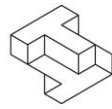


# DNA and Genetics

## Teacher Resource Guide



**The Tech**  
Museum of Innovation

201 S. Market St.  
San Jose CA. 95113  
1-408-294-8324  
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## Lab Summary

This lab introduces your students to DNA, the blueprint for life, and allows them to spool and view real DNA from animal cells. Students will also explore their own genes through an exercise in dominant and recessive traits.

Grade Levels: 6-12

Student Outcomes:

- 1) Students will be able to provide evidence that living things are made of cells by examining their own cheek cells.
- 2) Students will be able to explain the difference between dominant and recessive traits in classic Mendelian genetics.

State and National Standards Connections:

Next Generation Science Standards

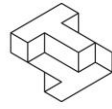
- Grades 6-8: *Life Science* MS-LS1-1, MS-LS1-3
- Grades 9-12: *Life Science* HS-LS1-1, HS-LS3-1, HS-LS3-3

Common Core Language Arts – *Speaking and Listening*

- Grade 6: SL.6.1b-d
- Grade 7: SL.7.1b-d
- Grade 8: SL.8.1b-d
- Grades 9-10: SL.9-10. 1b-d
- Grades 11-12: SL.11-12.1b-d

California Science Content

- Grade 6: *Investigation and Experimentation* 7.b, d, e
- Grade 7: *Life Science* 1.a-c, e; 2.b-e; 5.a; *Investigation and Experimentation* 7.a, c-e
- Grade 8: *Life Science* 6.c; *Investigation and Experimentation* 9.a, b
- Grades 9-12: *Biology and Life Sciences*: 1.a, 2.d-g



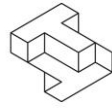
## Related Links and Games

The following links and games provide additional information about genetics and inheritance. We are not endorsing the following organizations, but feel that the information provided by said organizations may be of benefit to your students and may help enhance the learning experience of the lab

- Time.com: The Genetics Revolution: This site provides the most current news articles dealing with genetics. \*We recommend examining the articles first before directing students here as some articles may be inappropriate for your students' age level. <http://time.com/tag/genetics/>
- National Human Genome Research Institute: This site has a lot of great teacher and student resources for all things genetics, including the Human Genome Project, information on genetics careers, fact sheets, vocabulary terms (English and Spanish), articles, and more. <http://www.genome.gov/Education/>
- University of Utah Genetic Science Learning Center: This site has many genetics resources including interactive explorations, videos, and virtual tours of genes. <http://learn.genetics.utah.edu/>
- Toothpick Fish activity: The following is a great activity to study genetics and natural selection in the context of an environmental disaster <http://eeinwisconsin.org/content/eewi/101364/toothpickfish.pdf>
- Genetics Home Reference: This site provides information on genetic conditions as well as a glossary of terms and other resources to find out more about genetic conditions. <http://ghr.nlm.nih.gov/>
- DNA- The Double Helix: Play this interactive game to test your knowledge on proper base pair matching and DNA comparison! [http://www.nobelprize.org/educational/medicine/dna\\_double\\_helix/](http://www.nobelprize.org/educational/medicine/dna_double_helix/)

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### Related Texts

The following titles may provide students with a greater contextual understanding of the field of DNA and Genetics. Included in the list are narratives (fiction/nonfiction), referential texts, and books that extend learning beyond the scope of the lab. We are not endorsing the following authors, but feel that the information provided by said authors may be of benefit to your students and may help enhance the learning experience of the lab.

#### Narratives

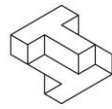
- Jurassic Park. By Michael Crichton.
  - Recommended for grades 7-12
  - An astonishing technique for recovering and cloning dinosaur DNA has been discovered and the plan is to recreate these extinct creatures so that the world can visit them – for a price. Until something goes wrong...
- The Stuff of Life: A Graphic Guide to Genetics and DNA. By Mark Schultz.
  - Recommended for grades 9-12
  - “A complete introduction to the history of genetics that’s easy to understand as it is entertaining to read.” (Amazon)
- Gregor Mendel: The Friar who Grew Peas. By Cheryl Bardoe. Illustrated by Jos. A. Smith.
  - Recommended for grades 3-6
  - A picture-book biography on Gregor Mendel, the friar that conceived and put into practice the pea experiment to determine heredity and the notion of genes.

