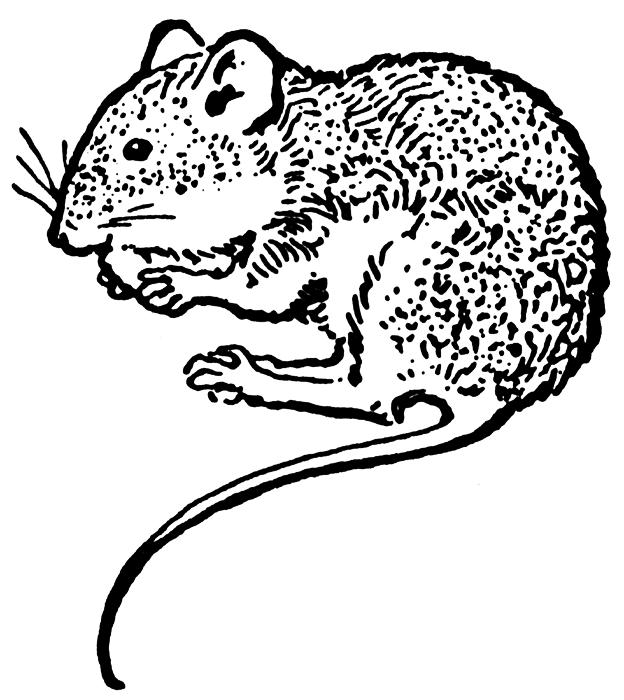
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| --- | --- |
| **Title** | **Molecular Biology – A Transgenic Mice Tale** |
| **Introduction** | Advances in 21st century research and genetic engineering have made it possible to create new genetically modified organisms (GMO). This new technique of manipulating genetic material is known as recombinant DNA technology. In a biotech lab, a molecular biologist (Science Investigator) selects specific genetic information that will either be added to an organisms DNA and/ or knocked out of the DNA. An organism that has newly inserted DNA, or genetic material removed and/ or replaced, is called *transgenic*. Many of the mice, rats, monkeys, and other animals used in scientific research are transgenic species.  This multi-lesson unit will follow a transgenic mouse’s tale from genetic manipulation, to the birth of founder mice, lab research, then ultimately to the end and sacrifice of the animal for scientific research.  In the first lesson, students will connect with 21st Century Science by taking the role of science investigator (molecular biologist) and simulating the creation of a knockout transgenic mouse using genetic engineering and biotechnical medical research.    **Lesson EQ**: How do scientists alter specific genetic information in laboratory animals? |
| **Curriculum Alignment** | North Carolina Science Essential Standards    8th Grade Science  8. L. 2 Understand how biotechnology is used to affect living organism.  8 L.2.1 Summarize aspects of biotechnology including:  Specific genetic information available  Careers  7th Grade Science  7. L. 1. Understand the processes, structures and functions of living organisms that enable them to survive, reproduce and carry out the basic functions of life.   * Compare structures and functions of plant and animal cells, including major organelles   7. L. 2 Understand the relationship of the mechanisms of cellular reproduction, patterns of inheritance and external factors to potential variation among offspring.  High School Biology  Essential Standard Clarifying Objectives  Bio.1.1 Understand the relationship between the structures and functions of cells and their  Organelles.  Bio.1.1.3 Explain how instructions in DNA lead to cell differentiation and result in cells specialized to perform specific functions in multicellular organisms.  Bio.3.1 Explain how traits are determined by the structure and function of DNA.  Bio.3.1.1 Explain the double-stranded, complementary nature of DNA as related to its function in the cell.  Bio.3.3 Understand the application of DNA technology.  Bio.3.3.1 Interpret how DNA is used for comparison and identification of organisms.  Bio.3.3.2 Summarize how transgenic organisms are engineered to benefit society. North Carolina Career and Technical Essential Educational StandardsStrands of this topic are discussed in the following High School Courses:Exploring Biotechnology – Course Number 6828Biotechnology and Agri-science Research I - Course Number: 6871Biomedical Technology- Course Number: 7200  * Exploring Biotechnology in Health Science- Course Number: 7205 * PLTW Biomedical Innovations- Course Number: 7273 * PLTW Principles of Biomedical Sciences- Course Number: 7270 |
| **Learning Outcomes** | Students will be able to simulate the process of altering of specific genetic information in laboratory mice DNA.Students will gain an understanding of the term “knockout” as it refers to genetic modification by taking out a gene sequence from their mock transgenic mouse.Students will use the scientific vocabulary terms: molecular biology, scientific protocol, genetic engineering, knockout mice, transgenic, and DNA as they relate to scientific investigations.Students will learn the career/ role of a molecular biologist in genetic engineering. |
| **Time Required and Location** | Two - 50 minute class periods |
