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Understanding by Design unit lesson plans for the next generation science standards: life science

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Abstract

The project that I focused on for my Creative Component is the creation of Understanding by Design (UbD) unit lesson plans that address the Next Generation Science Standards (NGSS) in the topic of Evolution. When the final framework was released of the NGSS in 2011, the need for teachers to revisit and align their curriculum became a necessary step to ensure appropriate content was taught. In the fall of 2013, Keokuk Community School District decided science teachers would begin implementing the new NGSS, anticipating that the state of Iowa will adopt the standards.

This creative component includes lesson plans correlated with selected NGSS Performance Expectations (PE) for the discipline of Life Science. At Keokuk Middle School, students are required to take three yearlong courses in science. In sixth grade students learn a variety of content, which mainly focuses on physical science content. Life science is the focus of the curriculum in seventh grade. Students in eight grade center the time in class on earth science. In order for students to master the 59 science standards from the NGSS, Keokuk Middle School teachers needed to begin the conversation of how to accomplish such a daunting number of standards in three years.

The first step the science staff took was determine the scope and sequence of the newly created standards, which served the purpose of ensuring all of the 59 Middle School Performance Expectations (PE) were covered. After meeting numerous times throughout the school year to determine that each Middle School PE would be covered in the three years a student spends in the middle school, it was determined that during a year of Life Science students would need to meet 22 PEs. Our school year consists of 178 student days, equaling an average time commitment of eight school days on each PE.

The goal of this creative component is to create curriculum that aligns with NGSS, grouping multiple PEs in a unit. The unit covers the topic of Natural Selection and Adaptations, addressing the topics of two crosscutting concepts: Patterns and Cause and Effect. Lessons focus on meeting five Middle School Life Science Performance Expectations of the NGSS. These five Performance Expectations will be divided into two subunits, creating the unit titled Adaptation/Diversity.

UNDERSTANDING BY DESIGN UNIT LESSON PLANS FOR THE NEXT GENERATION SCIENCE STANDARDS: LIFE SCIENCE

A Creative Component

Submitted

Master of Arts in Science Education

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CHAPTER 1

Introduction and Framework

The project that I focused on for my Creative Component is the creation of Understanding by Design (UbD) unit lesson plans that address the Next Generation Science Standards (NGSS) in the topic of Evolution. When the final framework was released of the NGSS in 2011, the need for teachers to revisit and align their curriculum became a necessary step to ensure appropriate content was taught. In the fall of 2013, Keokuk Community School District decided science teachers would begin implementing the new NGSS, anticipating that the state of Iowa will adopt the standards.

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CHAPTER 2

Relevance and Literature Review

To ensure the curriculum created is relevant to students and reflects what students are to learn, multiple steps occurred to align curriculum with the Next Generation Science Standards. Literature was reviewed, which allowed for a better understanding of the research behind each component, in order the fully understand the process selected of implementing the new standards. The primary literature was analyzed to determine whether the learning is adequate for the selected standards.

Next Generation Science Standards

Science standards should reflect how science is practiced in the real science world, where content, scientific and engineering practices, and crosscutting concepts are integrated (Achieve Inc., 2012). Next Generation Science Standards (NGSS) are used as standards for kindergarten through twelfth grade, to ensure all students have access to a challenging education in science (Achieve Inc., 2012). The creation of the NGSS was not a quick and easy process that consisted of a few individuals; instead it was the exact opposite. The National Research Council (NRC), the National Science Teachers Association, the American Association for the Advancement of Science, and Achieve – a nonprofit and independent organization that address and improve the low academic standards, as well as assessments and accountability – worked together to develop 2-step process that would allow NGSS to come about: 1) the Framework and 2) the Performance Expectations (Achieve Inc., 2014a; Achieve Inc., 2015). The creation of the NGSS took two years, where numerous meetings, revisions, and drafts took place (Achieve Inc., 2014b). During this time, 26 states were considered to be lead partners in the NGSS process (Achieve Inc., 2012).

The first step in the development of the NGSS was the creation of the Framework, which consists of a compilation of research on science and science learning, as well as a list of science concepts all students K-12 should know (Achieve Inc., 2014b). The NRC, which is part of the National Academy of Science, created a committee of current scientists, Nobel laureates, cognitive scientists, researchers of science education, and experts on science education standards and policy to identify the key science topics that students K-12 need to know. (Achieve Inc., 2014b). The NRC developed the Framework, so broad ideas and practices could be established to guarantee all students establish and master a desired set of skills and practices before graduating from high school (Achieve Inc., 2012). The Framework was created to extend, refine, and revise the scientific knowledge of students ranging from kindergarten to twelfth grade (Achieve Inc., 2014d). The second step was the development of standards based off the Framework (Achieve Inc., 2012). These standards are known as Performance Expectations (PEs), which are statements that describe student proficiencies in science and what students should be able to do to demonstrate their ability to apply knowledge in the Disciplinary Core Ideas (DCI) at the end of their grade/grade band (Krajcik, Codere, Dahsah, Bayer, & Mun, 2014).

Why they are needed. The need for new national standards was vast. Educators had moved away from the point of education and curriculum, focusing on standardized assessment and lost sight of what students must know prior to the end of their schooling to become successful adults (Bybee, 2013). The United States was performing below expectations, especially in math and science, leaving students ill equipped for the global economy (Achieve Inc., 2014c). The first confirmation for the need of new science standards was in 2011, when more than a third of eighth grade students scored below basic on the National Assessment of Educational Progress (Achieve Inc., 2014c). A year later in 2012, 69% of students graduating from high school did not meet college readiness benchmark levels in the science portion of the ACTs (ACT, Inc., 2012). After the creation of the National Science Education Standards fifteen years ago, it was apparent the science standards needed to be updated to address the issue of college readiness results and prepare students for the global economy (Achieve Inc., 2012).

The goals of NGSS are to prepare students for life in college, careers, and citizenship, as well as stimulate and build an interest for students in the areas of science, technology, engineering, and mathematics (Achieve Inc., 2012). Guidance is provided to students through the specification of the newly created standards (Krajcik et al., 2014). Not only do the detailed PEs help express what students should learn, but the other parts of the NGSS (e.g. science and engineering practices, disciplinary core ideas, and crosscutting concepts) help the implementation of the standards become clear to both educators and students.

The NGSS alter the focus of science education and allow for quality science education to take place at all levels from kindergarten through twelfth grade (Pratt, 2013). There are seven conceptual shifts teachers and schools must address when implementing the NGSS:

1. K-12 science education should reflect the real-world interconnections in science.
2. The NGSS are student outcomes and explicitly not curricula.
3. Science concepts build coherently across grades K-12.
4. The NGSS focus on deeper understanding and application of content.
5. Science and engineering are integrated in science education from kindergarten through 12th grade.
6. The NGSS are designed to prepare students for college, career, and citizenship.
7. Science standards coordinate with English language arts and mathematics Common Core State Standards.

"Numbers 1, 5, and 7 are new goals for virtually every one of us" (Pratt, 2013, p. 6).

The NGSS allow students to build their entire scientific knowledge as they complete grades kindergarten through senior by focusing on "depth over breadth" (Pratt, 2013). Knowledge needed for success in college and careers are the focus of NGSS, ensuring that all students mastered the required concepts of NGSS (Achieve Inc., 2012). Instead of science education focusing on fact-driven standards, the focus is now based on building deeper understandings and applications of content, including core ideas of engineering design and technology (Achieve Inc., 2013b).

The NGSS consists of three dimensions that make up the Framework: practices, crosscutting concepts, and content. Practices, the first dimension, describe the behaviors that scientists use as they investigate and build models and theories about the natural world. NRC decided to use the term "practices", rather than life skills, to emphasize that engaging in scientific investigation requires not only skill, but also knowledge that is specific to each practice (Falk and Brodsky, 2013). Crosscutting concepts are concepts that apply to all areas of science, illustrating how the different areas of science are linked together. The concepts are shared with students, so that students can organize and interrelate their science knowledge. The last dimension, disciplinary core ideas, focuses on K-12 instruction, assessments, and science curriculum. The core ideas focus on the essential concepts students can connect to key tools and life experiences. There are four domains in the disciplinary ideas: physical science, life science, earth and space science, and engineering, technology and applications of science (Achieve Inc., 2014d). The three dimensions are meant to work together to allow students to build a network of connected ideas and content (Krajcik et al., 2014). The Framework blends the three dimensions together so students can demonstrate their knowledge of the NGSS (Krajcik et al., 2014).

Impact on classrooms. The NGSS are not just to be read and implanted into the classroom. As stated by Pratt, "to understand the structure, content, and function of the NGSS, teachers must actively use them and interact with each element in the standards," (2013, p. 8). Performance expectations do not focus on how instruction needs to be developed nor are they meant to serve as objectives for a single day's lessons, instead PEs are meant to aid in what students should learn and be assessed on, as well as assist teachers and curriculum developers to plan lessons (Krajcik et al., 2014). If educators "bundle" PEs, which is where related PEs are put together, then they need to bundle PEs throughout the course of multiple lessons. In fact, it is recommended that more than one performance expectation be used to develop a single lesson (Krajcik et al., 2014).

The NGSS provide a foundation on which to build curriculum, assessments, and instruction (Achieve Inc., 2012). Curriculum and instruction built on NGSS provides students the opportunity to gain a deeper understanding in the different areas of science, especially since students are applying the newly learned concepts (Achieve Inc., 2013b). As students engage in the practice of the new content and engineering practices, they want to learn the new content and become involved with the concepts. Engagement in both content and practices is critical, allowing students to apply content, problem-solve, use critical thinking skills, and use evidence. This takes place when all three dimensions (science and engineering practices, disciplinary core ideas, and crosscutting concepts) are used, bonding practice with the new concepts (Krajcik et al., 2014).

When instruction aligns with the three dimensions and with PEs, students have a greater chance of mastering the content relevant to the selected PEs. Not only do lessons align with the three dimensions and the designated PEs, but they also allow students to understand both the science idea and engineering concept (Pratt, 2013). As instruction in the classroom shifts to align with the NGSS, so does assessment of student achievement. Time is needed to allow ample opportunities for teachers to create formative and summative assessments that work with and assess students on the concepts of NGSS (Pratt, 2013).

With the NGSS, teachers cover smaller numbers of DCIs and crosscutting concepts, as students explain phenomena and solve problems as they engage in science.

As students make and build more connections to each PE, they develop abilities to problem solve, make decisions, explain phenomena and make sense of new information, because, “when the dimensions are blended and work together, like strands of a rope, learning is stronger” (Krajcik et al., 2014, p. 158). Using the three dimensions together allows learning to be a cohesive experience as students practice science, learn about concepts that apply to an array of studies of science, and focus on key science concepts. Fortunately, the idea of NGSS allows students to build upon their previously gained knowledge, as they add to the specific, detailed PEs from year to year.

As learning opportunities take place, students master the concepts of the PEs and demonstrate their complete understanding of the designated PEs. In order for students to become proficient in the set PEs, they use science and engineering practices with a variety of DCIs and crosscutting concepts. Teachers design lessons using PEs, DCIs, and crosscutting concepts; one element on its own is not sufficient for students to truly master the desired PEs (Krajcik et al., 2014). Curriculum materials and professional development opportunities need to be offered to educators and curriculum directors in order for the NGSS to be implemented in the way it was intended (Krajcik et al., 2014).

The process behind the implementation of the NGSS requires a substantial commitment from the educator, as it necessitates the use of many resources to properly break down each standard and determine what should be assessed. Before beginning the process for creating curriculum that addresses NGSS, educators first read through all PEs to see which PEs fit together, also known as bundling. If bundling occurs, students can support their explanations of phenomena, as well as see how concepts connect (Krajcik et al., 2014). The process of bundling shows learners how to add new knowledge onto prior knowledge, so students can develop the understanding to become proficient in the areas of science concepts, as well as mastering all of the PEs during their schooling (Krajcik et al., 2014). The assessment indicates the level of student learning of the concepts from the selected PEs. Once the assessment has been identified and created, instruction and instructional materials logically follow, as the educator keeps the end result in mind while creating the curriculum around the PEs and assessments, known as Understanding by Design (Pratt, 2013). Once the need of assessment is defined, instructional materials become clear (Bybee, 2013).

There are multiple methods teachers use to assess what concepts students learn from the NGSS. The method I will be using is a combination of what I have experienced from two trainings. Most suggested methods have the same principles: read through PEs, examine other areas that relate to the PEs, determine assessments, relate to Common Core Math and Literacy Standards, and begin planning lessons and tasks (Krajcik et al., 2014).

Implementation of Next Generation Science Standards

The process used to develop the curriculum is found in Appendix A. The next section explains what the steps were and why it was needed to complete the curriculum work for the designated performance expectations. Multiple steps and resources were used to develop this project.

UbD: Understanding by design. Understanding by Design (UbD) is a process that creates lessons which flows naturally with the process of breaking down NGSS.

Once desired results on assessments have been identified, then teaching methods, order of lessons and teaching resources are determined. As lessons are created using the process of UbD, a clear vision of what is truly desired from students develops (McTighe and Wiggins, 1999). As teachers keep the assessment in mind throughout the instruction of the entire unit, students can demonstrate their knowledge and understanding of content at the end of the unit on the assessment (McTighe & Wiggins, 1999). Educators of all grade levels use UbD to create lessons, so engaging and effective instruction takes place in the classroom (Wiggins & McTighe, 2005). Understanding by Design, "is a way of thinking more purposefully and carefully about the nature of any design that has understanding as the goal" (Wiggins & McTighe, 2005, p. 7). This process of creating lessons provides a way to design or redesign curriculum to ensure that student learning is taking place the way it is intended (Wiggins & McTighe, 2005).

Just as NGSS suggests, educators should focus on what specific learning needs to occur first before putting any thought into the activities they hope to implement. "Curriculum should lay out the most effective ways of achieving specific results" (Wiggins & McTighe, 2005, p. 14). Understanding by design can be broken down into three stages (Figure 1).

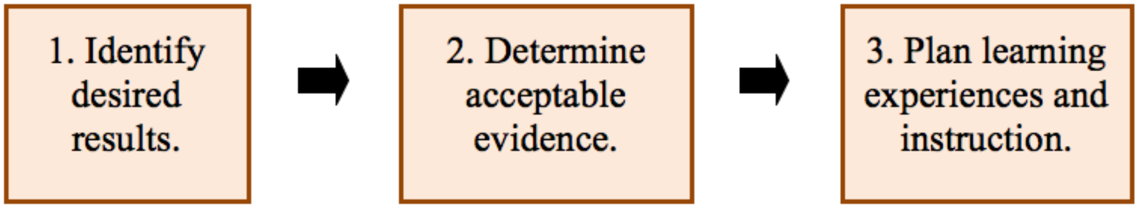

Figure 1. The three-stage UbD process to create curriculum. This figure illustrates the overall process used to develop curriculum following the UbD format. Adapted from Wiggins & McTighe, 2005, p. 18.

The three-step process establishes clear priorities and a purpose for content coverage and activities (Wiggins & McTighe, 2011). The focus of stage one is for the educator to determine what students should know, understand, and do for the assessment that illustrates students made connections between their existing and new knowledge. In stage two, the curriculum writer needs to think like an assessor to ensure students achieve the desired requirements selected during step one from the set goal, which in this case is the PE. The last stage, stage three, is where the educator designs and creates lessons and activities that align with the desired goals that were previously established (Wiggins & McTighe, 2011). The three stages are not all used immediately in the process of creating and aligning curriculum with the NGSS, steps two and three are used later.

