SAN DIEGO ZOO
INSTITUTE FOR
CONSERVATION
RESEARCH

THE LIVING DESERT
ZOO | GARDENS

DESERT
MANAGERS GROUP

Conserving the Desert Tortoise

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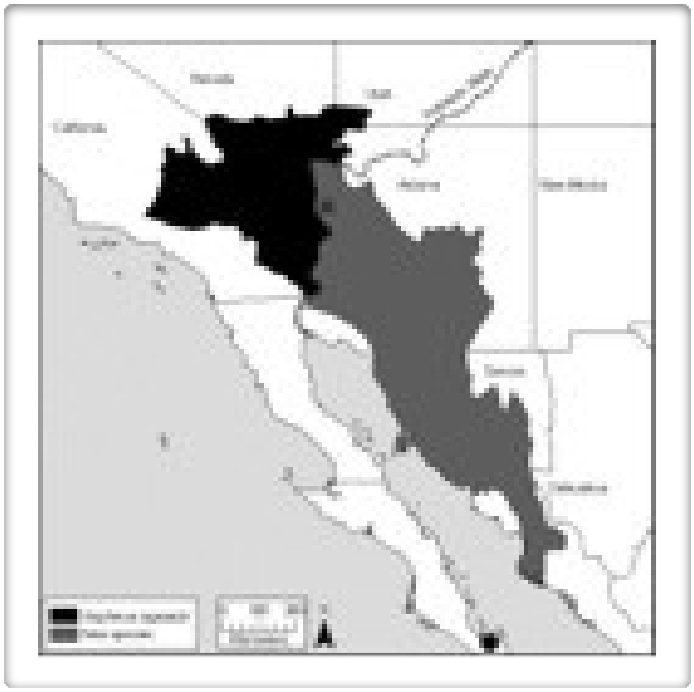
Desert Tortoise Overview

Habitat The desert tortoise (*Gopherus agassizii*) lives in the Mojave Desert. In the desert, there is not much rainfall and large fluctuations in temperature between the scorching summer and the freezing winter months. To deal with these temperature differences, the desert tortoise digs burrows in the ground. The tortoise uses these burrows as shelter from the sun in the summer and a place to hibernate in the winter. They lay their eggs in theses burrows and utilize them as protection from predators. Other animals also use these burrows as shelter from harsh winter conditions and from predators. Desert tortoises also disperse seeds from the native desert plants that they eat, which in turn repopulates the desert ecosystem. Thanks to these key components in their niche, desert tortoises can be considered a keystone species of the desert ecosystem.



Evolution It has been argued for decades whether or not the populations of desert tortoises above and below the Colorado River are the same species. A study in 2011 shows conclusively through genetic evidence, that the tortoises in different locations are in fact

Desert Tortoise Overview

different species. The species north and west of the Colorado River is *Gopherus agassizii* and the species located south and east of the Colorado River is *Gopherus morafkai*. This speciation was probably a result of physical separation and differences in environment. Some of the visible differences are shell shape, preferred habitat, and their egg laying season. *Gopherus agassizii* has a box-like, domed shell, and predominantly lives in valleys, digging its own burrows in the sand. They live mostly in the Mojave Desert around salt brush scrub, creosote bush scrub, desert scrub, and tree yucca woodland. They lay their eggs from April to mid-July, and are listed as threatened by the U.S. Fish and Wildlife Service. *Gopherus morafkai* on the other hand has a flatter, pear-shaped shell, and lives predominantly on slopes and rocky hillsides, burrowing under rock crevices. They live mostly in the Sonoran Desert around uplands, thorn scrub, and grasslands. They lay their eggs from June to early August and are not listed as threatened.

Social Interactions

The temperature of its egg during incubation determines the sex of a desert tortoise. Eggs with lower temperatures (26-30.6 C) become males and eggs with higher temperatures (32.8 – 35.3 C) become females. Life for a baby tortoise is difficult because their shell has not yet hardened, and they move slowly causing them to be vulnerable. During the active season males spar for the privilege of breeding, using their gular horn (part of the

Desert Tortoise Overview

plastron lying beneath the extended head) to hook other males and overturn them during aggressive interactions. When they fight, tortoises try to flip their opponent onto their back, and the one that gets tipped over loses, often dying from baking in the sun. Chin glands on a male serve as chemical and visual signals to other tortoises. Larger chin glands indicate that a tortoise has more testosterone therefore making it more sexually attractive to females. Males also bob their heads to get the attention of females. While mating, male tortoises are very rough to females until the female tortoises submit to their advances. Females will submit to their advances once the male has proven to be fit. This ensures that their offspring will be strong. Females can store the sperm until laying conditions are favorable, eventually laying 2 to 14 eggs the size of Ping-Pong balls in a shallow nest that she digs near her burrow. The female does not stay to tend to her young, instead she leaves them to fend for themselves upon hatching.

