomposer</b> (Minimum of <u>1</u>)</p>



# Invasive Species Project Research Placemat

\*Minimum of 3 for each of areas below\*

<p><b>Producers</b> or</p> <hr/>	<p><b>Primary Consumers</b> or</p> <hr/>
<p><b>Secondary Consumers</b> or</p> <hr/>	<p><b>Omnivore</b></p>