CTS: Curriculum topic study. After understanding the process of UbD, the next step in the implementation of the NGSS is completing a Curriculum Topic Study, (CTS) "to study, analyze, and apply content, curricular, instructional, and assessment findings related to the science and mathematics topics teachers teach," (About CTS: Curriculum Topic Study, 2014). A CTS serves the purpose for teachers of linking standards, research, and opportunities for students to learn math and science content, hence why CTS is known as "the missing link" for implementing the many forms of science standards and curriculum (About CTS: Curriculum Topic Study, 2014). A CTS is a study process, as well as a set of tools and strategies, all meant to assist teachers in improving the teaching and learning of science of their students (Keeley, 2005).

When science teachers use standards and research in the development of their curriculum, student achievement improves and educators can examine each topic that is taught, resulting in making informed decisions about what is taught in their classrooms to improve student learning (About CTS: Curriculum Topic Study, 2014). A CTS uses scientific professional readings for many different purposes, one being the process of identifying, examining, and taking action on student preconceptions (About CTS: Curriculum Topic Study, 2014). Additionally a CTS provides teachers the opportunity to learn about new topics they are currently teaching in classrooms at a much deeper level so they can better address how and what their students learn (Keeley, 2005). The CTS completed to guide the unit described here is found in Appendix B.

Essential questions. An essential question is a question that guides inquiry as a way for students to solve problems, gives context to inquiry, is clear and concise, does not have one right answer, and allows educators to see what a project should address (Wilhelm, 2014). Essential questions frame a unit of study, which allows students to connect their experiences and interests to issues of the real world (Wilhelm, 2012). As Brown (2009) states, “Essential questions are structured as open-ended inquiries that do not have an obvious, simple, or specific answer. In fact, a student’s response to a question may change over time as his or her understanding of the topic or issue expands, illustrating the fluid and evolving nature of knowledge.” P. 25.

Teachers should use essential questions in their classrooms, because they, "encourage inquiry and discussion; disagreement and disequilibrium; and above all, a humbling acceptance that some matters are never truly settled," (Frey, Fisher & Anderson, 2014, p. 53). Questions considered to be truly essential focus on content that occurs in students' lifetimes multiple times, so essential questions relate to their own experiences, allowing for connections to take place (Brown, 2009). When students connect the big ideas of essential questions to different subjects and content areas, "frameworks of coherence will begin to develop" (Brown, 2009, p. 26).

Characteristics that make for good essential questions include (Wilhelm, 2012):

- concise and clearly stated
- open-ended and arguable
- focuses on the subject matter
- has students come up with meanings
- helps create a lasting understanding
- interests students
- has students make judgments
- linked to data

To prevent essential questions from becoming a guessing game for students, they should: be interesting and compelling to students at the time, invite students to create knowledge through conversation, and allow students to learn and use content (Wilhelm, 2012). There are three basic steps to ensure compelling essential questions are written. The first is to identify and examine the concept of the curriculum. Next, use the six questions newspapers use when writing an article (who, what, where, when, why, and how). Lastly choose words that focus on impact, effect/affect, and if (Wilhelm, 2014). If essential questions are written properly, more questions will develop from the original question, which in turn motivates students to inquire about more knowledge (Brown, 2009).

Essential questions are structured to develop inquiry and critical thinking of students (Brown, 2009). Content and concepts are taught in a way that matters to students and that lead to conversations that continue and further learning (Wilhelm, 2014). To assist student learning, essential questions are used to work towards creating a curriculum aligned with the NGSS, foster student engagement, and to work towards transfer of knowledge and creativity as students converse about their thoughts (Wilhelm, 2014).

Assessments. Teaching and learning are supported when educators use formative and summative assessments properly (Sherdan, et al., 2014). Assessments provide educators a window into how and what their students are learning because, “the more information we have about students, the clearer the picture we have about achievement or where gaps may occur” (Garrison & Ehringhaus, 2010, p. 1). Assessments are useless unless the teacher establishes the exact concepts that students should have learned prior to the assessment. Consequently, teachers must use relevant assessment criteria when creating, modifying, and implementing assessments (Gielen, Dochy, & Dierick, 2003).

Identifying the Know, Understand, and Dos (KUDs) is essential to the process of creating assessments. Completing this task makes the focus of the curriculum clear and allows educators to distinguish what matters most for student success (Tomlinson, 2014).

It is beneficial for students to be informed of the assessment criteria so students know what is specifically required for them to demonstrate their understanding at the end of their assessment (Gielen et al., 2003). Flexibility during assessments allows students to express what they know, understand and can do is acceptable (Tomlinson, 2014).

Pre-assessments. Pre-assessments collect evidence, such as student readiness, interests, and learning profiles which, "taps the well of the student's mind to draw out anything he or she might know, understand (or misunderstand), and be able to do relative to the upcoming unit" (Hockett & Doubet, 2013, p. 51). A properly written pre-assessment reflects what understanding students have, not simply knowledge and skills. In order to collect the most recent student understandings, pre-assessments should be administered directly before the unit or lesson begins (Hockett & Doubet, 2013).

Educators must keep in mind the end goals when creating pre-assessments in order for the assessment to reflect what is truly wanted from the students. Therefore, the process of identifying KUDs prior to giving pre-assessments is especially useful, as the results of the KUDs determines a starting point of what students know regarding the material. Pre-assessments also allow educators to identify who might experience difficulty in the content or show early mastery, and what misconceptions students have prior to beginning the unit (Tomlinson, 2014). If multiple-choice questions or true-false questions are used as a pre-assessment, then students should be asked to justify or explain their answers, to ensure that students did not just happen to guess the correct answer (Hockett & Doubet, 2013).

Formative assessments. The details of formative assessment play a large role in determining what needs to be taught and how, because thinking and learning takes place as long as metacognitive and reflection strategies are taught and used in the classrooms; formative assessment allows for these strategies to take place (Garrison & Ehringhaus, 2010; Keeley, 2008). Teachers formatively assess their students by simply observing what their students are doing, looking for clues about the progression of learning and by asking students about their thoughts on the learning taking place. Therefore formative assessments are not typically recorded in the grade book (Tomlinson, 2014). When used as intended, formative assessments aid teachers in identifying the learning progression of their students, as well as what to modify during instruction (Hockett & Doubet, 2013; Tomlinson, 2014). Formative assessments without any sort of feedback between teachers and/or students are simply assessments and consequently irrelevant. The interactions that take place between students and their teacher based on this feedback allow students to reflect on scientific ideas (Keeley, 2008; Sherdan et al., 2014).

When formative assessment shows students are not understanding a concept, re-teaching needs to take place, but in a different form (Bakula, 2010). If teaching is not modified based on formative assessment results, the assessment becomes useless. Tomlinson stated, “formative assessment is a means to design instruction that’s a better fit for student needs, not an end in itself” (2014, p. 14). Probes are formative assessment tools meant to quickly and thoroughly inform the educator about student preconceptions and misconceptions, and to promote learning. Probes are especially useful when they align with standards and look at student misconceptions, allowing students to demonstrate their thinking (Duran, Duran, Haney, & Scheuermann, 2011).

Students play a major role in their own learning when provided with descriptive feedback about what they are doing well, what is missing, and how to reach the next step of knowledge (Garrison & Ehringhaus, 2010). Students who are fully engaged in the assessment process permits formative assessment to be more useful, helpful, and run smoothly in the future (Tomlinson, 2014). Teachers must work with students to help them "understand that assessments help them learn and that immediate perfection should not be their goal" (Tomlinson, 2014, p. 11).

Summative assessments. Summative assessments, on the other hand, are given to check what students know and do not know at certain points, therefore reflecting how students are doing with learning and mastering the content standards (Garrison & Ehringhaus, 2010). Summative assessments should be given at the end of instruction since they, "establish how well students have achieved learning objectives at the conclusion of the instruction" (Hockett & Doubet, 2013, p. 60). Summative assessments are assessments of learning, due to the amount of feedback about the type and amount of learning from the score and responses of the assessment (Crisp, 2012).

Summative assessments influence learning behaviors because students adjust their studying based on what they think the assessment will cover (Gielen et al., 2003). Summative assessments have a large influence on the attention of students, due to the larger stake consequences of the assessment (Crisp, 2012). This is especially true as students accomplish higher forms of education where the basis of most final grades attained in college focuses on summative assessments.

Summative assessments are meant to provide feedback and allow educators to analyze the teaching and learning process (Northern Illinois University, n.d.). At the end of the unit, the summative assessment is meant for students to demonstrate what was learned and how well it was learned (Johnson & Jenkins, 2003). "When summative and formative assessments are aligned, they can inform the instructional process and support both the daily instructional practices of teachers as well as the longer-term planning of curricula and instruction" (Johnson & Jenkins, 2003, p. 7).

Learning cycles. A learning cycle is a specific curricular format allowing students to become fully involved in a unit and is meant to align with standards (Duran et al., 2011). Duran, Duran, Haney, and Scheuermann stated, "learning cycles are research-based teaching tools that can help students explore concepts in science and assist teachers as they plan lessons intended to facilitate meaningful and deep understanding of the concepts being taught" (2011, p. 60). Learning cycles are intended to get students to think about new content, rather than just presenting students with the content they are expected to memorize.

Learning cycles encourage students to use mental processes to solve problems, resulting in more effective learning (Gang, 1995). Learning cycles are also effective because they let students to build concepts and to also use process skills (Gang, 1995). Inquiry, in general, is used to help students focus on content knowledge while allowing students to develop their understanding of science (Dunkhase, 2003).

There are multiple forms of learning cycles educators use in curriculum development. Learning cycles range from three-part learning cycles to more elaborate seven-part learning cycles (Figure 2). Depending on the model of learning cycle used, students are required to achieve the same end result, just the number of stages changes (Eisenkraft, 2003). Regardless of the number of parts to a learning cycle, all are structured to reach the same goal: facilitating learning to allow students to become interested in learning.

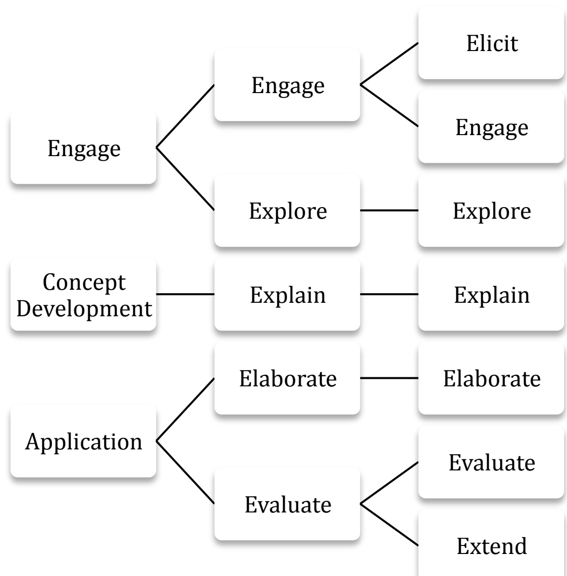

Figure 2. Variations of learning cycles. This image shows the components that comprise the three, five, and seven part learning cycles and their connectedness. Adapted from Eisenkraft, 2003, p. 57.

Regardless of which model one uses, all learning cycles use the first stage to gain the interests of students (Dunkhase, 2003). When students are provided time to explore content on their own, they begin to develop their own questions for further investigation. As students are guided through the middle portions of a learning cycle, teachers direct them towards the unit content. During the middle portions of a learning cycle structured lesson, teachers help students reach a definitive understanding about the covered content. Throughout the entire process of a learning cycle, formative assessments are given, allowing teachers and students to determine the progress being made. Pencil and paper tests are not necessarily needed for summative assessments when using learning cycles as a form of instruction and include student debates about the content, student generated models to demonstrate their understanding, and independent scientific investigations (Dunkhase, 2003). Considering the idea behind the NGSS PEs is to move away from the typical form of summative assessments, teachers must find more creative ways for students to demonstrate the desired outcome and learning of the unit.

Importance of Teaching Evolution

Students have many questions about why things are the way they are. For example: why are there so many different types of organisms and how can there be similarities between different organisms? Many students fail to realize that the reason for similarities in different organisms is because those organisms are related to one another and that they come from common ancestors (National Academy of Sciences, 1998). Evolution explains why so many things are the way they currently are on our Earth, "In short, biological evolution accounts for three of the most fundamental features of the world around us: the similarities among living things, the diversity of life, and many features of the physical world we inhabit" (National Academy of Sciences, 1998, p.3).

The importance of students' understanding of the impact evolution is crucial. Part of a student understanding the idea of evolution revolves around his/her understanding of the word "theory". One reason why students struggle with the meaning of the word is the difficulty they have in distinguishing between a theory and evidence for it. Additionally, "theory" is often used in everyday language to describe a prediction based on a guess and not evidence (AAAS, 1993; Driver, Rushworth, Squires, Wood-Robinson, 1994). Consequently, the importance of evolution is often misunderstood because of its association of the word, "theory"; therefore individuals look at evolution as a process that has minimal scientific backing (Baumgartner & Duncan, 2009).

Also, for students to understand evolution and the words used to teach evolution, students must get past their misconception of what the word evolution truly means. The word 'evolution' has many connotations; but "in the broadest sense [it] explains that what we see today is different from what existed in the past" (National Academy of Sciences, 1998, p. 55). Many students believe (incorrectly) that evolution is mainly about the theory of the origin of life and that life evolves randomly (Driver et al., 1994). The theory of evolution connects among biological topics as long as students understand basic biological processes first (Cavallo & McCall, 2008; Baumgartner & Duncan, 2009).

The misconception of the theory of evolution does not only occur amongst students, but adults as well. A national poll conducted in 2013 shows 33% of Americans do not accept the theory of evolution playing a role in the development of humans and other organisms to their current form, therefore indicating that many Americans do not understand or have misconceptions of the workings of biological processes (Pew Research Center, 2013). When compared to 33 European nations, in terms of acceptance of evolution, the United States scored higher than only Turkey. With less than 40 percent of Americans surveyed accepting evolution compared to other countries that have over 80 percent acceptance, the question lingers as to what makes the United States conflicted with the acceptance of evolution (Miller, Scott, & Okamoto, 2006)?

There are three reasons suggesting why evolution is not easily understood and endorsed by Americans: 1) religious views follow the teaching of the biblical literature of Genesis, 2) politics which insert demands on how evolution is viewed and taught, suggesting both creationism and evolution be taught equally, and 3) lack of a true understanding of genetics and inability to apply genetic information to the evolution of organisms (Miller et al., 2006). Many students become familiar with biblical literature as they are taught the information at a young age, resulting in evolution being misunderstood. Politics determine messages conveyed to the public and what gets taught in public classrooms, leading students to a swayed perception of evolution and creationism. Lastly, genetics is a concept that is especially tough for young students to understanding, which is a form of evidence that supports the role of evolution for all organisms, including humans (Miller et al., 2006). When any of the three pertinent issues exist, further work needs to be done so individuals can overcome the lack of understanding of evolution.

Educators have a large impact on student learning the content of evolution. Unfortunately, "students enter their classrooms with little scientific understanding of evolutionary processes, but hold many beliefs about the theory" (Cavallo & McCall, 2008, p. 522). Recognizing what students understand about the topic of natural selection is the starting point of creating curriculum that addresses evolutionary biology (Baumgartner & Duncan, 2009, p. 219). Students understand that organisms have adaptations that enable their survival and that successful adaptations become prominent in populations over a period of time, but students believe that the adaptations take place in response to the change in the environment. As such, teachers must work to explicitly address the misconception (Malone, 2012).

The debate within the scientific community regarding whether evolution has taken place is over, but how evolution has taken place still remains as a current debate (Skehan & Nelson, 2000). The exact details of “the processes and mechanisms producing change and what has happened during the history of the universe” are still unknown (Skehan & Nelson, 2000, p. 53). However, there is plenty of evidence teachers can use to support the instruction of evolution. For example, “scientific evidence ranging from the fossil record to genetic relationships among species” is easily integrated into curricular materials and examined by students (Bybee, 2013, p. 17). Evolution can be used to explain what and how historical phenomena happened, because fossils demonstrate patterns of organisms over a wide range of time. Additionally, comparing embryos of vastly different organisms illustrates patterns seen at the beginning stages of creation (Quammen, 2004). A discussion with students about fossils and organism development reinforce the theory of evolution and justifies the wide variety of life that currently exists on earth today (Cavallo & McCall, 2008).

