Evidence for Evolution Lesson Plan

Topic: Introduction and Evidence for Evolution
Date: Day 1
NSES: Content Standards A, C, F, G
Grade level: 10
SOL: BIO.1 b, e, k, BIO.6 a, b, c, d, e, BIO.7 a, e
Subject: General Biology
Daily Question: What are the clues that life has changed over time?

Procedures for Learning Experience	Guiding Questions	Materials Needed	**E**valuation (Assessment)	Time Needed
Engagement: From **pre-test**, have some statements that students wrote about evolution on the powerpoint. Have students discuss them in pairs and decide which one they most agree with and why. Show the theory of evolution description (life has changed over time) and scientific definition of evolution (a change in the gene frequencies of a population over time) and discuss how it is similar and different from the definitions that students came in with. Review discussion about what a scientific theory is, emphasizing that theories are **based on evidence**. Then introduce the science circus activity by saying that we are going to explore some evidence that scientists explain using the theory of evolution.	How do we describe evolution?	Information from pre-assessment, Powerpoint	Checking for understanding Discussion about theories assessed on test	15 minutes
Exploration: Science Circus with stations for Fossil record, Homologous structures, Vertebrate Embryos. and DNA evidence: Have 2 stations of each set up (2 sets on opposite sides of the lab). Have students get into their assigned (heterogeneous) groups of three and assign each group a side of the room and a number to start at. Tell students that they will have 10 minutes to complete each station. **Set a timer and move on when it rings**. The teacher should be walking around making sure that all students are staying on track and asking scaffolding questions or	What evidence gave us clues that life evolved over time? Why do scientists believe that life has changed over time?	Egg timer (to keep track of time at stations) Student hand- outs, laminated station instructions, colored pencils, duct tape, empty water bottles with screw on top, pieces of string,	Checking for understanding and participation and monitoring the progress of all groups during the activity Hand-out assessed for completion	45 minutes

more enriching questions depending on if groups are struggling or if they are moving through the activity very quickly		running water, embryo cards, DNA sequences		
Explanation: Powerpoint on evidence for evolution Make **explicit connections** between the activities that students did during the exploration to the scientific concepts. Students should have their labs out and be prepared to answer questions about what they observed and the predictions that they made. At fossil record slide, go to http://tiktaalik.uchicago.edu/meetTik2.html to explore show students the features of this transitional form and how it was discovered	What observations contributed to the formation of the theory of evolution?	Powerpoint, internet access	Material assessed on cumulative assessment later Checking for understanding	20 minutes
Extension: Reading: Antibiotic resistance (optional: students take turns reading aloud) Discussion: What is the evidence that evolution is occurring here? Why can we observe evolution happening in real time with these bacteria? Where else might we be able to observe evolution occurring?	What is the evidence that evolution is occurring here? Why can we observe evolution happening in real time with these bacteria? Where else might we be able to observe evolution occurring?	Copies of reading	Checking for understanding	10 minutes

Notes:
Misconceptions

- Misconceptions about definitions of evolution and the theory of evolution are addressed, based on what students said in pre-assessment
- Misconceptions about what a scientific theory is are addressed explicitly at beginning of lesson

Adaptations

- Heterogeneous grouping is used so that students can support each other during the exploration
- The exploration contains several hands-on activities and a creative activity. These experiences are revisited and presenting visually and orally so all students get the information from multiple perspectives
- In the collaborative class, students may take turns reading aloud from the antibiotic resistance so that students with difficulty reading may follow along

Technology

- Powerpoint is used during lecture, and internet access is required to link to webpage where the teacher will lead students through observations and discovery of a transitional form

Safety:

- When students are in lab, make sure they know to work only on their station at any one time and follow all lab safety rules

Fossils and History of the Earth Lesson Plan

Topic: Fossils, Fossil Dating, Earth's History
Date: Day 2
NSES: Content Standards A, B, C, D, G
Grade Level: 10
SOL: BIO.1 d, e, I, k, l, BIO.6 d,e, BIO.7 a,e
Subject: General Biology
Daily Question: How do we know about the history of life on Earth?