#### Reference

- Have a Nice DNA (Enjoy your Cells). By Frank Balkwill. Illustrated by Mic Rolph.
  - Recommended for grades 2-6
  - One in a series of books that uses a unique brand of simple but scientifically accurate commentary and colorful graphics to lead readers on an exploration of the world of cells, proteins, and DNA.
- Science Quest: Double Helix: The Quest to Uncover the Structure of DNA. By Glen Phelan.
  - Recommended for grades 5-8
  - A brief but informative view of the quest to understand the structure of DNA. It traces the story from Gregor Mendel and his pea plants to Crick and Watson.
- Decoding Life: Unraveling the Mysteries of the Genome (Discovery!). By Ron Fridell.
  - Recommended for grades 5-8
  - An informative book about the stuff of life that uses good academic vocabulary, and illustrations that support visual learners.
- High-tech Harvest: A Look at Genetically Engineered Foods. By Elizabeth L. Marshall.
  - Recommended for grades 7-10
  - An overview of genetically engineered foods that explains DNA technology, genetic engineering, and the techniques that are used to create crop plants and farm animals with desirable/attractive characteristics.
- Basher Science: Biology: Life As We Know It! By Dan Green
  - Recommended for grades 4-12
  - “Imagine life itself as a community of cool characters who keep our bodies and planet buzzing with activity. This book opens the doors and welcomes you into their amazing world.” ([www.basherbooks.com](http://www.basherbooks.com)) A creative and quick introduction to the field of Biology.

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### Extensions

- The Genomics Age. By Gina Smith.
  - Recommended for grades 7-12
  - The book explores the recent leaps in the understanding of DNA through the use of scientifically informative, yet easy to understand plain English. It covers how discoveries in the field of DNA and Genetics might change our lives and investigates the social, moral, and ethical questions that accompany topics such as anti-aging, stem cell research, and “designer” babies. Easily select chapters for study or read the whole thing.
- How to Clone a Mammoth: The Science of De-Extinction. By Beth Shapiro.
  - Recommended for grades 9-12
  - Could extinct species, like mammoths and passenger pigeons be brought back to life? The science says yes, and Beth Shapiro shows you how. This is the science behind engineering extinct traits from the genetic “blueprints” collected and mapped from remains.
- Brutes or Angels: Human Possibility in the Age of Biotechnology. By Professor Emeritus James T. Bradley Ph.D.
  - Recommended for grades 9-12
  - This is a guide to the rapidly progressing Age of Biotechnology. It provides basic information on a wide array of new technologies within the life sciences and raises the ethical issues associated with each. The ten biotechnologies considered: stem cell research, embryo selection, human genomics, gene therapies, human reproductive cloning, age retardation, cognition enhancement, engineering of nonhuman organisms, nanobiology, and synthetic biology. Easily select the most interesting chapters or read the whole thing. A great resource for engaging students in conversations on the social impact and moral issues that often accompany scientific discover.

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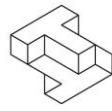
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## Gallery and Exhibit Connections

