**Making Connections Between Genes and Diseases**

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**Primary Learning Outcomes**

* Students will apply previously learned knowledge about chromosomes, DNA, RNA, genes, genome, DNA, transcription, translation, protein expression, and principles of genetics to explain how a specific gene results in a specific condition or disease.
* Students will gain experience in using online medical/scientific bioinformatics databases to research real life genetic disorders.

**Additional Learning Outcomes**

* Students will gain experience using PowerPoint as a tool for sharing information.
* Students will gain a deeper understanding of what is meant by a genome.
* Students will have an opportunity to research genetic disorders in which they have a personal interest.

**Materials**

* 1. An LCD projector or scan converter for showing the Web based video clip in Step 2 and to show the final PowerPoint presentation in Step 6
  2. For each student:
     1. a computer with Internet access
     2. PowerPoint software
     3. PowerPoint template (Chromosome Template) on disk or uploaded to school’s file server or teacher’s homepage
     4. Ability to give/send their completed slides to the teacher, either via a disk or uploading to the school’s file server
  3. Optional: Ability to post each final class PowerPoint presentation on the school Web site or teacher’s homepage

**Technology Connection**

Students will use Online scientific/medical bioinformatics databases to research and PowerPoint technology to present their research. Technology that enables students and teacher to share templates and contribute to one final presentation is utilized (server files, teacher homepages, school Web sites, etc.).

**Total Duration**

5 hours, 30 minutes – 6 hours, 30 minutes

**Procedures**

**Step 1 Duration: 1-2 hours**

**Teacher Preparation**  
Make arrangements for each student to have access to a computer that has both Internet access and PowerPoint for approximately 4 hours (approximately 2 hours for research and 2 hours to create their PowerPoint slides).   
  
Download the PowerPoint "Chromosome Template," alter it if desired, and make arrangements for each student to have access to it (attachment on a Web site, on disk, on a file server, etc.). Students will use this template to create individual presentations that will be combined into one class presentation.  
  
Download the "Human Genome Introductory PowerPoint Slides" which contains two PowerPoint slides to be used as the first two slides of the class PowerPoint presentation. When students complete their assigned chromosome templates, the teacher will copy and paste the student slides into this presentation in order of the chromosome number.   
  
Download "Sample Genome Slides" to view the introduction and 3 completed chapters (1, 2, and 23) as an example of what the final product will look like.   
  
Read the National Center for Biotechnology Information (NCBI) News Release that provides an overview of the Entrez search engine. In addition, visit the Entrez site and practice using it to become familiar with how quickly enormous amounts of genetic information can be accessed. Detailed directions for how to demo this site to students is included in Step 3. If needed, there is also a detailed handbook on using the Entrez database (Online NCBI handbook), but keep in mind that there is so much information contained in these databases that will never be investigated by students in the classroom.   
  
Visit NCBI's Genes and Disease Web site. This site's searchable format is easier for students to access than Entrez. This is the site that students might want to visit first to familiarize themselves with different chromosomes, genes, and resulting conditions/diseases.

**Web Resources**

Title: NCBI News Release About the Entrez Search Tool  
URL: <http://www.ncbi.nlm.nih.gov/Web/Newsltr/FallWinter03/index.html>  
Description: This NCBI News Release provides an overview of the Entrez (The Life Sciences Search Engine) search and retrieval system that the students will need to use for this project.

Title: Entrez: The Life Sciences Search Engine  
URL: <http://www.ncbi.nih.gov/Entrez/>  
Description: Entrez is a cross-database search page that can be used as a starting point for all of the research the students will need to do on their chromosome, gene, and disease. It is a part of NCBI.

Title: Online NCBI Handbook  
URL: <http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=handbook>  
Description: This handbook provides any extra information you would want about what each database provides and how to use it.

Title: NCBI's Genes and Disease site  
URL: [http://www.ncbi.nlm.nih.gov/books/bv.fcgi?call=bv.View.. ShowTOC&rid=gnd.TOC&depth=2](http://www.ncbi.nlm.nih.gov/books/bv.fcgi?call=bv.View..%20ShowTOC&rid=gnd.TOC&depth=2)  
Description: If this is used as a starting point, students merely click on a chromosome to receive information about genes contained on it (very few per chromosome are listed), then click on one of the genes to receive extensive information on the condition or disease related to the gene. Students might also research in reverse order, but clicking on the conditions/disease in the left hand column to gain needed information, including gene and chromosome number. It is part of NCBI as well.

