SCIENCE: BIOLOGY
UNIT #1: CELLULAR GENETICS -- (5 WEEKS)

SYNOPSIS: Students investigate the role of DNA molecules as the specific genetic instructions for any organism and its relationship to genes and chromosomes which provide the framework for DNA to do its work. Students realize the significance of the direct production of specific proteins based on inherited DNA by following the sequence of steps involved. Students understand how genetic variations can occur at the time of meiosis and sexual reproduction. Students write about genetic errors that can occur and may result in mutations that are harmful, beneficial or neutral to the organism.

ENABLERS

Elementary school: plants and animals have life cycles and offspring resemble their parents.
Middle school Students learn that living things are a result of one or two parents, and traits are passed on to the next generation through both asexual and sexual reproduction. They learn that traits are defined by instructions encoded in many discrete genes and that a gene may come in more than one form called alleles. Other topics include Mendelian genetics with explanations of genetic patterns of inheritance (including dominance and co-dominant), inherited traits and diversity of species.

STANDARDS

I. HEREDITY

A. Cellular Genetics

1. Genomes are the DNA that are part of the genes.
    a. life is specified by genomes (each organism has a genome that contains all the biological information needed to build and maintain a living example of that organism)
    b. biological information in genome is encoded in DNA and carried in genes; genes are segments of DNA and code for protein
    c. the sequence of DNA bases in a chromosome determines sequence of amino acids in a protein
2. Meiosis is reviewed from 8th grade.
3. Variations occur in reproduction.
    a. recombination occurs in sexual reproduction
    b. sorting occurs at meiosis

B. Structure and Function of DNA in cells

1. Sequence of DNA bases determines the sequence of amino acids used to build a specific protein.
2. Body cells can be very different from one another.
    a. they are descended from a single cell and have identical genetic instructions
    b. different genes are active in different types of cells (differentiation results from gene regulation)
    c. DNA is influenced by the cell's environment and past history

D. Mutations

1. Inserting, deleting, substituting segments of DNA alters genes.
    a. altered gene may be passed on to every cell that develops from it
    b. resulting features may help, harm or have little or no effect on offspring's success in its environment
2. Gene mutations - - when they occur in gametes - - can be passed to offspring.
3. Gene mutations result in specific features.
4. There is a relationship of linkage to variation.

IV. CELLS

B. Cellular processes

1. Characteristics of life are regulated by cellular processes
    c. the sequence of DNA bases on a chromosome determines the sequence of amino acids in a protein.
        (1) proteins catalyze most chemical reactions in cells
        (2) protein molecules are long, usually folded chains made from combinations of the 20 typical amino acid sub-units found in the cell
        (3) the function of each protein molecule depends on its specific sequence of amino acids and the shape the chain takes as a result of that sequence

LITERACY STANDARDS

RST.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

WHST.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

MOTIVATION	TEACHER NOTES
1. Teacher introduces heredity by asking students to respond to true/false statements based on "**Old Wives Tales**" about **heredity**. Students write answers to questions then discuss with other students in small groups. Then groups share out in a follow-up class discussion. 2. Teacher shows **PPT: Heredity Wheel of Fortune**; students fill in the wheel to determine if they are dominant or recessive for each trait! Teacher introduces Activity: **Alike, But Not the Same** (see website below) in which students conduct a class inventory of human traits, collect data, construct histograms, and play a brief game that introduces the notion of each individual's uniqueness. Major concepts include: humans share many basic characteristics, but there is a wide range of variation in human traits. Most human traits are influenced by several genes and environmental factors. website: http://science.education.nih.gov/supplements/nih1/genetic/guide/activity1.htm 3. Students work in small groups to discuss 3 questions – a. Some human traits can be changed by human intervention and some cannot. Provide examples for each of these types of traits. b. Some traits are genetic and others are environmental. But most human traits reflect an interaction between genetic and environmental factors. Name some traits that might fall into this category and explain why you think they do. c. How can genetic variation be beneficial, detrimental or neutral? Group responses for the three questions are recorded on chart paper, discussed in class and remain posted for the entire unit. 4. Teacher previews for students what the end of the unit authentic assessment will be and what students will be expected to do. 5. Students write personal and academic goals for the unit	1. "**Old Wives Tales**" about Heredity **attached on page 7** 2. **PPT**: **Heredity Wheel of Fortune** 2. Activity notes: **Alike, But Not the Same attached on page 8**

TEACHING-LEARNING	TEACHER NOTES
1. Teacher explains how the goal of the **Human Genome Project** to provide the complex sequence of the human genome illuminated the extent of human genetic variation (see notes). These differences reflect a complex interplay between both genetic and environmental factors. Students watch a video about the Human Genome Project and what it accomplished. Video: http://youtu.be/PdUpbJsjnkc (4:20) (**IA1a, b, c**) 2. Students read an **article and discuss cartoons about the Human Genome Project**; students conduct a "**write chat**" of the cartoons to make comments related to the intended sarcasm/satire portrayed. Students analyze the author's purpose of these works by defining the question the author seeks to address. (**IA1a, b, c**) Article website: http://ornl.gov/sci/techresources/Human_Genome/project/about.shtml Cartoons: A Lighter Look at DNA and the Human Genome Project http://library.thinkquest.org/C006821/history.html note: click on title in left side bar 3. Teacher shares **cartoon of the Gene Chromosome Model** to review relationships among	1. Information on **Human Genome Project attached on pages 8** 2. Directions for a **"Write Chat" of cartoons attached on pages 8-9** 3. **The Gene Chromosome Model** (cartoon) **attached on**