### Biodesign Studio (Upper Level)

- *Living Colors Lab*: Engineer bacteria to grow in new colors never seen before!
  - Connection to the lab:
    - Students will use lab techniques to insert specially engineered DNA into safe E.coli bacteria, which will promote the bacteria to produce different colors under certain circumstances (different color genes, different amounts of promoter, varying environmental changes, etc.).
    - Students will have the opportunity to see DNA in action and how it can be used to engineer certain results. The techniques used in this activity are very similar to those that are used in science labs to produce insulin from non-human cells cultures.
  - Activities to complete at the exhibit:
    - Perform the activity presented in the gallery – all guidance is done by the augmented lab bench instructions and videos.
  - Questions to guide student learning:
    - Do you think we can engineer bacteria to do something beneficial to health? How?
    - How does the DNA get into the bacteria? How do you think the bacteria will respond?
    - What color(s) did you find? Has this color been found before?
    - Why do you think scientists would want to engineer a bacteria to do something other than what it does naturally? Why does DNA have to be involved in said process?
- *Creature Creation Station*: Mix and match a kit of tangible building blocks that represent real-world DNA parts with specific functions to explore how biological circuits are constructed.
  - Connection to the lab:
    - Students use tangible manipulatives that represent the three basic parts of DNA: a gene (what), RBS (how much), and a promoter (when). DNA pieces must be put together in the correct order (when → how much → what) or the DNA doesn't "work" to create the creature.
    - This activity will go a bit deeper into how DNA works and the different parts of DNA that make it functional.
  - Activities to complete at the exhibit:
    - Create a creature using the tangible DNA manipulatives.
  - Questions to guide student learning:
    - Can you use multiple genes in one piece of DNA? What about multiple promoters?
    - What happens if you put the pieces in the wrong order?



## Writing Prompts

The following writing prompts and questions are just a few examples of journal topics to incorporate writing into your students' lab experience. If you feel that one of the below prompts does not meet your needs, you are welcome to use your own, but please make sure it is related to the chosen lab experience. If you have a related writing prompt you would like to share with The Tech and other teachers, please let us know on our teacher survey that will be available in the lab.

Most of the writing topics could be used as either pre-lab or post-lab writing. You may choose the prompts that work best for your class and schedule.

### Pre-Visit Writing Topics/Prompts

#### Generic

- We will be attending \_\_\_lab name\_\_\_ at The Tech Museum of Innovation; what do you think we will learn about in the lab? What do you want to know about this topic? What do you already know about this topic?
- We will be attending \_\_\_lab name\_\_\_ at The Tech Museum of Innovation; what are you looking most forward to in this lab? Why?

#### Specific to DNA and Genetics

- What is your favorite thing about yourself (personality, laugh, sense of humor, physical trait, etc.)? Do you think this is a genetic trait? Why? Do you see this trait in your parents? Siblings? Grandparents?
- If someone in your family was diagnosed with a genetic disease, would you have a genetic test to see if you could get the same disease? Why or why not?

### Post-Visit Writing Topics/Prompts

#### Generic

- We learned a lot in our \_\_\_lab name\_\_\_ lab. What were your two favorite things you learned in the lab? Why?
- The principal is excited to hear all about your lab experience. Explain what you did and learned about in the lab since she or he was unable to attend the lab.

#### Specific to DNA and Genetics

- Since we now have the technology to use genetic fingerprinting to catch criminals, should we make every US resident provide a blood sample for genetic fingerprinting so that all US residents are on government file making it easier to catch criminals? Write one paragraph explaining why this should happen and one paragraph explaining why this should **not** happen.
- All humans share approximately 99.9% of the same DNA. If we share this much, why do you think all people aren't more alike? Explain



## Pre-Visit Vocabulary and Activities

*These are words and concepts that we will discuss in the lab. Your students' experience will be enhanced if they are familiar with these terms prior to your visit. Below you will find several graphic organizers and games to aid in your vocabulary review.*