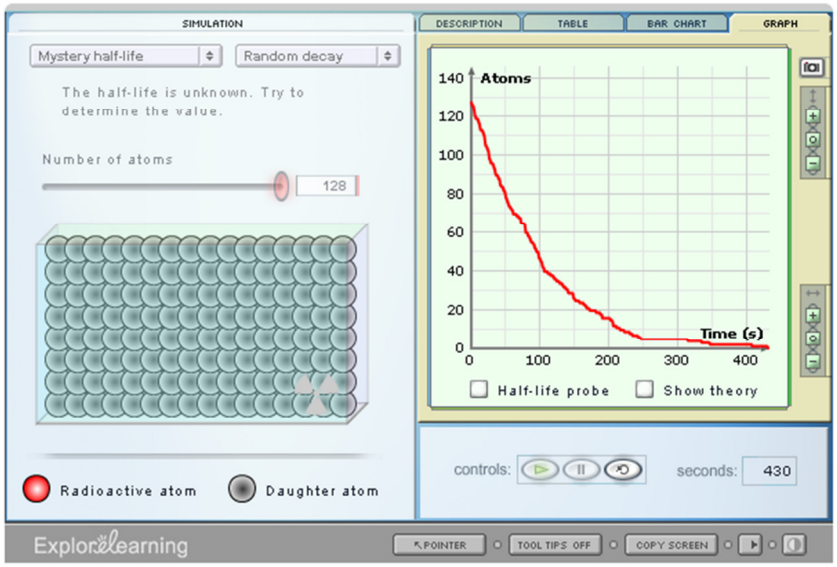
Procedures for Learning Experience	Guiding Questions	Materials Needed	**E**valuation (Assessment)	Time Needed
Engagement: Yesterday we learned about fossils and how their location tells us about the sequence of life forms over time. I'm going to give you a scenario that's similar. I have a box here that I threw a bunch of stuff into this morning. You come across the box and want to know what order I put each item in the box. Can you tell? How? *Items on the top will be last put in, on the bottom will first put in. Order items on the board – then ask* Can you tell **when** I put each item in the box? This is the difference between the two ways that we figure out how old rocks and fossils are.	Why do we need two different ways to date fossils?	Materials for lab stacked in clear plastic container	Checking for understanding and participation	5 minutes
Exploration: Mini-explanation of a radioactive isotope and a half-life followed by The Half Life of Candium Lab with students in pairs Questioning: You have a sample that is between 1 and 3 years old. Can you use Candium to identify its age? If you could change something about Candium in order to date the sample, what would you change? **Think-pair-share** How would you change it? Carbon has a half like of about 5,700 years, From your graph, about how much time would pass before the Carbon-14 levels got down to nothing? What ideas can we come up with to date fossils older than that?	What patterns do you observe as the atoms decay? How does the half-life of an isotope affect the ranges of dates it can be used for?	Skittles or M&Ms, cups or Ziploc bags, paper towels Lab hand outs	Checking for understanding while students are completing lab Lab turned in for a grade	20 minutes for lab 5 minutes for discussion