TEACHING-LEARNING	TEACHER NOTES
the genetic material. Teacher introduces Mitosis, Meiosis and Fertilization Activity; students use model chromosomes to simulate the processes of mitosis, meiosis and fertilization and also learn how a mistake in meiosis can result in Down Syndrome. (**IA2**) Activity - http://serendip.brynmawr.edu/sci_edu/waldron note – scroll down to title of activity	**page 10**
4. Students view a computer animation comparing **mitosis** and **meiosis.** Teacher reviews meiosis to show how it reduces the number of chromosomes by half to produce haploid gametes with one chromosome from each pair of homologous chromosomes**.** Students record in notes a class created **T-chart comparing mitosis and meiosis** and include **vocabulary.** (**IA2**) Animation - http://www.pbs.org/wgbh/nova/baby/divide.html#	4. **Mitosis/Meiosis Vocabulary** list **attached on page 10** 4.**T-chart Comparing Mitosis and Meiosis attached on page 11**
5. Teacher asks class to consider why no two people are genetically alike, except for identical twins and uses **PPT: Meiosis – Its Role in Genetics** to show how **genetic variability** results from events of meiosis (**sorting**) and fertilization (**recombination**). Teacher explains activity and students use popsicle sticks (or other materials) to carry out 4 steps of activity – meiosis with one set of homologous chromosomes, meiosis with two sets of homologous chromosomes, resulting possible zygotes from fertilization, resulting possible zygotes if **linkage** occurs (see attached notes). (**IA3 a, b**)	5. **PPT: Meiosis – Its Role in Genetics** 5.**Notes: Genetic Variability Activity attached on page 11**
6. Teacher explains how **sorting and recombination** that occur during meiosis and fertilization are responsible for genetic variability. Students take notes and label their drawings from the previous activity to show sorting and recombination. Teacher extends the concept beyond two sets of chromosomes and has the **class determine how many different gene combinations could be produced in a zygote** which result from the each parents' contribution of 23 chromosomes each containing over a thousand genes? Students work in small groups to create an equation to solve problem and express in scientific notation. (**IA3 a, b**)	6. **Math Challenge: Number of Zygote Possibilities attached on page 12**
7. Teacher shows **PPT: DNA** Basics; students record answers to "quiz" questions while viewing **PPT**. Class discusses answers after each section. Next, students watch a short 3-D animation (see notes) to show how DNA is tightly packed up to fit into the nucleus of every cell. Students consider the length of DNA in human cell looking at data table. (**IA1 b**) **PPT:** http://www.freeclubweb.com/powerpoints/science/dna.html DNA animation – http://www.hhmi.org/biointeractive/dna/DNAi_packaging_vo2.html (1:43)	7. **Questions for PPT: DNA Basics and Code Chart attached on pages 13-14** 7. **Length of a Human DNA Molecule (table) attached on pages 15-16**
8. Teacher selects a lab for students to conduct a DNA extraction; students follow lab directions and complete required lab report/questions. (**IA1b**) Consider other suggested labs - **attached lab –using wheat germ** www.lessonplansinc.com/lessonplans/dna_extraction_lab.pdf (strawberries and bananas) http://serendip.brynmawr.edu/sci_edu/waldron (cheek cells or split peas) www.accessexcellence.org/AE/AEC/CC/**DNA_extractions**.php (several options)	8. **Lab: What Does DNA Look Like To The Naked Eye**? (using wheat germ) **attached on page 16**
9. Teacher shows video and **PPT: Introduction to DNA → Protein** to introduce concept of **gene expression** - the ability of a gene to produce a biologically active protein. Teacher lectures how the information stored in the DNA molecule is passed on to the next generation (**replication**) and how it is used to make protein. Students investigate 2 modules of a DNA interactive site to see replication (copying &reading the code) and how it is used to make protein (**transcription-translation**). Then students use DNA, mRNA, tRNA codons to determine how at least 5 specific amino acids can be used to build a protein molecule. (**IA1 b,c; IB1; IV.B1c1,2,3**) Video: http://www.dnatube.com/video/2933/The-Human-Genome_Project-Video--3D-Animation-Introduction (3:33)	9. **PPT: Introduction to DNA → Protein** 9. **DNA → Protein Guided Notes attached on pages 17-18**
10. Teacher explains (Clues to) **Copying the Code** activity in which students view animations of	

TEACHING-LEARNING	TEACHER NOTES
DNA replication and transcription, as well as short video clips of several scientists involved in working out how DNA is copied and used. As students work through the Copying the Code module of the DNA web site, they are asked to decide which "clues" provided evidence that was used to understand replication and/or translation. Student s complete worksheets with questions and clues (**IA1 b,c; IB1, IV.B1c1,2,3**)(**RST.1**) Activity: http://www.dnai.org/teacherguide/guide.html click (Clues to)**Copying the Code**	
11. Students do the activity From Gene to Protein – Transcription and Translation to learn how a gene provides the instructions for making a protein, and how the gene for sickle cell hemoglobin can result in sickle cell anemia. (**IA1 b,c; IB1, IV.B1c1,2,3**) Activity –- http://serendip.brynmawr.edu/sci_edu/waldron/	**11. Protein Synthesis Simulation with Cards attached on pages 19-22**
12. Teacher shows **PPT: Mutations** to describe how inserting, deleting, or substituting DNA segments can alter a gene and how mutations in the DNA sequence of a gene may be silent or result in phenotypic change in an organism and in its offspring. Students complete guided notes for each frame of PowerPoint presentation. Students read and discuss article – What Is A Mutation?; students complete activity – Mutate a DNA Sequence which uses the universal genetic code to predict the amino acid sequence encoded by a DNA sequence. Students discuss how the altered gene may be passed on to every cell that develops from it and that the resulting features may help, harm or have little effect on the offspring's success in its environment. (**ID 1,2,3,4**) **PPT: Mutations** – http://science.pppst.com/dna.html Article and Activity: http://learn.genetics.utah.edu/archive/mutations/index.html Videos (*optional*) –http://www.youtube.com/watch?v=o3yQZp5Rs-o (8:58) -- One Wrong Letter video about children with Tay-sachs - http://www.youtube.com/watch?v=rvAJ_u3Q0Hw (3:14) -- Chernobyl Decay and Deformed environmental and genetic devastation of a nuclear accident (*note – teacher discretion is advised due to the disturbing nature of the film)	12. **Mutations guided notes attached on page 23**
13. Teacher introduces **cell differentiation** by asking the class how many different types of human cells there are (e.g., nerve cells, muscle cells, skin cells, blood cells, etc.) and lists responses on the board. Students compares class list to one provided by Wikipedia of about 210 types of human cells. Teacher poses two questions to class: a. What makes one cell type different from the other cell types? After all, each cell in the body has exactly the same genome (the entire DNA sequence). b. How do different cells grow to look so different and to perform such different functions? And how do they get to be that way, out of homogenous (single cell type) early embryonic cells that are produced by cell division of the zygote (the fertilized egg)? Students discuss questions in small groups and record answers on chart paper. Class discusses each question. (**IB2a,b,c**)	
14. Teacher introduces **gene regulation;** students use interactive slide show to see that some genes in our genome act as switches, turning other genes on or off at different times and for different lengths of time. The slides reveal how these gene switches play a predominant role in laying out the animal's basic body plan in its early embryonic stages and perform other early functions. Students read and discuss **article: Gene Expression Regulates Cell Differentiation** and discuss how the patterns of gene expression are specific to cell types and are directly responsible for the differences between the form and functions of different cells. Students give other examples of gene expression. Teacher explains the mechanism by which one embryonic cell induces differentiation of other cells in the embryo. Teacher addresses students' questions. (**IB2a,b,c**) Interactive slide show- http://www.pbs.org/wgbh/nova/body/gene-switches.html	14. **Article: "Gene Expression Regulates Cell Differentiation" attached on pages 24-25**