In addition to using scientific evidence when educating students on evolution, there are plenty of additional resources to help teachers reinforce the topic of evolution. Evolution can be used to connect students to many current events in the world so that students can see the connection of evolution to existing topics, as it is “an important one, more crucial nowadays to human welfare, to medical science, and to our understanding of the world than ever before" (Quammen, 2004). Teachers have the responsibility to educate students in science, so when they teach biological evolution they have to address a variety of beliefs from the public because their students bring those ideas with them into classroom (Bilica, 2012). Evolution is discussed in many of the NGSS PEs and better student understandings allows students to see the role it plays in the area of life science.

The National Science Teachers Association (NSTA) gave their full support to teachers on the teaching of evolution. In fact, NSTA supports using evolution as a unifying concept and to explain multiple scientific events (National Science Teachers Association, 2013). Similarly, publishers of textbooks should also use evolution as a unifying concept, within their publications (Skehan & Nelson, 2000). The Iowa Core showed support of teaching evolution as well, since one of their standards focuses on the biological adaptations in populations (Bilica, 2012; Iowa Department of Education, 2010). The NGSS not only includes the concept of evolution, but also diversity, natural selection, and adaptation (Achieve Inc., 2013a).

NGSS is a relatively new concept to the teaching world. To assist educators with understanding the new standards, breaking down the standards properly aids in what concepts need to be taught, as well as misconceptions students may have prior to beginning the standard. The work of writing effective lesson plans that support research allows essential questions to be properly answered and assessments that reflect the concepts gained by students.

CHAPTER 3

Project

As the process of implementing the NGSS began at Keokuk Community School District, curriculum was revamped and discussed to guarantee that every PE is addressed and taught throughout a child's education. The process explained in Chapter 2 was applied, to ensure the selected standards are used properly in the classroom to best improve student learning. Three PEs, MS-LS4-1, MS-LS4-2, and MS-L4-3, were selected and bundled together to create a unit titled "Natural Selection and Adaptation" (Table 1).

Table 1

Selected Performance Expectations for the Unit Titled "Natural Selection and Adaptation"

PE	PE Description
MS-LS4-1	Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and changes of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
MS-LS4-2	Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
MS-LS4-3	Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.

All three PEs were bundled based on several similarities: they cover many of the same DCIs, are connected by the "patterns" of crosscutting concepts, and are found under the topic of Biological Evolution: Unity and Diversity from NGSS. Below is the process used to develop curriculum based on the selected PEs, which followed the UbD process of curriculum development.

Part 1 & 2: Unpacking and KUDs

The selected PEs were examined and the skills and concepts students should gain from completing instruction on the PEs were determined. Once the skills and concepts were determined, the PEs were examined for what students should know, understand, and be able to do as a result of mastering the designated PEs. Both steps were merged together, since once the skills and concepts were identified, KUDs can be addressed. Tables 2, 3 and 4 demonstrate how unpacking took place to determine the Knows, Understands, and Dos of each PE. In order to unpack a PE, verbs identified the skills performed by students and nouns categorized the concepts students show know and understand. Italicizing and underlining words made it clear how each PE was broken up into skills and concepts.

Table 2

KUDs for MS-LS4-1: *Analyze and interpret data for patterns*[1] in the fossil record that document the existence, diversity, extinction, and changes of life forms[2] throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

Know	**Understand**	**Do**
Prior Vocabulary • Analyze • Interpret • Data • Patterns • Fossils • Change *New Concepts* • Fossil record • Document • Existence • Diversity • Extinction • Life forms • Natural laws	• Use graphs, charts, and images to identify patterns in data. • Layering of fossils shows existence, diversity, extinction, and change of many life forms.	• Analyze and interpret data to determine similarities and differences in findings.

[1] Italics indicate skills (verbs) students should be able to perform
[2] Underlining indicates concepts (nouns) student should know and understand

Table 3

KUDS for MS-LS4-2: Apply scientific ideas to *construct an explanation* for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to *infer* evolutionary relationships.

Know	**Understand**	**Do**
Prior Vocabulary • Apply • Scientific ideas • Fossils • Construct • Similar • Different *New Concepts* • Organisms • Anatomy • Explanations can vary • Evolution • Relationships – there are many uses for this word	• Patterns can be used to identify cause and effect relationships. • Anatomical similarities and differences can be used to connect living organisms to fossils.	• Apply scientific ideas to construct an explanation for real-world phenomena, examples, or events.

Table 4

KUDs for MS-LS4-3: Analyze displays of *pictorial data* to *compare patterns* of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.

Know	Understand	Do
Prior Vocabulary • Analyze • Data • Patterns • Similar	• Compare embryological development of different species to reveal similarities and show relationships. • Use graphs, charts, and images to identify patterns in data.	• Analyze displays of data to identify linear and nonlinear relationships.
New Concepts • Anatomy – vocabulary • Embryo – different stages of development show different amounts of character • Relationships – there are many uses for this word • Species		

Part 3: CTS

The process of completing a CTS required multiple sources and is a compilation of content I needed to fully understand the selected three PEs. Once the CTS was completed, the process of developing curriculum becomes one step closer. The Curriculum Topic Study I completed for the three selected PEs is found in Appendix B.

Part 4: KUD Revision

Once I completed the CTS, I revised the KUDs, as student misconceptions and prior knowledge were addressed during the process. Modifications were made during the revision process after examining the concepts and content students should know by certain grade levels/adults and misconceptions students have about concepts. The final and modified KUDs are listed above in Tables 1, 2, and 3.

Part 5: Writing Essential Questions

After completing the CTS, I developed two essential questions to highlight the big ideas of the unit and outline what students should be able to answer after completion of the unit and they are:

- What evidence exists to show that different species are related?
- How does the environment influence genetic traits in populations over multiple generations?

Both essential questions are focused on the selected content, are open-ended, require students to make judgments, and generate responses that can be supported by data. As such, they follow the criteria for good essential questions.

Part 6: Probes for Pre-Assessments and Formative Assessments

Two probes were selected to assess students on their knowledge; one on theory and the other on biological evolution and both are used as pre-assessments and formative assessments. Prior to starting the content covered about theories and biological evolution, students completed the two probes as an ungraded pre-assessment. Three days after covering the content of theories and two days after biological evolution, students were given back their probe they completed as a pre-assessment and corrected/changed their thoughts if needed. Once students updated and made the necessary changes to their probes, their answers were assessed to gather information about whether or not students comprehended the information that was covered. The probes were not used as a grade in the grade book but as an indication of whether or not students understood the content, to continue with the content, or if more time needs to be used to re-teach and further cover concepts before moving on with the next concept. Students revisited both probes one time and updated their responses before completing it again, so responses can be assessed for conceptual growth. The probes I used were modified from Page Keeley's probes (Keeley, Eberle, & Dorsey, 2008; Keeley & Tugel, 2009) and are found in Appendix C.

Another form of formative assessments that were used to evaluate student understanding were a variety of activity sheets for the lessons (Appendix D). The activity sheets were written after the creation of the summative assessments, while writing the UbD unit lesson plans. The responses from students on each activity provided information about how well students understood the topics from the lessons, as well as their ability to apply concepts gained from each activity. I anticipated modifying further instruction once I assessed their learning based on student responses to these activities, just as I did with the probes.

Each activity aligns with one of the three selected PEs. Before moving on to the next part of the learning cycle lessons, I used student responses to determine if more instruction or clarification needed to be given. The activities provided students the opportunity to use newly learned information and/or data to indicate their understanding as the unit progressed.

Part 7: Summative Assessments

Once students completed the lessons for the three selected PEs, they moved on to the last stage of the unit where summative assessments were used. Each summative assessment was created with the previously listed KUDs to ensure that students were assessed on the Understands and Dos identified during Part 1 and 2. For MS-LS4-1, students use data to identify similarities and differences in layered fossils to show diversity and change; MS-LS4-2, students construct an explanation about patterns in anatomical similarities and differences of current and past organisms; MS-LS4-3, students use data to identify patterns in embryological development. The assessments focus on the items in the Understand and Do category, since items listed in the Know portion includes content that must be applied as students demonstrate their ability to complete the Understands and Dos. The summative assessments are found in Appendix E.

As I created the four summative assessments for these PEs, I continually looked at the work completed during the unpacking process and from the CTS. The assessments truly reflect what knowledge I want my students to demonstrate. Since there are few resources available for teachers that align with the NGSS, the four summative assessments included as part of the project were created to be used in my classroom, as there are no assessments yet available for use that are aligned with NGSS and to ensure they aligned with the work done previously during the KUD and CTS portions of this project. I wanted to ensure that students were being assessed on what the standards intend to assess and the UbD process completed as part of this project focuses on evaluating students on what should have been taught to align curriculum with the PEs.

Three of the four summative assessments created for this UbD unit act as quizzes, where students apply their content knowledge from the recently completed PE. The fourth summative assessment acts as the final assessment, where content from all three

PEs were applied as students completed the assessment. Students completed all four assessments individually, as a paper-pencil assessment.

MS-LS4-1 states students should use data to explain how similarities and differences exist in the fossil record, therefore leading me to develop an assessment where students used their understanding about the fossil record to describe the image presented to them. The second summative assessment, for MS-LS4-2, has students explain their understanding of evolution when addressing similarities and differences of previous and current organisms, so the assessment created has students compare and contrast two organisms as well as the reasoning why they would determine they are related. PE MS-LS4-3 assessed students on their ability to use data to explain relationships between various organisms by simply looking at the different stages of development, resulting in the assessment to have students analyze data from an image and create a flowchart showing the relationship of how organisms go from similar to dissimilar. Lastly, the comprehensive assessment was created to see if students would be able to merge and apply the three concepts together for the PEs, determining if student saw a connection between the overlapping concepts. In order the take the three PEs concepts of fossil records, anatomical similarities, and embryological development, a paper and pencil test allows for students to apply and combine their thoughts and knowledge.

Part 8: Lesson Plans

Lesson plans are arranged in the form of 3-part learning cycles. During the creation of the lesson plan, I constantly reflected on what students should Know, Understand and Do to ensure that I met the three bundled PEs. The summative assessments were given at the end of instruction for each PE and a final comprehensive summative assessment at the very end of the unit. The comprehensive summative assessment brings together all three PEs from the three 3-part learning cycles and students apply content learned from each. The lesson plan calendar and teacher notes are in Appendix F.

Two of the three selected PEs are new to my curriculum for the 2014-2015 school year. Lessons were inspired by a variety of lessons posted on the Internet and modified as needed to meet the selected PEs. All lesson plans encourage students to think about their learning experiences and reflect on the content/concepts to draw conclusions about each activity.

Table 5

Calendar of Activities Taught During the 3-Part Learning Cycle for MS-LS4-1: Analyze and Interpret Data for Patterns in the Fossil Record that Document the Existence, Diversity, Extinction, and Changes of Life Forms Throughout the History of Life on Earth Under the Assumption that Natural Laws Operate Today as in the Past

Learning Cycle Stage	**Title**	**Description**	**Time Needed to Complete**
Pre-Assessment	"Is It a Theory? Probe"	Students complete a probe to pre-assess student knowledge of the word "theory".	Beginning part of Day 1
Engage	"Sequencing Time"	Students arrange when a variety of events took place in their life. From there, a variety of random events will be pulled for students as a class to sort chronologically.	Remainder of Day 1
Concept Development	"Fossil Tour"	Students take part in the web activity. Once the web activity has been completed, students then describe and illustrate the needed steps to become part of the fossil record.	Majority of Day 2
Concept Development	Theory Discussion	Students participate in a discussion about the meaning of theory.	End of Day 2
Concept Development	"Stories From the Fossil Record"	Students take part in the web activity. As they complete the web activity, students complete the Evidence Chart.	Day 3
Application	"How Whales Evolved"	Students are given a set of drawings of past organisms. Students organize the images to show how whales evolved, based on patterns of the images. Students then explain their hypothesis of how the organisms changed over time.	Beginning part of Day 4
Formative Assessment	"Is It a Theory? Probe?	Students complete a probe to review/update student understandings of the word "theory".	Part of Day 4
Summative Assessment	"Assessment for MS-LS4-1"	After looking at a fossil record, students explain how current and former organisms look similar and different.	Remainder of Day 4

Table 6

Calendar of Activities Taught During the 3-Part Learning Cycle for MS-LS4-2: Apply Scientific Ideas to Construct an Explanation for the Anatomical Similarities and Differences Among Modern Organisms and Between Modern and Fossil Organisms to Infer Evolutionary Relationships

Learning Cycle Stage	**Title**	**Description**	**Time Needed to Complete**
Pre-Assessment	"Biological Evolution Probe"	Students complete a probe to pre-assess student knowledge of the biological evolution.	Beginning part of Day 5
Engage	"Fossil Lab Hunt"	Students assemble fossils, as more and more get "discovered". Students hypothesize as to what animal they have, as well as what similarities it has with current organisms.	Remainder of Day 5
Concept Development	"Life has a History"	Students take part in the web activity about the history of life and diversity we see of organisms. As students complete the web activity, students complete a scavenger hunt for the lesson.	Day 6
Formative Assessment	Biological Evolution Probe	Students complete a probe to review/update student understandings of the meaning of biological evolution.	Beginning of Day 7
Application	"What's Next"	Students select a current animal, add on features to improve the current organism and explain how the additions will improve the current organism. Lastly, students select an organism that they believe would be related to their original organism, as well as describing how the organisms would be related.	Remainder of Day 7
Summative Assessment	"Assessment for MS-LS4-2"	Students compare and contrast a current and former organism based on evidence provided in an image.	Day 8

Table 7

Calendar of Activities Taught During the 3-Part Learning Cycle for MS-LS4-3: Analyze Displays of Pictorial Data to Compare Patterns of Similarities in the Embryological Development Across Multiple Species to Identify Relationships Not Evident in the Fully Formed Anatomy

Learning Cycle Stage	**Title**	**Description**	**Time Needed to Complete**
Engage	"Which Organism Is It?"	Students are given a series of pictures and cards with names of organisms. Students match the names of the organisms with the series of embryo pictures.	Day 9
Concept Development	"Identify the Embryo"	Students select two organisms from a list and research them on the Internet, looking up what the organisms look like at the embryo stage and what they look like at the end of development. Students will print off the images for each organism.	Day 10
Application	"Compare Your Organisms"	Students analyze their selected organisms and complete a Venn diagram of how the 2 images look as an embryo. Another Venn diagram will be completed to show how the 2 images look as fully developed.	Day 11
Summative Assessment	"Assessment for MS-LS4-3"	Students explain how various organisms go from looking similar to looking different.	Day 12
Final Summative Assessment	"Final Unit Assessment for MS-LS4-1 to MS-LS4-3"	Students combine all content learned from the unit and apply information.	Day 13

CHAPTER 4

Reflection on the Project

Professional Community Impacted

The science department at the school where I teach has worked together to ensure every part of NGSS is covered in our classrooms. Many of them are unsure how to tackle creating units that align with the standards. This unit and the process I used to design it serves as a model to other science teachers who wish to create their own NGSS aligned curriculum. I have already provided the science staff at my school with the document titled “Process of Creating UbD Unit Lessons”, which details the method followed to complete an UbD lesson plan for the NGSS. Many of my colleagues found it to be a useful tool in how to go about the curriculum work for NGSS. This document was also shared with the other science teachers in our AEA monthly meetings as a resource to guide them in creating their own UbD units.