Explanation: Powerpoint on formation of fossils and incomplete fossil record, relative and absolute dating Half-Life Gizmo as a demo – Explore different half lives Ask question: How old is the Earth? Students make guesses. Before giving answer, perform Geologic Time Demo with toilet paper unrolling with important geologic dates (see attached excel sheet) written on it to scale. *Could be teacher walking around room unraveling roll or students passing it and reading the events in the order they're unraveled – depends on behavior of class.* Notes: History of the Earth. Use online guided tour from http://www.ucmp.berkeley.edu/education/explorations/tours/geotime/gtpage2a.html that demonstrates important events in geologic time and compares with human history. - Start with step 2, skip to 7-8 as reviews of fossil dating if time allows,	How are fossils formed? How do we use fossils to tell us about the history of life on Earth? What is the difference between relative and radioactive dating? How old is the Earth? How and when has the Earth changed over time?	Powerpoint, internet access Toilet paper roll with geologic time dates written to scale Guided notes	Checking for understanding Concepts assessed later on assessment	20 minutes on fossils 5-10 minute geologic time demo 15 minutes for geologic time notes and website
Extension: Nat Geo Video: History News: Fossil Found in Kitchen Counter http://video.nationalgeographic.com/video/news/history-archaeology-news/egypt-fossils-wcvin/ Include question set to go with it - This video shows students the ongoing importance of fossil discoveries and communicates that we're constantly discovering and modifying our ideas about the history of life on the planet - This video also mentions the migration of animals from Asia to Africa and the subsequent change of those animals – an opportunity to poll students about their thoughts about how adaptations occur in preparation for the next days' lesson on Natural Selection and Adaptations Bridging transition into adaptations and natural selection with response to question about adaptations mentioned in the video.	How do fossil discoveries continue to tell us about Earth's history? How do organisms evolve?	Link to video Guided notes	Checking for understanding Collecting responses to questions about adaptations – pre-assessment	15 minutes for video and student responses

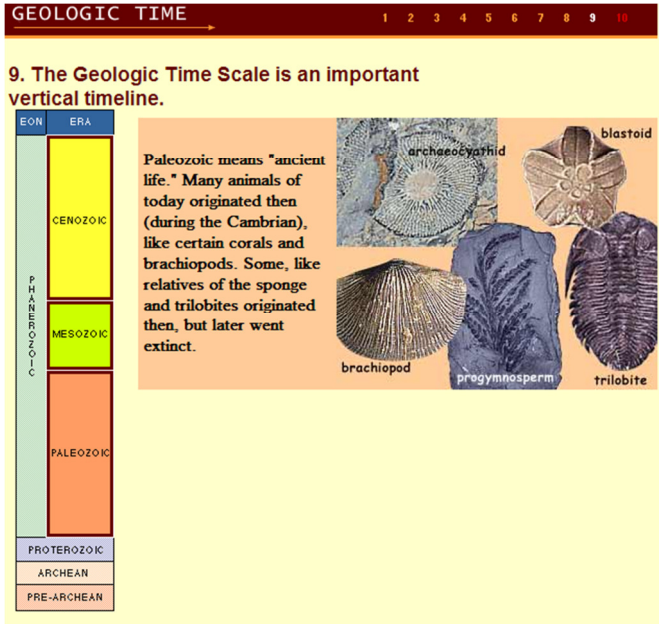
This question should bring out many misconceptions for students.				

Notes:

Gizmo:



Guided Tour of Earth's History:



Misconceptions that are addressed in this lesson:

- The fossil record shows a direct lineage of organisms from ancestors to living forms (rather than many extinct related side branches)
  - Addressed explicitly in powerpoint
- Evolutionary theory is invalid because it is incomplete and cannot give a total explanation for the biodiversity we see around us. Gaps in the fossil record disprove evolution.
  - Addressed through class discussion
- The Earth is not very old and most of the time has existed as we know it today
  - Addressed with several different activities to demonstrate the immense time scale of the Earth and the relatively small amount of time it has resembled its current state

Adaptations / UDL:

- Presenting difficult concept of half-life in hands on ways
- Showing concept of geological time in several visual, oral, hands and hands on ways, including making several different analogies
- Hand out of notes to students with IEPs
- On the Half Life of Candium lab, the questions toward the end are “challenge questions”: more difficult questions that all students are not required to get to but should challenge and take some time for the students who moved through the lab more quickly
- At the end of the class period, I will collect the students writings about their understandings of how animals adapt and use their levels of understanding and misconceptions to modify differentiate instruction for the next day’s lesson