**Supplemental Documents**

Title: Chromosome Template

File Name: [Chromosome\_Template.ppt](http://www.glc.k12.ga.us/builderv03/LPTools/LPShared/attach-display.asp?attachID=80428)  
Description: This template consists of four PowerPoint slides that outline the information needed by each student to complete his/her part of this research process.

Title: Human Genome Introductory PowerPoint Slides

File Name: [Genome\_Project\_Intro.ppt](http://www.glc.k12.ga.us/builderv03/LPTools/LPShared/attach-display.asp?attachID=80198)  
Description: These two PowerPoint slides make the base of each classes' presentation. All of the student made slides (created from a template) will be spliced into this presentation in order of their chromosome number.

Title: Sample Genome Slides

File Name: [Sample Genome Slides.ppt](http://www.glc.k12.ga.us/builderv03/LPTools/LPShared/attach-display.asp?attachID=81073)  
Description: This is a partially completed example of what the final class Human Genome PowerPoint will look like. It includes chromosomes 1, 2, and X and their corresponding disorders: Glaucoma, Waardenburg Syndrome, and Duchenne Muscular Dystrophy.

**Step 2  Duration: 10 minutes**

**Connect Activity**  
Teacher shows the “Impact of Diagnosis Video Clip” in which seven individuals briefly share about their own diagnosis with a genetic disease. This video clip can be found in the attached Web resource and is provided by the Genetic Interest Group of the UK. There are five video clips at this URL and the last one, entitled "Impact of Diagnosis," is the one to use. Click on the "video clip" link and then choose either the dial-up connection, broadband connection, or download option. Next to the "video clip" link a "text page" link is also provided. This contains a complete transcript of the video clip. This is an excellent reference with the names of the disorders and some of the details that are difficult to understand. This "text page" could also be printed for students that are absent when this lesson is introduced.   
  
Ask students for their reactions to the personal perspectives shared about the various genetic disorders. Welcome students to share about other genetic conditions or diseases with which they are familiar.

**Web Resources**

Title: Impact of Diagnosis Video Clip  
URL: <http://www.gig.org.uk/clips.htm>  
Description: This Genetic Interest Group (GIG) Web site provides links to video clips about personal experiences with genetic disorders. Use the "Impact of Diagnosis" video clip (last one) to introduce students to this lesson.

**Step 3  Duration: 30 minutes**  
**Information and Practice**   
Teacher hands out the "Human Genome Presentation Overview" and explains that the students are going to take all that they have been learning and apply it to understand how a gene, that is located on a chromosome within the nucleus of each human cell, can result in a certain condition or disease.   
  
Teacher presents a brief demo of how to navigate the NCBI site before letting students jump in and try it for themselves. See the attached "NCBI Site Demo" for detailed directions for the demonstration.  
  
Students go to work on their own computers to start researching. Their first task is to choose a condition/disease to research and determine the chromosome on which the gene(s) are located. Use the "Class Chromosome Chart" spreadsheet for students to sign up for their chromosome. In order to try and cover the entire genome, don't let more than one student research a disease on the same chromosome unless there are more than 24 students in the class. Students should be encouraged to research conditions/diseases in which they have a personal interest (they or someone they know has it).

**Web Resources**

Title: Entrez, The Life Sciences Search Engine  
URL: <http://www.ncbi.nih.gov/Entrez/>  
Description: Entrez is a cross-database search page that will be used as a starting point for all of the research the students will need to do on their chromosome, gene, and disease. It is part of NCBI.

Title: NCBI's Genes and Disease Site   
URL: [http://www.ncbi.nlm.nih.gov/books/bv.fcgi?call=bv.View..ShowTOC&rid=gnd. TOC&depth=2](http://www.ncbi.nlm.nih.gov/books/bv.fcgi?call=bv.View..ShowTOC&rid=gnd.%20TOC&depth=2)  
Description: If this is used as a starting point, students merely click on a chromosome to receive information about genes contained on it (very few per chromosome are listed), then click on one of the genes to receive extensive information on the condition or disease related to the gene. Students might also research in reverse order, but clicking on the conditions/disease in the left hand column to gain needed information, including gene and chromosome number. It is part of NCBI as well.

**Supplemental Documents**

Title: Human Genome Presentation Overview

File Name: [Genome\_Presentation\_Overview.doc](http://www.glc.k12.ga.us/builderv03/LPTools/LPShared/attach-display.asp?attachID=80200)  
Description: This document contains a brief introduction and graphic organizer for this project.