### Terms and Definitions

- **Allele:** an alternate form of the same gene or same genetic locus (location of specific gene).
- **Cell:** The basic structural unit of all organisms.
- **Chromatin:** a complex of DNA and protein found within the nucleus of a cell-condenses to form chromosomes.
- **Chromosome:** compact transportable structures composed of chromatin
- **Dominant:** One of a pair of alternative alleles that masks the effect of the other when both are present in the same cell.
- **DNA (deoxyribonucleic acid):** The genetic material of living organisms; makes up chromosomes of each cell; the "blueprint" or "recipe" for life.
- **Gene:** The basic physical unit of heredity.
- **Genotype:** the genetic makeup of an individual with particular emphasis on a particular gene (i.e.: XX is the genotype for a female)
- **Nucleus:** A large, membrane-bound structure within a living cell, containing the cell's hereditary material and controlling its metabolism, growth, and reproduction.
- **Phenotype:** the physical outcome/presentation of a genotype with emphasis on a particular gene. (Female is the phenotype for the genotype XX)
- **Phospholipid bilayer:** a semi-permeable two layer membrane that comprises the cell membrane.
- **Punnett Square:** a diagram used to predict the outcome and probability of genotype and phenotype of a breeding experiment.
- **Recessive:** one of a pair of alternative alleles whose effect is masked by the activity of the second when both are present in the same cell.
- **Trait:** A genetically determined characteristic or condition, like hair-color, dimples, or sex.

### Vocabulary Activities:

#### Graphic Organizers

- **Frayer Graphic Organizer:** The Frayer Graphic Organizer is a great tool for vocabulary development. This graphic organizer allows students to write their own definitions, define characteristics, and provide examples and non-examples. This tool will lead your students to a deeper understanding of the vocabulary and how it relates to their lives. On page 8 you will find a blank Frayer Graphic Organizer for your use in the classroom.
  - For more information on the Frayer Model and how to implement it, please visit the following link: <http://www.theteachertoolkit.com/index.php/tool/frayer-model>
- **Vocabulary Graphic Organizer:** This graphic organizer is a great tool for younger students as well as English Language Learners. Although very similar to the Frayer Model, this graphic organizer includes a drawing of the vocabulary term and the use in a sentence. On page 9 you will find a blank Vocabulary Graphic Organizer for your use in the classroom.
  - **Circle Map:** This graphic organizer is a great tool for helping all students develop an overall sense of a topic. It is also very helpful for beginning and early intermediate English Language Learners. This graphic



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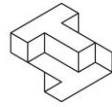
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organizer lets students brainstorm what a term or concept means to them and provides a frame of reference for the term. On page 10 you will find a blank Circle Map for your use in the classroom.

- For more information on the Circle Map and other Thinking Maps, please visit the following link:
- <http://thinkingmaps.com/why-thinking-maps-2/>

