

Lesson Title: Cell Differentiation

Overview of Lesson Plan: As a class, students role-play as individual developing cells in an embryo to understand how cells in human body have the same DNA, yet through epigenetics become specialized and take on a unique epigenetic profile.



Big Understanding: The changing epigenome informs gene expression in a cell. As an embryo develops, signals received over time causes increasing changes in gene expressions. Epigenetic markers create further changes in the genes expressions as the markers shut down some genes and activates others nudging a cell toward its final destiny. The epigenetic profiles of each cell grow increasingly different over time. In the end different cell types form, each with a distinct identity and specialized function.

Essential Questions:

How do developing embryo cells develop into specialized cells such as bone, muscle, and skin?

Grades: 5-8

Subjects: General

Time required: 30 minutes

Objectives: Introduce how epigenetics leads to specialized cells in a developing embryo

Background:

- Genes provide the instructions for development and maintenance of the body.
- A second set of instructions called the epigenome interact with DNA to activate or suppress the expression of particular genes.
- Certain chemicals known as epigenetic markers turn genes off or on without changing the underlining genetic code.
- [Online Resources](#)

Materials: A class set of cut-out [Cell Differentiation Game Cards](#), [Directions for Cell Game](#)

Activities and Procedures:

1. If possible, take students to a big open space
2. Hand each student a number/symbol *Cell Differentiation* game card.
3. Then have students line up with their card in a horizontal line across back of space in a random order
4. Explain to the students that they all represent cells in a developing embryo. Every cell in the embryo while containing the same DNA will over time develop into specialized cells. This is due to the epigenetic markers that create changes in gene expressions as the markers shut down some genes and activates others within a cell. In the end, different cell types form, each with a distinct epigenetic profile and specialized function. For example some will become bone cells, muscle cells, skin cells, liver cells, heart cells, brain cells, stem cells etc.
5. Their game cards have letters which represent specific proteins in a gene.
6. Remind students to take fairly uniform size steps forward and backward depending on what the symbols are called out on their card.
7. Read all the “Gene Expression Instructions” out loud informing students to move forward or backward based on the letter combinations.

8. While students are still in the formation created at the end of game, explain how the each symbol on their card stands for using epigenetic marker being expressed.

Assessment/Reflection: As a class or individually, have students compare and analyze their experience in the game simulation to the role epigenetics play in cell differentiation.

Epigenetic Cell Differentiation	Game Simulation – Student experiences
<ul style="list-style-type: none"> ▪ Early in development, genes are “poised” like runners in the starting blocks, ready to jump to action 	
<ul style="list-style-type: none"> ▪ Epigenetic markers shut down some genes and activate others as it nudges a cell toward its final fate. 	
<ul style="list-style-type: none"> ▪ Different cell experiences causes the epigenetic profiles of each cell type to grow increasingly different over time. 	
<ul style="list-style-type: none"> ▪ In the end, hundreds of cell types form, each with a distinct identity and a specialized function. 	

Beyond the game reflection

- **Early in development**, most signals come from within cells or from neighboring cells. Mom's nutrition is also important at this stage. The food she brings into her body forms the building blocks for shaping the growing fetus and its developing epigenome. Other types of signals, such as stress hormones, can also travel from mom to fetus.
- **After birth and as life continues**, a wider variety of environmental factors start to play a role in shaping the epigenome. Social interactions, physical activity, diet and other inputs generate signals that travel from cell to cell throughout the body. As in early development, signals from within the body continue to be important for many processes, including physical growth and learning. Hormonal signals trigger big changes at puberty.
- **Even into old age**, cells continue to listen for signals. Environmental signals trigger changes in the epigenome, allowing cells to respond dynamically to the outside world. Internal signals direct activities that are necessary for body maintenance, such as replenishing blood cells and skin, and repairing damaged tissues and organs. During these processes, just like during embryonic development, the cell's experiences are transferred to the epigenome, where they shut down and activate specific sets of genes.

Cell Differentiation Game - Take One Step Forward...