| **Materials Needed** | CrayonsScissorsTape[Student](#Student) Handout 1– A mouse to cut and color [Lesson](#Lesson) 1 - Student Lab Sheet  10 cm strip of 1 inch “Base DNA” Ribbon (The ribbon represents the DNA strand of the mouse)  ½ inch Ribbon cut 2 cm long (3 color types representing different knockout transgenic mice types)  Example: Red ribbon – black mouse / replacement protein A  Blue ribbon- white and gray mouse/ replacement protein B  Green ribbon – brown wild type mouse / replacement protein C  (Fruit-Roll Up candy, string, and paper, and other colors can be substituted)  Balloons (or plastic baggies)  Science Journal/ or notebook paper  Basket |
| **Participant Prior Knowledge** | Before this lesson is taught, students will need to review the parts of a cell, specifically the components and function of cellular DNA. It would also be helpful to discuss genomes. |
| **Facilitator Preparations** | The teacher should create several “control” mouse eggs by placing 10 cm of base DNA ribbon in a balloon along with a piece of paper that says “control” and states a gender of the mouse.  All of the mice “eggs” should be placed in a basket or container marked “Mother Mouse.”  Background information on recombinant DNA technology, genetic engineering and knock-out mice is available in the [Supplemental Resources](#13-0-0) section.  **Technology resources**  Teachers will need a computer to research additional types of transgenic organisms. |
| **Activities** | Engage: Each student is given the role of molecular biologist for a biotech lab. As an investigator they need to first understand what their job requires. The teacher should ask questions like:What would a biologist study? (Answer: living things)If a person studies molecular biology, what would they study? (Answer: very small living things)What type of tools would a molecular biologist need in the research lab? (Answer: microscopes, instruments that measure very small amounts, glassware, living things, etc.)Teacher note: Explain the use of specialized equipment, like electrophoresis, and gas spectrometers in isolating very small amounts of particles. These particles will be used in genetic research and engineering transgenic animals for lab studies. There are some molecular biological that work in Nano biotechnical labs that work solely in minute particles.Exploration:Each student is given the activity materials, a Student Lab sheet and Handout 1 with a picture of a mouse and one 10 cm ribbon which will represent a normal DNA strand of a mouse.They are told that as a molecular biologist – in order to create a genetically modified mouse they will need to remove a ½ inch by 2 cm long section of the mouse’s DNA and add new DNA material from a new species. (In this case it will be a protein A, B, or C which will affect fat absorption). Using a pair of scissors they should cut a small section of their DNA strand ribbon either 1 cm from the top or bottom.  |  | | --- | |  |  Teacher Note: This activity can be made microscopic by reducing size of ribbon and using small scissors under a microscope.The teacher will have several 2 cm cut outs that will fit the “knocked-out” section of DNA ribbon strand. Students will select a foreign DNA sample color to add into their DNA cutout. (In a laboratory this is done by attaching it to a virus or injecting the foreign DNA right into the nucleus of an embryo.) There should be 3 choices of colors each representing a different protein type. (A, B and C)Using tape- the genetic addition will be secured to the cut out section. (This additional gene pool will possibly make the egg develop into a mouse that will be different both genetically and physiologically.) The teacher should point out that not all engineered mice are born transgenic. That is why further testing and breeding is necessary.The students roll up their new DNA strand and put it inside of a balloon (egg) along with the name and gender they select for their knockout mouse on a small piece of paper. They tie off the end and tape it to the picture of the mouse on Student Handout 1.Teacher note: The teacher should create several normal species specific “eggs” with just ribbon inside of a