Technologies
- A Half-life Gizmo is used to explore the half-life of different isotopes and discuss the effect of half-life on usability for date ranges.
- Guided tour through geologic time used to show demonstrate geologic time, review fossils, and explore eons, eras, and periods of Earth.
- Video from National Geographic is used to show students what paleontologists actually do, the luck involved in scientific discovery, and ongoing impact of discovering fossils and learning about the history of life on Earth

Safety Notes:
- Make sure that students wash hands before candy lab so they can eat the candy
- If there are allergic students or diabetic students in class who can’t eat candy, make sure they know this and have some alternate non-food reward available for them (stickers, pencils, erasers)

Natural Selection and Adaptations Lesson Plan (Spans 2 days)

Topic: Natural Selection and Adaptations
Date: Days 3 & 4
NSES: Content Standards A, C, F, G
Grade level: 10
SOL: BIO.1 a, b, d, e, i, k, l, BIO.5 d,f, BIO.7 b, c, e
Subject: General Biology
Daily Question: How do adaptations develop?

Procedures for Learning Experience	Guiding Questions	Materials Needed	**E**valuation (Assessment)	Time Needed
Engagement: Do-now: Pull out some main ideas from the responses from students yesterday about how adaptations occur and put them on the powerpoint (or have them printed off as a handout). Ask students to write down or circle which ideas sound right to them and which do not. Discuss as a class: what do students have questions about? What have they heard that they're not sure about? Show pictures of adaptations and a short video of animal adaptations http://www.youtube.com/watch?v=2WtmfMfCjfQ Tell students, I'm sure when you've see some crazy features that organisms have, you've wondered how and that organism came to look or act in such a way. As scientific thought became more advanced, many scientists began to wonder the same thing. In the 1800s, a lot of hypotheses emerged. We're going to look at two now: one written by a scientist named Lamarck and another by a man named Darwin.	What ideas do we have now about how adaptations occur? What confusion do you have about how adaptations form? How do adaptations occur?	Powerpoint, internet access, video links	Checking for understanding	10 minutes
Exploration: Students are divided into two groups. One will read a short passage about Lamarck. The other group will read a short passage about Darwin. The students should underline or highlight important points in the readings about each of the scientist's beliefs. The students are then assigned partners who read about the other scientists. They share what they learned and	What did Darwin and Lamarck believe? How did these beliefs differ? How were they the same?	Darwin and Lamarck Readings	Checking for understanding and participation	15 minutes

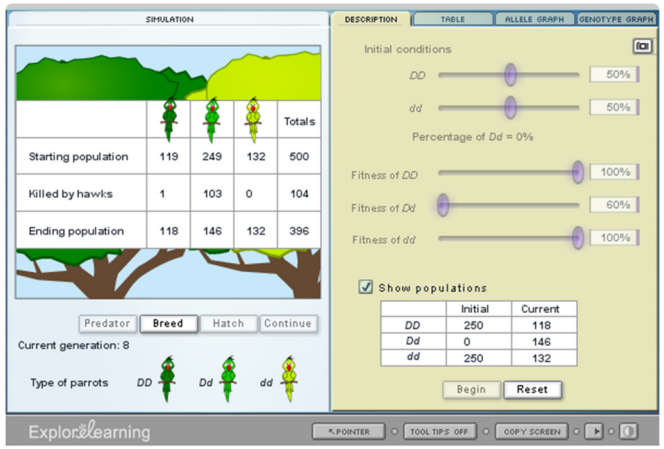
make a Venn Diagram about the differences and similarities of the two scientists' beliefs. Partners are instructed to discuss and write which views make the most sense to them, which they are unsure of or disagree with Then, teacher opens up a class discussion: Which beliefs were you unsure about? What kind of information would you want to help answer your questions?	Which beliefs do we agree with, disagree with, and which are we unsure about?			
Mini-Explanation: Lamarck's theory of inheritance of acquired characteristics Darwin's voyage on the Beagle and evidence and development of his theory of natural selection	What observations lead to the formation of the theory of evolution?	Powerpoint	Checking for understanding Assessed later on test	15 minutes
Exploration: Goldfish Lab: Divide students into their lab groups of 2 or 3 and read through the pre-lab as a class. In this lab, students observe the variation that exists in an actual population of goldfish, and are introduced to thinking about how this variation is essential for adaptations.	How do organisms vary? What are the sources of this variation? How does this variation lead to adaptation?	Lab handouts, data chart on whiteboard, Goldfish, two aquariums, nets, petri dishes, metric ruler	Lab collected and graded	50 minutes
Day 2 of lesson:				
Engage to start Day 2: Do-now: Remember back to our units on genetics (think Mendel). You know more about genetics than Darwin did. He had no clue about what Mendel was working on. List at least 2 sources of genetic variation and write a short paragraph to Darwin explaining each to him.	What are the sources of variation?	Powerpoint	Checking for participation and understanding	10 minutes
Explanation: Distinguish between adaptation as it is used commonly and as it is used scientifically. Make it clear that individuals do not adapt (in terms of evolution) Only populations can adapt.	Can individuals adapt? What are the sources of variation and why	Powerpoint, black construction paper, newspaper, hole punches of both types of	Checking for understanding Concepts assessed on test	20 minutes of notes 10 minutes for peppered