1. If you have an A on your card take ONE step forward.
2. If you have an M and an G on your card take ONE step forward.
3. If you have a T or a C on your card take ONE step forward.
4. If you have a K symbol on your card take ONE step forward.
5. If you have a G and an R on your card take ONE step forward.
6. If you have the numbers 30 or higher on your card take ONE step forward.
7. If you have an H or a W on your card take ONE step back.
8. If you have a V on your card take ONE step forward.
9. If you have a D on your card take TWO steps back.
10. If you have an A and an R on your card take TWO steps forward.
11. If you have an M, T and a Y on your card take ONE step forward.
12. If you have the numbers 25 or lower on your card take ONE step back.
13. If you have a B or D with a number higher than 27 on your card take TWO steps forward.
14. If you have a W and a Y on your card take ONE step forward.
15. If you have a B and an R on your card take ONE step forward.
16. If you have an A, G and T on your card take ONE step forward.
17. If you have an M, B, and S on your card take ONE step back.
18. If you have an H, D and Y on your card take TWO steps back.
19. If you have an R on your card take TWO steps forward.
20. If you have an A on your card take ONE step forward; anyone with an M take ONE step back.
21. If you have a G on your card take ONE step forward; anyone with an H, W and V take ONE step back.
22. If you have a C or T on your card take ONE step forward; anyone with a B and D take ONE step back.
23. If you have a number higher than 32 on your card take ONE step forward; anyone with a number lower than 28 take a step back.
24. If you have an R on your card take ONE step forward; anyone with a Y take ONE step back.
25. If you have a K symbol on your card take ONE step forward; anyone with an S take ONE step back.

Have students look around to see who is standing near them. Based on their locations and who is closest to them, help students get into four different groups. These four groups represent the following tissues:

- Group one (the group that moved forward the most) is part of the brain cells.
- Group two (the next group) is part of the ectoderm mesoderm cells (kidney, muscle, heart, immune, etc.)
- Group three (the next group) is part of the germ cells.
- Group four (the group that moved forward the least) is part of the stem cell.

To go further in depth, share with students the following handouts on various types of cells and the graphic on “Snap Shot: Directed Differentiation of Pluripotent Stem Cells”

Stem Cell

1. Germ Cells – sperm or egg cells

2. Ectoderm Cells

- a. Epithelial Cells - skin cells (keratinocytes) and pigment skin cells (melanocytes)
- b. Vision cells (Eye Photoreceptors)
- c. Hearing cells (Hair cells in the ear)
- d. Brain cells
 - i. Neurons
 1. Movement cells (Motor neurons)
 - a. Motor coordination cells (Purkinje cells in cerebellum)
 - b. Leg movement cells (spinal motor neuron)
 2. Thinking and Being cells (Cortical neurons)
 - a. Breathing cells (brainstem cells)
 - b. Parkinson's-affected cells (Dopamine neurons)
 - c. Memory formation cell (hippocampal neuron)
 - d. Memory storing cell (cortical neuron)
 - ii. Support cells in the brain (Glial cells)
- e. Eye pigment cells (retinal pigment cells)

3. Endoderm Cells

- a. Liver cells (hepatocytes)
- b. Pancreas cells (beta cells)
- c. Lining of gastrointestinal tract cells (type of epithelial cell)
- d. Lung cells