In particular, there is one member of the science department who utilized the work completed from this creative component. She teaches two sections of seventh grade Life Science and implemented the same lesson plans, labs, assessments and activities as I did in my classroom. I also collaborated with her at the beginning stage of writing the UBD lesson plans, as I wanted to check that she agreed with how I unpacked the 3 PEs and the Know, Understand, and Do’s. She also provided me with feedback about how each lesson went in her classroom, as well as instructions/activities that her students struggled with. Feedback was provided through face-to-face conversations, where we discussed what worked in the classroom and what did not. Also, discussion of student responses to instruction and activities took place through the weeks of unit implementation.

As NGSS continues to be an educational document accepted by more and more states, teachers must to be able to understand the meaning behind each PE. Teachers need to update their curriculum to ensure that students are learning the appropriate content at the right age range in school, so students are well informed about all aspects of science. The work completed from this creative component allows others to see the benefit and ease of using NGSS in their classrooms and how to achieve the goal of implementing the NGSS.

Possible Changes Upon Reflection

As I reflect how this unit went as a whole, based on activity and assessment scores, I truly feel students benefited from the variety of activities, discussion, and assessments. My opinion is supported by data from their final assessment piece. The unit assessment in previous years focused on a large variety of factual content and did not focus on the big concepts about evolution or require students to apply the concepts learned. The newly created final assessment allowed students to apply content from three PEs that connected together, demonstrating their knowledge on the three PEs together.

When comparing data from previous years' assessments from content covered from this unit, the class averages from previous years were lower; indicating student understanding was not as high previous to the implementation of this unit (Figure 3). When I averaged how students did on this year's assessment, students scored at a 93%. This is an improvement from the previous five years of test scores and I am happy that the scores reflected the students understanding the curriculum at a deeper level and ability to apply concepts learned. When comparing data from 2010-2011 and 2014-2015, the students from the school year of 2010-2011 were a higher achieving academic class throughout the entire school year; therefore resulting in higher scores on all assessments completed that school year.

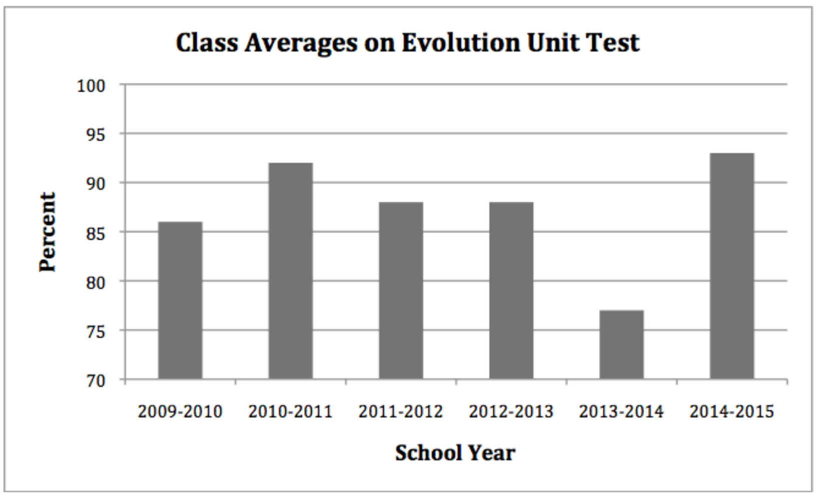

Figure 3. Average evolution unit test scores. Average classroom student data about the concept of evolution over six years.

After implementing this UbD unit, I personally would like to include additional readings from outside sources, to provide students with additional evidence as a supplemental learning resource. Reading is always something that is encouraged in all classrooms, so I would like to include more opportunities for students. I think students would appreciate having the chance to find these outside sources themselves that support what is being learned during the unit. Students not only look for and read articles about the subject matter, but also about studies that have been completed, as well as the history behind the content. I believe students value learning when they make it their own and also provides students the chance to find reading materials on their own that they personally find interesting. The learning process, in a student-centered classroom, allows for students to learn independently (Cubukcu, 2012). Students finding supplemental reading materials allows the students to play a role in their education, resulting in a way of developing a student-centered classroom (Cubukcu, 2012). I am not sure how much leniency would be given to the students as they perform their research, as many factors will play into the success of discovering outside resources.

When reflecting about how each part of the unit went, there are many changes I would like to implement next year. Specifically, given student answers from probes, it was hard to determine how far off students were with their answers on the two formative assessment probes. A rubric would allow me to better assess where students knowledge stand in the provided subjects. This would also provide me a clearer sense of exactly what to look for when evaluating the answers from their probes. Once completing the "Is it a Theory? Probe", more time spent discussing the meaning of the word 'theory' would better address student misconceptions and lead students to better understanding.

The lesson titled "Fossil Tour" needs improvement. Based on student comments and responses, I found that students struggled with creating a diagram of the process of becoming a fossil based on the type and amount of information provided from the lesson. Considering the tour actually provides students with a diagram of the process of becoming a fossil at the end of the tour, many students did not realize and/or understand the answer that was provided at the end of the lesson. Only a small handful of students realized this and provided the exact diagram provided from the website as their answer, which was not the purpose of the activity. I wanted students to reflect on the information they had read about while completing the activity to derive their answers, not simply finding the diagram at the end of the online tour. I struggle with removing this activity from the unit though, as it gave students a nice idea about the work involved in forming fossils and an introductory activity about the fossil record.

As students completed the "Life Has a History" activity, many students struggled with answering the questions on their provided activity sheet. In future years I am going to specifically state that the answers are found in the same order as they complete the website's activity. Many students had to go back through the website, as they were expecting the questions to be mixed up and not follow the natural flow of how the website was designed. The simple statement to my students that the answers are in order, although not explicitly stated, will resolve this issue. I wanted students to focus on the content, not searching for answers all over their page.

Lastly, a major addition is to include rubrics for scoring the four summative assessments from the unit. I forgot to include this portion for the unit, which is an important step for UbD lessons and ensures fair grading. Students provided answers that made me question the correctness of their answer and if I used a rubric to assess student answers, I would have been more certain I graded all students fairly. For example, on the final assessment students provided partial answers about evidence that supports the organisms being related and the use of the provided terms in their answers. Even though I listed creating rubrics as part of the "Process of Creating UbD Lessons," I did not follow my suggestion and this made grading their assessments fairly much more difficult. I also would like to provide students with the same rubric that will be used to score their final unit assessment piece, so students will know how they are graded and what I am looking for before they even begin working on the final assessment. When a clear picture of teacher expectations is provided to the students, students work towards the needed requirements with much less confusion (Brophy, 1987).

Professional Growth

The creative component I completed is a true collection of what I learned from the UNI Masters program, as well as a reflection of the type of teacher I am and how I believe students learn content. As the NGSS are considered for adoption in the state of Iowa, I feel very confident in my learning from Masters program that the resources I provided my colleagues will aid them in using NGSS appropriately in their classrooms. Instead of creating labs and learning activities around the standard and then creating an assessment for the end of the unit, a method was followed to ensure that students were being properly assessed on the standard, lessons pertained directly to the standard, and that multiple opportunities were provided for students to demonstrate their understanding of the content covered.

I will, of course, continue to develop UbD unit lesson plans for the remaining NGSS selected for seventh grade Life Science students. The groundwork and curriculum created during this project allow me to reflect back as new curriculum is developed. I can create a UbD unit lesson plan that aligns with NGSS properly, as my knowledge learned through the Master’s program and completion of this creative component provided me with instruction, confidence, and knowledge to thoroughly educate my students on the PEs meant to be covered within a school year. It is also very reassuring to know that when people talk about the NGSS and are skeptical of what it entails I can educate them on what NGSS means and how it is an important and positive turn for the world of science education.

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APPENDIX A: Process of Creating UbD Unit Lessons

Process of Creating UbD Unit Lessons

UbD: Stages of Backward Design

1. Identify desired results → CTS, Iowa Core Curriculum for Science, NGSS, KUDs, Essential Questions
2. Determine acceptable evidence → Formative and Summative Assessments Rubric Work
3. Plan learning experiences and instruction → Learning Cycle, Iowa Core ELA and Math

How to go about the UbD Process:

1. Unpack performance expectation – look at each word in the performance expectation and determine if it is skill or concept
    - Concepts (important nouns and noun phrases) are underlined and are what students need to KNOW and UNDERSTAND
    - Skills (verbs) are circled and are what students need to be able to DO and apply
2. Know, Understand, Do (KUD's) – take words underlined and circled and then create Knows, Understands, and Do's. http://assessment.aaas.org/topics to help with writing them under the sub-ideas
    - Know – facts, vocabulary, formulas, prior (look through previous PE's to see if terminology has been taught)
    - Do – what should students eventually be able to do as a result of the knowledge and skills acquired in the unit → *Science & Engineering Practices* are the Do's (skills)
    - Understand – what will students need to understand/big concepts (Essential learning goals) by the end of the unit → *DCI's and Cross-Cutting Concepts* are the Understands
3. CTS (Curriculum Topic Study) https://docs.google.com/a/uni.edu/document/d/1t4MJEMguF8chpCFXNLQWqjVDz9SVpsLgEFYw0qCKLb8/edit is the template
    - Complete 7 parts of CTS. Science Curriculum Topic Study book is used to see what pages and where to answer the 7 parts. https://docs.google.com/a/uni.edu/file/d/0B657HQBh2PHpbkJUYkVOeThWeGc/edit
        1. SFAA to demonstrate what all adult Americans should know. http://www.project2061.org/publications/sfaa/online/sfaatoc.htm and Science Matter Book and AAAS http://assessment.aaas.org/topics to see misconceptions and how many based on grade have the misconception. *Science Matters → use CTS Section 1B handout for page numbers*
        2. Instructional Implications for Benchmarks and NSES http://www.nap.edu/catalog.php?record_id=4962#
        3. Benchmarks http://www.project2061.org/publications/bsl/online/index.php?txtRef=

http%3A%2F%2Fwww.aaas.org%2Fsearch%2Fgss%2Fbenchmarks&txtURIOld=%2Ftools%2Fbenchol%2Fbolframe.html and NSES http://www.nap.edu/catalog.php?record_id=4962#

4. Benchmarks http://www.project2061.org/publications/bsl/online/index.php?txtRef=http%3A%2F%2Fwww.aaas.org%2Fsearch%2Fgss%2Fbenchmarks&txtURIOld=%2Ftools%2Fbenchol%2Fbolframe.html and Making Sense of Secondary Science BOOK
5. Atlas http://strandmaps.nsdl.org/
6. State Standards (Iowa Core) https://www.educateiowa.gov/iowacore
7. CTS Updates to Framework on WEBSITE https://docs.google.com/a/uni.edu/file/d/0B657HQBh2PHpbkJUYkVOeThWeGc/edit

4. KUD revision – modify KUD's based on information collected from CTS
5. Writing Essential Questions
   - Begin combining sub-units based on P.E and Crosscutting Concepts.
   - Use "Framework for K-12 for Science Education Essential Questions" to see essential questions
   - Things to consider when creating essential questions:
     - Have a relationship between ideas and helps us make sense out of confusing things
     - Asks for meaning, using reasoning, not recall
     - Isn't googleable
     - Not a yes or no question/answer (open-ended/more than one answer) and is arguable
     - Uses prior knowledge to answer
     - Leads to more questions and provokes discussion
     - Uses analysis
     - Higher order questions
     - Relates to big idea
     - Gets revisited and recurs throughout one's life
     - Sparks connections with prior learning and experiences
     - To the student, not the teacher
   - Sites to help with Essential Questions
     1. essentialquestions.org → 25 Essential Questions and EQ Exchange
     2. July 15 – am – Framework for Science Ed. Essential Questions https://docs.google.com/a/uni.edu/file/d/0B657HQBh2PHpUVFRaWpfMHBUN2c/edit
     3. bit.ly/gwiggins
   - What's the intent of the question? → Determines a successful question
   - 2 types of Essential Questions
     1. Overarching
     2. Topics

- 2-5 E.Q. per unit is the *recommendation*
- Encourage "argument" and NOT "opinion" (Data + claim = argument)

6. Probes for F.A. and Misconceptions – look at PE and U and D's
   - http://www.uncoveringstudentideas.org/science_tools (tells us which Keely probes to use for which DCI)
   - http://assessment.aaas.org/topics
   - Use Planning for a Pre-assessment for Readiness to identify student answers on probes, which in turn determines what type of knowledge they have and what they need to do next (similar to a rubric)
7. Devise summative assessment based on the P.E., understands, and do's. Create rubrics for the assessment
8. Begin creating/compiling Learning Cycle lessons, keeping in mind the essential questions and your KUD's

APPENDIX B: CTS Summary

CTS Summary

CTS Summary for:
MS-LS4-1 *Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and changes of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.*
MS-LS4-2 *Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.*
MS-LS4-3 *Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.*

Section 1: Adult Content Knowledge

Science for All Americans (Rutherford & Ahlgren, 1990)

- Current organisms evolved from common ancestors, even traveling back 4 billion years to unicellular organisms.
- Evolution is evidence for the variety in current living organisms, similarities in current living organisms, and fossils found one after another in layers of rock were formed billions of years ago.
- Anatomical evidence provides support of sequencing of previous organisms.
- In order to get to the complexity of organisms that currently exist, evolution took place over billions of years.
- Natural selection allows for advantages amongst organisms to successfully survive to reproduce.
- Molecular and fossil evidence support that humans came from other organisms.
- Human beings and other species have common characteristics resulting in common ancestors.
- Evidence of changing life forms are found in successive layers of rock.

Science Matters (Hazen & Trefil, 2009)

- Evolution is a testable theory that is subject to change.
- Fossils form when organisms die and are buried.
- If an organism contains hard parts of the body, there is an increased chance of it becoming a fossil.
- The history of the Earth is divided into eras based on the type of life that dominated the lands and oceans during that time.
- The human species, in regards to the history of earth, is a result of recent evolution.
- Darwin argued that evolution takes place at slow and steady rates, where small changes lead to large ones.
- Extinction is part of the process of evolution.
- The average lifetime of a species in the fossil record is a few million years.
- There have been numerous mass extinctions.
- The impact of large asteroids or comets is the suggestion reason for mass extinctions.

Section 2: Instructional Implications → By the end of 8th grade, students should know the following content.

Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993)

- Fossil evidence can be used to support evolutionary history.
- Students can understand some of the commonalities between human beings and other animals.
- Sedimentary rock records plant and animal remains, sequencing the order of appearance and disappearance.

National Science Education Standards (*National Science Education Standards: Observe, Interact, Change, Learn,* 1996)

- The idea of adaptations are often misunderstood by students, thinking that organisms deliberately adapt if their environment changes.
- The Earth's history provides evidence of populations of living organisms.

Section 3: Concepts and Specific Ideas

Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993)

- Many thousands of layers of sedimentary rock provide evidence for the long history of the earth and for the long history of changing life forms whose remains are found in the rocks. More recently deposited rock layers are more likely to contain fossils resembling existing species.
- Fossil evidence is consistent with the idea that human beings evolved from earlier species.
- Similarities among organisms are found in the internal anatomical features, which can be used to infer the degree of relatedness among organisms. In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance.
- Thousands of layers of sedimentary rock confirm the long history of the changing life forms whose remains are found in successive layers. The youngest layers are not always found on top, because of folding, breaking and uplifting of layers.