Disease Desert tortoises are significantly affected by upper respiratory tract disease (URTD). URTD is a chronic, infectious disease responsible for population declines across the entire range of the desert tortoise. It is suspected that the disease arose in captivity, and spread to wild populations through the release of pet desert tortoises. It is caused by the infectious agents Mycoplasma agassizii and Mycoplasma testudineum. Another disease

Desert Tortoise Overview

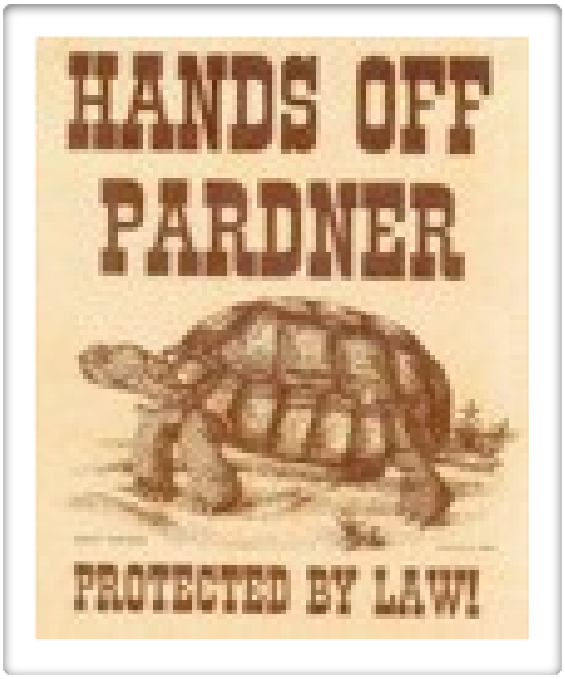
that has affected the desert tortoise populations is Cutaneous dyskeratosis (CD), a shell disease that has unknown implications on the desert tortoise population. Not much is known about CD, but it is hypothesized to be either an autoimmune disease, the result of toxic chemicals, or possibly a nutrition deficiency disease.

Human Effects

Due to human development in their natural environment, desert tortoise populations in the wild have decreased significantly. Roads can be especially dangerous to tortoises since they are a relatively small species, and are easily run over by cars. Off-road vehicles often do not see tortoises before they are crushed. Before it was illegal, people visiting the desert would take wild desert tortoises home with them to be pets. It is not a good idea to do this because many of the people who picked them up were not prepared for proper desert tortoise care. Today, it is illegal to remove desert tortoises from their native habitat, but it is possible to adopt them through local turtle and tortoise clubs.

Conservation Efforts Since 1989, the US government has afforded federal protection to desert tortoises. In 2009, San Diego Zoo Global partnered with the U.S. Fish and Wildlife Service, the Bureau of Land Management, and the Nevada Department of Wildlife to operate the

Desert Tortoise Overview



Desert Tortoise Conservation Center (DTCC) to aid in the recovery of wild desert tortoise populations as well as the Mojave Desert ecosystem in general. The DTCC helps to teach the public about the desert tortoise through community outreach. At the DTCC, tortoises are put through a full health assessment before they are treated for any ailments. The tortoises that stay there are put into adult-sized pens which are predator-proof, so they can be content and live safely. Every year more and more tortoises are released back into the wild from the DTCC, some with transmitters on them so that they can be tracked in the future to monitor their behavior back in the wild. For more information see the San Diego Zoo website at:
http://animals.sandiegozoo.org/animals/desert-tortoise

If there are any missing or broken pieces in the kit, please contact the center you rented the kit from right away.

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Trunk Checklist

Permanent equipment	Qty.	Condition
Receivers/ Antennas/ Handles	2	
Tortoise Plush Toys	3	
Transmitters on plush toys	3	
Tortoise Shell	2	
Velcro board	1	
USB stick	1	
1M Laminated cards	8 White folder (8)	
3M Laminated cards	5 Yellow folder (5)	
Baggies of Velcro karyotype puzzle pieces	2	
Karyotype Keys 6 cards	Red folder (6)	
Materials Binder	1	
Clipboard	2	
DVD: Tortoise in Peril	1	

Trunk Checklist

Consumable Supplies	Qty.	Storage
Student Workbook	Print one per student	USB drive

Lesson Sequence

Day	Activity	Next Generation Science Standards Practice
1M	Evolution	MS-LS4-2 MS-LS4-4
2M	Radio telemetry	MS-LS2-2
3M	Sex Differences	MS-LS$-2
4M	Karyotype	MS-LS3-1
5M	Conservation	MS-LS2-1 MS-LS2-4
6M	Ravens	

Desert Tortoise Roundtable

Theme/Concept:	Reflection on what students know about desert tortoises.
Goals:	To understand what students know, what they want to know and to help assess what students have learned.
Objectives: (Evidence of student learning)	Students will be able to: 1. List what they know about tortoise 2. List what they want to know about tortoise
Materials in Kit:	None
Materials provided by teacher:	White board, document cam, poster paper Markers for above materials
Materials on USB drive:	None

Desert Tortoise Roundtable

Engage • 10 minutes

DESCRIPTION

Create a chart that can be kept over the week as the students are learning. Add to this chart throughout the week. This can be a rubric to assess what the students are learning.

This is a brainstorming activity to determine what students know, what they want to know, and what they learned. Explain to students that they will be learning about the desert tortoise this week. Ask students what they know about tortoises. Write responses on the chart. Ask students what they want to know. Write responses on chart. Leave the third column blank. Encourage students to share their responses in full sentences.