4. Mesoderm Cells

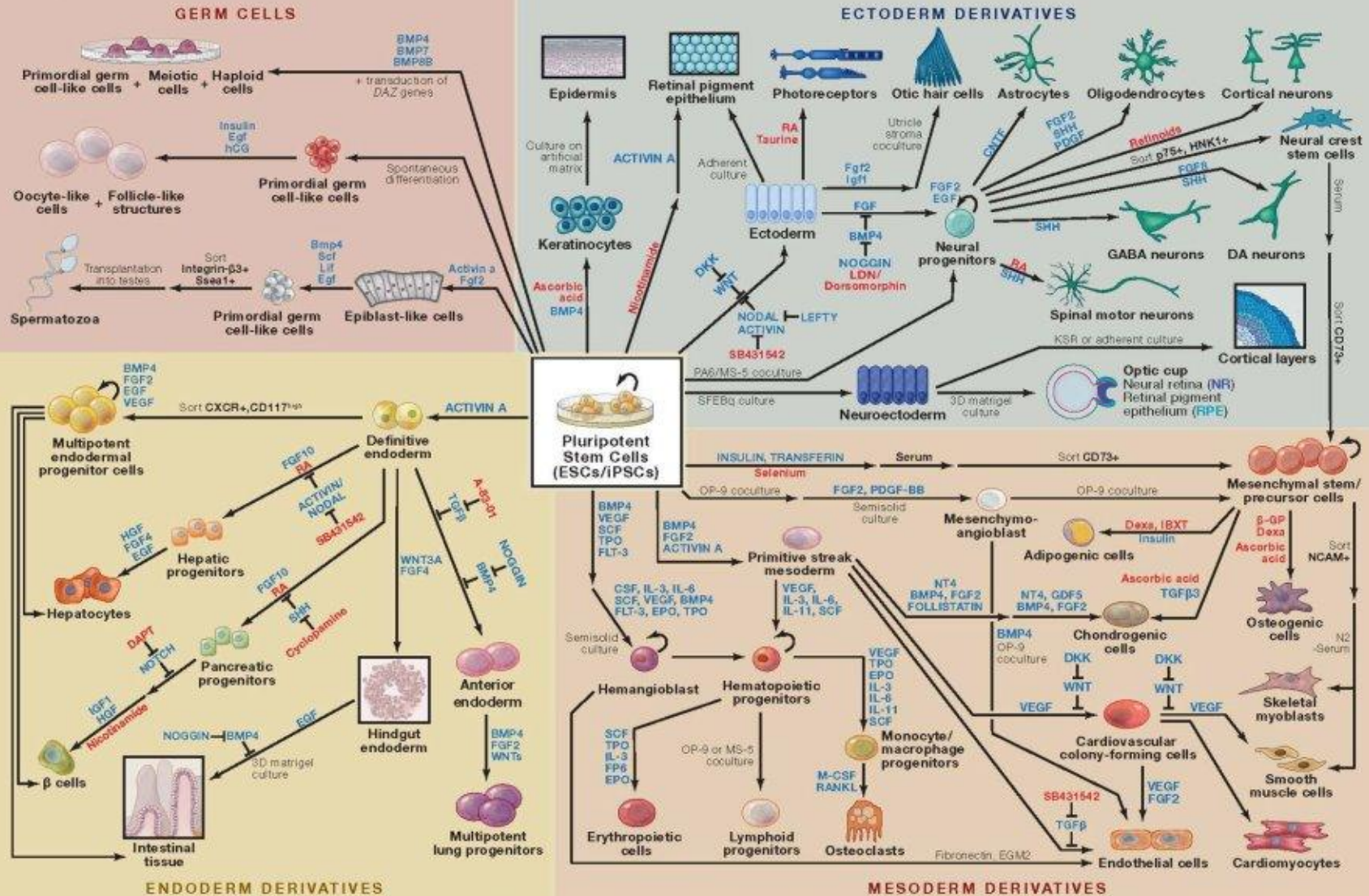
- a. Mesoderm Epithelial cells
 - i. Kidney cells (nephrons)
- b. Mesenchymal stem/precursor cells
 - i. Cartilage cells
 - ii. Tendon cell
 - iii. Ligament cell
 - iv. Fat cells (adipose cells)
 - v. Bone cells (osteogenic cells)
 - vi. Arm and leg muscle cells (skeletal myoblasts)
 - vii. Smooth muscle cells (blood vessels, bladder, iris of eye)
 - viii. Heart cells (cardiac myocytes)
- c. Hemangioblast (<http://www.nature.com/onc/journal/v24/n37/images/1208920f2.jpg>)
 - i. Blood vessel lining cells (Endothelial cells)
 - ii. Myeloid Cell
 1. Red blood cell (Erythrocyte)
 2. Blood clotting cells (Platelets)
 3. Bacteria eating immune cell (macrophage)
 4. White blood cell (first-responder type of immune cell) - (neutrophil)
 5. Toxin-releasing immune cell (eosinophil)
 6. Allergy (histamine-releasing) cell (basophil)
 7. Nose-lining immune cell (dendritic cell)
 - iii. Lymph System Cells (Lymphoid progenitor)
 1. Antibody forming cells (B cells)
 2. Immune cells (T cell)
 - a. Cytotoxic T cell (CD8+ immune cell)
 - b. Helper T cell (CD4+ immune cell)
 3. Natural Killer Immune Cell (NK cell)
 - iv. Bone eraser cell (osteoclast)