Peppered moth activity: Present the problem to students: It's the prime of the industrial revolution in England. Factories are pumping out heavy smoke every day. This smoke starts to change the landscape around the cities, blackening the once light colored trees. Even the moths started changing colors. People noticed that they were seeing dark colored moths more frequently. Some people thought that the moths were being stained by the dust. Let's see if we can come up with any alternative explanations. In groups of two, half the students get black background and half get newspaper background. Each student gets a 50/50 distribution of black hole punches and newspaper hole punches. In 30 seconds, each group collects as many as possible. Students count how many they collected of each type and tally it up on the board for the whole class. Discussion: how did the background affect the number of moths that were caught? Do you think the next generation of moths would be different? Why or why not? How does the illustrate natural selection? Powerpoint on natural selection, including discussion of underrepresented Scientist Rosemary Grant and her husband Peter Grant continuing Darwin's work in the Galapagos. Students examine their data and discuss how it shows the different characteristics of natural selection (variation, inheritance, selection) Introducing modern theory of evolution, including reinforcing the fact that evolution refers to a change in gene frequencies. Explain allele frequencies, genotype frequencies, and phenotype frequencies Discuss kin selection and sexual selection: Play the first 1:20 of the Birds of Paradise Video (unless time allows for all 5 minutes): Class discussion: Are traits that best enable an individual	is it necessary for natural selection? How does natural selection act over time?	paper		moth competition

reproduce (pass on their genes) always the best for their survival? In evolutionary terms, which is more important?				
Extension: Hand out Microevolution Gizmo worksheets. Students go to the computer lab and use the Microevolution gizmo:http://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=521 This gizmo allows students to experiment with changing the fitness of genotypes. This gizmo reinforces that natural selection occurs by changing gene frequencies in a population. Introduce Alternative Assessment Activity: Time will be given next class for students to do some research on the adaptations of an organism of their choosing. They have the option to write a short essay, make a presentation (ppt or on poster), create a cartoon, with description of adaptation, description of environment, how this adaptation is suited to environment, they propose a mechanism of how this adaptation evolved. See project sheet for **rubric**. - I will have saved the writings from the students' responses two days ago when they wrote about how they think adaptations like a giraffe's neck occur. This will be a direct comparison to see how students' ideas have changed after instruction on natural selection and adaptation.	How do genotype frequencies change over time when fitness is controlled? Why are most disease causing alleles recessive?	Powerpoint and internet access Computers and access codes for explorelearning Microevolution Worksheets Adaptation Project Sheets	Microevolution gizmo worksheet collected and graded	10 minutes for sexual selection and kin selection videos/discussion 30 minutes to use gizmos 5 minutes to hand out and introduce assignment