An alternative to this activity is the creation of a concept map. The concept map should have main ideas in bubbles, and writing on the arrows between the concepts to explain the connections.

These activities are suggested for a full class, but can also be used as personal activities. If used as a full class it is suggested to do it on poster paper or a board that will not need to be erased over the duration of the week, so that it can be added to at the end of each day. If you do not have time to revise it each day as a class, maybe give each student a few sticky notes and ask them to add to the chart by writing it on a sticky note and putting it on the chart. If it is used as a personal activity, have each student put it on binder paper to be graded at the end of the unit.

Desert Tortoise Roundtable

Sample Teacher Questions

- Do you think tortoises are turtles? How are they the same or different?
- Do you think that desert tortoises are big or small? Why?
- Have you seen a desert tortoise before? Does anyone have one as a pet?
- Where do they live? What do they eat?
- How do you think they reproduce?

Anticipation of Student work and common misconceptions:

- Turtles and tortoises are the same thing so tortoises live in water
- That these tortoises are big like Galapagos tortoises
- You can take them home after a vacation in the desert
- That they are carnivores
- That they will live to be 100 years old in the wild

Example 1: KWL Chart

What I know	What I want to Know	What I learned
They live in the desert.	What they eat?	
They are related to turtles	How old they get?	
They lay eggs	Can they swim?	
They are cold blooded		

1M: Evolution/Population Genetics

Theme/Concept:	(Speciation, evolution, population bottleneck) The desert tortoise has evolved to be more than one species.
Goals:	Students will know the differences that scientists use to decide that two species have evolved into separate species.
Objectives (Evidence of student learning)	Students will be able to 1. Identify the similarities and differences between Agassiz's and Morafka's Desert tortoises 2. Argue that there are or are no different species of desert tortoises
Next Generation Science Standards Practice	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-LS4-4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

1M: Evolution/Population Genetics

Specific Background Info for Lesson

When the species *Gopherus agassizii* was first described in the nineteenth century, it was described to live in North America, mainly in the Mojave and Sonoran deserts. However, over the past century, it has become apparent that there are differences in the desert tortoise based on the region that each population lives in.

In recent years, scientists have determined that there are at least two different species of desert tortoise. Agassiz's tortoise, which lives north and west of the Colorado River, mainly in the Mojave Desert. And the Morafka's Desert tortoise, which lives south and east of the Colorado River mainly in the Sonoran Desert. They determined that the tortoises are different species based on the analysis of mitochondrial DNA and DNA fingerprinting in conjunction with differences such as certain behaviors like where they construct their burrows and shell shape.

Because these tortoises were thought to be of the same species until very recently, they share many characteristics such as the food they eat and the burrows that they dig. However, some of their morphological differences such as shell shape could be due to the fact that they live in slightly different habitats with different resources available to them. Agassiz's desert tortoises live predominately in valleys whereas Morafka's desert tortoise like to live on rocky slopes and hillsides.

Speciation takes place over time. There is no one defining event that causes one species to differ from its parents. It is an accumulation of

events and mutations. In the case of one species branching off into two, we call that divergent evolution. In the case of the desert tortoise, we do not know when it branched off, because we lost the samples that were taken when the species was described in the nineteenth century to the San Francisco earthquake, so as far as we know, both species could have changed from what was originally described. As the species radiates to different regions, not the entire species is moved to the new location. The founding population determines the overall genetic diversity and make up for the new population, so if a specific trait was seen more in this founding population, it is likely to be more prevalent in the new population. This is called the founding effect. The desert tortoise has been found in the fossil record up to 19 million years ago, so who knows how different the tortoises of today look like compared to the tortoises of back then!

1M: Evolution/Population Genetics

Materials in Kit	•USB stick – PowerPoint/worksheet •Laminated cards - white folder (marked A-H)
Materials provided by teacher	•Optional student worksheet or science journal or binder paper (can be supplied by students)
Safety Requirements	N/A
Materials on USB drive	•PowerPoint presentation •Notes •Activity Worksheet

1M: Evolution/Population Genetics

Engage • 10 min

See KWL chart (previous lesson)

Explore • 15 min

DESCRIPTION

Students will be given laminated sheets with information about the two desert tortoises. Then, in groups, they will decide if there are more than one species of the desert tortoise.

GETTING READY

1. Read up on the desert tortoise! There are plenty of materials in the trunk, but for times sake please at least skim the background information at the beginning of the lesson.

2. Check your technology! The presentation is in powerpoint (.ppt), keynote (.key), and pdf (.pdf) formats, so at least one should work on your computer. Make edits to suit your classroom needs.

LEADING THE INVESTIGATION

1. Set up the experiment by either explaining it to your students using the powerpoint to set it up. The students will be split into groups of four. Each member in the group will have an assigned role. Each role is of equal importance. If necessary count off numbers 1-4 to each student and assign the roles to each number in the group. Emphasize that they are not constrained to their roles and are all expected to participate in the group discussion.

The Fetcher – Retrieve the materials from the teacher at the beginning. They are also responsible for trading laminated sheets when their group is done with one.