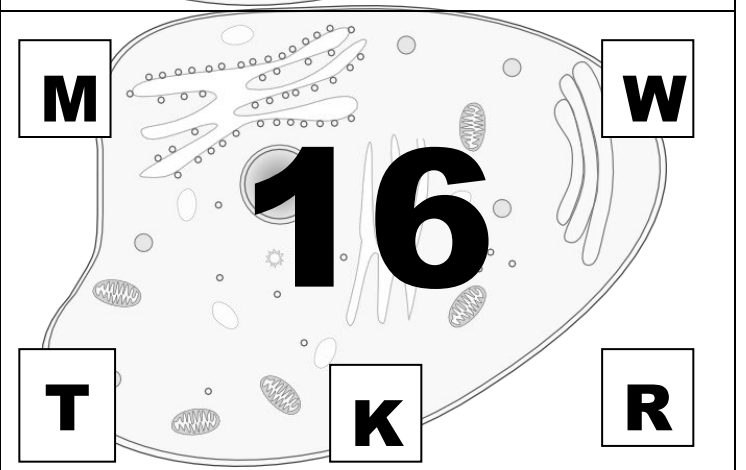
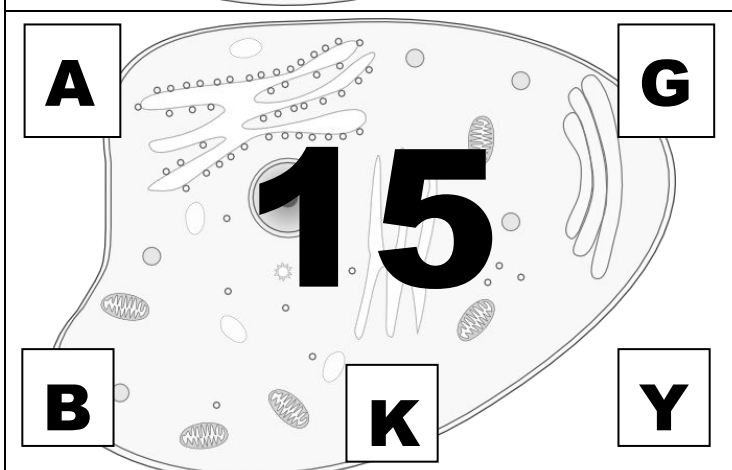
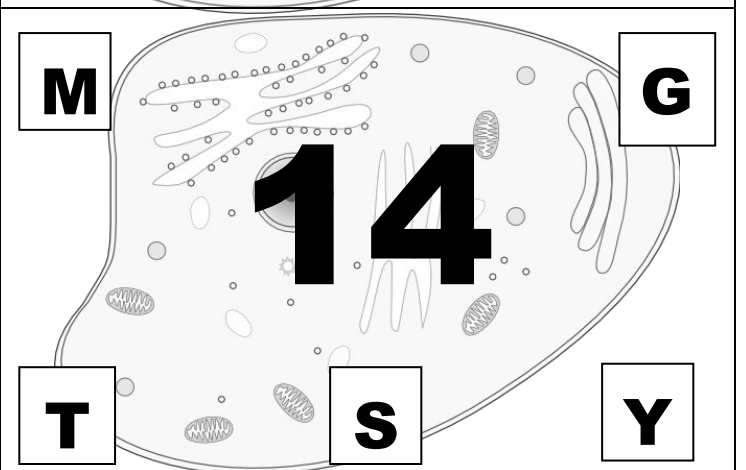
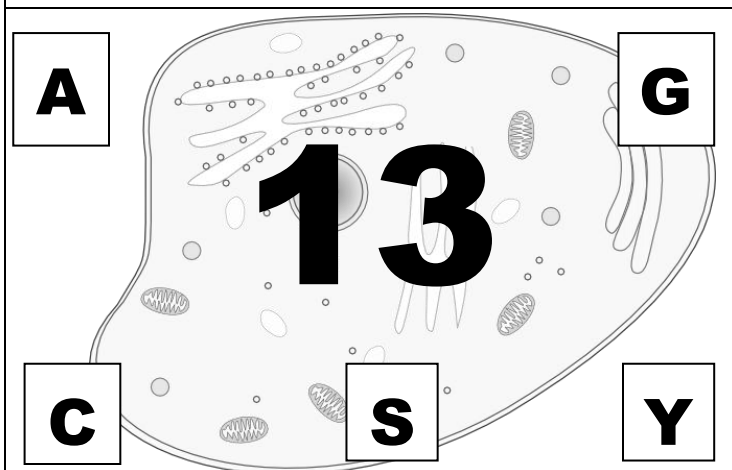
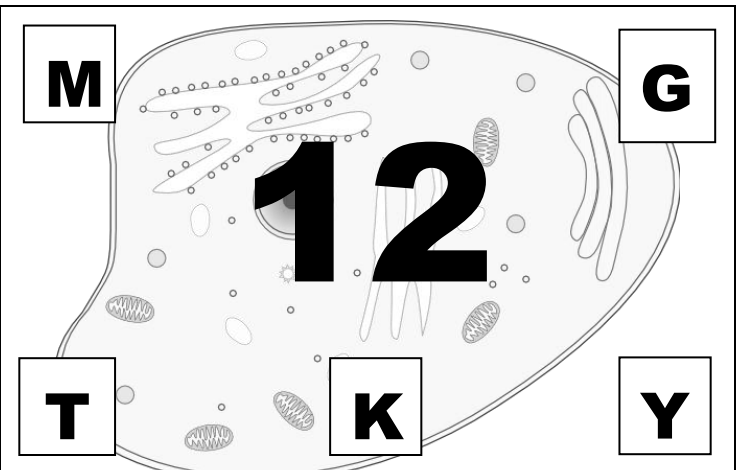
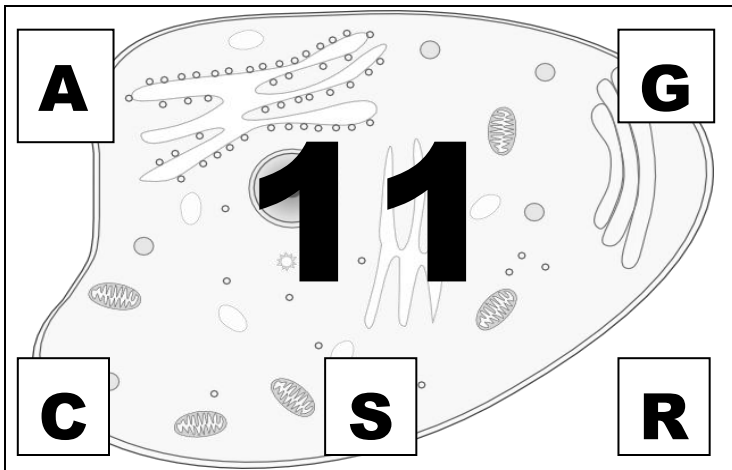
SnapShot: Directed Differentiation of Pluripotent Stem Cells