Notes:

Gizmo:



Misconceptions:

- Misconceptions about inheritance of acquired characteristics, use and disuse, and evolution as a progressive ladder are addressed in discussion of Lamarck
- The misconception that individuals change over time rather than populations is explicitly addressed
- The common use of the word adaptation is contrasted with scientific use to address that misconception

Adaptations:

- Instruction is based on student responses from the day before, changes may be made to instruction based on what a class knew beforehand
- Jigsawing activity may be done with partnered reading the first time in a class where one or more students may have difficulty reading the passages
- Heterogeneous grouping is used during lab
- Extra sheet on Goldfish Lab that may be given out to groups that finish early
- Hand out notes to students with it in their IEPs

Technology:

- Videos are used to engage students and expose them to the diversity of life
- Microevolution Gizmo allows students to make the connection between evolution and Mendelian genetics and explore real life questions about genetics of disease

Safety:

- Students will be instructed to treat Goldfish with respect and to work quickly and gently with them

Patterns of Natural Selection Lesson Plan

Topic: Patterns of Natural Selection
NSES: Content Standards A, C, G
SOL: BIO. 1b, d, e, f, j, BIO.7 b, c, e
Daily Question: How does the environment shape adaptations?

Date: Day 5
Grade level: 10
Subject: General Biology

Procedures for Learning Experience	Guiding Questions	Materials Needed	**E**valuation (Assessment)	Time Needed
Engagement: Students define mutation and list at least 3. Respond to question: Are mutations good or bad?	Are mutations good or bad?	Powerpoint	Discussion to check for understanding	5 minutes
Exploration: Lab: Environmental Impact on Fitness Lab stations are set up with three different environments: 1. Corn in a wide foil tray 2. Corn in a medium sized jar (too small for largest scoop) 3. Small amount of corn in a wide foil tray AND corn in narrow graduated cylinder Students will be assigned a small/medium/large beak phenotype and must use this tool to collect as much food as they can in one minute. After each trial, students weigh the amount they collected, put their data up on the board and move to the next environment. After they've competed at all three environments, students make observations about which one they were most successful and least successful in based on their phenotype. Students then average the class data for each trial and graph the food collection for each beak in the three different environments. The teacher will model creating the graph for one environment with questioning and class input on the board (including asking students about IV/DV labeling, what type of graph to use, how to find averages). Students graph the other two environments independently and answer questions.	How does the environment impact fitness of a trait?	Small, medium and large scoops, foil tray, medium jar, graduated cylinder (or narrow vase), corn/beans/"food", cups for collection,	Lab collected Checking for participation Discussion questions for understanding	30 minutes

Class discussion on what students observed about the success of their phenotype. Have students predict what the beaks would look like at each environment after many generations.				
Explanation: Powerpoint Presentation: Sickle Cell Anemia/Malaria Example, engagement questions with Ryan Clark (football player) not being able to go to Denver because of altitude Patterns of Natural Selection	How does the environment affect the selection of traits? How can we describe the different patterns of selection?	Powerpoint	Checking for understanding with questioning Assessed later on test	30 minutes
Extension: Time to work on Adaptations project. Researching their organism's environment to determine what traits might have been beneficial. What type of selection pressure is it under now?	What types of selection might my chosen adaptations be under now?	Computers	Make sure students are working on project – portion for this in rubric	25 minutes

Notes:

Misconceptions

- This lesson continues to review and address misconceptions about adaptations and natural selection
- The misconception that all mutations are bad is addressed
- The idea that certain traits are good and certain traits are bad is addressed here and the importance of the environment is emphasized

Adaptations

- Students are in heterogeneous groups who should be able to provide assistance to students who are struggling with creating and interpreting the graph
- Information is presented in hands-on, visual, and oral ways to suit all learning preferences
- Copies of notes to students whose IEPs require it

Technology

- Students will use computers to research their adaptations

Safety:

- Students are instructed to be respectful during their competition and not push or be physical with anyone else during the procedure
- In the computer lab, student activity will be monitored to make sure they're engaging in safe online practices

Speciation and Macroevolution Lesson Plan

Topic: Speciation and Macroevolution
NSES: Content Standards A, C, F, G
SOL: BIO.1 b, e, BIO.7 b, c, d, e
Daily Question: How do new species form over time?

