Zoo Genetics: Key Aspects of Conservation Biology
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**Zoo Genetics: Key Aspects of Conservation Biology**

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Illinois State Learning Standards Satisfied by This Curriculum:

**Middle/Junior High School**

11.A.3a  Formulate hypotheses that can be tested by collecting data.
11.A.3c  Collect and record data accurately using consistent measuring and recording techniques and media.
11.A.3d  Explain the existence of unexpected results in a data set.
11.A.3e  Use data manipulation tools and quantitative (e.g., mean, mode, simple equations) and representational methods (e.g., simulations, image processing) to analyze measurements.
11.A.3f  Interpret and represent results of analysis to produce findings.
11.A.3g  Report and display the process and results of a scientific investigation.
11.A.3b  Analyze historical and contemporary cases in which the work of science has been affected by both valid and biased scientific practices.
13.A.3c  Explain what is similar and different about observational and experimental investigations.
13.B.3e  Identify advantages and disadvantages of natural resource conservation and management programs.

**Early/Late High School**

11.A.4a  Formulate hypotheses referencing prior research and knowledge.
11.A.4c  Collect, organize and analyze data accurately and precisely.
11.A.4d  Apply statistical methods to the data to reach and support conclusions.
11.A.4e  Formulate alternative hypotheses to explain unexpected results.
11.A.5a  Formulate hypotheses referencing prior research and knowledge.
11.A.5d  Apply statistical methods to make predictions and to test the accuracy of results.
12.A.4a  Explain how genetic combinations produce visible effects and variations among physical features and cellular functions of organisms.
12.A.4c  Describe processes by which organisms change over time using evidence from comparative anatomy and physiology, embryology, the fossil record, genetics, and biochemistry.
12.A.5b  Analyze the transmission of genetic traits, diseases, and defects.
12.B.4b  Simulate and analyze factors that influence the size and stability of populations within ecosystems (e.g., birth rate, death rate, predation, migration patterns).
12.B.5a  Analyze and explain biodiversity issues and the causes and effects of extinction.
12.B.5b Compare and predict how life forms can adapt to changes in the environment by applying concepts of change and constancy (e.g., variations within a population increase the likelihood of survival under new conditions).

13.A.4b Assess the validity of scientific data by analyzing the results, sample set, sample size, similar previous experimentation, possible misrepresentation of data presented, and potential sources of error.

13.A.4c Describe how scientific knowledge, explanations, and technological designs may change with new information over time (e.g., the understanding of DNA, the design of computers).

13.A.5b Explain criteria that scientists use to evaluate the validity of scientific claims and theories.

13.A.5c Explain the strengths, weaknesses, and uses of research methodologies including observational studies, controlled laboratory experiments, computer modeling, and statistical studies.
A Teacher’s Resource for Interspecific Genetic Activities

Award-winning geneticist and researcher Dr. Jean Dubach at the Chicago Zoological Society’s Brookfield Zoo and Jason Crean, biology teacher at Lyons Township High School and Brookfield Zoo, have developed exercises that include real data from ongoing research projects taking place in the zoo’s Conservation Science Department. The classroom materials are all available on a Web site specially designed with the high school and college teacher in mind.

Some activities include:

**Aotus: The Owl Monkey Mystery**
In order to determine to which species an individual belongs, students will karyotype an owl monkey (genus Aotus), analyze one of its genes, and compare the gene to known RFLP patterns on paper. Chromosome spreads and RFLP patterns are available online.

**Who’s Your Daddy?**
By using simplified DNA fragments, students will determine paternity of a dolphin calf, along with its mother and possible fathers. The “gel” is available online for students to fill in and compare.

**Interspecific Karyotyping**
When using this activity, you can assign each student a different chromosome spread and allow students to determine the species by comparing their finished karyotype to a series of completed karyotypes. Chromosome spreads and known karyotypes are available online.

**It’s Not All Black and White!**
Penguins of the same genus can look very similar, so it is important to know each species to avoid hybridization. In this activity, students will use both a nuclear gene and a mitochondrial gene to determine the species of each individual within a genus. The actual gene sequences for Humboldt, Magellanic, and African penguins are available online.

There's more, including perplexing possums and lion family labs!

Visit www.xy-zoo.com to view and sample these activities for free.

Updates are available as research is completed.
The Importance of Genetics in Conservation

1.1 Different Methods and Procedures Used, Gender Determination

There is much to consider when managing animal populations in zoos, especially today, when zoos engage in many cooperative breeding programs. Zookeepers and managers must abide by carefully researched husbandry guidelines, which typically include dietary requirements, training and enrichment strategies, and behavioral observations. Demography also plays a major role insofar as keeping records of breeding and offspring helps eliminate inbreeding and maintains a healthy gene pool for each managed population. Genetics, the final cornerstone of effective population management, is absolutely imperative when maintaining healthy genetic diversity among populations.

![Diagram showing the relationships between Husbandry, Demography, and Genetics]

Why does genetics play such an important role in conservation?