TEACHING-LEARNING	TEACHER NOTES
15. Teacher shows audio slides**- A Tale of Two Mice** which explain the role that the e**pigenome** plays in regulating **gene expression**; students write a summary paragraph to describe two ways researchers know how genes can be turned on and off. Teacher introduces 24 hr. activity in which students use a checklist to record some of the epigenome-influencing factors present in their environments such as diet, physical activity and stress. The next day, class talks about the activity discussion points (including optional points). Teacher asks students why twins look less and less alike as they age even though they have identical genes; students watch and discuss the **video: Insights From Identical Twins**. (**IB2a,b,c,d**) (**WHST.4**) **slides:** www.pbs.org/wgbh/nova/body/epigenetic-mice.html **activity**: http://learn.genetics.utah.edu/content/epigenetics ; click on Teacher Resources in top right, click on Epigenetics: Supplemental Materials; select activity in right column- Your Environment, Your Epigenome; download print- and- go PDF video: http://learn.genetics.utah.edu/content/epigenetics/twins/ (4:48) **Insights From Identical Twins** 16. Students **conduct lab activity: How Microarrays Work** (see website) to model how scientists use DNA microarrays to determine levels of gene expression in breast cancer patients, and then choose treatments based on what they learn. Students will read all handouts and complete the assigned work. (**IB2a,b,c,d**) website: www.pbs.org/wgbh/nova/education/activities/3413_genes.html	

TEACHER ASSESSMENT	TEACHER NOTES
1. 2-and 4-point responses 2. Assignments / worksheets / notebooks 3. Science Notebooks – includes students work on labs, activities, literacy standards 4. Quizzes 5..Out of class work – research	

TRADITIONAL ASSESSMENT	TEACHER NOTES
1. Unit Test: Multiple-Choice.	

AUTHENTIC ASSESSMENT	TEACHER NOTES
1. Students evaluate their goals for the Unit 2. Students select a **genetic disorder** from a provided list and write a report to explain the biology of the disorder in terms of its high incidence rate, known genetic cause, and severity of symptoms. Information for the disorder should be organized according to the following questions: ➢ What is it? ➢ What causes it? ➢ How is it inherited? ➢ How is it diagnosed? ➢ How is it treated? ➢ What is it like to have it? Students are encouraged to include related drawings/diagrams and information from patient and/or physician interviews provided at website: **Your Genes, Your Health** (http://www.ygyh.org). (**ID 1,2,3,4**)(**RSL.1**)(**WHST.4**) **OR** 3. **Writing Prompt**:	**Genetic Disorders attached on page 26**

AUTHENTIC ASSESSMENT	TEACHER NOTES
➢ You have been commissioned to work with the Joint United Nations Program on HIV/AIDS. You have read articles that: **Genetic Mutation Protects Against Both HIV and Plague - -** Not so, say scientists at Scripps Research. ➢ A group of scientists at The Scripps Research Institute have provided strong evidence that a popular hypothesis concerning the origins of a genetic mutation common among Caucasians of Northern European descent that protects against human immunodeficiency virus (HIV) *is wrong*. ➢ It is your job to investigate this claim and find accurate and relevant scientific findings in favor or against it. Results should include verifiable facts and statistics that establish clear relationships among the claims, counterclaims, reasons, and evidence. (**ID 1,2,3,4**)(**RST.1**)(**WHST.4**)	

BIOLOGY UNIT 1: CELLULAR MECHANISMS

AUTHENTIC ASSESSMENT RUBRIC

PROJECT COMPONENTS	1	2	3	4
Organization of report	Some required components are missing and a clear organization is not evident	Contains all or some components and/or lacks a coherent order and clarity	Contains all required components presented in a logical order	Complete, well organized, and easy to interpret
Statement of Purpose, Problem or Task	Inadequately presented for the report	Stated but not clear and/or complete	Adequately presented for the report	Clearly stated or delineated
Pertinent Facts and Results	Information concerning results provided but incorrect	Information concerning results provided but not complete	Enough information and results provided to inform problem	All pertinent facts and results provided in easy-to-interpret manner
Interpretation (Inferences/Conclusions)	No clear statement of findings or conclusions provided	Findings, inferences and/or conclusions provided but incomplete	Findings, inferences and conclusions adequately presented	Findings, inferences and conclusions related to problem/tasks clearly presented
TOTAL =				

Motivation #1

OLD WIVES' TALES ABOUT HEREDITY	True/False
1. A widow's peak is a sign of intelligence.	1. **F**
2. There are more males born than females each year.	2. **T** The ratio of 51% boys to 49% girls- - is representative of overall US birth rates.
3. The more children a woman has the more likely she is going to give birth to an equal number of boys and girls	3. **F** It's always a 50/50 chance; one event does not influence the other
4. Pregnant women who eat strawberries have babies with birthmarks	4. **F**
5. Male pattern baldness appears to be largely influenced by genes inherited from mothers	5. **T** It is sex-linked on X chromosome
6. A pregnant women craving sweets will have a girl; if she craves sour things, it's a boy.	6. **F**
7. Children born to older parents lack vitality compared to children born to younger parents.	7. **F**
8. The parent with the stronger will influences the sex of the children.	8. **F**
9. A child tends to be of the same sex as the parent who is less stressed at the time of conception.	9. **F**
10. If parents have poor eyesight their kids will inherit that trait.	10. **F**
11. It is rare for two blue-eyed parents to produce a brown-eyed child, but two brown-eyed parents can produce a blue-eyed child.	11. **T** Brown is dominant over blue
12. Both boys and girls can be be color-blind	12. **T** 8% boys, less than 1% girls – sex-linked trait

Motivation #2 PPT: Heredity Wheel of Fortune

Motivation #2 Activity: Alike, But Not the Same

Teacher introduces a class-wide inventory activity that highlights similarities and differences among humans and reflects the influence of genetic and environmental factors. Students are given a copy of the inventory of human traits (see website); and teacher defines traits (i.e., detached earlobes, hitchhiker's thumb, mid-digital hair, cross left thumb over right) to be examined by students working in pairs. The class data is collected recorded (histograms) and analyzed. Teacher asks students to identify evidence in the data that people share many traits and also, that people are different.

Teacher asks students to predict and record how many traits they would have to consider to identify any given student in the room as unique. Teacher asks for a volunteer. Student identifies his/her phenotype for each of the 13 human traits listed on the inventory. The activity begins with all students standing. The volunteer begins with the first trait and proceeds sequentially. As the volunteer states his/her phenotype for each trait, students who share the trait remain standing. All others sit down. This continues until the volunteer is the only one standing. The class counts how many traits the class had to consider to distinguish the volunteer from the other students in the class. Students work in pairs to answer questions about human variation.