National Science Education Standards (*National Science Education Standards: Observe, Interact, Change, Learn,* 1996)

- An organism's behavior evolves through adaptation to its environment. How a species moves, obtains food, reproduces, and responds to danger are based in the species' evolutionary history.
- Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry.
- Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and

reproductive success in a particular environment. • 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 the earth no longer exist. • Fossils provide important evidence of how life and environmental conditions have changed.
Section 4: Research on Student Learning **Benchmarks for Science Literacy** (American Association for the Advancement of Science, 1993) • Students struggle with merging the two processes of evolution: the occurrence of new traits in a population and their effect on long-term survival. • Students believe that environmental conditions are responsible for changes in traits, or that organisms develop new traits because they need to survive or that they over-use or under-use certain bodily organs or abilities. • Students believe that the world was always as it is now or that changes occurred were sudden and comprehensive. **Making Sense of Secondary Science** (Driver, Rushworth, Squires, Wood-Robinson, 1994) • Students show little understanding of the organization of species, using genetics to explain groupings. • Students confuse an individual's adaptation during its lifetime with inherited changes in a population over time, believing in the inheritance of acquired characteristics. • Few students correctly apply a process of selection to explain evolutionary changes, thinking that individuals can adapt to change in the environment if they need to, and that these adaptations are inherited. • Students are often unable to show evidence of applying the concept of change and probability to inheritance and evolution.
Section 5: Examine Coherency and Articulation **Atlas of Science Literacy** (American Association for the Advancement of Science & National Science Teachers Association, 2001) • Similarities among organisms are found in internal anatomical features and patterns of development, which can be used to infer the degree of relatedness among organisms. • Patterns of human development are similar to those of other vertebrates. • More recently deposited rock layers are more likely to contain fossils resembling existing species. • Many thousands of layers of sedimentary rick provide evidence for the long history of the earth and for the long history of changing life forms whose remains are found in the rocks. • Sediments of sand and smaller particles (sometimes containing the remains of organisms) are gradually buried and are cemented together by dissolved minerals to form solid rock again.

Section 6: State Standards/Benchmarks/Essential Skills & Concepts/District Curriculum **Iowa Core Curriculum (**Iowa Department of Education, 2010) • Species acquire many of their unique characteristics through biological adaptation which involves the selection of naturally occurring variations in populations. • Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.
Section 7: CTS Update to Framework **A Framework for K-12 Science Education** (Schweingruber, Keller & Quinn, 2012) • Fossils are mineral replacements, preserved remains, or traces of organisms that lived in the past. • Thousands of layers of sedimentary rock not only provide evidence of the history of Earth itself but also of changes in organisms whose fossil remains have been found in those layers. • The collection of fossils and their placement in chronological order is known as the fossil record. • The fossil record documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. • Anatomical similarities and differences between various organisms in the fossil record enable the reconstruction of evolutionary descent. • Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully formed anatomy.

APPENDIX C: Probes

Name ___________________________
Date _____________ Period _____

Is it a Theory? Probe

Put an X next to the statements you think best apply to scientific theories.

_____ **A** Theories include observations.

_____ **B** Theories are "hunches" scientists have.

_____ **C** Theories can include personal beliefs or opinions.

_____ **D** Theories have been tested many times.

_____ **E** Theories are incomplete, temporary ideas.

_____ **F** A theory never changes.

_____ **G** Theories are inferred explanations, strongly supported by evidence.

_____ **H** A scientific law has been proven and a theory has not.

_____ **I** Theories are used to make predictions.

_____ **J** Laws are more important to science than theories.

Examine the statements you checked off. Describe what a theory in science means to you.

____

____

____

____

Scoring "Is it a Theory" Probe

Purpose: The purpose of this assessment probe is to elicit students' ideas about the nature of science and what students know about theories and how theories differ from laws.

Addressing Student Responses:

- A, D, G, and I should be checked.
- Explanations will vary, but may include the following thoughts:
  - Evidence-based explanations based on observations
  - Based on solid body of supporting evidence that has been tested and supported by multiple lines of evidence
  - Widely accepted in the scientific community
  - They can change if new evidence becomes available

Name ________________________
Date ___________ Period ____

Biological Evolution Probe

Four friends were discussing the meaning of the term *biological evolution*. This is what they said:

Mario: "I think it is another term for natural selection."

Sally: "I think it mainly explains how life started."

Carl: "I think it mainly explains how life changed after it started."

Paul: "I think it includes both how life started and how it changed after it started."

Who do you most agree with? Explain what you think biological evolution is.

____

____

____

____

____

____

____

Scoring "Biological Evolution" Probe

Purpose: The purpose of this assessment probe is to get the ideas of students about biological evolution. The probe will distinguish between student's ideas of biological evolution, origin of life, and the mechanism of biological evolution.

Addressing Student Responses:

- Carl has the best response of "I think it mainly explains how life changed after it started."
- Explanations may vary, but may include:
    - Living things share common ancestors
    - How life is diverse
    - Helps scientists explain how life started
    - Associated with chemical evolution
    - Life has branched and diversified
    - How new organisms continue to be discovered

APPENDIX D: Activity Sheets

Name ______________________________
Date __________ Period _________

Sequencing Time

Directions: Look at the events listed on the sheet below. Arrange these events in order, by placing the number 1 in front of the event that occurred first in your life, a number 2 for the second, etc…

__________ When you started second grade

__________ When you were born

__________ When you started pre-school

__________ When you learned to ride a bike

__________ When you learned to walk

__________ When you learned to read

__________ When you lost your first tooth

__________ When you entered middle school

__________ Today's date

Name ______________________
Date __________ Period _______

Fossil Tour

Directions: Create a diagram showing the steps needed to take for an organism to become part of the fossil record.

Name ________________________
Date ___________ Period ________

Stories From The Fossil Record
Evidence Chart

Directions: Complete the evidence chart as you complete the web activity about the fossil record.

Evidence	**What it tells us:**
Past Lives	
1. growth rings in fossil trees or shells	Growth rings tell us the number of years that individuals lived.
2. curled up fossil trilobites	
3. the contents of fossil nests	
4. fossils of many individuals of the same species together	
5. a change in the shape of feature over time	
Geologic Time	
1. layers in the rocks	
2. index fossils	
3. fossil shells on mountain tops	
4. identical fossils on widely separated continents	
Paleoecology	
1. fossil marine animals in the desert	
2. shapes of leaf edges	
3. tooth marks in fossil shells	
4. fossil pollen	
Biodiversity	
1. fossils of organisms no longer alive today	

2. features that are shared by more than one species	
3. the extinction of many fossil species at the same time	
4. the extinction of one group of organism, like corals, on which other organisms depend	

Name ______________________
Date __________ Period _______

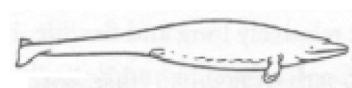
How Whales Evolved

Directions: Use the images and information below to assist in answering the next page.

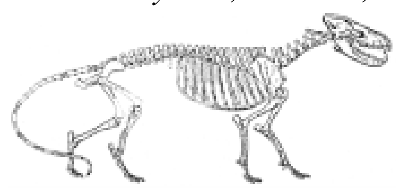
a. *Zygorhiza, Prozeuglodon, Dorudon*


a


b


c

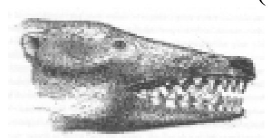
2. Mesonychids (extinct land mammals, with whale-like teeth)
   Pachyaena, Dissacus, Haplodectes

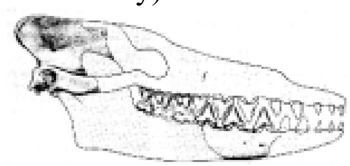

a

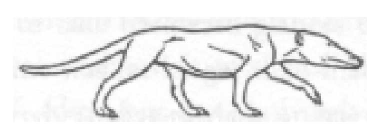

b


c

c. *Pakicetus inachus* (skull and teeth only)

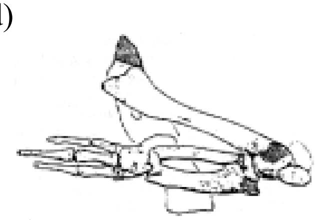

a


b


c

d. *Basilosaurus isis* (hind leg found)


a

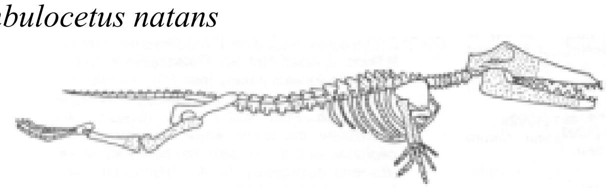


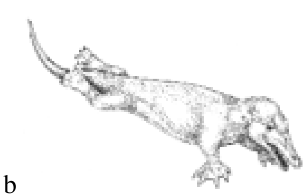
e. *Rodhocetus kasrani*

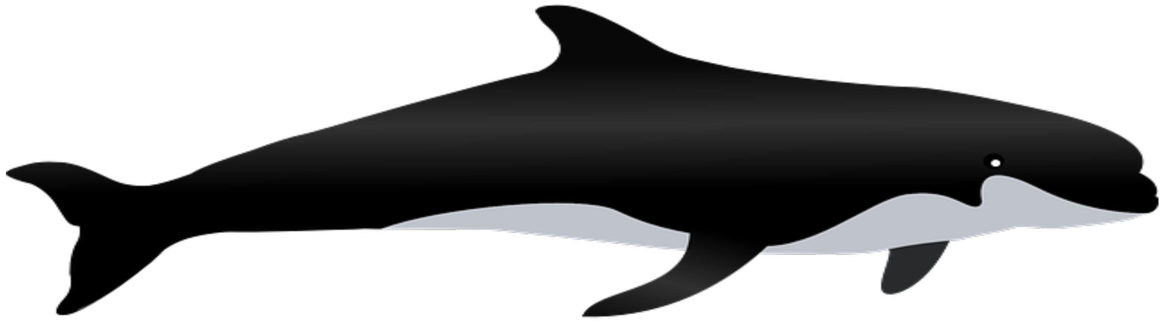

a


b

f. *Ambulocetus natans*


a


b



1. List the order of organisms that you believe that led to the evolution of the whale by using the images on the previous page. (list the names of the organisms). 1 will represent the farthest from whales and 6 will represent the closest descendants of whales.

1.
2.
3.
4.
5.
6.

3. Provide your hypothesis of how you think the whale came about from the species on the front of the page.

Name ________________________________ Period ______ Date ______________

Fossil Hunt Lab

Overview and Purpose

Only rarely are scientists lucky enough to find a complete set of fossilized bones from an animal. In most cases, they find bits and pieces. However, even without a complete skeleton, there is much scientists can learn about ancient life from even a few fragments of an ancient animal's remains. In this investigation, you will:

- analyze pieces from a model fossil skeleton
- determine the difficulties involved in interpreting fossil data

Question

You've probably seen colorful drawings and life-size models of dinosaurs and other creatures that are now extinct. You may have wondered how scientists managed to learn so much about these animals just from studying the fossilized remains. Write a question about what scientists need to look for when making inferences based on fossil evidence (or what question they need to constantly ask themselves when identifying fossils).

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Procedure

1. Imagine that it is the end of your day at a fossil site. Open your envelope and pull out **5** fossils. These are the fossils you found today. *Do **not** look at the other fossils in the envelope.*

2. Place the fossils on the table. Work with your group to arrange the fossil pieces. Spend 5 minutes considering the different combinations and whether some pieces seem to fit together. In the table, write down any ideas your group has about what types of bones and other body parts you have unearthed. Also, record any ideas about which type of animal the body parts might have come from. You can write down several possibilities.

3. Now, suppose it is Day 2 at the site. Pull **5** more fossils from your envelope. Again, do **not** look at the fossils that are still in your envelope.

4. Lay the fossils out with the fossils from the previous day. Work with your group to arrange the pieces. Spend 5 minutes doing this and looking for pieces that might fit next to other pieces. In the table, write down any ideas your group has about which types of bones or other body parts you have. Also, record any new ideas about which type of animal the body parts might have come from.

5. Repeat steps 3 and 4 (for **5** more bones) for Day 3.

Table: Fossil Observations		
	Types of Bones or Body Parts	Possible Animals
Day 1		
Day 2		
Day 3		

Observe and Analyze

1. **Model** In the space below, draw a picture of the arrangement of your pieces that seems most logical. *If you think there is more than one possible way, the pieces can be arranged into 2 drawings.*

2. **Compare** Now spend a minute visiting the other groups, to see how they have laid out their fossil finds. Did looking at other groups' fossils support your ideas or make you want to change your mind?

3. **Analyze** Look at your data table. How did your ideas about what the animal might be change from Day 1 to Day 3? Did new body parts make you change your mind about the animal or help you rule out one or more possibilities?

4. **Classify** Describe any fossils that don't seem to fit anywhere. What do you think scientists do when they find fossils that are difficult to identify?

Conclude

1. **Infer:** How do you think the animal gets around? Does it walk on land? If so, does it walk on 2 legs or 4? (Flies or swims?) Explain why you think this.

2. **Infer:** What kind of animal do you think you have? Does it remind you of any animals living today?

3. **Identify Limits:** What type of information is not provided by your paper fossils and the data you gathered in your fossil hunt?

4. **Evaluate:** A paleontologist is a scientist who studies and interprets fossils. Based on your experience as a fossil hunter today, what skills do you think would be important for a paleontologist to have?

5. **Apply:** Scientists can get things wrong. In the late 1800's, scientists reconstructed a skeleton of a newly discovered dinosaur (now known as *Apatosaurus*) even though they didn't have all of its bones. They set up the dinosaur skeleton in a museum. At the time, some scientists questioned the accuracy of the reconstruction. Nearly 100 years later, scientists finally proved that the skull that had been placed on the *Apatosaurus* skeleton actually belonged to another type of dinosaur (*Camarasaurus)*. How do you think a mistake like this can happen? How can scientists try to prevent such mistakes?

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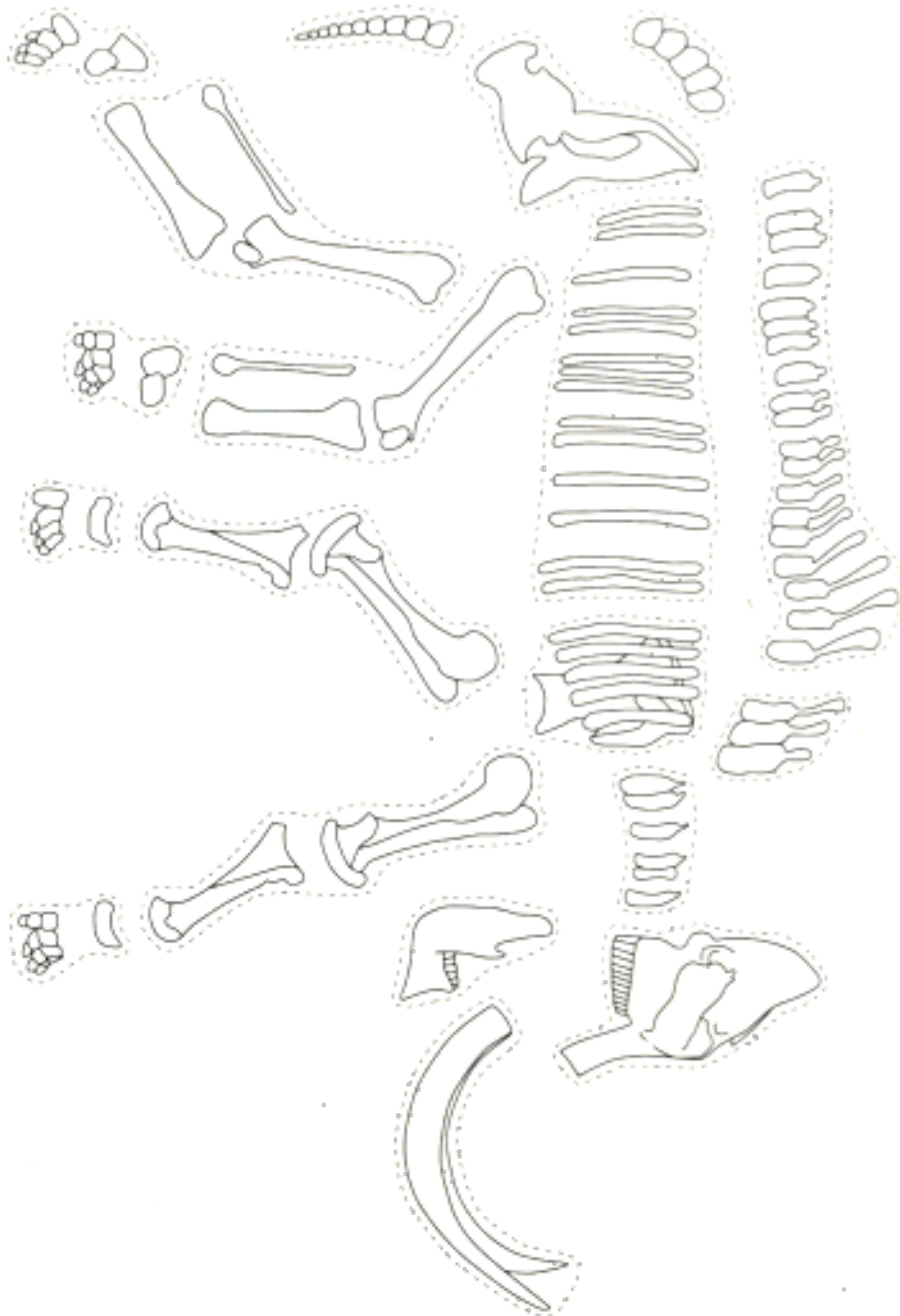
Fossil Hunt Lab "Bones"



Name ______________________
Date __________ Period _______

Life Has a History

Directions: Go to http://ucmp.berkeley.edu/explotime.html and selected "Life Has a History". Then selected "Level 2". As you navigate through *Life Has A History*, keep your eyes open for answers to the following questions.