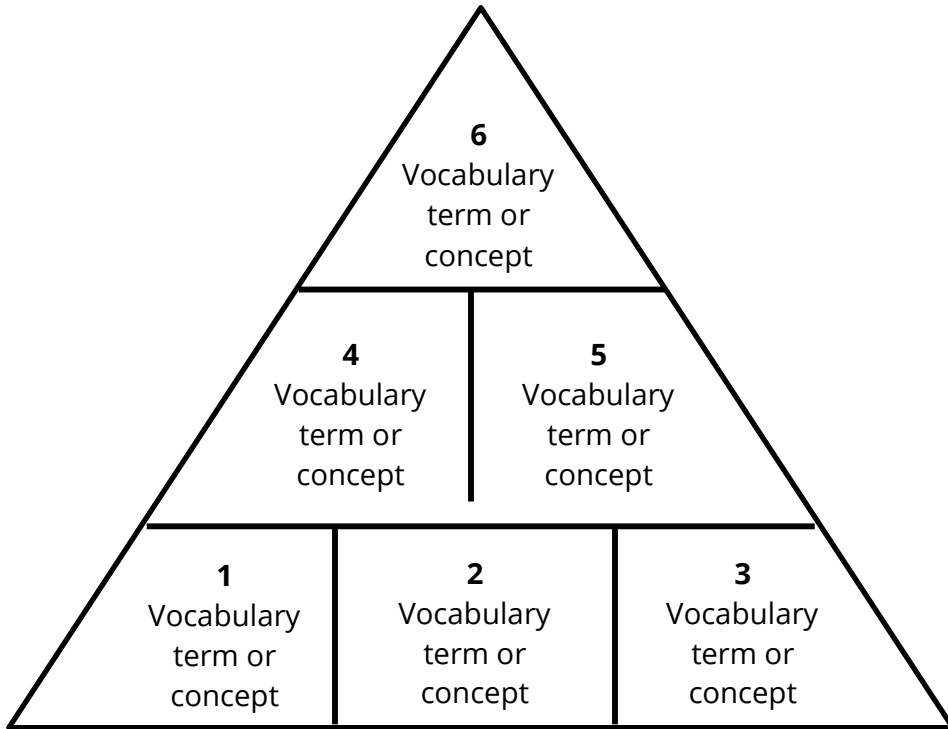
### Vocabulary Review Games

- **Quiz, Quiz, Trade:** This is a fun cooperative game for students to review vocabulary terms. For more details and to see an example of Quiz Quiz Trade in action, please visit the following link:  
<http://www.theteachertoolkit.com/index.php/tool/quiz-quiz-trade>
  1. Create questions or vocabulary cards. On one side of an index card, write the question or vocabulary term; on the other, the answer or definition. Pass out the cards to students. If there are not enough terms for everyone to have a different card, try using different “back” sides to the same cards (e.g. instead of the definition again, have a drawing, a question about the term, characteristics of the term, or an example of the term).
  2. Pair up. When all cards have been passed out, students find a partner to quiz with their card.
  3. Hands up. When both partners have completed the quizzes correctly, they put their hand up to show other students that they are ready for a new partner to quiz.
- **Back-words:** This game is part Charades part 20 Questions. In this review game, students have to guess the vocabulary term that is on their back by asking questions of a partner or having the partner act out the term.
  1. Write your vocabulary terms on index cards. If there aren't enough terms for each student to have a different one, you can make two sets and divide the class into two groups. You may also add in other related vocabulary terms that you have been studying in class.
  2. Tape one term onto the back of each student so that he or she cannot see the word.
  3. Have students pair up. Each partner should look at the word on their partner's back. Partners take turns asking questions or acting out or gesturing about the term that is on their back. (e.g. “Am I an element? Am I part of an atom? Do I make up all matter? Etc.) Partners must ask at least 2 questions before guessing their word.
  4. When both partners have correctly guessed their word, they put a hand up to signal that they are in need of a new partner. Continue game play until everyone has guessed their word.
- **\$10,000 Pyramid:** This review game is exactly like the classic game show. Students will work in pairs, taking turns to describe the words and to guess the words.
  1. Break up the terms into two groups. Each partner will take on one group of words.
  2. Have each partner fill out the worksheet on the next page with their group of words.
  3. For the first round, Partner A will be the one describing the term and Partner B will be the one guessing the term. Partner A will describe the term (starting with 1) using the words he or she wrote down on the worksheet. From the description, Partner B will guess what the term is.
  4. When Partner B guesses the word correctly, Partner A moves on to the next word.
  5. When Partner B correctly guesses all the words in Partner A's pyramid, they switch places and Partner B will describe the terms on his or her pyramid while Partner A guesses the terms.
  6. You can time this activity like on the quiz show, but it may intimidate some students.