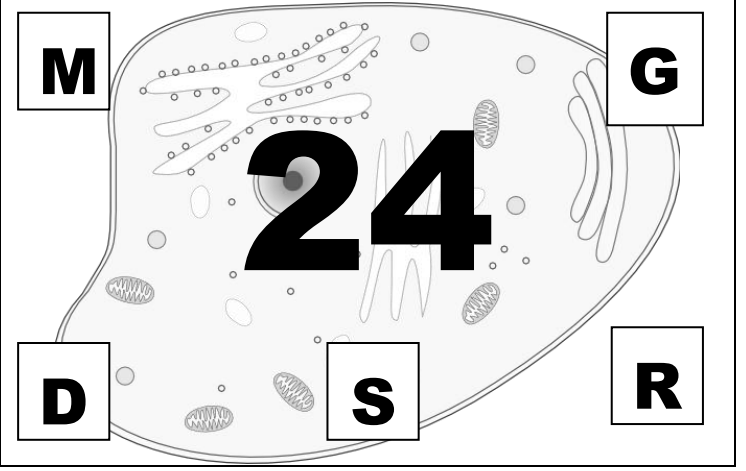
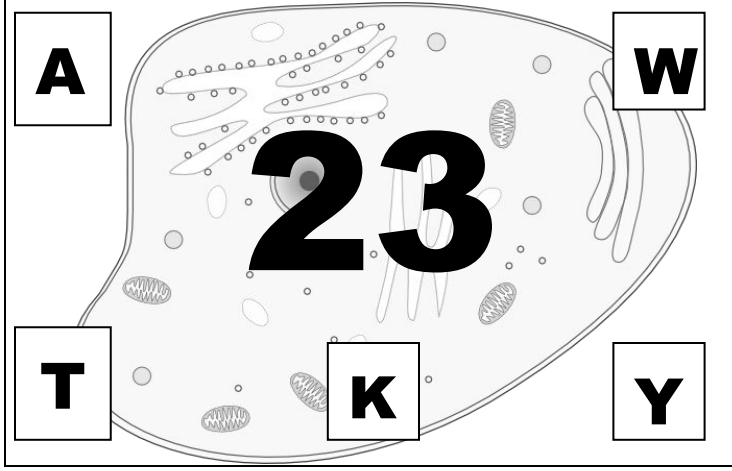
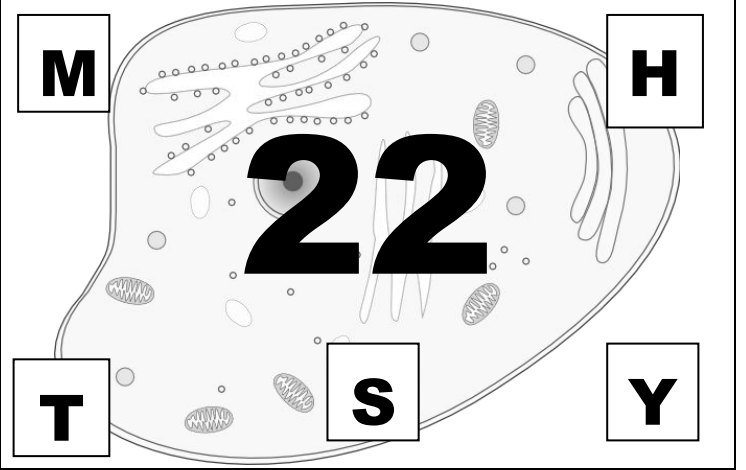
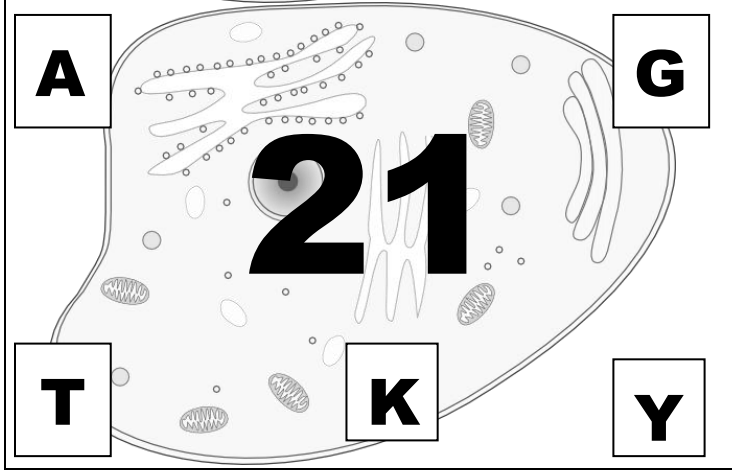