1. Find the information describing the 30 million species of living organisms. Of the 30 million, how many are NOT animals? (HINT: Subtract the total number of animal species currently known.)

2. Find the three lens views comparing the oceans through time. Name one animal common to today's ocean whose relatives were also around 470 million years ago.

3. Find the timeline. How many millions of years did dinosaurs exist on Earth before they became extinct? (HINT: Subtract)

4. Find and name at least five things other than bones that can be preserved as fossils.

5. Find a picture of *Deinonychus* and three of its relatives. What feature do the birds all share that *Deinonychus* does not?

6. During this tour, you will learn about cladograms. When you reach that point, complete this sentence:

A cladogram is a diagram that shows…

7. Find the bar graph that shows the differences in beak size among three species of Galápagos finches. Name the species of finch that has a beak that can be longer than 15 mm.

8. Find the page showing three graphs side by side. The graph on the right shows an increase in the finch's body and bill size. Why did that happen?

Name ___________________________
Date ________________ Period _____

What's Next

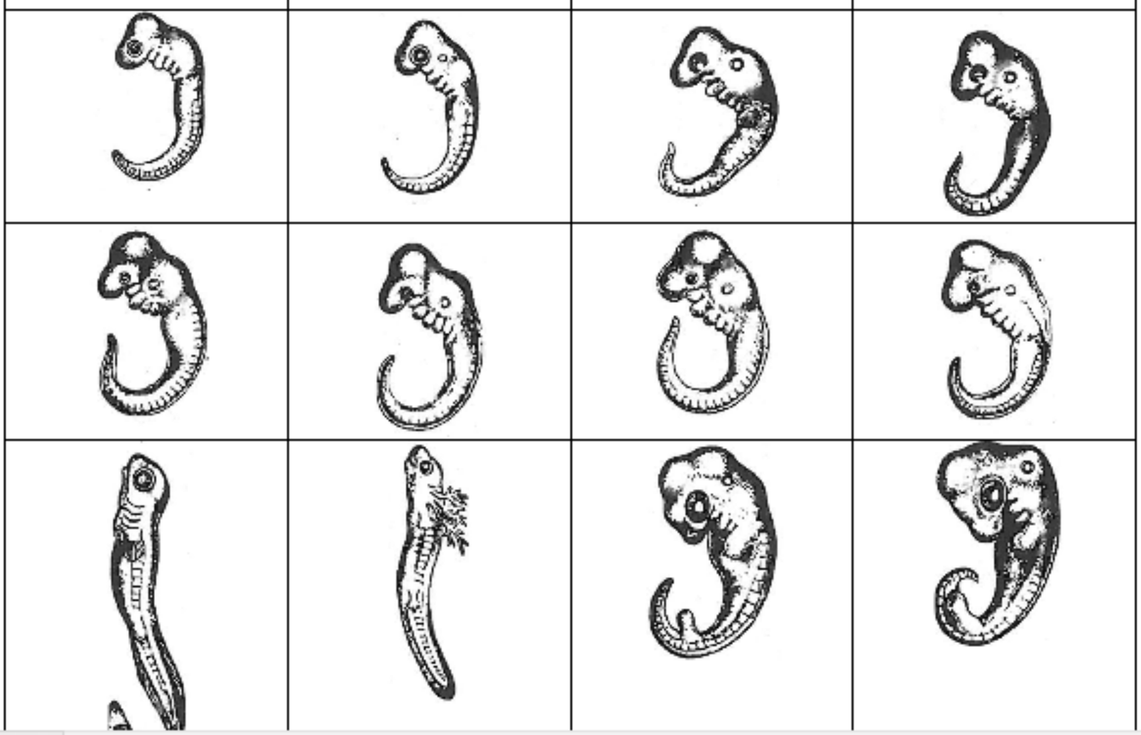
1. Select an organism and write name below.

2. Roll the dice <u>once</u> to determine what feature improves the current organism AND explain how the improvement will better the current organism. (You may either draw the improved feature on the organism or use words to describe the improved feature on the organism.)
   Dice meanings: 1-longer tail, 2-longer appendages, 3-stronger/bigger muscles, 4-bigger nose, 5-shorter appendages, 6-shorter hair/fur

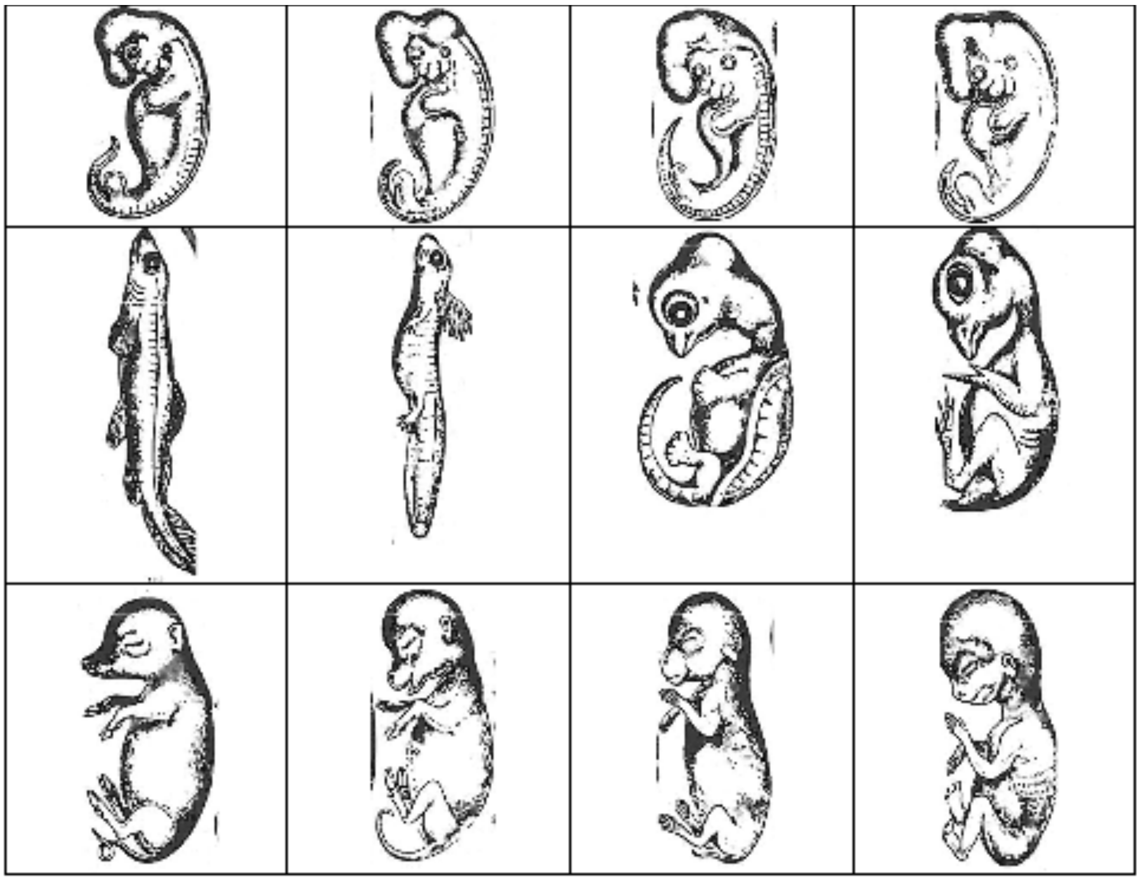
3. Now, select an organism that you believe would be related to the new organism and explain why you think they are related (provide multiple examples of evidence).

Cards for "Which Organism Is It?"

Fish	Salamander	Tortoise	Chicken
Pig	Cow	Rabbit	Human



Cards for "Which Organism Is It?"



Name ___________________________
Date ____________ Period ____

Identify the Embryo

Directions: Select two organisms from the list below and research on the Internet what the organisms look like at the embryo state and what they look like at the end of development. Print of a picture of the two organisms at both stages of development.

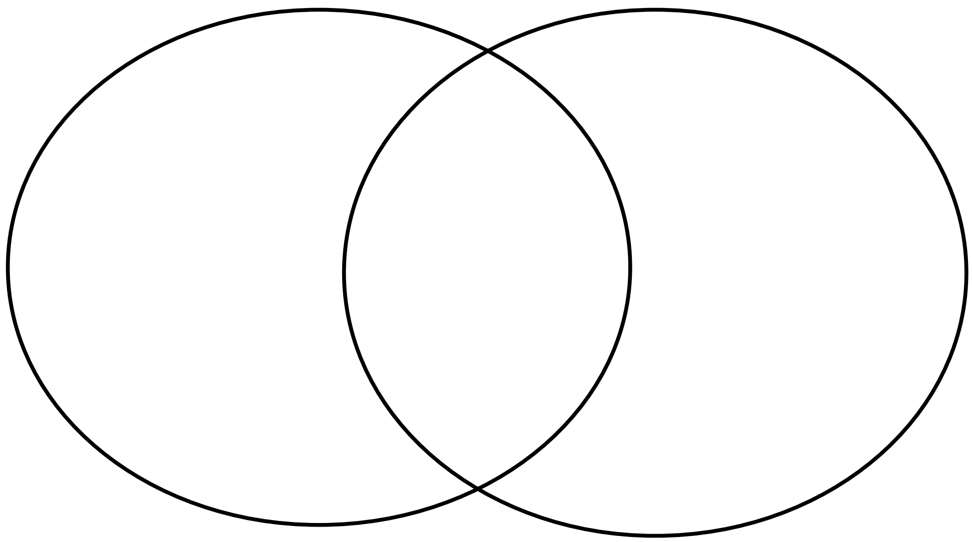
List:

Whale	Elephant	Mouse
Alligator	Dog	Cat
Kangaroo	Dolphin	

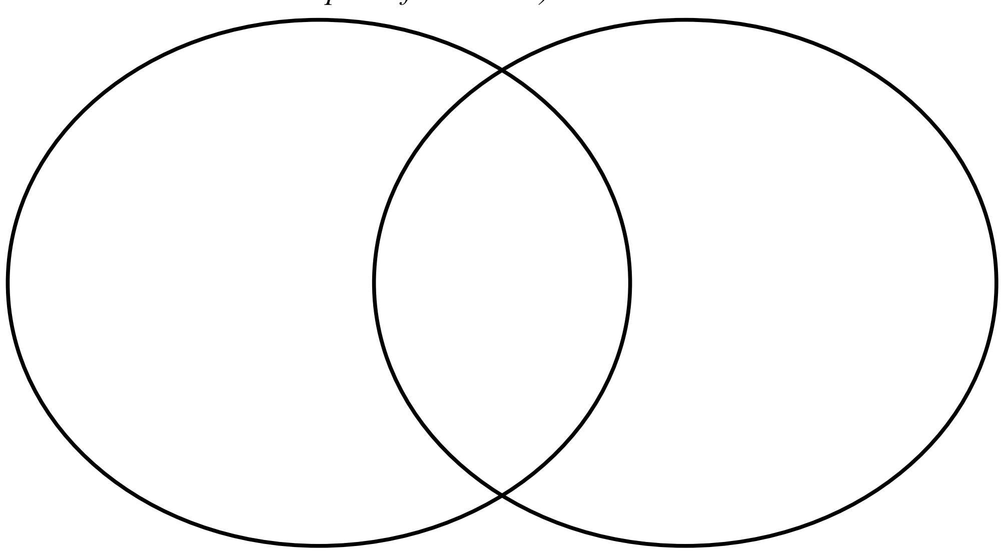
Name ________________________
Date ___________ Period ____

Compare Your Organisms

Directions: Take the images from your selected organisms from "Identify the Embryo" and complete a Venn diagram of how the 2 images look as an embryo. (Provide at least 2 statements in each part of the circle)



Directions: Take the images from your selected organisms from "Identify the Embryo" and complete a Venn diagram of how the 2 images look later in development. (Provide at least 2 statements in each part of the circle)



APPENDIX E: Summative Assessments

Name ___________________________
Date ____________ Period ____

Assessment for MS-LS4-1

DIRECTIONS: Look at the provided fossil records and explain how the organisms look **similar**, but yet so **different**.