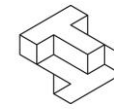
Student Name: \_\_\_\_\_

**\$10,000 Pyramid**

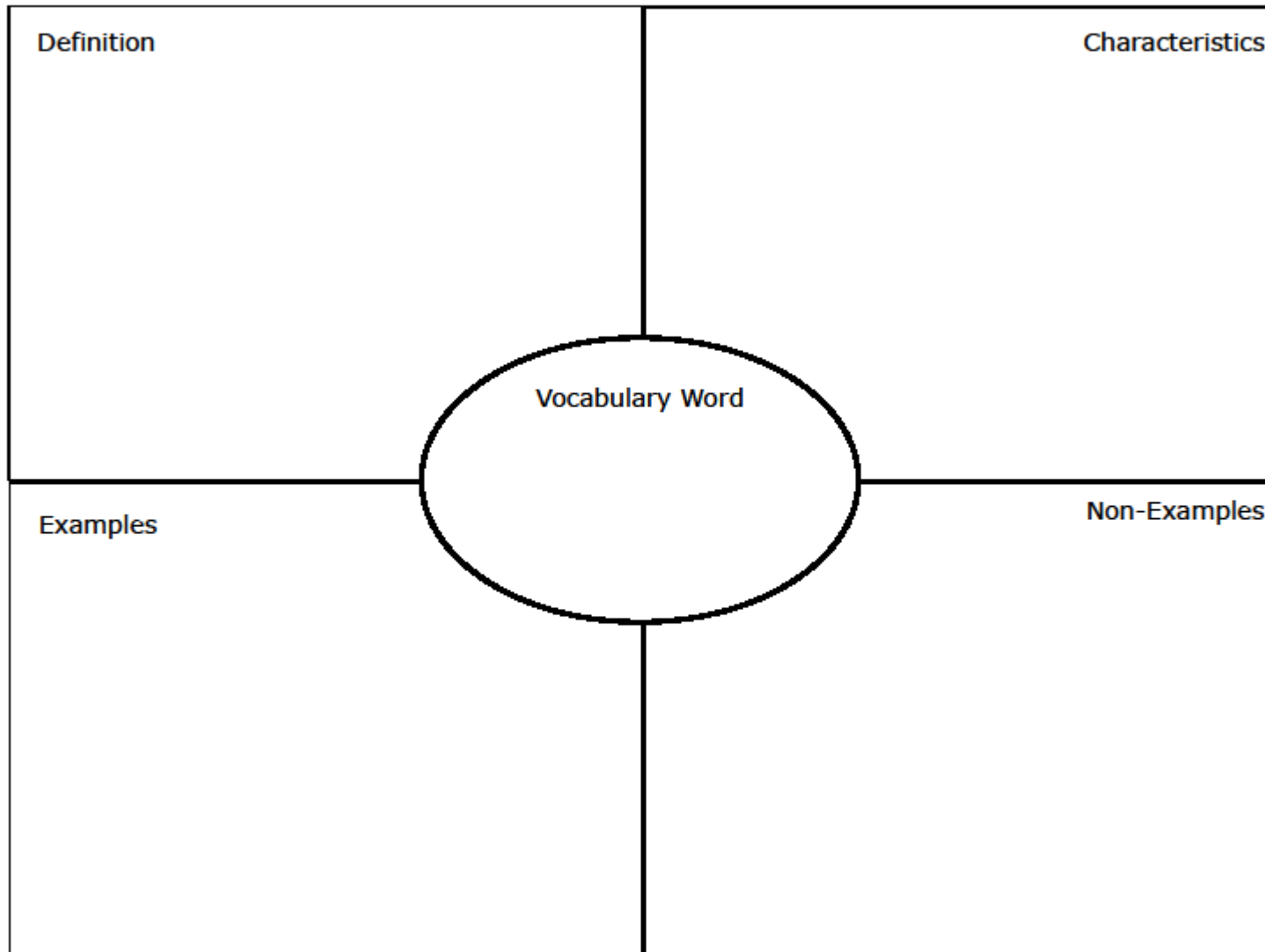


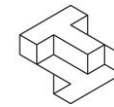
Write descriptive clues about each vocabulary term or concept

1. \_\_\_\_\_  
\_\_\_\_\_
2. \_\_\_\_\_  
\_\_\_\_\_
3. \_\_\_\_\_  
\_\_\_\_\_
4. \_\_\_\_\_  
\_\_\_\_\_
5. \_\_\_\_\_  
\_\_\_\_\_
6. \_\_\_\_\_  
\_\_\_\_\_



**Frayer Graphic Organizer**





**Vocabulary Graphic Organizer**

Definition	Characteristics
Sentence	Drawing

Vocabulary Word

**Circle Map**