1M: Evolution/Population Genetics

The Scribe – Writes down the observations from the evidence and the conclusions that the group draws based on the evidence. They will have to turn in the group work at the end of class, so make sure they have everyone's name on the paper!

The Spokesperson – During the class discussion this student will be the "go to" person in the group to share the group's ideas. They should share with the class at least once during the discussion period.

The leader – Oversees all the other roles and leads the discussion within the group. This student is responsible for keeping the group on task.

2. Have the "fetchers" come get the first round of laminated sheets. Make it clear that each group should get at least 4 pieces of evidence by the end of the investigation time. If you want you can ring a bell when it is time for the groups to switch cards (3-5 minutes). Because each group is going to see different evidence, they will construct a slightly different argument.

3. Give each group a minute or two to write a sentence with evidence that the desert tortoise is or is not multiple species. When setting this up, use the phrase "convince yourself, convince a friend, convince a skeptic" to guide their discussions.

4. Have a couple groups share their decisions. Ask classmates if they agree or disagree with what their peers are saying and why. Make sure each group uses evidence when they make their claims and when they respond to the claims of their classmates. Unless the class is unanimous, make sure to hear an argument from each side.

Sample Teacher Questions

- What does this piece of evidence tell us? Does it prove anything?
- Why do you think that?
- Do you agree or disagree with (name)? Why?

1M: Evolution/Population Genetics

Explain• 15 min

DESCRIPTION

Explain speciation using the theory of evolution using provided PowerPoint. Fill-in notes are provided on the thumb drive. Or you can have students take their own notes on the material.

Sample Teacher Questions

- Does one organism evolve on its own?
- Do species have to look incredibly different to be different species?
- What does it mean to have a common ancestor?
- Why do species have to adapt?

Evaluate/ Extend• 10 min

DESCRIPTION

Students will brainstorm what it means to be a different species. They can talk with others, and at the end they should have at least two bullet points as to what makes two species different.

Sample Teacher Questions

- Write at least two bullet points down that separates one species from another.
- What did you learn today?
- Why is this important?

Other possible extension questions

- Have an expert come in to talk about different species and biodiversity in the local area.
- List other pairs of animals that are different species but could share an ancestor and why?
- Brainstorm some mutations that could change humans into another species.

2M: Radio Telemetry

Theme/Concept:	Researchers use radio-tracking equipment to study desert tortoise home range.
Goals:	Students understand that tortoises live in multiple burrows, spend much of their time underground, and have a “home range.” They understand how we study desert tortoises to discover this information.
Objectives (Evidence of student learning)	Students will be able to: 1. Identify how we use radio telemetry to study animals in the wild. 2. Identify where Desert Tortoises live.
Next Generation Science Standards Practice	MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

2M: Radio Telemetry

Specific Background Info for Lesson

Radio telemetry uses radio waves to send a signal from a transmitter to a receiver. These radio waves are not the same frequency as those used for FM radio, so you don't have to worry about it interfering with your jams. Radio telemetry is commonly used when tracking animals for research because it is a simple way to track the movement of animals.

By knowing where the animal is, we can extrapolate its home range. The home range is the area that an individual lives their life within. It is important to know the home range of an animal so that we can study the other factors that make up its environment. In doing so, we can figure out what the niche of the animal is, what it eats, who eats it, where it lives and how it constructs its shelter.

From studies with radio telemetry among other tools including data analysis on computers, we have been able to learn a lot about the desert tortoise. We learned that the desert tortoise spends 90% of its time underground in its burrow. Usually the desert tortoise will not live in the same burrow all year, rather it will dig multiple burrows for different reasons. Such as the winter burrow is for hibernation, and it is generally deeper than the summer burrows. The summer burrows are used for estivation, which is like a summer version of hibernation, a longer nap if you will. Sometimes tortoises will reuse the same burrows, and sometimes they will dig new ones. Generally no more than two tortoises will live in the same burrow, but it has been found that some as many as a dozen tortoises have burrowed together to make a winter den for hibernation. Burrows provide protection from harsh weather conditions as well as predators. Desert tortoises are not the only ones who use their burrows! Other

2M: Radio Telemetry

desert animals will also use them to live in and for protection as well. This makes them a keystone species of the desert environment.

The equipment used to do these experiments is more advanced than what is included in the trunk. In the trunk there are simple radio transmitters that work to find an individual. If a transmitter like this were to be used in the wild, then we could find an individual that has been released and observe how it is doing perhaps a year later. This technique has been used since the early 1990s to track desert tortoise movement and study the impact humans have when we intrude on their natural environment.

To use the radios first you have to set them up.

- Check all the batteries to make sure that they work.
- Unfold the antenna from the receiver
- Attach a handle on to the receiver

Next, you want to test the transmitter. Turn on the receiver to a channel that you have a transmitter to. You should hear a beeping noise. If you do not, play with the volume and the range knobs. Do this with all the transmitters that you have. It is also a good idea to play with the technology a bit before you explain it to your students.

More detailed instructions on how to set up the investigation are in the lesson. To put away the set up, there is a button on the handle to release and slide it off. There is also a button for each antenna to fold them down. Make sure the receiver is off, then put everything back in the bag it came in. The toy tortoises might be a bit dirty, so clean them up before placing them back in the trunk.