T-L #1 Notes – Introduction: Human Genome Project

Human Genome Project: It provided a detailed picture of human similarities and differences at the molecular level. Research indicates that any two individuals are 99.9 percent identical at the level of the DNA. The 0.1 percent where we vary from one another (about 1 out of 1,000 DNA bases) is clearly important. It is within this small fraction of the genome that we find clues to the molecular basis for the phenotypic differences that distinguish each one of us from all others.

T-L #2 Directions for a "Write Chat " of Cartoons

HOW TO HOLD A WRITE CHAT IN YOUR CLASSROOM

Materials:

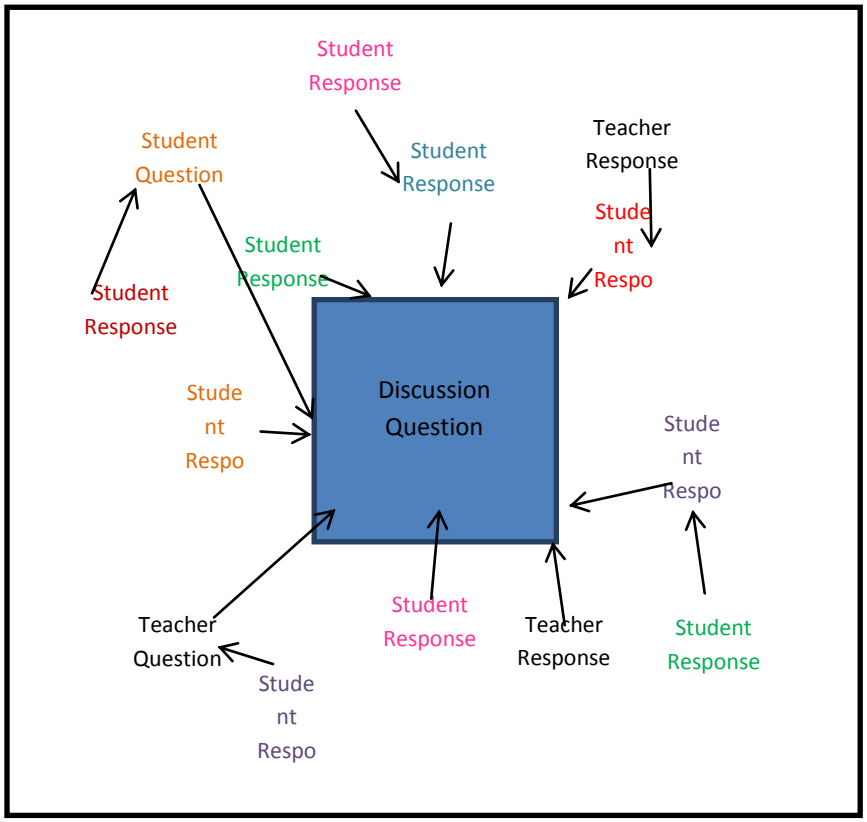
- 25" x 30" Post-It Easel Pad (or large sheets of bulletin board paper)
- 3" x 3" Post-It Notes
- Stopwatch or clock
- Permanent Markers, Watercolor Markers, Pens, Pencils (any writing utensil works, but using different colored permanent or watercolor markers and letting students have their own color helps to keep track

Directions:

1. Teacher writes key discussion questions on 3" x 3" Post-It Notes, then places these small Post-Its in the center of the larger Post-It, one discussion question per sheet. (If Post-Its are not available, teacher can use large sheets of bulletin board paper and just write in the center of the paper.)
2. Teacher then places each large piece of paper at a different "station." Stations can be a group of desks, a single desk, a table, etc. Anything that provides a decent writing surface.
3. Students take their writing utensil with them and circulate through the stations, spending a predetermined amount of time at each station (teacher decides how much time is needed at each station). They write their responses to the discussion questions and draw an arrow from their response to the discussion questions. They should also respond to others by drawing arrows connecting their responses to their peers', and can pose their own questions related to the topic (See diagram). All of this is done **WITHOUT TALKING**.

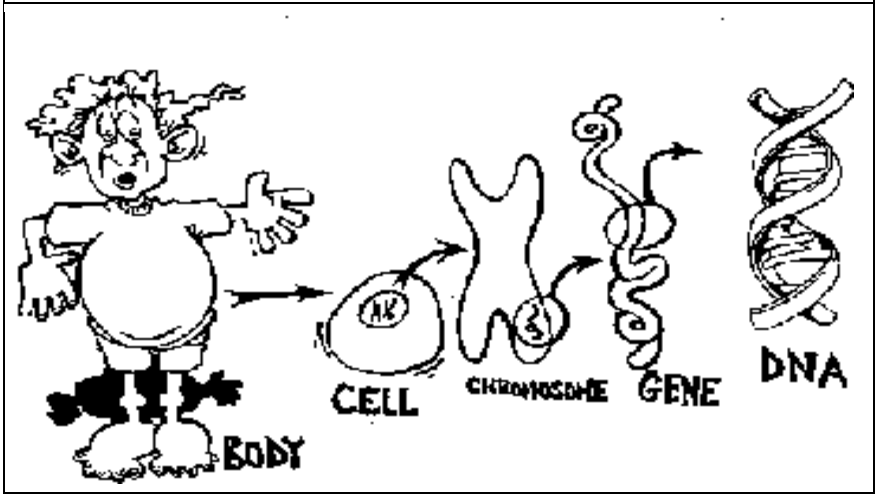
4. Teacher can have students circulate as many times as necessary.
5. Teacher can also circulate, adding in his/her own responses or taking opposing sides to stimulate conversation stimulated.
6. When the time limit for writing is up, students can then circulate back through stations to put initials or checkmarks by statements that they agree with.
7. Write chat papers can then be hung around the room for further discussion -- talking allowed.