Title: Demo NCBI Site

File Name: [Demo NCBI Site.doc](http://www.glc.k12.ga.us/builderv03/LPTools/LPShared/attach-display.asp?attachID=80983)  
Description: This document contains detailed directions for the teacher to demonstrate the use of NCBI's Entrez searchable databases before the students start their research.

Title: Class Chromosome Chart

File Name: [Class Chromosome Chart.xls](http://www.glc.k12.ga.us/builderv03/LPTools/LPShared/attach-display.asp?attachID=80430)  
Description: This Excel spreadsheet is for recording student’s chromosome number, student’s name, selected gene and the condition/disease to be researched.

**Step 4  Duration: 4 hours**

**Student Research and Presentation Preparation**   
Students research their chosen chromosome and create PowerPoint slides using the "Chromosome Template" provided in Step 1. Make sure that students have access to the Online research sites so that they can continue their individual research at home or after school.

**Step 5 Duration: 20 minutes**

**Peer Edit**  
Students pair up and show their slides to each other, comparing the completed work to the “Genome Rubric” on which it will be assessed. Positive feedback and suggestions for ways to improve the slides are shared between partners. Time should then be provided for students to make changes and a deadline (immediately, the next day, etc.) given for final submission of slides to the teacher. This presentation will be made public so it is important to ensure that students put forth their best work. This peer editing process can also be accomplished by having students print handouts of their slides, exchange with a peer, and then the positive comments and suggestions for improvement can be written directly next to the slides. Writing down the feedback in this manner will increase accountability and provide a helpful guide for students to follow when making corrections.

**Supplemental Document**

Title: Genome Rubric

File Name: [Genome\_Rubric.doc](http://www.glc.k12.ga.us/builderv03/LPTools/LPShared/attach-display.asp?attachID=80199)  
Description: This rubric is for assessing student's individual slides. These slides are created using the chromosome template and based on information gained through research of Online medical/scientific databases. They are then integrated into one class presentation of the Human Genome. This rubric is used for the peer edit as well as the teacher’s final evaluation.

**Step 6 Duration: 30 minutes**

**Celebrate**   
After the teacher or other designee has copied and pasted all of the students’ slides into one class presentation it's time to show it. Present the class's "The Human Genome: 23 Chromosomes in 23 Chapters" PowerPoint presentation, allowing the author of each set of slides to verbally describe what they learned. Students will be showcasing their research as well as learning about the research of their peers. Post each class's presentation on the school Web site or teacher homepage for students to share with their parents and other audiences. The teacher will evaluate students’ contribution to the PowerPoint using the rubric provided in Step 5.

**Assessment**

A rubric (included in Step 5) will be used to assess the quality of each student's contribution to the class PowerPoint presentation. Students should self-assess their work before the teacher completes the rubric so that the assessment process becomes more of a conversation between the student and the teacher. The "Sample Genome Slides" is included in Step 1 as a reference for what the students' PowerPoint slides should look like and what they should include.

**Modifications**

**Extension**

Students can research the prevalence of the condition/disorder in the United States. Other possible research questions include:

1. Is there genetic testing for it?
2. Is there a treatment?
3. Are any gene therapies being developed?

The NCBI site can again be used for such research (see Steps 1, 3) as well as the Centers for Disease Control and Prevention site.

**Web Resource**

Title: Centers for Disease Control and Prevention  
URL: <http://www.cdc.gov>  
Description: The Centers for Disease Control and Prevention provides an starting point for investigating incidence and prevalence data.

**Education Standards**

**National Science Education Standards**

LIFE SCIENCE, CONTENT STANDARD C:

As a result of their activities in grades 9-12, all students should develop understanding of

* The cell
* **Molecular basis of heredity**
* Biological evolution
* Interdependence of organisms
* Matter, energy, and organization in living systems
* Behavior of organisms

SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES, CONTENT STANDARD F:

As a result of activities in grades 9-12, all students should develop understanding of

* **Personal and community health**
* Population growth
* Natural resources
* Environmental quality
* Natural and human-induced hazards
* Science and technology in local, national, and global challenges

**Georgia State Science Standards**

Grade: 9-12, Science, Biology 2

Topic: Research

Standard: Demonstrates appropriate use of reference sources to access, analyze, evaluate, and present information related to research problems.

Grade: 9-12, Science, Biology 8

Topic: Biochemistry (Protein Synthesis)

Standard: Explains the structure of DNA and RNA and their role in protein synthesis.