2M: Radio Telemetry

Materials in Kit	(2) Receivers/antennas (2) Handles (3) Tortoise plush toys (3) Transmitters (on plush toys)
Materials provided by teacher	(optional) Conclusion questions/exit slip printout M2 (optional) Explore guide 2M
Safety Requirements	Students are respectful to each other and other classes while outside of the class.
Materials on USB drive	•PowerPoint 2M •Explore guide 2M •Conclusion Questions/Exit Slip •Equipment manual

2M: Radio Telemetry

Engage • 5 min or less

DESCRIPTION

You will be playing a game of Hot and Cold. Choose an object in your classroom, for instance use a stapler and put it in a place that you usually do not keep it. Then ask for a student volunteer. Tell them that they are looking for the stapler. As they walk around, say "hot" when they get closer, and "cold" as they get further away. Add adjectives such as "really hot" or "scorching" when they get very close to the object. After they have found the object transition into talking about the purpose of the activity. If you want the game to take less time (which you might) hide the object in a more obvious place.

The purpose of this game is to model how the signal transmitted from the radios will change as the position of the radio changes in relation to the object that is being tracked.

Explore• 25 min

DESCRIPTION

The students will investigate the desert tortoise through reading and hands-on time with radio telemetry equipment.

GETTING READY

1. Set up, test, and play with the equipment. Detailed instructions are in the lesson. If you need more instructions the manual is included in the thumb drive.

2. Hide the tortoises around the school. Make sure to hide them in a place that will not be too disruptive during class. Good places might be in a planter, the locker room, or outside another teacher's classroom. Make sure facilities knows about them so they do not get moved or thrown away.

2M: Radio Telemetry

3. Write down where you hid each tortoise and the transmitter number on it.

LEADING THE INVESTIGATION

1. Split the students into groups.

2. Give students time (5-10 min) to do research using blogs and other materials in the kit. Have them write a summary about what they researched. It is suggested to also let them talk about what they learned with their group or as partners before moving on.

3. Demonstrate the equipment for radio telemetry, remind the students that you are borrowing the equipment and that it is very expensive.

4. Take the classroom out in their groups to find the tortoises using radio telemetry.

5. After the groups have found their tortoises, have a "challenge tortoise" race. Give all the students a new frequency to the last desert tortoise and see who can find it first.

6. Debrief the activity and return the plush toys to the trunk.

Sample Teacher Questions

- What were some issues you had with the investigation?
- How did you fix them?
- How else could you use this to research?
- What sorts of things make up a niche?
- Do you think that a niche and a home range are the same thing?
- What did you learn while researching the tortoise?
- What did you learn from the blogs?
- Is there anything else you want to know about the desert tortoise now?

2M: Radio Telemetry

Explain • 10 min

DESCRIPTION

Explain home range and ecological niches using the powerpoint on the thumb drive. Fill in notes are included on thumb drive. Note that this is called spatial ecology.

Sample Teacher Questions:

- What are biotic and abiotic factors?
- What is your home range? Is it bigger than an animal?
- Why do you think Desert tortoises burrow?
- What is the advantage of hibernation?

Evaluate • 5 min (Optional) GRADED

DESCRIPTION

Students will answer "exit slip" before they leave. Emphasize that it must be answered in a full sentence.

Sample Teacher Questions:

How is radio telemetry used to research tortoises?

Extend• 5 min (Optional)

DESCRIPTION

Update the KWL chart from yesterday. Revise the things from K if they were not correct, add to W, and add to L.

2M: Radio Telemetry

List a couple other possible extension questions

- What are some other animals that have similar home ranges to the desert tortoise?
- What are other possible uses for radio telemetry?
- What are other possible ways to find out the niche of any given animal?
- How is this similar and/or different from your game of hot and cold?

Anticipation of Student work and common misconceptions

Misconceptions:

- Desert tortoises are awake all year long
- The desert tortoise gets really big and lives for a very long time
- We don't need to know where a desert tortoise goes because it is such a small area because they move very slowly

3M: Gender Differences in Desert Tortoises

Note: This lesson is designed to be shorter so that if day 2M goes long you do not have to fall too far behind.

Theme/Concept:	Desert tortoise gender is determined by what temperature their eggs are incubated at. When they reach sexual maturity in their teens, they start to show physical differences.
Goals:	Students will understand the differences between male and female tortoises and why they are important.
Objectives: (Evidence of student learning)	Students will be able to: 1. State some physical differences between mature male and female desert tortoises. 2. State why tortoise eggs become male or female.
Next Generation Science Standards Practice	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.

3M: Gender Differences in Desert Tortoises

Specific Background Info for Lesson

Desert tortoises, like many reptiles, do not have a determinate sex until they hatch. The sex of the tortoises is determined by the temperature at which their clutch was incubated. If the eggs are incubated at a lower temperature, then the tortoises will hatch male, and if the eggs are incubated at a higher temperature, then the tortoises will hatch female. Even though the sex of the tortoises is concrete at birth, tortoises look reasonably the same until they reach sexual maturity.

At sexual maturity, males develop more male features, and females develop more female features.