Date: Day 6
Grade level: 10
Subject: General Biology

Procedures for Learning Experience	Guiding Questions	Materials Needed	**E**valuation (Assessment)	Time Needed
Engagement: Pose question: What is a species? What criteria would you use if you had to come up with a definition for a species? **Think-pair-share.** Show scientific definition of a species and brainstorm problems. Put up slides about diversity of life and pose the question: how did we get from one common ancestor to all the species that exist today?	What is a species? What are the problems with our definition of species? How did all the species present on Earth today come to be?	Powerpoint	Check for understanding and participation	10 minutes
Exploration: Ensatina salamander species lab. Students break into groups of 2-3 in the lab. They follow the directions on their lab to plot the collection of species on a map and answer questions interpreting their findings. After students have finished, class discussion: Do you think these are different species? Why or why not? What does the difficulty answering this tell you about our definition of species? How do you think these species formed? What was the original population and why do you think so?	How do species form? When do we know that a new species has formed	Speciation Lab Handouts, Colored Pencils or Markers, Laminated color copies of salamanders	Monitoring students to check for understanding of procedure and concepts Labs collected and graded	45 minutes
Explanation: Powerpoint: Mechanisms of speciation. Students compare and contrast allopatric speciation with sympatric speciation. After discussing these, ask students to infer how the Ensatina salamanders subspecies/species formed. Emphasize that the only two required factors are **isolation** and **time**. Discuss other factors	How do species form? What are the steps in speciation?	Powerpoint Spectrum of Paint Chips	Checking for understanding, participation, Material assessed on test	20 minutes

may increase the rate of speciation. Use a spectrum of paint chips to illustrate the change from an intermediate species gradually changing down two lines to form totally different colors. Discuss how this illustrates a ring species. Then, ask students to think about how ring species shows evolution happening with all the transitions still alive. It is a very special case that this happens in evolution. In most cases the common ancestors and transitional forms go extinct. Ask students to imagine that now the common ancestor is living millions of years ago and the two ends of the branches are a human and a chimpanzee. The human did not evolve from a chimpanzee, rather they shared a common ancestor millions of years ago that they have both changed from significantly. *This activity actively addresses the misconception that evolution states that humans are descended from chimpanzees* *This activity adapted from Joe Walsh @ http://www.indiana.edu/~ensiweb/ring.spec.demo.pdf* Powerpoint: Punctuated Equilibrium vs. Gradualism, Convergent Evolution vs. Divergent Evolution, Co-evolution - During discussion of Punctuated Equilibrium vs, Gradualism remind students of the paint chip demo and ask students to identify what pattern of evolution it showed. Discuss how it would look different if those species had evolved in a pattern of punctuated equilibrium.	What are the types of speciation? How does evolution occur on a grand time scale? How do organisms affect each other's patterns of evolution?		later	
Extension: Reading: Speciation in real time. Follow up questions: What type of speciation does this article refer to for each type of bird? What do you predict might happen with the birds in the future? Do most speciation events occur in time spans that we can observe or over long periods of time?	Are new species still forming? How do people affect the organisms around us?	Copies of reading	Checking for understanding	15 minutes

Notes:

Misconceptions:

- Misconceptions about the rate of evolution are addressed in this lesson
- Students misconceptions about how new species form are addressed
- Specifically, the misconception that evolution says that humans evolved from chimpanzees is addressed

Adaptations:

- Heterogeneous grouping used during lab activity
- Material presented with hands-on, modeling, visual, and oral descriptions to address multiple learning styles

Technology

- Powerpoint is used to structure lecture

Safety:

- Students will follow general safety guidelines when moving about the room and completing their labs

Classification and Taxonomy Lesson Plan

Topic: Classification and Taxonomy
NSES: Content Standards A, C, F, G
SOL: BIO.1 b, l, m, BIO.6 d, e, BIO.8 e
Daily Question: How do we find relationships among organisms?