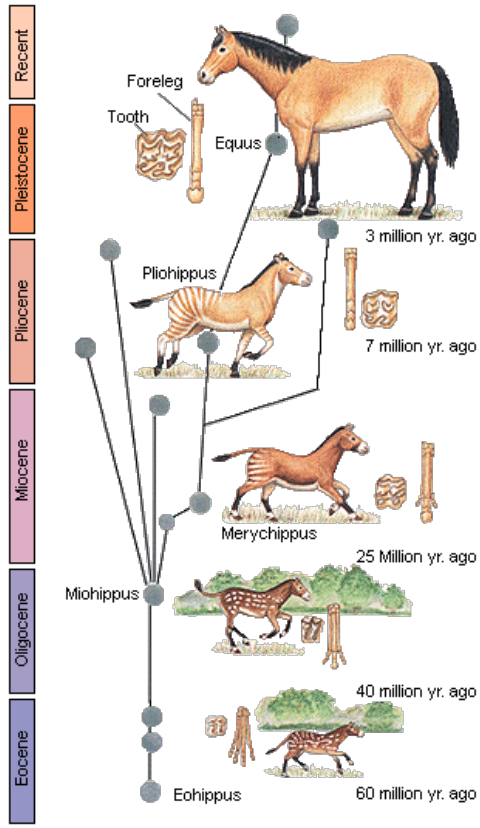


Image obtained from: http://darwiniana.org/equid2t.gif

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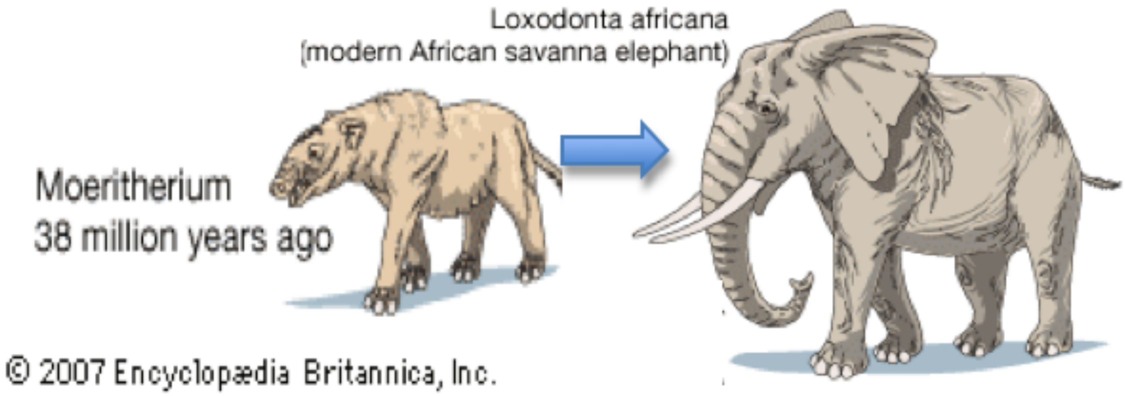
Name ___________________________
Date _____________ Period ____

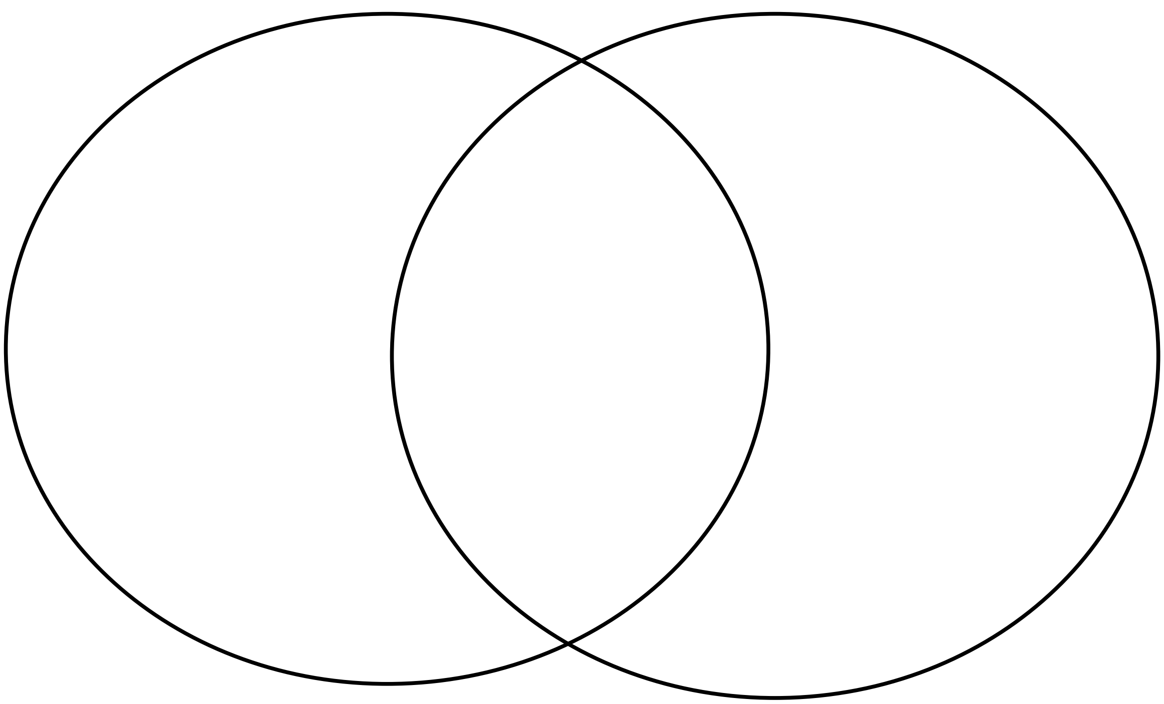
Assessment for MS-LS4-2

DIRECTIONS: Complete the Venn diagram comparing the description and image of a former organism to a current organism. Provide at least two parts in each part of the Venn diagram. When finished, complete the question on the next page.



Moeritherium (former organism)

Loxondonta africana (current organism)



Provide reasoning that would lead to believe that these two organisms are related.

Name ___________________________
Date ____________ Period ____

Assessment for MS-LS4-3

DIRECTIONS: Use the pictures of organisms at different stages of embryological development to make a flow chart of how features of organisms go from looking similar to looking different.

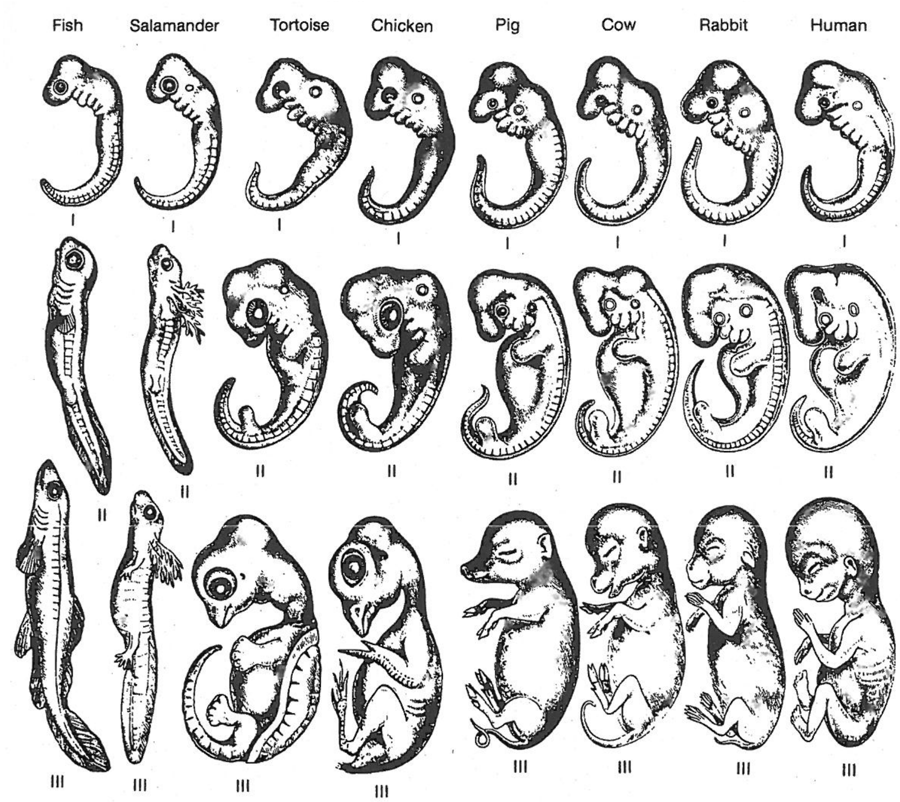
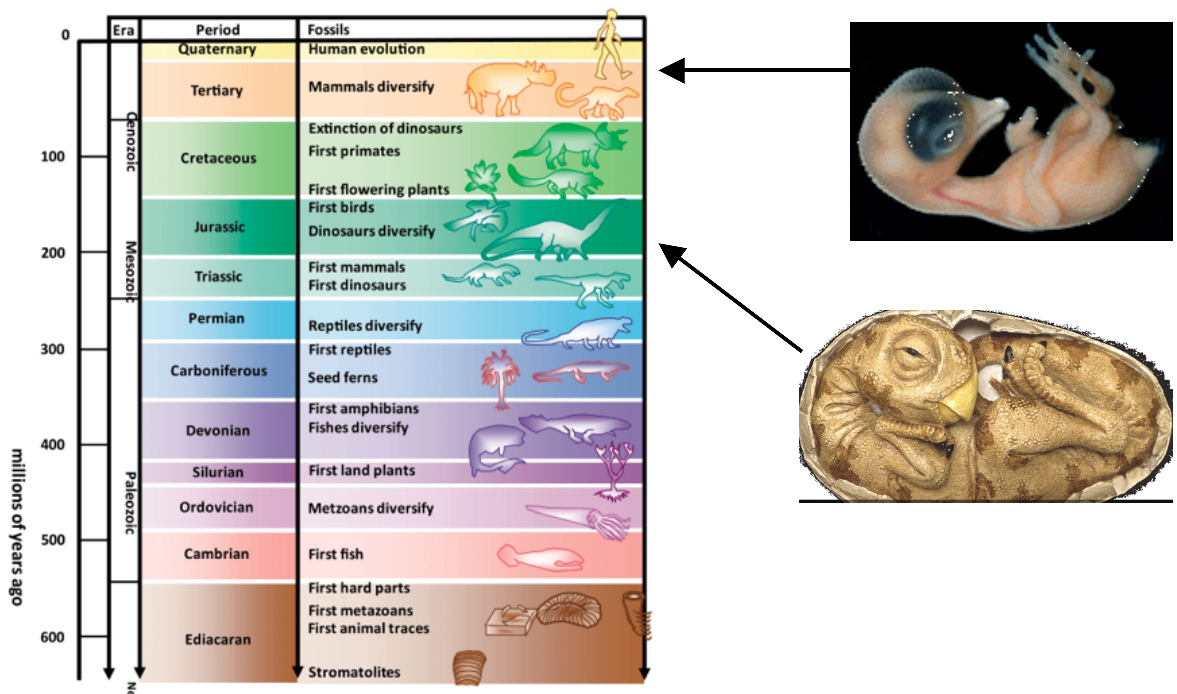


Image obtained from Prothero, 2004

Name ____________________________
Date _____________ Period ____

Final Unit Assessment for MS-LS4-1 to MS-LS4-3

Imagine you found two fossilized embryos while on an archeological dig. Explain how you would go about determining details about these two organisms of how they are related. Consider the following to help form your explanations: fossil record, extinction, anatomy, evolution, relationship, embryo, and patterns.



APPENDIX F: Lesson Plans

Lesson Plan Calendar

Day 1: Is It a Theory? Probe
Sequencing Time
Day 2: Fossil Tour
Theory Discussion
Day 3: Stories From the Fossil Record
Day 4: How Whales Evolved
Is it a Theory? Probe
Assessment for MS-LS4-1
Day 5: Biological Evolution Probe
Fossil Hunt Lab
Day 6: Life has a History
Day 7: Biological Evolution Probe
What's Next
Day 8: Assessment for MS-LS4-2
Day 9: Which Organism Is It?
Day 10: Identify the Embryo
Day 11: Compare Your Organisms
Day 12: Assessment for MS-LS4-3
Day 13: Final Unit Assessment for MS-LS4-1 to MS-LS4-3

Teacher Notes Day 1

Day: *1 – Engage*

Objective: Students will be able to organize a series of events during their life in order.

Performance Expectation: MS-LS4-1

Materials: Is It a Theory? Probes, Sequencing Time handout

Teaching Strategies:

1. Provide a copy of "Is It a Theory" probe. Remind students to complete the second portion of the probe. Allow time for students to complete both sections of the probe.
2. Provide a copy of "Sequencing Time" handout to each student. Inform students that each event should have a number placed beside it, with a 1 representing the event that happened the farthest away and a 9 representing the event that is most current (Scotchmoor, 1997).

Sample Answers to "Sequencing Time"

7 When you started second grade

1 When you were born

3 When you started pre-school

4 When you learned to ride a bike

2 When you learned to walk

5 When you learned to read

6 When you lost your first tooth

8 When you entered middle school

9 Today's date

Teacher Notes Day 2

<u>*Day:*</u> *2 – Concept Development*

<u>Objective:</u> Students will be able to experience the process of an object becoming a fossil.

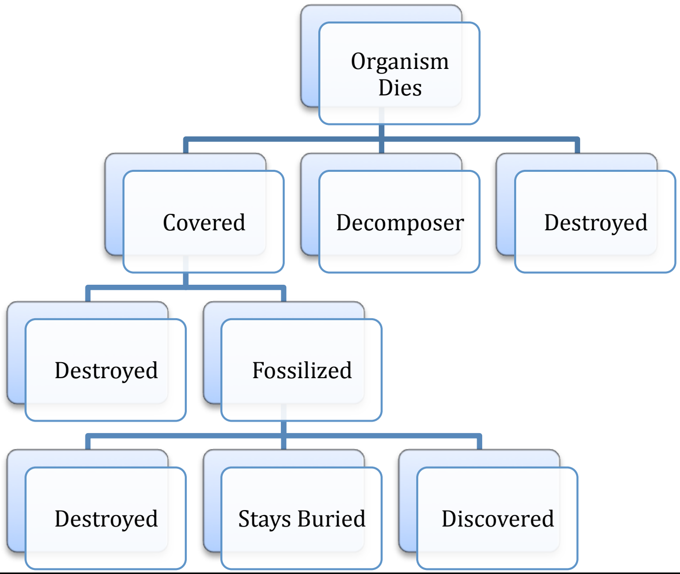
<u>Performance Expectation:</u> MS-LS4-1

<u>Materials:</u> Electronic devices, Fossil Tour handout

<u>Teaching Strategies:</u>

1. Provide a copy of "Fossil Tour" handout to each student (University of California Museum of Paleontology, 2000). Inform students of the web address they need to go to:
    a. http://www.ucmp.berkeley.edu/education/explorations/tours/fossil/5to8/Intro.html
    b. Ensure that students are on Level 1 (grades 5-8).
    c. Assist students if any troubles come about arriving at the designated page. Inform students that some pages will require them to click on images, words or the word "More". Inform students to click "Next" when completed with each page and follow the directions of the site as they progress through the site.
    d. Inform students that as they go through the web activity, they can begin creating their diagram on the provided sheet.
2. Discussion of the meaning of the word "theory".
    a. Provide students their "Is It a Theory" Probe.
    b. Have students share their thoughts of the meaning of the word.
    c. Share with student's examples of theories.
        i. Cell Theory
        ii. Germ Theory
        iii. Big Bang Theory
        iv. Climate Change Theory
        v. Collision Theory
    d. Have students discuss as a class why evolution is referred to as a theory.
    e. Have students adjust their probes, based on student perception of the word.

<u>Sample Answers to "Fossil Tour"</u>



Teacher Notes Day 3

Day: 3 – Concept Development

Objective: Students will be able to better understand how fossils can be used.

Performance Expectation: MS-LS4-1

Materials: Electronic devices, Stories From The Fossil Record Evidence Chart handout

Teaching Strategies:

1. Provide a copy of "Stories From The Fossil Record Evidence Chart" handout to each student (University of California Museum of Paleontology, 2006). Inform students of the web address they need to go to:
    a. http://www.ucmp.berkeley.edu/education/explorations/tours/stories/middle/intro.html
    b. Inform students that they are to click on the 4 ovals and as they complete each section, the evidence chart needs to be completed. When one section is completed, select the next area.