Besides the physical differences, tortoises also show behavioral differences based on their gender. Such as, if a female encounters another female nothing spectacular will happen. However, if a male encounters another male most likely they will fight. The way that male tortoises fight is that they try to flip one another over putting the loser into a submissive position that could end up being fatal. Don't worry though, even if a desert tortoise gets flipped on his back, it is possible for him to turn over and walk away fine. Desert tortoises fight often for territory or the right to mate, just like other animals as well as humans. If a male tortoise encounters a female tortoise during mating season, he will try to mate with her. If she does not deem him worthy, she will run away, making it near impossible for the male to pass on his genetic material to her.

3M: Gender Differences in Desert Tortoises

Materials in Kit	Tortoise Shells
Materials provided by teacher	Optional notes worksheet
Safety Requirements	Handle shells with care
Materials on USB drive	•3M Gender Difference Presentation •3M Notes

3M: Gender Differences in Desert Tortoises

Engage • 5 min

DESCRIPTION

Students will work together as a class to make a Venn diagram about the differences between males and females on the board. Before you open the class up to discussion, this is a good chance to do a think-pair-share. Give students a minute to think and talk to their nearby classmates. Then lead the class discussion by calling on students and asking them what they want to add, where it goes on the chart, and why it goes there.

Sample Teacher Questions:

- What are some differences between males and females? What are some similarities?
- Do these differences apply to animals? To reptiles? To Desert tortoises? Why do you think that?

Explore/ Explain • 20 min

DESCRIPTION

Just as in lesson 1M, the students will have cards to rotate through. This time, they are trying to answer the question "How are male and female tortoises different?" Then continue on to the accompanying powerpoint presentation.

Sample Teacher Questions

- Will all the eggs in the clutch be the same gender? (yes)
- Do you think we can control the gender of the tortoises in captivity? (yes)
- How do you think the gular horn is used? (in fights)
- How do you think tortoises recognize one another as each gender? (chin glands)
- What is the other type of reproduction? (asexual)
- How are they similar to the Venn diagram we made before? How are they different?

3M: Gender Differences in Desert Tortoises

Evaluate• 5 min

DESCRIPTION

Students will revise the Venn diagram by adding more things about the desert tortoise and deleting things that do not apply to the desert tortoise.

Sample Teacher Questions

- Why does [thing on diagram] apply to tortoises?
- Why doesn't [thing] apply?
- Is there anything from yesterday that you learned that you can add? Where did you find it?

Extend• 5 min

DESCRIPTION

Using the tortoise shells in the trunk, pass them around and have the class decide what gender each shell is. Encourage students to use evidence when sharing their argument.

List a couple other possible extension questions

- Have an expert come and talk about the gender differences between desert tortoises. Such as behavior or genetics.
- Talk about other animals in nature whose gender are influenced by their environment such as clownfish and other reptiles.

4M: Karyotypes

Theme/Concept:	Karyotyping is a method scientists use to take a look at the genetics of a species. Each species has a different number of chromosomes.
Goals:	Students will understand that the genetic material for different organisms differs in organization. But they all use DNA, and we can use the same method of DNA analysis to compare the different organisms or species.
Objectives: (Evidence of student learning)	Students will be able to: 1. Match chromosomes together and cooperatively put together chromosome maps. 2. State that genetic material comes from DNA, also known as chromosomes 3. State that desert tortoises do not have sex chromosomes
Next Generation Science Standards Practice	MS-LS3-1: Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.

4M: Karyotypes

Specific Background Info for Lesson

Chromosomes are a type of genetic material. They are a combination of DNA and protein which is condensed. You can only see chromosomes during mitosis, because otherwise the DNA is not super-condensed, but floating in the nucleus. Karyotypes are a way to visualize chromosomes and compare them to different organisms or individuals.

Karyotypes are an arranged grid of chromosome pairs from largest to smallest, so that you can see the full genetic profile of an organism. You can differentiate and match each chromosome pair by its size and banding pattern. Each band on a sister chromatid is an allele and two alleles at the same position on sister chromatids make up a gene. Mutations can sometimes occur in genes, thus affecting the genotype of an individual. If multiple mutations occur, and they are conserved among generations, then this could lead to evolution, aka speciation.

Mammals can have a variable amount of chromosomes. But one thing that is always conserved is that they have sex determining chromosomes. XX denotes a female individual and XY denotes a male individual. The difference in sex is determined at conception. The number of chromosomes is represented as 2n= . In humans, 2n= 46, meaning we have 46 chromosomes in somatic body cells.

Avian species are similar to mammals in that they have sex determining chromosomes, but we do not use the same terminology as mammals. WW is a male individual and WZ is a female individual.

Some reptile species do not use sex determining genes to determine their sex. Rather, the temperature that their eggs are incubated at determines their sex. In the case of many reptiles, including the

4M: Karyotypes

desert tortoise, males are hatched at a lower temperature than females. For more information on this topic, you can consult sources such as Wikipedia.

Karyotyping is a type of genetic analysis. When looking at a karyotype, scientists look at the absolute sizes of chromosomes, the differences in the position of centromeres, the differences in the sizes of centromeres, the basic number of chromosomes, the differences in number and position of satellites to the chromosomes, and the differences in the degree of distribution of heterochromatic regions. If there are any abnormalities, genetic diseases can easily be identified in the individual. It is common for research centers to have countless binders of reference karyotypes for many different organisms.