DIAGRAM OF WRITE CHAT



T-L #3 The Gene Chromosome Model

The Gene Chromosome Model



T-L#4: Mitosis/Meiosis Vocabulary list

Mitosis	Meiosis
mitosis	homologous
cytokinesis	diploid
chromatid	haploid
centromere	meiosis
interphase	tetrad
cell cycle	crossing-over
prophase	interphase
centrioles	prophase I and II
spindle	metaphase
metaphase	anaphase
anaphase	telophase
telophase	sorting
	recombination

T-L #4 T-chart Comparing Mitosis and Meiosis

CRITERIA	MITOSIS	MEIOSIS
Purpose for the cell division		
Type of cells dividing		
Number of resulting cells		
Total number of chromosome pairs in the resulting cells compared to original number		
Number of sets of chromosomes in resulting cells		
Haploid/diploid condition resulting from division		

T-L #5 PPT - Meiosis – Its Role in Genetics

T-L # 5 Notes: Genetic Variability Activity

Teacher shows how **genetic variability** results from events of meiosis and fertilization**:**

a. Teacher explains how students use chromosome models (posterboard, popsicle sticks, clay) that have two different alleles for the gene for albinism (A for normal skin and a for albinism) to model each step of meiosis. Students draw models in notes and summarize events of each stage of meiosis I and II in terms of the chromosomes.

b. Then students add two new chromosomes that have two different alleles for the gene for dwarfism (D for dwarfism and d for normal height) to model meiosis in a cell which has two pairs of homologous chromosomes with the genetic makeup AdDd. Students predict how many different types of eggs will be produced by meiosis of this cell. Students draw and summarize events of each stage of meiosis I and II in terms of the chromosomes. Student compare outcome to their predictions.

c. Next, students consider that the father will also produce sperm with different alleles. Students predict the combinations of chromosomes in the resulting zygotes from fertilization by the possible egg and sperm. Students list the three different combinations of the alleles in the zygotes.

d. Finally, students determine the possible combinations of alleles in gametes if the genes are linked on the same chromosomes.

T-L #6 Math Challenge: Number of Zygote Possibilities

Students consider the fact that since each person has thousands of genes on 23 pairs of homologous chromosomes, the children produced by a couple could have many more different genetic combinations. Teacher poses a math challenge question – Scientists estimate that there are about 25,000 genes in the cells of the human body. Students can determine how many different gene combinations could be produced in a zygote which result from the each parents' contribution of 23 chromosomes each containing over a thousand genes. Consider how many different combinations of chromosomes could be found in the egg or sperm and zygotes combinations from fertilization. Class creates a formula to use for finding the answers.

To illustrate this concept, consider the variety derived from just three hypothetical chromosome pairs. Each pair consists of two homologues: one maternal and one paternal. Here, capital letters represent the maternal chromosome, and lowercase letters represent the paternal chromosome:

- Pair 1: **A** and **a**
- Pair 2: **B** and **b**
- Pair 3: **C** and **c**

When these chromosome pairs are reshuffled through independent assortment, they can produce eight possible combinations in the resulting gametes:

- **A B C**
- **A B c**
- **A b c**
- **A b C**
- **a B C**
- **a B c**
- **a b C**
- **a b c**

A mathematical calculation based on the number of chromosomes in an organism will also provide the number of possible combinations of chromosomes for each gamete. In particular, the independence of each chromosome during meiosis means that there are 2^n possible combinations of chromosomes in gametes, with "n" being the number of chromosomes per gamete. Thus, in the previous example of three chromosome pairs, the calculation is 2^3, which equals 8. Furthermore, when you consider all the possible pairings of male and female gametes, the variation in zygotes is $(2^n)^2$, which results in some fairly large numbers.

What about chromosome re-assortment in humans? Humans have 23 pairs of chromosomes. That means that one person could produce 2^{23} different gametes. In addition, when you calculate the possible combinations that emerge from the pairing of an egg and a sperm, the result is $(2^{23})^2$ possible combinations. However, some of these combinations produce the same genotype (for example, several gametes can produce a heterozygous individual). As a result, the chances that two siblings will have the same combination of chromosomes (assuming no recombination) is about $(3/8)^{23}$, or one in 6.27 billion. Of course, there are more than 23 segregating units.

While calculations of the random assortment of chromosomes and the mixture of different gametes are impressive, random assortment is not the only source of variation that comes from meiosis. In fact, these calculations are ideal numbers based on chromosomes that actually stay intact throughout the meiotic process. In reality, **crossing-over** between chromatids during prophase I of meiosis mixes up pieces of chromosomes between homologue pairs, a phenomenon called recombination. Because recombination occurs every time gametes are formed, we can expect that it will always add to the possible genotypes predicted from the 2^n calculation. In addition, the variety of gametes becomes even more unpredictable and complex when we consider the contribution of **gene linkage** (which will be discussed with mutations). Some genes will always co-segregate into gametes if they are tightly linked, and they will therefore show a very low recombination rate. While linkage is a force that tends to reduce independent assortment of certain traits, recombination increases this assortment. In fact, recombination leads to an overall increase in the number of units that assort independently, and this increases variation.

T-L #7: QUESTIONS FOR PPT: DNA BASICS

PART 1 – REPLICATION

1. Why is replication necessary?

2. When does replication occur?

3. Describe how replication occurs?

4. Use the complementary rule to create the complementary strand for AGCTAGAGCAGT

PART 2 – TRANSCRIPTION-TRANSLATION

1. Why is transcription necessary?

2. Describe transcription.

3. Why is translation necessary?

4. Describe translation.

5. What are the main differences between DNA and RNA?

6. Using code chart, identify the amino acids coded for by these codons. UGGCAGUGC

T-L #7 Code Chart

20 Amino Acids In Human Protein:
Table of DNA Base Triplets, RNA Codons & Anticodons

Amino Acid	DNA Base Triplets	M-RNA Codons	T-RNA Anticodons
alanine	CGA, CGG, CGT, CGC	GCU, GCC, GCA, GCG	CGA, CGG, CGU, CGC
arginine	GCA, GCG, GCT, GCC TCT, TCC	CGU, CGC, CGA, CGG AGA, AGG	GCA, GCG, GCU, GCC UCU, UCC
asparagine	TTA, TTG	AAU, AAC	UUA, UUG
aspartate	CTA, CTG	GAU, GAC	CUA, CUG
cysteine	ACA, ACG	UGU, UGC	ACA, ACG
glutamate	CTT, CTC	GAA, GAG	CUU, CUC
glutamine	GTT, GTC	CAA, CAG	GUU, GUC
glycine	CCA, CCG, CCT, CCC	GGU, GGC, GGA, GGG	CCA, CCG, CCU, CCC
histidine	GTA, GTG	CAU, CAC	GUA, GUG
isoleucine	TAA, TAG, TAT	AUU, AUC, AUA	UAA, UAG, UAU
leucine	AAT, AAC, GAA, GAG GAT, GAC	UUA, UUG, CUU, CUC CUA, CUG	AAU, AAC, GAA, GAG GAU, GAC
lysine	TTT, TTC	AAA, AAG	UUU, UUC
methionine	TAC	AUG	UAC
phenylalanine	AAA, AAG	UUU, UUC	AAA, AAG
proline	GGA, GGG, GGT, GGC	CCU, CCC, CCA, CCG	GGA, GGG, GGU, GGC
serine	AGA, AGG, AGT, AGC TCA, TCG	UCU, UCC, UCA, UCG AGU, AGC	AGA, AGG, AGU, AGC UCA, UCG
stop	ATG, ATT, ACT	UAA, UAG, UGA	AUG, AUU, ACU
threonine	TGA, TGG, TGT, TGC	ACU, ACC, ACA, ACG	UGA, UGG, UGU, UGC
tryptophan	ACC	UGG	ACC
tyrosine	ATA, ATG	UAU, UAC	AUA, AUG
valine	CAA, CAG, CAT, CAC	GUU, GUC, GUA, GUG	CAA, CAG, CAU, CAC