balloon and the word “control” written on a piece of paper. (These will be added to the basket/ or bag for selection.)Explanation:As molecular biologists, the students must adhere to very strict protocols for producing knockout transgenic mice. The entire process of genetic engineering is costly, approximately $4000.00 per animal, and the process takes at least 25 weeks from gene introduction/ or deletion to a functioning pool of knockout transgenic mice.To understand this process the students will follow as the teacher reads the following timeline and copy the basic time line below in their scientific notebook. (Modified time– eliminate student copy to reduce class time)The teacher should read and discuss the timeline as it is copied.Week 1 (Start) – Mouse DNA has additional/ or different genetic information introduced into the DNA strand and then injected into an egg. The genetically altered ovum (egg) is implanted into a host mother mouse.Week 3 (average 18-21 days) – Mouse is born.Week 7 – Begin to wean mouse and obtain a sample of DNA from the mouse’s tail. (Cut off a small part at the end) OR cut off a small toe from a back foot.Week 8– Isolate DNA and identify like founders (similar DNA patterns) from DNA samples of tail/ toe biopsies.Weeks 9-10 – Investigators put male/ female mice together to generate offspring of selected DNA type.Week 13 – Mice are born (average litter size is 5-10 pups)Week 17 – Wean mouse and obtain tail biopsies or cut off back toe of mouse.Week 19 – Isolate DNA and screen mice. Select and mate DNA specific mice to create transgenic offspring.Week 22 –Transgenic mice are born.Week 25 – Wean mice and obtain a tail or toe DNA sample. Isolate DNA and identify transgenic mouse type.Student Copied Timeline:  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | Week 1Genetic alter DNA of egg cell | Week 3Mice born | Week 7Collect DNA sample | Week 8Isolate DNA | Week 9-10Mate similar Mice | Week 13Mice are born | Week 17Collect DNA Sample | Week 19Isolate DNA sample | Week 22Knock-out mice born | Week 25Identify transgenic mouse type |      1. The teacher will handout Student Handout for Lesson 1, scissors, crayons, and one balloon (baggie) from the mouse basket.   Teacher note: To help extend knowledge of scientific protocol in a molecular biology lab – The teacher will explain that after mice are born, investigators must let the mice mature approximately 4 weeks before they can begin to see if they have created transgenic knockout mice. When the mice are weaned from their mothers (Week 7) the molecular biologist can biopsy tissue and blood from the mouse to see what they have genetically engineered. (Remember - not all genetic changes/ recombinant DNA make the desired genome types for research. Nature doesn’t always follow a researcher’s plan)  The scientist then removes a toe or the tip of the tail for pathology reports. Blood and tissue samples will allow the molecular biologist to determine the DNA for each mouse.       1. Students will cut out the mouse from the handout then simulate the cutting of the toe/ or tail on the cut-out. Using the DNA strand found in their balloon – they will color the mouse according to the DNA strand sample. Student Handout 1 - 2. They should tape the DNA genome balloon to the back side of the mouse for later reference. Also – select a name for their mouse and decide on a preferred sex. (Male/ female). 3. The teacher can access understanding by having the students record the name/color/ type/ and gender of their mouse on the board. 4. The students will then analyze the pool of each type of recombinant DNA mice they have in the class and graph the results in a pie graph. 5. Students complete conclusion questions on their lab sheet.   **Extension -**  To simulate the complete timeline of events in the knockout mouse tale – students will need to repeat the mating/ and identifying process for Weeks 9 through Week 25. Mating of mice occur at (Week 9-10). During the extension; two students donate DNA strands that have similar protein knockout DNA to a mouse balloon “Egg.” The fertilized egg is attached to a picture of a mouse and at Week 13 – a recombinant DNA mouse is born. DNA samples are taken from the tail or back toes are removed for biopsies to verify type.  **To extend knowledge** of different transgenic organisms**-** The teacher can show various pictures of GMO’s. Several are high interest, like “GloFish” and “GloBunny”, two engineered mammals that glow using phosphorescence from jellyfish. (Research Websites are: <http://www/ekac.org//gfbunny.html> and http://www.isb.vt.edu/articles/jun0405.html  There are many varieties of transgenic plants; most have been modified to assist in crop growth such as drought resistance and pest inhibitors.    Fieldtrip opportunity: Many biotech centers offer tours for interested student groups. Contact the Human Resources Department of the facility. |
| **Assessment** | Formative Assessments of concept understanding-Evaluate student understanding as they put their mouse information on the board. Ask to see their drawing and DNA strand. (Correct color of mouse to protein type) Students were also asked to record the name/color/ type/ and gender of their mouse on the board and then to put the information in a pie chart for the entire class by type.  Assessment Rubric for Pie Graph:  Students were asked to record the name/color/ type/ and gender of their mouse on the board.  Assessment Rubric:     |  |  |  |  | | --- | --- | --- | --- | | 3 | 2 | 1 | 0 | | Student has listed all class data types: color/type/ and gender represented in class. Mathematic calculations are correct and pie sections clear and representative of amount | Student has listed all of the class data types on the graph. Student mathematic calculations are correct but pie totals do not clearly represent amounts calculated. | Student has listed all of the class data types on the graph. The percentage calculations were incorrect so sections are not represented accurately. | Student has not created a pie chart or has given grossly inaccurate information. |  Teacher Review and Answer Key: Conclusion Questions from the Student Lab sheet.What made the mice different? (They were genetically altered)Why would scientist benefit from mice that have similar DNA to humans? (The mice would provide valuable information concerning human physiology and genetic response to medications.)Why would molecular biologists use mice instead of humans for lab testing? (Researching on humans is illegal and immoral)What other types of animals do you think biomedical molecular scientist use in research? (Monkeys, dogs and rabbits)If a scientist wanted to create a mouse to research obesity, and mice do not normally become obese, what type of genes would need to be added? (A scientist would use a genetic protein DNA material from another species that has been found to cause obesity.)Students that answer 3 of the 5 correctly have adequate understanding of the content material.Summative Assessment- Students should successfully use the scientific terms in subsequent lessons as well as on unit tests. Learning outcomes that suggest content understanding include the use of scientific terms: scientific investigator, scientific protocol, transgenic, DNA, knockout gene, genetics, molecular biologist. |
| **Critical Vocabulary** | Molecular biology- the branch of [biology](http://dictionary.reference.com/browse/biology) that deals with [the](http://dictionary.reference.com/browse/the) [nature](http://dictionary.reference.com/browse/nature) of biological phenomena at the molecular level through the study of DNA and RNA, proteins, and other macromolecules involved in genetic information and cell function, characteristically making use of advanced tools and techniques of separation, manipulation, imaging, and analysis.Transgenic – a species which contains a gene or genes transferred from another species.  * Scientific Protocols- is a predefined written procedural method in the design and implementation of experiments followed precisely by the researcher. * Knockout mouse- a transgenic mouse that has been genetically engineered by molecular biologist in a biotech lab. The researchers have inactivated, or "knocked out," an existing [gene](http://en.wikipedia.org/wiki/Gene) by replacing it or disrupting it with an artificial piece of [DNA](http://en.wikipedia.org/wiki/DNA). Knockout mice are commonly used in health research because they can be used to mimic human conditions and diseases. |