Date: Day 7
Grade level: 10
Subject: General Biology

Procedures for Learning Experience	Guiding Questions	Materials Needed	**E**valuation (Assessment)	Time Needed
Engagement: Dichotomous Key shoe activity: Students take off one shoe and put it at the front of the classroom. To students: how could we sort these shoes and make a key to identify each? Teacher models creating the dichotomous key and then each student who gave a shoe follows the steps to identify their shoe to get it back. To students: these are called dichotomous keys and they're how we identify many organisms in natures. Now you're	How can we distinguish between different groups?	Shoes (from students) White board/doc cam	Student participation and understanding	10 minutes
Exploration: Dichotomous Key Activity with pasta shapes. In groups of 2-3, students create an either/or series of questions/choices to narrow down to each pasta shape. Groups then switch their keys and use them to identify one pasta shape. Debrief: What criteria did you use? What criteria would be useful when trying to identify a plant, a frog, an insect?	What criteria are bets to use for dichotomous keys?	Different types of pasta. Handout	Checking for understanding, Student keys are collected	15 minutes
Explanation: Powerpoint: Dichotomous Keys	What is a dichotomous key and how are they used?	Powerpoint	Checking for understanding	10 minutes
Exploration: Teacher models what a cladogram looks like and shows how it represents relationships. With their partners, students creating a cladogram of the pasta shapes that students had based on similarity. Debrief: How did you decide which pasta shapes were most similar? What do you think scientists use to decide on the	How can we display relationships between groups? What do scientists use to determine	Whiteboard/ smartboard	Monitor for understanding	5 minutes

similarity of organisms? **Review of evidence for evolution (biochemistry, developmental stages, fossil record)**	relationships between species?			
Explanation: Powerpoint: Cladograms // Phylogenetic Trees Basic Unit of classification is **species** Use www.timetree.org (which gives the estimated time of divergence between two species or taxa) to show example relationships. - Have students make predictions about which organisms will be more closely related to one another. - Use the data to construct a sample cladogram on the board. *Emphasize adaptable nature of classification *Linnaean taxonomy and Binomial nomenclature*	How do we classify organisms? What evidence do we use to figure out evolutionary relationships between organisms? Can our classifications change? What do branch points of a cladogram represent?	Powerpoint, internet access, whiteboard or smartboard	Check for understanding Material assessed on test	25 minutes
Extension: Students use dichotomous keys to identify real species (using pictures from around W&M campus – Campus Tour of Woody Species: http://www.wm.edu/as/biology/planttour/index.php) and real leaf specimens that I will have collected	How can we use dichotomous keys to learn more about the species around us?	Internet access for campus tree photo tour Leaves from campus trees		20 minutes

Notes:

Misconceptions:

- Address misconceptions that cladograms show more advanced forms on the right

- The misconception that a long branch on a phylogeny indicates that the taxon has changed little since it diverged from other taxa is also addressed in discussion of cladograms
- Misconceptions about species closer at tips being more related will be addressed by emphasizing that students need to find branching points to determine evolutionary relatedness
- The adaptable nature of our classification system is emphasized to address the misconception that our classification system is fixed and unchanging. However, the solid evidence that our classification systems are based on is also emphasized to show that relationships are well founded.

Adaptations:
- Heterogeneous grouping during activities
- Hands-on activities to suit many learning styles
- Notes copies to students with it in their IEPs

Technology
- Timetree.org used so that students can gather information about evolutionary relatedness
- Campus tree tour used for pictures of campus trees

Safety:
- Make sure that students don't have any allergies to any of the leaves that I might bring in
- Make sure that students don't try to eat the pasta