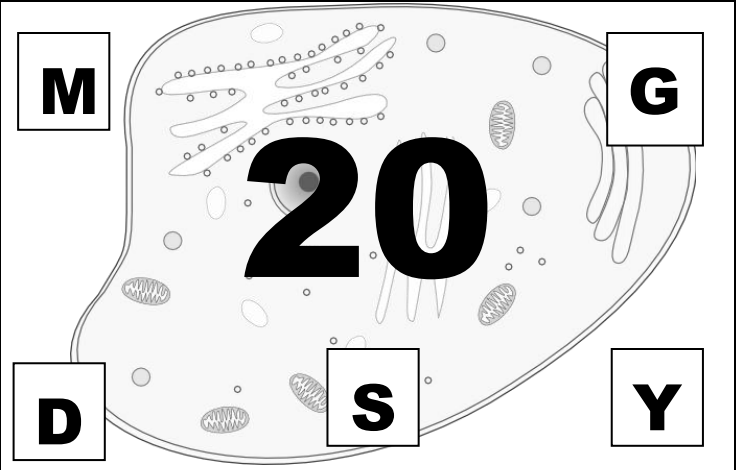
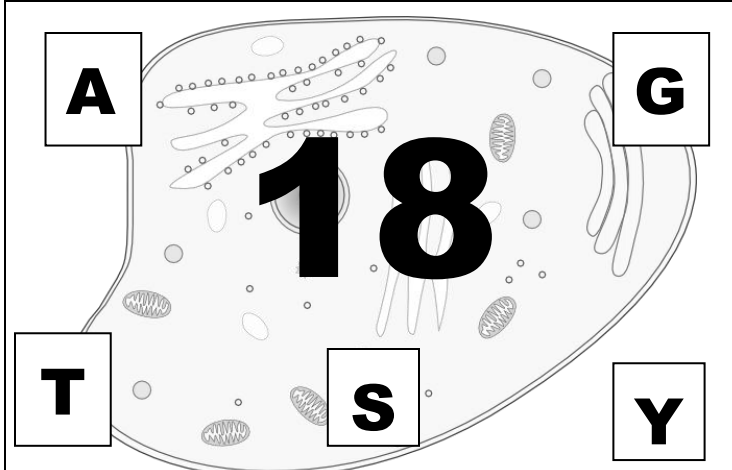
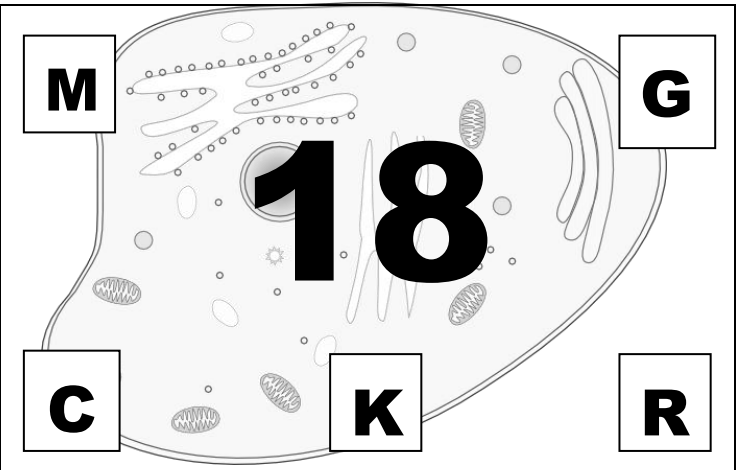
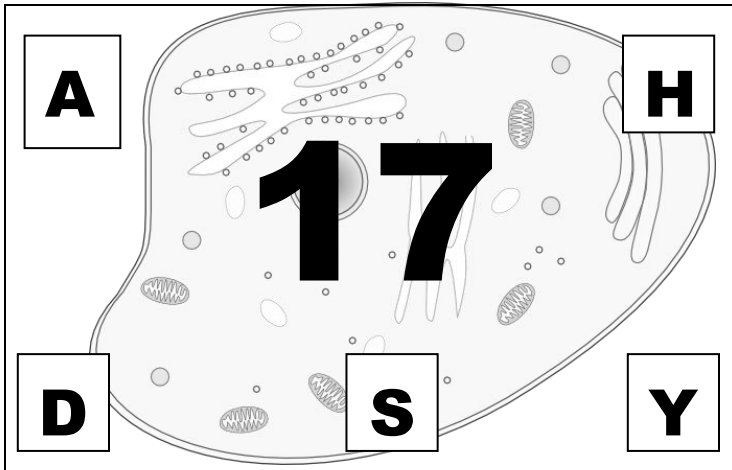