| **Modifications** | Students with physical limitation can be given materials precut during the activities that require manual dexterity.  Students with learning difference such as Written Language deficits and English as a 2nd Language learners should be given copies of the Timeline so they can follow and highlight important information as it is discussed in class. |
| **Alternative Assessments** | As necessary- students with modifications can respond verbally to the 6 questions at the end of the lesson. |
| **References** | GFP-Bunny –“Glo-Bunny”: This site explores the albino bunny created with the addition of the phosphorescence gene that cause it to glow under a black light...  <http://www/ekac.org//gfbunny.html>  Glo-Fish- This site is devoted to the creation of glow in the dark fish. These fish are available for purchase in many pet and retail shops.  <http://isb.vt.edu/articles/jun0405.html>  Mouse drawing – provided by Clipart for Free  <http://clipart-forfree.blogspot.com/2010/07/mouse-clipart.html>  Recombinant DNA technology-  <http://www/answers.com/topic/recombinant-dna.html>  Information on Knockout Mice-  The National Genome Research Institute- <http://www.genome.gov/12514551.html>  Career Information  Career Pathways – Biotechnology Edition <http://www.ncpublicschools.org/docs/cte/publications/career/biotechnology.html>  Additional information about Nobel Laurent Oliver Smithies -  <http://www.hsl.unc.edu/specialcollections/highlights/smithies.cfm>  **Information on Biotechnology in North Carolina:**  North Carolina Biotechnology Center - Information on Businesses, Education, Bio Basics, Workforce and Grants- North Carolina Biotechnology Center <http://www.ncbiotech.org/>  The Center of Innovation for Nano Biotechnology- <http://www.ncbiotech.org/business-commercialization/biotech-sectors/nanobiotechnology/inside-nanbiotechnology.html>  Piedmont Triad Biotechnology Park- <http://www.ptrp.com>  ForsythTech Community College- Biotechnology degree program information  <http://www.forsythtech.edu/credit-programs/credit-track/programs-a-z/biotechnology.html> |
| **Supplemental Information** | Recombinant DNA technology  DNA molecules from two different species that are inserted into a host organism to produce new genetic combinations that is valued in medical, agricultural, and industrial research. Using this technology, scientists can isolate genes, determine nucleotide sequence, study transcripts, mutate the strand the way they desire and reinsert it into a living host,  Genetic Engineering:  There are many different types of transgenic organisms genetically engineered and developed by investigators. Genetically modified organisms include plants, insects and mammals.  Mice and humans are genetically very similar. So a molecular biologist will knockout (remove) part of the mouse’s genome and insert new DNA in its place. This makes an organism that would not normally be affected by human diseases and conditions – respond. Transgenic mice are most often used in biotechnical and biomedical laboratories that study the biological effects of: cancer, obesity, heart disease, arthritis, diabetes, ageing, Parkinson’s disease and Anxiety Disorders.  Knockout mice:  A knockout mouse is an animal that has been [genetically engineered](http://en.wikipedia.org/wiki/Genetic_engineering) for research experiments. The scientific researchers (molecular biologists) have inactivated, or "knocked out," an existing [gene](http://en.wikipedia.org/wiki/Gene) and replaced it with an artificial piece of [DNA](http://en.wikipedia.org/wiki/DNA) (genes from another source). The change in DNA often causes changes in a mouse's [phenotype](http://en.wikipedia.org/wiki/Phenotype). The mouse may change in appearance, behavior, or some other biochemical characteristic. The changes caused by DNA disruption or replacement are important to studying the role of genes within a genome. Any observable differences can assist the researcher to infer a probable gene function.  