Karyotypes understandably do not come in neat charts as we see in textbooks, but usually a mash-up puddle of chromosomes. Scientists analyze banding and size to put together the karyotype by dyeing each chromosome. This dye helps to visualize the chromosomes.

4M: Karyotypes

Materials in Kit	Felt board (1) Baggies of Velcro karyotype puzzle pieces (2) + Keys (6) in red folder
Materials provided by teacher	Optional activity worksheet
Safety Requirements	
Materials on USB drive	•4M PowerPoint •4M Notes

4M: Karyotypes

Engage • 5 min (Optional)

DESCRIPTION

Students will watch a video then have time to ask questions about what they watched. Suggested videos are below (Youtube links).

This is a good time to introduce the idea of genes and how they match up in homologous chromosomes.

Alternate Videos:

- String karyotype http://www.youtube.com/watch?v=FQTTzf6FCYg
- Okay methods video: http://www.youtube.com/watch?v=7ShPzzrCetE

Sample Teacher Questions

- What is genetic material? (DNA) Where is it found? (In the nucleus)
- Does DNA always look like what it does in these pictures, the X's? (no, they are condensed into chromosomes which only happens during cell division)
- Do you think that these karyotypes will look the same within a species? (yes)
- Do you think that these karyotypes will look the same between different species? (No? Yes? This leads to the next activity)

Explore • 20 min

DESCRIPTION

Students will discover the differences between different species of animals by doing an interactive class karyotype of mammals, birds, and then the desert tortoise. The major things they should notice are that each species has a different number of chromosomes. Then they should see that there are sex-determining chromosomes in the mammal and bird, but not the desert tortoise (reptile).

4M: Karyotypes

GETTING READY

1. Check to make sure you have an even number of sister chromosome cards (if not, find the one without its pair and take it out. Contact where you got the trunk and tell them it is missing).

   Note: When putting away cards, match up sister chromosomes and stick them together before replacing them in the bag.

LEADING THE INVESTIGATION

1. Hand out the sister chromosome cards to the class. Each student will get one random sister chromosome. Depending on your number of students you may have to have students with two cards or students without cards at all. This is fine since you will be running the activity three times so there will be a chance for everyone to participate. Start with the mammal.
2. Have students find their matching sister chromosome by comparing banding patterns and size.
3. After everyone is matched up, have them line the homologous chromosomes up in order of longest to shortest. There is Velcro on the back of each card and it should stick easily to the board. Pass the board around so everyone can see it.
4. After you have this up have the students guess if this individual is male or female and why. Then show them the image of the other gender on the PowerPoint slide.
5. Repeat this process with the bird and the desert tortoise. When you get to the gender of the desert tortoise, you will notice that there are no sex-determining chromosomes. That is because male and female tortoises develop the same genetically and sex is not determined until the egg is incubated at a specific temperature.

4M: Karyotypes

Sample Teacher Questions

- Do you think that this genome belonged to a male or female? Do you agree with your classmate on that position? Why or why not?
- What evidence supports your statement?
- Do you think that the bird will be the same as the mammal?
- Do you think that the tortoise will be the same as the mammal and/or the bird? Why or why not?
- What differences did you notice between the different organisms?

Explain• 10 min

DESCRIPTION

The teacher will go through the provided presentation and ask probing questions about genetics.

Sample Teacher Questions:

- Why do you think this happens this way?
- What are some things that you are still unsure about?
- (See above for more)

Extend• 10 min

DESCRIPTION

The importance of karyotypes to conservation is so that we can see when animals can no longer breed to produce fertile offspring, such as a donkey (horse and mule) because they have a different number of chromosomes. This ties nicely into the lesson from day 1 and how the desert tortoise was split into multiple species through genetic analysis (even though it was not this type of genetic analysis).

4M: Karyotypes

List a couple other possible extension questions

- Update the KWL chart with new information.
- Have a cytogeneticist come and talk to the class about genetics.
- Have the students do another karyotype and find the number of chromosomes (n) as well as what gender it is (you can find these online). For homework, they could choose a plant.
- Explain how we can use them to track heredity. This includes how each allele is inherited from the parent. On a larger scale, we can see how the cell machinery messes up because some organisms have more or less chromosomes with different information located on them.

5M: Conservation

**Note: This lesson has two different versions, one which is half a lesson and one which is a full lesson. The half lesson is designed so that you can give a short unit quiz to sum up the lesson. For the half lesson skip the explore and just use the PowerPoint before the quiz. For the full lesson include the explore portion. **

Theme/Concept:	There are many benefits that come from desert tortoise conservation.
Goals:	Students will understand the effects that humans have had on the desert tortoise's environment as well as knowing the steps they can take to help conserve the desert tortoise.
Objectives: (Evidence of student learning)	Students will be able to: 1. State why conservation of desert tortoises and their environment is important 2. Complete a quiz on the desert tortoise
Next Generation Science Standards Practice	MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. MS-LS2-4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

5M: Conservation

Specific Background Info for Lesson

(Including definitions)

Conservation education is one of the most important goals for San Diego Zoo Global. With the desert tortoise, we work mainly at researching pressing issues such as the effect of upper respiratory tract disease as well as the current desert tortoise population in the Mojave Desert.