Grade: 9-12, Science, Biology 10

Topic: Genetic (Medelian Genetics)

Standard: Explains and uses the basic Mendelian genetic principles.

Grade: 9-12, Science, Biology 11

Topic: Genetics (Patterns of Inheritance)

Standard: Describes patterns of inheritance and genetic engineering.

Grade: 9-12, Health, Health 21

Topic: Disease Prevention: Risk Factors

Standard: Evaluates how one's genetics and health choices contribute to disease (heredity, inactivity, diet, stress, environment, infection, and degenerative processes) and proposes strategies to reduce risk.

**Human Genome Presentation Overview**

Making Connections Between Genes and Disease

Julia Koble, CDC’s 2005 Science Ambassador Program

***(Insert name of class here)* Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Hour 1 2 3 4 5 6 7**

***Essential Question:*** *If genes just code for proteins, how can a gene cause a condition or disease? By what mechanisms are such conditions/diseases passed down, generation after generation?*

Each student will choose one of the 23 pairs of human chromosomes to research, focusing on just one of the genes that it contains. The gene that you choose must be linked to a condition or disease that you have a personal interest in. As soon as you have chosen a chromosome and one of its genes, let your teacher know so it can be added to the class chart. Only one student should research a condition/disease per chromosome, with the exception that two separate students may research the “X” and “Y” chromosomes. The signing up for chromosomes will be on a first-come, first-serve basis. As diagrammed below, the student will combine all that he/she has learned about chromosomes, genes, DNA, RNA, protein synthesis, and genetics with individual research to explain how that gene is translated into a protein and how that protein results in the trait (condition or disease). To share this new learning, each student will create a minimum of 4 PowerPoint slides (a step-by-step template will be provided) on their chromosome, with the goal that we will publish information on all of the 23 chromosomes (human genome) each class period. A rubric will be provided so that you know how this project will be assessed.

**Human Genome**

23 pairs of Chromosomes

Chromosome from Dad

(DNA)

Chromosome from Mom

(DNA)

* How does the protein/enzyme result in a trait or disease (relate to structure/function)?
* Describe the trait/disease in detail
* If a disease, is there a cure, treatment, gene therapy, etc.?

Trait

Almost everything in the body is made up of or made by proteins

Dominant or recessive, A or a

Dominant or recessive, A or a

*translated*

*Cytoplasm*

*Nucleus*

New Gene Combination

(homozygous, heterozygous)

Protein

(Amino acid sequence)

1 Gene

(ATCACGA..)

1 Gene

(ATCACGA...)

**Demo: National Center for Biotechnology Information Site**

**Teacher demonstration of how to navigate the NCBI site**

Making Connections between Genes and Diseases

Julia Koble, CDC’s 2004 Science Ambassador Program

It is important for the teacher to present a brief demonstration of how to navigate the NCBI site before letting students jump in and try it for themselves.