Laboratory experiments with mice are important because their genes are easily knocked out and knocked in. They are currently the most closely related laboratory animal to humans that this technique can be used easily in the lab. This makes the transgenic knockout mouse an important link to study of human diseases, conditions and physiological genetic disorders.  “Many of these transgenic mice are named after the gene that has been inactivated or knocked out. For example, the p53 knockout mouse is named after the [p53](http://www.genome.gov/glossary.cfm?key=p53) gene, which codes for a protein that normally suppresses the growth of tumors by arresting cell division. Humans born with mutations that inactivate the p53 gene suffer from Li-Fraumeni syndrome, a condition that dramatically increases the risk of developing bone cancers, breast cancer and blood cancers at an early age. Other mice are named after physical characteristics or behavior disorders like ‘Methuselah’ because it lives a long time and ‘Frantic’ which is used to study anxiety disorders.” (National Genome Research)  The 2007 Nobel Prize for Medicine was awarded to [Mario R. Capecchi](http://en.wikipedia.org/wiki/Mario_Capecchi), [Martin Evans](http://en.wikipedia.org/wiki/Martin_Evans) and [Oliver Smithies](http://en.wikipedia.org/wiki/Oliver_Smithies) for their "for their discoveries of principles for introducing specific gene modifications in mice by the use of embryonic stem cells.” These researchers created the first knockout mouse in 1989.  It is important to note that Dr. Oliver Smithies is a Professor in the Department of Pathology and Laboratory Medicine at the UNC School of Medicine in Chapel Hill, N.C.  **Related Career Fields in Biotechnology to Explore with Students:**  Career Pathways: A Guide for Students, Parents and Educators  <http://www.ncpublicschools.org/docs/cte/publications/career/biotechnology.pdf>  Biotechnology Edition-   * Scientists (pages 10-11) * Laboratory Technicians (pages 12-13) * Engineers (pages 14-15) * Process Technicians (pages 16-17) * Maintenance and Instrumentation * Technicians (pages 18-19) * Corporate Scientific Professionals (pages 20-21)   **The North Carolina Biotechnical Center** - links to various career opportunities and resources for teachers. http://www.ncbiotech.org/ |
| **Comments** | Students may also be interested in the courses available in High School that offer additional exploration into the field of Biotechnology. Most college campus’s now offer pre-biological undergraduate studies, and ForsythTech Community College in Winston -Salem has a state-of-the-art facility and career tract especially designed for Biotechnology training.  The Winston-Salem/ Forsyth County area has numerous research labs and exciting and innovative 21st Century biomedical projects in Piedmont TRIAD Research Park (PTRP). This facility offers guided tours to school groups upon request. Email: [PTRPinfo@wfubmc.edu](mailto:PTRPinfo@wfubmc.edu) or phone 336.716. 8672. |
| **Author Info** | This lesson was written by Martha Tedrow. She teaches eighth grade at Jefferson Middle School in Winston-Salem, NC. She has been teaching for 28 years, has Bachelors in Education from UNC – Chapel Hill and Masters in Education from Gardner Webb University. In 2004, she became Nationally Board Certified in Science. This curriculum module lesson was designed as part of a Kenan Fellowship and in cooperation with Carol Kent and Dr. Lawrence Rudel, molecular biologists at Wake Forest Baptist Medical Center’s Biotechnology Center. Martha’s mentor for the Fellowship was Robert Sox, a Professional Development Leader with North Carolina’s Department of Public Instruction. |