5M: Conservation

Materials in Kit	
Materials provided by teacher	Optional quiz Optional notes
Safety Requirements	
Materials on USB drive	•5M PowerPoint •5M notes •Unit Quiz

5M: Conservation

Explore/ Explain• 30 min

DESCRIPTION

Students will use data given to find out how fast the desert tortoise population has decreased. Then they will try to figure out why and how they can help preserve desert tortoise populations.

GETTING READY

1. Divide students into groups of 4 or 5. Make sure to have a student that is stronger in math in each group.
2. Write the following on the board, or use the powerpoint.

Decade	Population Density
1950s	250 tortoises/mi^2
1980s	200 tortoises/mi^2
1990s	90 tortoises/mi^2
2000s	10 tortoises/mi^2
2010s	5 tortoises/mi^2

Available environment: 8,000 mi^2

LEADING THE INVESTIGATION

1. Working in small groups, students will work to answer the question: "If the desert tortoise populations continue to decline, when will they go extinct?"
2. Instruct the students to use math to figure out when the tortoise will go extinct if we don't step in to help in their recovery. Perhaps they could draw a graph or create an equation. They could figure out the approximate number of tortoises in the wild and what percentage is lost between each decade. This is a math modeling problem, so hopefully students will come up with various answers.

5M: Conservation

3. After students come up with their solutions, ask them to share with the class what they came up with and how they came up with it. Give the other students an opportunity to agree or disagree with them, and ask them to justify why.
4. Then, show the powerpoint telling the students what exactly is leading to the decrease in population.
5. Before getting to the portion about how they can help, have students brainstorm ways to help conservation efforts.

Evaluate• 30 min

DESCRIPTION

There is a short unit quiz with 15 multiple choice questions and two short answer questions.

Extend• 5min

DESCRIPTION

Have students revisit the KWL chart one last time. Make sure that all the "Want to know" questions are answered.

List a couple other possible extension questions

- Can you explain what you have done in the past and how it differs from what you will do in the future? Why?
- Now that you know a little about desert tortoises, what more is there to learn? Is there anything else you want to know?
- If you had your own pet desert tortoise, what would it need to survive?

6M: Impact of Ravens

Theme/Concept:	Ravens are a known predator of desert tortoises, especially hatchlings. Ravens are also very resourceful and opportunistic. As the number of people in the desert increases, ravens have been able to take advantage of human trash for food and human artifacts like utility poles for nesting. As a result of these newly available resources, raven populations have grown immensely over the last few decades greatly increasing their impact as predators of desert tortoise hatchlings.
Goals:	Students will understand how human activity in the desert has allowed raven populations to grow, and how raven population growth negatively impacts desert tortoises.
Objectives: (Evidence of student learning)	Students will be able to identify three reasons raven populations have grown over the past several years. Students will be able to explain how an increase in raven populations impacts desert tortoise populations.
Next Generation Science Standards Practice	MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

6M: Impact of Ravens

Specific Background Information for Lesson
(Including definitions)

The desert tortoise was listed as a threatened species under the Endangered Species Act in 1990. Many factors, including habitat loss and fragmentation, disease, invasive species and predation led to the listing of this species, and continue to impact the survival of the desert tortoise today. In fact, some desert tortoise populations have experienced a 90% reduction in their numbers.

Since tortoises were listed, people have spread further into California's deserts. Along with the spread of human populations, comes an increase in activities that have allowed ravens, a known predator of desert tortoises, to occupy the desert in unprecedented numbers. People provide ravens with unnatural food and water sources as well as nesting sites, resulting in a major increase in raven populations by as much as 1,500% in some desert areas.

The increase in raven populations in California's desert impacts the desert environment, especially for the desert tortoise. Raven predation of desert tortoises, especially the vulnerable hatchlings, reduces the odds of tortoise survival as a species.

We can help desert tortoises in their struggle to survive by taking some simple steps to help reduce raven populations.

1. Make sure all trash finds its way to a secured trash receptacle,
2. Do not feed ravens, and
3. Do not overwater your lawns allowing water to run off or pool up, which provides water sources for ravens.

6M: Impact of Ravens

Materials in Kit	Tortoise In Peril DVD
Materials provided by teacher	
Safety Requirements	
Materials on USB drive	•6M PowerPoint •6M notes

6M: Impact of Ravens

Engage – 5 min

DESCRIPTION

Students will be asked to list factors that are negatively impacting desert tortoises, and the teacher will create/write down this list on the board/poster, etc.

Sample Teacher Questions

- How has human activity in the desert changed over the past 20 years?
- What are some predators of desert tortoises?
- Why is it important to pack all your trash out of a wilderness area?
- Can you think of ways that human activity has indirectly impacted desert tortoises?

Explore – 30 min.

DESCRIPTION

Students will watch the video *Tortoise in Peril* and discuss what they learned, and what surprised them or how they might change their actions and share this information with friends and family.