T-L #7 Length of a Human DNA Molecule

Bibliographic Entry	Result (w/surrounding text)	Standardized Result
Mitchel, Campbell Reece. *Biology Concept and Connections*. California, 1997.	"At actual size, a human cell's DNA totals about 3 meters in length."	3.0 m
McGraw Hill Encyclopedia of Science and Technology. New York: McGraw Hill, 1997.	"If stretched out, would form very thin thread, about 6 feet (2 meters) long."	2.0 m
Matthews, Harry R. *DNA Structure Prerequisite Information*. 1997.	"The length is (length of 1 bp)(number of bp per cell) which is (0.34 nm)(6 × 10^9)"	2.0 m
Leltninger, Albert L. *Biochemistry*. New York: Worth, 1975.	"Chromosome 13 contains a DNA molecule about 3.2 cm long."	1.5 m
"Cell." *The World Book Encyclopedia*. Chicago: Field Enterprises, 1996.	"On the average, a single human chromosome consists of DNA molecule that is about 2 inches long."	2.3 m

The chromosomes in the nucleus of a cell contain all the information a cell needs to carry on its life processes. They are made up of a complex chemical (a nucleic acid) called deoxyribonucleic acid, or DNA for short. Scientist's decoding of the chemical structure of DNA has led to a simple conceptual understanding of genetic processes. DNA is the hereditary material of all cells. It is a double-stranded helical macromolecule consisting of nucleotide monomers with deoxyribose sugar and the nitrogenous bases adenine (A), cytosine (C), guanine (G), and thymine (T). In the chromosomes of a cell, DNA occurs as fine, spirally coiled threads that in turn coil around another, like a twisted ladder.

The DNA molecule is threaded so fine that it is only possible to see it under high powerful electron microscopes. To get a sense of exactly how long an uncoiled DNA molecule is compared to a typical cell, a cell is magnified 1000 times. At this scale, the total length of all the DNA in the cell's nucleus would be 3 km -- the equivalent distance of the Lincoln Memorial to the capital in Washington, DC.

The human genome comprises the information contained in one set of human chromosomes which themselves contain about 3 billion base pairs (bp) of DNA in 46 chromosomes (22 autosome pairs + 2 sex chromosomes). The total length of DNA present in one adult human is calculated by the multiplication of

(length of 1 bp)(number of bp per cell)(number of cells in the body)

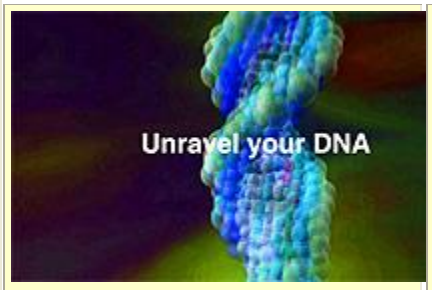
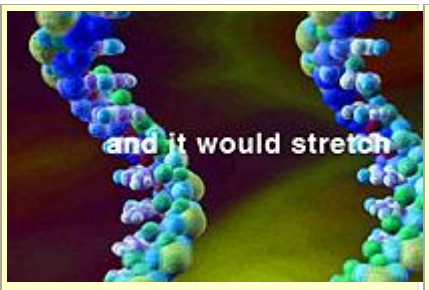
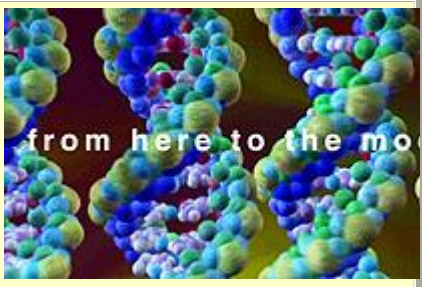
$(0.34 \times 10^{-9}\ m)(6 \times 10^9)(10^{13})$

2.0×10^{13} meters

That is the equivalent of nearly 70 trips from the earth to the sun and back.

2.0×10^{13} meters = 133.691627 astronomical units
133.691627 / 2 = 66.8458135 round trips to the sun

On the average, a single human chromosome consists of DNA Molecule that is almost 5 centimeters.

Bibliographic Entry	Result (w/surrounding text)	Standardized Result
WNET-DT 13.1, 5:00 PM 10 May 2006.	"Unravel your DNA and it would stretch from here to the moon"	3.85×10^8 m
		

T-L #8 Lab: What does DNA look like to the naked eye? (using wheat germ) (20 min)

GOAL: To show what DNA looks like from another, less magnified, perspective

- DNA is too small to see clearly with the naked eye—but if you have enough of it, you can see a big clump. So next, we're going to extract DNA from wheat germ. Remember, I said that all living things have DNA? Well, the wheat germ is the embryo, the part of the wheat seed that grows into a new plant, and it has DNA too.
  - Distribute trays of materials to each 4-6 participants. Instruct students to fill a plastic cup halfway with water, and demonstrate as you go along.
  - Add about 1 tsp. of wheat germ to the cup and mix.
  - Add 7-10 drops soap and stir quickly for one minute.

- The reason we add soap is to break open the cells, in order to get to the DNA inside.
  - Allow the wheat germ to settle on the bottom of the cup for 1 minute.
  - Using a plastic dropper, transfer two or three droppers-full of just the liquid at the top of the cup (try to avoid the solids at the bottom) to a test tube.
  - Use a clean plastic dropper or transfer pipette to dribble an amount of alcohol equal to the amount of wheat germ liquid down the side of the tube. Make sure to tell participants to try not to mix the two layers. • We add alcohol because DNA does not dissolve in alcohol, like it does in water.

- So there you have it—that white feathery stuff floating in there is the wheat DNA.

Optional: have participants reach in with a glass rod or coffee stirrer and fish out the DNA.

Review: DNA is in all living things, and this is the DNA from wheat, which we extracted from inside the wheat cells.