**Student Handout 1: Molecular Biologist – A Transgenic Mouse Tale**

After Week 3 – Your mouse is born. Cut out the mouse below- then cut off a toe/ or the tip of the tail to simulate DNA collection. Color your mouse according to the DNA sample extracted from the balloon you picked up from the samples. (Red ribbon /Protein A – black, blue ribbon /protein B – white, green ribbon/ protein C – brown) **Tape the DNA ribbon to the back of the mouse.**



Lesson 1: Student Lab Sheet Transgenic Mouse Tale(Tail) Name \_\_\_\_\_\_\_\_\_

Background Information: Advances in 21st Century research and genetic engineering have made it possible to create new genetically modified organisms (GMO). The technique of manipulating genetic material is known as recombinant DNA technology. In a biotech lab, a molecular biologist (Science Investigator) selects specific genetic information that will either be added to an organisms DNA and/or knocked out of the DNA. An organism that has newly inserted DNA, or genetic material removed and/ or replaced, is called *transgenic.*

Purpose: To demonstrate how molecular biologist genetically engineer laboratory mice known as “knockout” mice for research.

Materials: Crayons, Scissors, balloon (or baggies), 10 cm of 1inch ribbon, 2 cm of ½ inch ribbon, tape, paper, Student Handout 1 (mouse picture)

Procedure (Scientific Protocol):

1. Collect materials- one 1 inch ribbon 10 cm long (represents mouse DNA strand), one ½ inch ribbon cut 2cm long (the additional DNA that will be added), tape, scissors, and a balloon.
2. Using the scissors make a ½ inch by 2 cm long cut in the upper or lower part of the 10 cm ribbon. (The cut should be the exact size of the addition DNA strand ribbon you are going to add.) Measure precisely. (See model below)

|  |  |
| --- | --- |
| |  | | --- | | Remove this section | |

1. After the section of DNA has been removed- tape the new genetically engineered DNA in the empty space.
2. Roll up the recombinant DNA mouse strand and put it inside of a balloon (baggie). The balloon represents the mouse fertilized egg. DNA is added directly into mice ovum (egg cells) or attached to a virus which is then inserted into mice ovum.
3. Name your “knockout” mouse and decide if it will be a boy or girl. Write both on a small scrap piece of paper and place it inside the egg.
4. Place the egg in the teacher basket (Mother mouse) and wait for the birth of the pups (baby mice).
5. Copy timeline of genetic engineering then select a balloon from the pile and Student Handout 1
6. Cut out the mouse from the handout and tape the balloon (baggie) to the back.)
7. You are now ready to biopsy the mouse to isolate the DNA and see what type of mouse you have.
8. Using he scissors- cut off the tip of the tail OR one of the toes from the back foot. This is the method used to biopsy tissue and blood from the mouse for a DNA sample.
9. Now look at the DNA strand in the bag and determine see what type of mouse has been born. (There will be some mice that have not been genetically altered – this happens often in the process of creating GMO’s in the initial stages – these are used as the control mice.)
10. Using the mice genome strand from the bag - color the cutout mouse.

Control mice stay solid white, Red knockout mice (protein A) – are colored black, blue knockout mice are colored white/ and gray (protein B), and Green knockout mice (protein C) are colored brown.

Note: The differences in appearance can be a result of the additional new genetic code added during engineering. Other differences may be size, behavior, susceptibility to diseases, or drug interactions.

1. Record the name, color, type and gender of the mouse in the table below.

Data:

|  |  |  |  |
| --- | --- | --- | --- |
| Mouse Name | Color | Type | Gender |
|  |  |  |  |

Data Analysis:

Using the information from the board recorded by all student mice births:

Generate a pie graph of the data below. (Hint: To calculate percentages: Add up total number of mice types listed on the board. Then divide the number of color, type, gender by the total number of mice. The percentages should equal 100.)

## 

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## Conclusion: Respond to the questions below as they relate to lab.

## 1. What made the mice different?

## 2. Why would scientist benefit from mice that have similar DNA to humans?

## 3. Why would molecular biologists use mice instead of humans for lab testing?

## 4. What other types of animals do you think biomedical molecular scientist use in research?

## 5 If a scientist wanted to create a mouse to research obesity, and mice do not normally become obese, what type of genes would need to be added?

## Answer Key for Lesson 1- Conclusion Questions:

## What made the mice different? (They were genetically altered)

## Why would scientist benefit from mice that have similar DNA to humans? (The mice would provide valuable information concerning human physiology and genetic response to medications.)

## Why would molecular biologists use mice instead of humans for lab testing? (Researching on humans is illegal and immoral)

## What other types of animals do you think biomedical molecular scientist use in research? (Monkeys, dogs and rabbits)

## If a scientist wanted to create a mouse to research obesity, and mice do not normally become obese, what type of genes would need to be added? (Genetic protein DNA material from another species that has been found to cause obesity)