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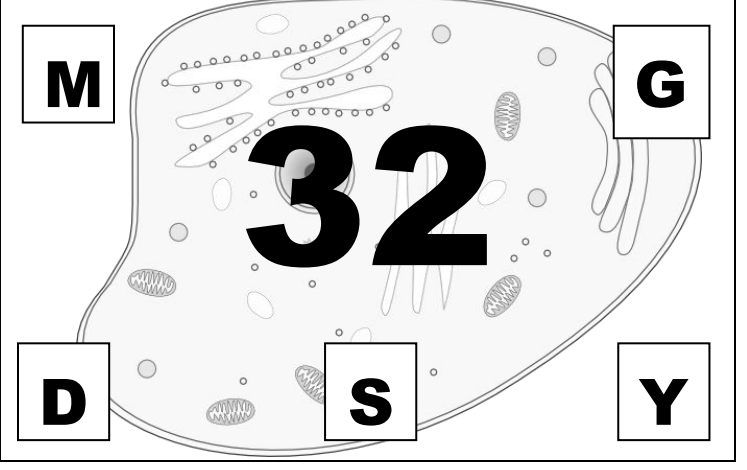
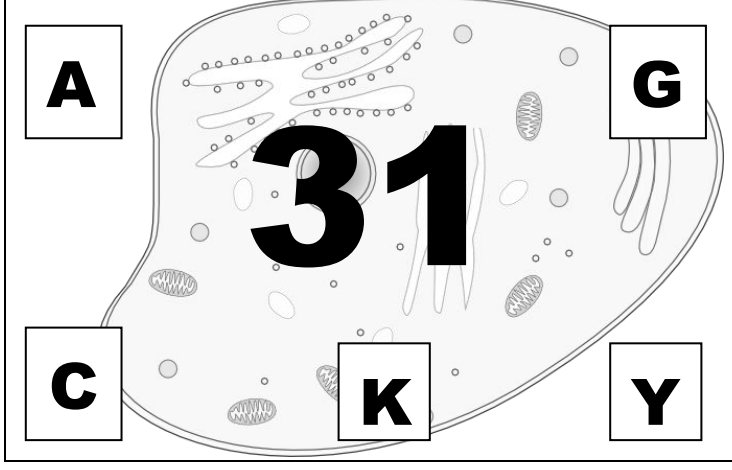