T-L#9 DNA → Protein Guided Notes

DNA → PROTEIN

- DNA contains instructions for _____
- DNA also contains instructions for
  - Making _____
  - Making _____ (but _____do the work)
- DNA = _____, RNA = _____
- DNA's genetic message = _____ on the DNA chain
  - They're not just stuck randomly stuck on!
- Nucleotide order (or sequence) is a coded language
  - Code determines an _____
- _____ MAKES mRNA
  - Transcription = making a copy
- TRANSLATION MAKES_____
  - Translation = reading the copy & putting it in a different "language"
  - _____ DO THIS
- DNA → mRNA → PROTEIN

DNA → PROTEIN: Transcription

- DNA is unzipped
- mRNA strand is made (synthesized) kind of like DNA is made during replication
- mRNA uses _____ instead of Thymine (T)
  - In transcription (_____) and (_____)
- WHY CAN'T PROTEINS JUST BE TRANSLATED RIGHT FROM DNA?
  - Using RNA provides protection for DNA & its info
  - Using RNA allows more protein copies to be made at the same time
  - BLUEPRINT EXAMPLE

DNA → PROTEIN: Translation

- In translation, _____ read the "code" and make chains of amino acids based on what the code is telling them.
  - Chains of amino acids = _____
- **mRNA code is a _____**
  - **3 N-bases read together = _____**
  - Codons tell which _____ to make
    - AUG = start (or Met)
    - UAA, UAG, UGA = stop
- _____ says
  - ACCAAACCG
- _____ replies
  - UGGUUUGGC
- _____**make**
  - **Trp-Phe-Gly**

T-L #11 Protein Simulation with Cards

Protein Synthesis Simulation

Materials: see the back of this page

- 20 DNA fragment cards
- 64 tRNA cards (put the anti-codon on one side and the word on the back)
- Worksheets (1 per student)

Preparation:

1. Tape the t-RNA cards around the room with the anti-codons showing.
2. Place the DNA fragments in the nucleus (front desk)

Activity Overview:

Set the scene by describing the classroom to the students as one big cell, with the front desk as the nucleus and the student desks as the ribosomes (etc.). Students will start at the nucleus by picking a DNA fragment and transcribing it to mRNA. They should not leave the nucleus for this step. They then go to one of the ribosomes to write out the corresponding tRNA sequence. Next they will search the room for the matching anti-codons on the tRNA cards. On the back of each card they will find a word (representing an amino acid) and the words should form a sentence (the protein). If the final sentence does not make sense, they have a mutation and should go back to figure out where they made a mistake.

This activity can also be done in groups, with one student doing the transcription *in the nucleus, another student working as the ribosome, and a 3rd searching the* room for the anti-codons.

Note: from "Biology With Junk" (Wartski)

For a 50 min. class period, precede this activity with a brief review of transcription and translation and follow it with a discussion of mutations. Some students will have time to complete 2 sentences.

20 Sentences;

1) Your mother wears a rubber band.
2) Your mother dresses you *funny.*
3) We have dog breath.
4) The Beatles are the best rock band.
5) An *old* rubber band breaks when pulled.
6) Biology is the best subject.
7) Drink water every *day.*
8)1 love *rock* and roll music.
9) We are all demented puppies.
10) Biology is **so** much fun.
11) Education is the door to the future.
12) Your father wears *a dress.*
13) Your *brother* wears nothing.
14) We are all in this together.
15) We must be informed every *day.*
16) Rock and roll music is the best.
17) Biology is all around you.
18) Read a little every *day.*
19) DNA is the code of life.
20) DNA must be read for life.

tRNA card with Words (that **go on the back):**

UAG = Stop (period)
AUG = Initiator (Start)
AAA = Your
AAC = mother
ACG = funny
ACA = breath
AGU = Beatles
AUC = band
CAC = rubber
CCA = when
CUC = love
GAA = all
GAU = and
GCG = fun
GGC = to
GUA = a
GUU = nothing
UAU= this
UCG = be
UGC = you
UUA= DNA
UUU= life

CCG = is
CCU = subject
CGA = *drink*
AAG = *wears*
ACC = have
AGA = the
AGC = best
AUU= an
CAG = breaks.
CCC = Biology
CUG = roll
GAC = demented
GCA = so
GCU = education
GGG = future
GUC = dress
UAA = we
UCA = together
UCU = informed
UGG = read
UUC = code

CGC = water
CGG = every
CGU = day
AAU = dresses
ACU = ***dog***
AGG = are
AUA = rock
CAA = *old*
CAU = pulled
CUA = I
CUU = music
GAG = puppies
GCC = much
GGA = *door*
GGU = father
GUG = brother
UAC = in
UCC = **must**
UGA = around
UGU = little
UUG = for

1) ATGAAAAACAAGGTACACATCTAG

2) ATGAAAAACAATTGCACGTAG

3)ATGTAAACCACTACATAG

4) ATGAGAAGTAGGAGAAGCATAATCTAG

5) ATGATTCAACACATCCAGCCACATTAG

6) ATGCCCCCGAGAAGCCCTTAG

7) ATGCGACGCCGGCGITAG

8) ATGCTACTCATAGATCTG(- II I AG

9) ATGTAAAGGGAAGACGAGTAG

10) A'IGCCCCCGGCAGCCGCGTAG

11) ATGGCTCCGAGAGGAGGCAGAGGG'TAG

12) ATGAAAGGTAAGGTAGTCTAG-

13) ATGAAAGTGAAGG ITTAG

14) ATGTAAAGGGAATACTATTCATAG

15) ATGTAATCCTCGTChCGGCGTTAG

16) ATGATAGA CGAGAAGCTAG

17) AT C,C000CGGAATGA PGCTAG

18) ATGTGGGTATGTCGGCGTTAG

19) ATGTTACCGAGATrCI GTTTTAG

20) ATGITATCCTC AG

If you like this lab be sure to see the ad on the last page for more from th

Name (s):

Protein Synthesis Simulation

1. Start at the "nucleus". Pick up a DNA strand and write the number *of* the DNA strand here:

2. Staying in the "nucleus", transcribe the DNA into mRNA. Write the mRNA sequence here:

3. Go to one *of* the "ribosomes" and write the tRNA sequence that corresponds to your mRNA here:

4. Split the tRNA sequence into anti-codons (groups *of* 3 letters)

5. Look around the room for the tRNA cards that match your anti-codons. Write down the words in order.

If you complete this correctly, you should have a sentence. *If* it does not make sense, you have made a mistake and need to go back and start over. Check your answer with the teacher when you are done and then answer the questions on the back *of* this sheet.

If you have time, you may complete another DNA sequence for bonus points.

Questions:

1. Why did you have to stay in the "nucleus" to write down the mRNA?

2. Which part of this activity represents transcription?

3. Which part of this activity represents translation?

4. What happens in the ribosomes during protein synthesis?

5. What does the final sentence represent in terms of protein synthesis?

6. What does each word represent in terms of protein synthesis?

7. All DNA sequences started with ATG and ended with TAG? Why?

8. How does this activity differ to doing protein synthesis problems using the genetic code?

T-L #12 PPT: Mutations Guided Notes

1. What does the cartoon imply?

2. Mutations are _____ in _____ that affect _____ information.

3. _____ mutations are changes in _____ nucleotides

4. Change something in the sentence to illustrate each type of **point mutation.**

THE FAT CAT ATE THE RAT	**TYPE OF POINT MUTATION**
Change in sentence _____	_____ mutation
Change in sentence _____	_____ mutation
Change in sentence _____	_____ mutation

5. Describe how **insertion** is a frameshift.

Describe how **deletion** is a frameshift.