1. Show students the "Genes and Disease" site, <http://www.ncbi.nlm.nih.gov/books/bv.fcgi?call=bv.View..ShowTOC&rid=gnd.TOC&depth=2>, focusing on how quickly and easily you can jump between the chromosome, its genes and the corresponding conditions/diseases. You can simply click on one of the numbered chromosomes at the top of the page to see a few disease genes located on that chromosome and then click on the gene for the detailed information. Alternatively, you can click on specific diseases from the list to find out more about them as well as the chromosome on which they are located. However, caution students that with this Web site they will be limited to just a few gene options per chromosome.
2. Show students the "Entrez" site, <http://www.ncbi.nih.gov/Entrez/>
   1. Ask students to name any disease that might be inherited (asthma, diabetes, cancer, etc.) and tell them that we can type any of these in the search box, but that you have chosen to type "**PKU**" or Phenylketonuria, a disease that all newborn babies are tested for, in the search box. Have students notice that the numbers beside all of the categories change once you hit enter or click on "go."
   2. From the search results, click on the "**gene**" database (it has a #2 to signify that there are only 2 hits) and notice that two different genes are displayed. Only the first one, PAH or phenylalanine hydroxylase can be our gene since it is in a Homo sapien (human) gene and the second gene isn't. Point out that many of the diseases students are going search for are going to have a larger number of hits for the genes. Be sure to only look at genes in Homo sapiens. The gene listing also shows you that it is located on chromosome 12 along with other location information. Students will need both the gene name and the chromosome number for their projects.
   3. Hit the back button to return to the Entrez search results. Click on the "**nucleotide**" database to find out how many base pairs are in the PAH gene. Again, there will be many hits, scroll to find one that lists PAH in a Homo sapien. When you click on it, you will receive a page that has a number such as 2181 at the top, followed by “bp” which stands for base pairs. Students will need this information for their project. If you scroll to the bottom of this page under the heading of ORIGIN, the sequence of all 2181 bases (A, T, C and G) is listed.
   4. Hit the back button twice to return to the Entrez search results. Click on the "**protein**" database to find out how many amino acids in the protein. Again, there will be many hits, scroll to find one that lists PAH in a Homo sapien. When you click on it, you will receive a page that has a number such as 452 at the top, followed by “aa” which stands for amino acids. Also, the name of the protein is phenylalanine hydroxylase (what the PAH gene stands for). It might be worthwhile to mention/remind students that proteins that end in “ase” are enzymes. Students will need the protein name and number of amino acids for their project. If you scroll to the bottom of this page under the heading of ORIGIN, the sequence of all 452 amino acids (each amino acid is represented by a different letter of the alphabet) is listed.
   5. Hit the back button twice to return to the Entrez search results. Click on the "**OMIM**" database (Online Mendelian Inheritance in Man) to gain some general information about PKU. Click on a Phenylketonuria link. This site provides far more information than the students will need. The short description indicates that “Phenylketonuria is an inborn error of metabolism resulting from a deficiency of phenylalanine hydroxylase and characterized by mental retardation.” Though the readability of this text is a bit difficult, students can get some basic information. The categories of information can be found in the left margin (blue area). Clicking on the “Clinical Synopsis” link will provide a short list of symptoms (listed by system) and mode of inheritance for PKU.
   6. Hit the back button twice to return to the Entrez search results. Click on “**site search**” to access other text information. Click on the Phenylketonuria link. This “Genes and Disease” site provides easier to read information. Students should recognize that this is the first site that was demonstrated. This text explains that PKU develops due to a lack of the protein, phenylalanine hydroxylase, an enzyme responsible for breaking the amino acid phenylalanine down into another amino acid called tyrosine. Without this enzyme, phenylalanine builds up to toxic levels. The text also explains that PKU is an autosomal recessive disorder. All of this information is needed for the student projects. Links to even more sites with information on PKU are found in the left hand margin.

**Genome Rubric**

Making Connections Between Genes and Diseases

Julia Koble, CDC’s 2005 Science Ambassador Program

***(insert name of class here)* Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Hour 1 2 3 4 5 6 7**

|  |  |  |  |
| --- | --- | --- | --- |
|  | 10 8 | 6 4 | 3 2 |
| **Gene--> DNA --> mRNA---> protein**  **--> trait (condition or disease)** | Student accurately completes the diagram on their 1st slide, clearly showing their understanding of the involved molecules and processes. Their understanding of how their protein results in the trait or disorder is evident. | Information conveyed was not totally accurate and/or the student's understanding was not evident. | Lack of accurate information or student understanding. |
|  | 10 8 | 6 4 | 3 2 |
| **Description of Condition or Disease** | Key characteristics of the trait or disorder and how it affects individuals are given, helping the audience understand what it truly is. Your name is included as the author. Where applicable, pictures are included. | The nature of the trait or disorder is not totally clear to the audience (your peers and the public) based on the information included. | Little or no descriptive information is included. |
|  | 10 8 | 6 4 | 3 2 |
| **Genetics (how the trait or disorder is inherited)** | Accurate information about how the trait or disorder is inherited and includes an appropriate visual that reinforces the written explanation (punnett square, karyotype, etc.). | Explanation of inheritance lacks accuracy and/or appropriate visual. | Little or no accurate information is included. |
|  | 10 8 | 6 4 | 3 2 |
| **Research** | The information presented shows evidence of extensive research (two or more sources) and goes above and beyond what was learned in class. The sources used in the research process are cited. | Only one source is used in the research process and/or unreliable sources are used (websites made by students, etc.) | Presentation lacks evidence of prior research or the research used all came from unreliable sources. |
|  | 10 8 | 6 4 | 3 2 |
| **Quality of Presentation** | Presentation is in an organized, logical order, captures the attention of the viewer, is completed in a professional manner, and its explanations are made understandable for sophomore students (your peers). | Presentation lacks one of the criteria listed. | Little or no attempt is made to create a professional presentation. |

**Student self-assessment: \_\_\_\_\_\_\_\_\_/ 50 Teacher assessment: \_\_\_\_\_\_\_\_\_/ 50**

**Extra Comments:**