In today’s genetics lab, much more can be learned about how animals live than ever before. DNA, the genetic molecule that serves as a blueprint to build all living things, can reveal many of the mysteries that animals keep. Among the commonly used purposes and methods are:

**Purposes:**
- **Paternity testing** – This is a method by which a father can be determined by comparing his genetic material with that of his possible offspring.
- **Relatedness testing** – This process compares genetic material from two or more individuals to assess if they are related to one another.
- **Gender determination** – Many animals are monomorphic, where genders appear alike, and genetics can now be used to ascertain who is male or female.
- **Species identification** – Some species appear very much like other species, and separating them usually can be difficult, so specific DNA sequences can tell us who is who.

**Methods:**
- **Karyotyping** – This technique allows researchers to observe the chromosomes, the packages of DNA in each cell, in order to view patterns unique to each species.
- **DNA fingerprinting** – This procedure allows researchers to view the DNA fragments that form a pattern unique to every individual.
- **Genotyping** – This practice involves finding unique patterns in DNA and comparing an individual’s pattern with another individual’s pattern.

The role of genetics is a monumental one, and the information obtained from the methods above are very important to maintaining a healthy animal population. Zoos that work together contribute updated information to the central person who coordinates the management of a given species, and proper records are kept to maximize the genetic diversity within each group.
Gender Determination Using Polymerase Chain Reaction (PCR)

DNA sexing has become the preferred method of determining the sex of many monomorphic species. With accuracy rates greater than 99%, it is no surprise that this method of sexing has become the most commonly used protocol in zoos and conservation organizations worldwide. Over the years, the genetics laboratory at the Chicago Zoological Society (which manages Brookfield Zoo) has conducted thousands of DNA-based tests for an array of institutions all over the world, ranging from private individuals and breeders to entire zoo populations.

Why is DNA gender determination so accurate? The answer to this question can be found in the technology used. Advances in molecular diagnostics have led to the development of a technique known as Polymerase Chain Reaction, or PCR. This technique takes advantage of the self-replicating nature of DNA, which allows one to amplify (replicate) DNA molecules. In this technique, double-stranded DNA is heated to a high temperature so that the strands separate. Then short segments of DNA, known as primers—with sequences complimentary to the ends of the region that one wishes to amplify—are allowed to locate and attach to the longer template molecules. A special version of the polymerase enzyme begins the next step. The DNA molecules replicate exponentially, resulting in quick and efficient amplification of the selected DNA segment. Using PCR in the laboratory, the DNA of male and female birds can be amplified and differences can be detected.

Here’s one way DNA sexing works. DNA sexing of birds takes advantage of the fact that males and females have different sex chromosomes, much like mammals. The main difference between female and male birds is that females carry a ZW chromosome pair, so they determine the sex of the offspring. Male birds carry a ZZ chromosome pair and can contribute only a Z chromosome. This is just the opposite of mammals, including humans. Male humans possess an XY pair and females carry the XX pair. For many species, a coding region of DNA that differs in size between the Z and W chromosomes is copied many times. A single type of PCR product is observed for males and two PCR products are present for females, one for the Z and one for the W chromosome, as shown in the picture above.

There are different very safe and noninvasive sources for getting DNA from an animal. These sources include shed feathers, hair with bulbs, and feces. It is a common misconception that blood samples are more accurate than feather samples for determining gender. In reality, using blood versus feathers or hair yields a 100% identical result with regards to accuracy. Since both methods ultimately result in isolating and identifying specific fragments of DNA, the source of the DNA should have no impact on the final results of this test.

Why PCR? First and foremost, as mentioned, this method is noninvasive and does not result in any harm to animals. Even a very small sample can yield a sufficient quantity of DNA. Conservation geneticists also use these genetic techniques to answer questions about the interbreeding of populations or to determine if these populations are isolated from each other by some type of barrier. These answers are extremely important to conservation efforts. Small, isolated populations are more likely to become extinct faster, or certain managed populations should be maintained separately to minimize hybridization between species and thereby maintain maximum diversity within each species.
The Importance of Genetics in Conservation

1.2 Conservation in Today’s Zoos, Pedigrees

Conservation Genetics in Today’s Zoos

Many years ago, zoos became concerned with husbandry and providing the right environment so that species would be comfortable enough to breed and produce young. Today, zoos have programs that monitor which individuals are mating so that they can maintain a healthy gene pool and sustainable populations. They keep careful records to limit inbreeding and to maintain the valuable genetic make-up of the population’s founders: the original individuals who have genes unrelated to the genes of others in the population.

Below is a pedigree, or family tree, of a group of golden lion tamarins (*Leontopithecus rosalia*). Each letter represents an identified allele, or version of a gene, which helps to determine parentage. This pedigree was determined before genetic monitoring was in place. The mean kinship value (MK), is a number calculated to estimate how related an individual is to the rest of the population. Mean kinship is the average of all pairwise kinship values between a given individual and all other living individuals in the population. The higher the number, the more relations and the less desirable it is to breed that individual. Using the pedigree below, answer the questions below to determine how genetics is used to manage this species.

![Pedigree Diagram](image-url)
Analysis questions:

1) Why do you think it is almost always a priority to breed founders?

2) In managed populations in zoos, it is now common practice to separate offspring from their parents once they have matured and become independent. Based on the information in the pedigree, why do you think this is the case?

3) In the living population, which individual(s) is/are most likely not going to be bred? Why?

4) In the living population, which individual(s) is/are most likely to be paired and bred? Why?

5) What important information may not have been clear to the keepers but was revealed in the tamarin group by genetic analysis?