6. Give an example for each type of **chromosome mutation** of the original chromosome

ABC DEF

Deletion _____ **Inversion** _____

Duplication _____ **Translocation**_____

7. Give two examples for the significance of different mutations.

Neutral	**Harmful**	**Beneficial**
_____	_____	_____
_____	_____	_____

8. What are two ways DNA can be mutated?

9. How is Down syndrome a chromosome mutation?

10. How is Cri-du-chat a chromosome mutation?

11. What makes XYY a sex chromosome abnormality?

12. Why is Turner's syndrome a sex chromosome mutation?

13. Why is Trisomy X considered a sex chromosome mutation?

T-L #14: Article: Gene Expression Regulates Cell Differentiation

How is it that your body with all of its specialized organs developed from a single cell? Scientists are exploring how gene expression patterns and their timing regulate cell differentiation.

All of the cells within a complex multicellular organism such as a human being contain the same DNA; however, the body of such an organism is clearly composed of many different types of cells. What, then, makes a liver cell different from a skin or muscle cell? The answer lies in the way each cell deploys its genome. In other words, the particular combination of genes that are turned on (expressed) or turned off (repressed) dictates cellular morphology (shape) and function. This process of gene expression is regulated by cues from both within and outside cells, and the interplay between these cues and the genome affects essentially all processes that occur during embryonic development and adult life.

Do All Cells Really Contain the Same DNA? (T-L #14 continued)

Figure 1: Dolly the sheep.
Dolly, the first mammal to be cloned, was born in 1996.

Several lines of evidence support the proposal that all of the cells within a multicellular organism contain the same genome. For instance, although you started as a single cell with a half-genome from each parent, that single cell quickly divided and new cells began to differentiate, or become different from each other. While this process of differentiation established a wide variety of cell types (e.g., skin, liver, muscle, etc.), it was not accompanied by any permanent loss of genetic material. This is demonstrated by the fact that fully differentiated cell types are still capable, within the right environment, of giving rise to an entire new animal. This capability was first shown by way of an experiment in which the nucleus of an adult frog skin cell was transplanted into an enucleated donor embryo, eventually leading to the development of a cloned adult frog (Gurdon *et al*., 1975). Later, the intact complete genome of a differentiated cell was used in the cloning of the famous sheep Dolly (Figure 1), showing that in mammals, genes are not lost during development, so they must therefore be regulated (Wilmut *et al*., 1997).

Today, researchers understand that the specialized, differentiated cell types of the adult body contain a genome as complete as any embryo's. This fascinating demonstration has led to the proposal that changes in gene expression, rather than losses of genetic material, play a key role in guiding and maintaining cell differentiation.

Cell-Extrinsic Regulation of Gene Expression

Gene expression is regulated by factors both extrinsic and intrinsic to the cell. Cell-extrinsic factors that regulate expression include environmental cues, such as small molecules, secreted proteins, temperature, and oxygen. These cues can originate from other cells within the organism, or they can come from the organism's environment. Within the organism, cells communicate with each other by sending and receiving secreted proteins, also known as growth factors, morphogens, cytokines, or signaling molecules. Receipt of these signaling molecules triggers intercellular signaling cascades that ultimately cause semipermanent changes in transcription or expression of genes. Such changes in gene expression can include turning genes completely on or off, or just slightly tweaking the level of transcript produced. This process is thought to regulate a vast number of cell behaviors, including cell fate decisions during embryogenesis, cell function, and chemotaxis.

In addition, gene expression changes can lead to changes in an entire organism, such as molting in insects. In *Drosophila*, for example, the molting process is regulated by levels of a hormone called ecdysone. This hormone acts as a signal, triggering a cascade of events and leading to changes in gene expression. Not surprisingly, the genes that are expressed in response to ecdysone are also the genes that are involved in the molting process (White *et al*., 1997). Thus, ecdysone acts on the organism level as a cell-extrinsic factor to bring about physiologically meaningful changes in gene expression.

By: Amy Ralston, Ph.D. (Write Science Right) & Kenna Shaw, Ph.D. (Nature Education)
Citation: Ralston, A. & Shaw, K. (2008) Gene expression regulates cell differentiation. Nature Education 1(1)

GENETIC DISORDERS		
Aceruloplasminemia	Down syndrome	Niemann-Pick Disease
Achromatopsia	Duchenne muscular dystrophy	Noonan Syndrome
Achondroplasia	Epidermolysis Bullosa	Osteogenesis Imperfecta
Acid Maltase Deficiency	Fabry Disease	Patau Syndrome
Albinism	Fibrodysplasia Ossificans	Pfeiffer Syndrome
Alexander Disease	Fragile X Syndrome	Phenylketonuria
Alkaptonuria	Galactosemia	Polycystic kidney disease
Alzheimer's	Gaucher's Disease	Porphyria
Angelman syndrome	Gilbert's Syndrome	Prader-Willi syndrome
Bardet-Biedl Syndrome	Haemochromatosis	Progressiva syndrome
Barth Syndrome	Huntington's Disease	Retinoblastoma
Best's Disease	Hurler Syndrome	Rett Syndrome
Bipolar Disorder	Hypophosphatasia	Rubinstein-Taybi Syndrome
Bloom Syndrome	Jackson-Weiss Syndrome	Shwachman Syndrome
Canavan syndrome	Joubert Syndrome	Sickle-cell anemia
Carnitine Deficiencies	Klinefelter Syndrome	Smith-Magenis Syndrome
Charcot-Marie-Tooth Disease	Krabbe Disease	Stickler Syndrome
Coeliac disease	Langer-Giedion Syndrome	Thalessemia
Coffin Lowry Syndrome	Leukodystrophy	Triple X Syndrome
Color blindness	Lesch-Nyhan Syndrome	Turner Syndrome
Cooley's Anemia	Marfan Syndrome	Usher Syndrome
Cowden Syndrome	Menkes Syndrome	Von Hippel-Lindau Syndrome
Cri-du-Chat Syndrome	Mowat-Wilson Syndrome	Variegate Porphyria
Crouzon Syndrome	Mucopolysaccharidosis (MPS)	Waardenburg Syndrome
Cystic fibrosis	Muenke Syndrome	Wilson's Disease
Cystinosis	Myotonic Dystrophy	Xeroderma Pigmentosum
Dominant otosclerosis	Nail-Patella Syndrome	XXXX Syndrome/tetrasomy
	Neurofibromatosis	YY Syndrome