Sample Answers:

Evidence	**What it tells us:**
Past Lives	
1. growth rings in fossil trees or shells	Growth rings tell us the number of years that individuals lived.
2. curled up fossil trilobites	Roll up for protection from predators
3. the contents of fossil nests	How an adult took care of their young
4. fossils of many individuals of the same species together	They lived in herds
5. a change in the shape of feature over time	Where it might have evolved from
Geologic Time	
1. layers in the rocks	New layers were recently formed when compared to those underneath
2. index fossils	Can determine the age of the rock preserved in
3. fossil shells on mountain tops	Mountain top was once the ocean floor
4. identical fossils on widely separated continents	Continents used to not be separated
Paleoecology	

1. fossil marine animals in the desert	Thered use to be an ocean where the desert is
2. shapes of leaf edges	Indicates either cool or warm temperatures existed
3. tooth marks in fossil shells	Predator/Prey Interaction
4. fossil pollen	Dispersal patterns
Biodiversity	
1. fossils of organisms no longer alive today	Different organisms once existed
2. features that are shared by more than one species	That species are closely related
3. the extinction of many fossil species at the same time	Mass extinction took place
4. the extinction of one group of organism, like corals, on which other organisms depend	Other organisms go extinct

Teacher Notes Day 4

Day: *4 – Application and Assessment*

Objective: Students will be able to analyze and interpret data for patterns in the fossil record that document the changes of life forms throughout the history of life

Performance Expectation: MS-LS4-1

Materials: How Whales Evolved handout (lesson idea and image modified from http://www.pbslearningmedia.org/resource/tdc02.sci.life.evo.lp_fossilevid/the-fossil-evidence-for-evolution/), Is it a Theory? Probe, Assessment for MS-LS4-1 handout

Teaching Strategies:

1. Provide a copy of "How Whales Evolved" handout to each student (printing suggestion: do not print so the first page is on the front of the second page, instead print as a stapled set) (WGBH Educational Foundation and Clear Blue Sky Productions, Inc., 2001).
    a. Students are to use the images as evidence to properly sort how whales evolved. Students will indicate their answers on the second sheet.
2. Once students have completed the application activity, provide students their original paper that had their answers from the "Is it a Theory? Probe".
    a. Students are to update and change their answers to reflect what their new thinking is of the word theory.
3. Once the probe activity is complete, provide a copy of "Assessment for MS-LS4-1" handout to each student.
    a. Students are to use the fossil record to compare and contrast organisms through evidence of the fossil record

Sample Answers for "How Whales Evolved":

1. Mesonychids (b) – 55 mya
2. Pakicetus inachus (c) – 50 mya
3. Ambulocetus natans (f) – 48 mya
4. Rodhocetus kasrani (e) – 46 mya
5. Basilosaurus isis (d) – 37 mya
6. Zagorhiza, Prozeuglodon, Dorudon (a) – 36 mya

Sample Answers for "Is it a Theory? Probe":

1. A, D, G, and I should be checked.
2. Explanations will vary

<u>Sample Answers for "Assessment for MS-LS4-1":</u>

1. The overall look of the organism over the 60 million years is generally the same.
2. The fossil record indicates that based on the same general appearance, the organism from 60 million years ago is a relative to the current organism today.
3. The teeth of the species are not the same and gradually changed.
4. The shape and formation of the leg and hooves have changed based on the number of bones in the leg from 60 million years ago to today.

Teacher Notes Day 5

<u>*Day:*</u> *5 – Engage*

<u>Objective:</u> Students will be able to experience the challenges of assembling discovered fossils and use observations to hypothesize the organism found.

<u>Performance Expectation:</u> MS-LS4-2

<u>Materials:</u> Biological Evolution Probe, Fossil Hunt Lab handout (lesson idea modified and image from *Unit Resource Book: Life Over Time.* (2004). Evanston, IL: McDougal Littell.), envelopes, cut-outs of bones (1 set of bones per envelope)

<u>Teaching Strategies:</u>
1. Provide each student with a copy of the Biological Evolution Probe. Have students complete and turn in the probe.
2. Provide a copy of "Fossil Hunt Lab" handout to each student.
3. Provide an envelope of cut-out bones to each group.
4. Instruct students the follow the directions on their handout.
5. Once students have completed the lab, reveal to students to true organization of bones.

<u>Sample Answers for Biological Evolution Probe:</u>
- Carl has the best response of "I think it mainly explains how life changed after it started."
- Explanations may vary, but may include living things share common ancestors, how life is diverse, and how new organisms continue to be discovered.

<u>Sample Answers for Fossil Hunt Lab:</u>
- Questions can range from "How many notes make up the organism?" to "Which part of the body does the fossil belong to?" to "How old is the organism?".
- Table should be completed with four bones on the left side based on what was retrieved from the envelope and guesses of animals based on the bones retrieved.
1. Sketches will reflect the organism they arranged from the retrieved bones.
2. Students either answer the question that their ideas did not change or that they should have assembled their fossils differently.
3. Based on the fossils pulled and order of the fossils pulled, both answers will reflect the chart above.
4. Students will describe or draw the parts of the organism they had a tough time. For the second question, most students either respond that they set the unknown fossil(s) aside or they continue to rotate and turn the fossil.

Conclude answers:
1. Most students will believe that the organism gets around on land by walking on 4 legs, based on the number and shape of large bones that would make up the leg bones.
2. Answers will reflect the organism of their sketch on the previous page. Their second answer will be based on how the fossils were arranged and pulled from the envelope.
3. Answers vary, samples: size of the bones, if they are bones, is the organism is a current organism or extinct, and what do all of the bones look like together.
4. Most answers reflect the skills needed as patients and curiosity.
5. Students respond that mistakes can happen if they don't have all of the bones or by simply turning it to be in the wrong position. Students respond that scientists can prevent mistakes by taking time, research, patience, and to continue digging for other fossils in the area.

Teacher Notes Day 6

Day: *6 – Concept Development*

Objective: Students will be able to see how biodiversity takes place in life. Students will be able to distinguish between student's ideas of biological evolution, origin of life, and the mechanism of biological evolution.

Performance Expectation: MS-LS4-2

Materials: Life Has a History handout, electronic devices

Teaching Strategies:

1. Provide a copy of "Life Has a History" handout to each student (Regents of the University of California, 2006). Inform students of the web address they need to go to:
    a. http://www.ucmp.berkeley.edu/education/explorations/tours/intro/Intro5to12/tour1nav.php
    b. Go over the first page with students on the website with students.
    c. As students go through the tour, they are to complete the handout.

Sample Answers:

1. Find the information describing the 30 million species of living organisms. Of that 30 million, how many are NOT animals? [HINT: Subtract the total number of animal species currently known.] **28.1 million species**

2. Find the three lens views comparing the oceans through time. Name one animal common to today's ocean whose relatives were also around 470 million years ago. **Squid, octopi, coral**

3. Find the timeline. How many millions of years did dinosaurs exist on Earth before they became extinct? **160 million years**

4. Find and name at least five things other than bones that can be preserved as fossils. **Leaves, bacteria, shells, bark, tracks**

5. Find a picture of *Deinonychus* and three of its relatives. What feature do the birds all share that *Deinonychus* does not? **Wings**

6. During this tour, you will learn about cladograms. When you reach that point, complete this sentence:

A cladogram is a diagram that shows... **how each group of animal is related to others; a family tree; common ancestors of organisms**

7. Find the bar graph that shows the differences in beak size among three species of Galápagos finches. Name the species of finch that has a beak that can be longer than 15 mm. **Geospiza scandens**

8. Find the page showing three graphs side by side. The graph on the right shows an increase in the finch's body and bill size. Why did that happen? **They were able to eat the larger seeds and had more food available to them**

Teacher Notes Day 7

<u>Day:</u> *7 – Application*

<u>Objective:</u> Students will be able to edit an existing organism and explain why changes were applied.

<u>Performance Expectation:</u> MS-LS4-2

<u>Materials:</u> Biological Evolution Probe, What's Next handout, dice

<u>Teaching Strategies:</u>

1. Provide the copy of "Biological Evolution Probe" handout completed by students two days earlier to individually update and complete.
2. Provide a copy of "What's Next" handout to each student.
3. Once each student has determined their organism and recorded their answer, provide each student with a dice.
4. To assist students in selecting and/or drawing/explaining organism, students may need to access electronic devices or books.
5. Students will individually complete the activity.

<u>Sample Answers for Biological Evolution Probe:</u>
- Carl has the best response of "I think it mainly explains how life changed after it started."
- Explanations may vary, but may include living things share common ancestors, how life is diverse, and how new organisms continue to be discovered.

<u>Sample Answers for What's Next:</u>
1. Selected organisms will vary.
2. Dice will determine altered features of organisms. Student explanations about the new feature focus on allowing the organism to live longer.
3. Answers of the related organism reflect the feature added to the original organism. The explanation will reflect the features added.

Teacher Notes Day 8

Day: *8 – Assessment*

Objective: Students will be able to apply ideas to construct an explanation for the anatomical similarities and differences in modern organisms when compared to past organisms.

Performance Expectation: MS-LS4-2

Materials: Assessment for MS-LS4-2 handout

Teaching Strategies:

1. Provide a copy of "Assessment for MS-LS4-2" handout to each student.
2. Instruct students that they are to individually complete the Venn diagram, providing at least two answers in each portion of the diagram.

Sample Answers:
Answers will vary for each student on the Venn diagram. Below are some sample answers for the Venn diagram.

Moeritherium	Alike	Loxondonta africana
Smaller in size	Tail	Larger in size
Short trunk	Hooves	Longer trunk
Fur	Trunk formation	Exposed skin (no fur)
Small ears		Large ears
		Tusks

Answers will vary for each student on the short answer responses. Student answers should be based on the number of physical similarities that would link these two organisms as relatives.

Teacher Notes Day 9

<u>Day:</u> *9 – Engage*

<u>Objective:</u> Students will be able to analyze pictures of various embryos to determine which organism is which throughout development.

<u>Performance Expectation:</u> MS-LS4-3

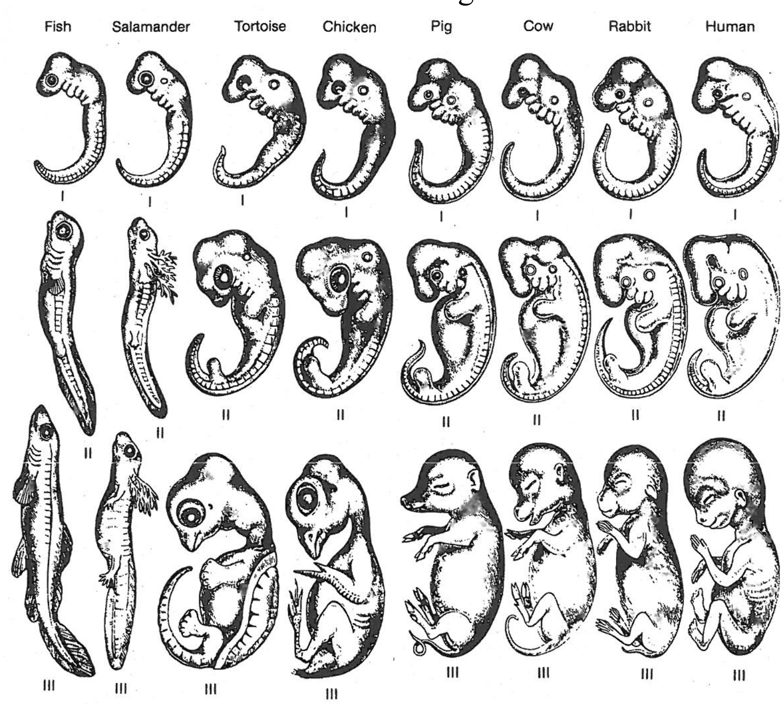
<u>Materials:</u> Which Organism Is It? printed and cut cards, envelopes

<u>Teaching Strategies:</u>

1. Provide an envelope of the "Which Organism Is It?" handout cut up as cards to each student group (Prothero, 2004).
2. Instruct students that they are to work to assemble the cards demonstrating the development of the 8 organisms at 3 different stages of development in order.
3. Once each group has finished assembling their cards, reveal the proper order of how the cards should be arranged.

<u>Sample Answers:</u>

The reveal to students should be based on the image below.



Teacher Notes Day 10

<u>Day:</u> 10 – Concept Development

<u>Objective:</u> Students will be able to identify the development of 2 organisms.

<u>Performance Expectation:</u> MS-LS4-3

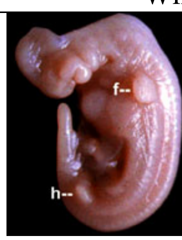
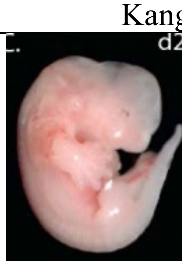
<u>Materials:</u> Electronic devices and printer, Identify the Embryo handout

<u>Teaching Strategies:</u>

1. Provide a copy of "Identifying the Embryo" handout to each student.
2. Instruct students to select 2 organisms from the list and find images of the 2 selected organisms at the embryo stage and then later in development.
3. Once images are found, instruct students that they are to print off the four images.

<u>Sample Answers:</u>

Printouts will vary for each student as the activity is completed. Below are samples of organisms at the 2 stages.

Whale	Elephant	Mouse
 	 	 
Alligator	Dog	Cat
 	 	 
Kangaroo	Dolphin	
 	 	

Teacher Notes Day 11

Day: 11 – Application

Objective: Students will be able to analyze pictures of embryos to compare patterns of similarities across multiple species.

Performance Expectation: MS-LS4-3

Materials: Images printed off the previous day, Compare Your Organisms handout

Teaching Strategies:

1. Provide a copy of "Compare Your Organisms" handout to each student.
2. Have students take out the images they printed off from the previous lesson.
3. Instruct students that they will be using their printed images from yesterday to complete the 2 Venn diagrams.

Sample Answers:
Answers will vary for each student based on the images printed from the previous day.

Teacher Notes Day 12

Day: *12 – Assessment*

Objective: Students will be able to analyze pictures of embryos to compare patterns of similarities across multiple species.

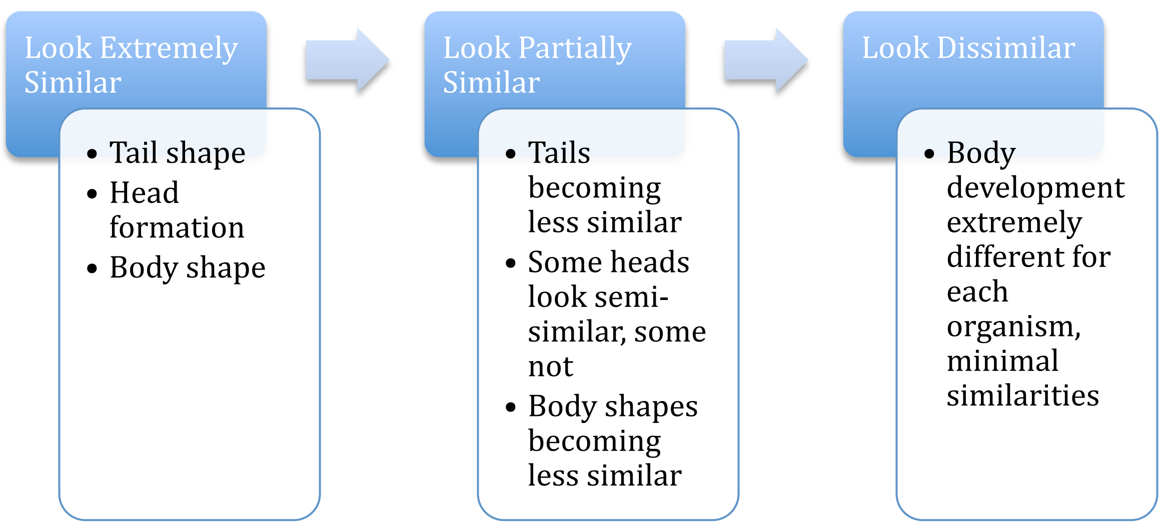
Performance Expectation: MS-LS4-3

Materials: Assessment for MS-LS4-3 handout

Teaching Strategies:

1. Provide a copy of "Assessment for MS-LS4-3" handout to each student.
2. Have students create a flow chart demonstrating how organisms go from looking extremely similar to dissimilar.

Sample Answers for:
Answers will vary, below is a sample flow chart.



Teacher Notes Day 13

Day: 13 – Final Assessment

Objective: Students will be able to apply content and concepts gained from this unit to explain their thoughts behind two organisms.

Performance Expectation: MS-LS4-1, MS-LS4-2, MS-LS4-3

Materials: Final Unit Assessment for MS-LS4-1 to MS-LS4-3 handout

Teaching Strategies:

1. Provide a copy of "Final Unit Assessment for MS-LS4-1 to MS-LS4-3" handout to each student.
2. Instruct students that they are to explain how they would determine these two organisms are related.
3. Inform students that using the list of terms in their responses may assist them.

Sample Answers:
Answers will vary for each student as the assessment is completed. Below is a sample answer.

> Based on the fossil record, the first organism from the Jurassic period that became extinct shares common anatomy in the development of an organism's embryo from the Tertiary period. Patterns in development and anatomy show that evolution from the organism from the Jurassic period led to the more recent organism from the Tertiary period.