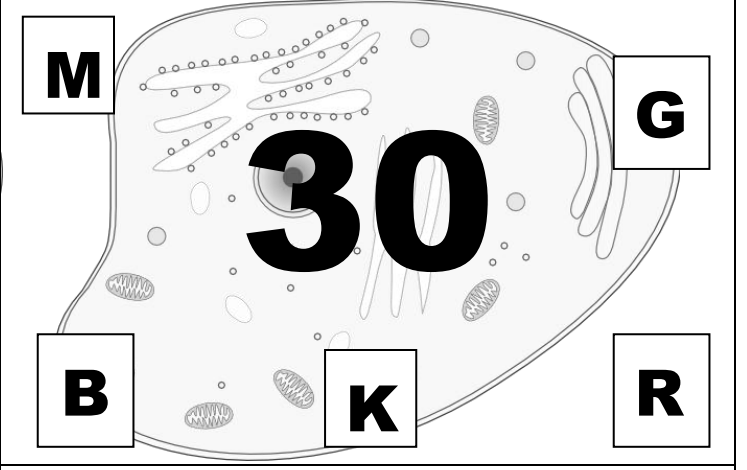
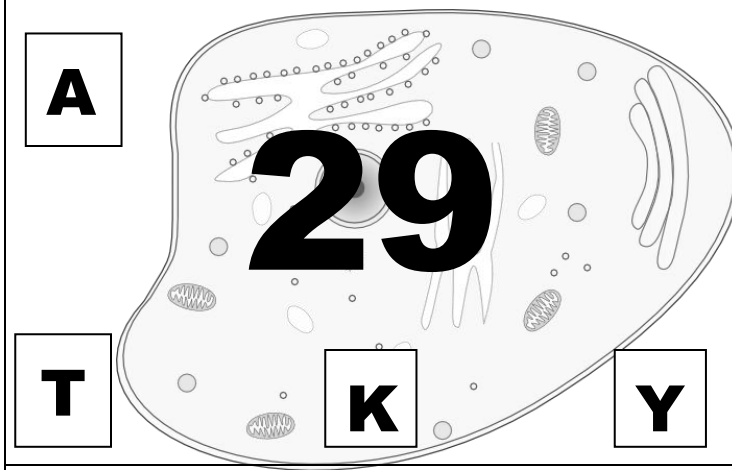
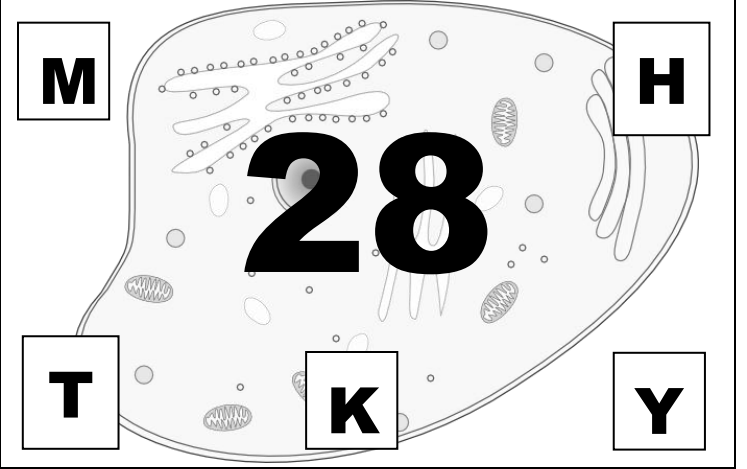
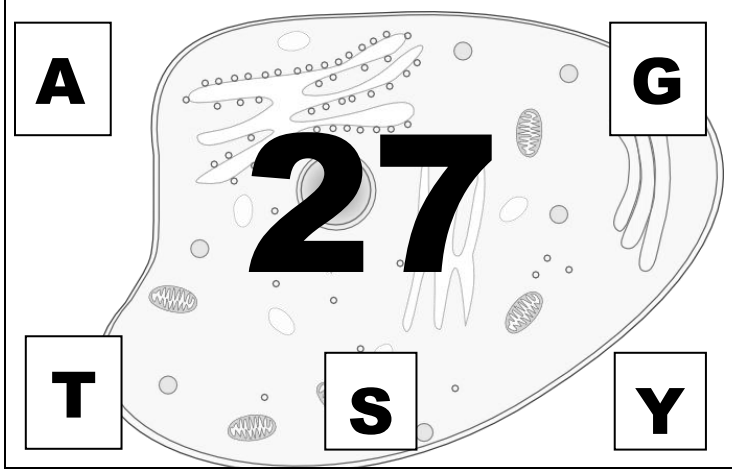
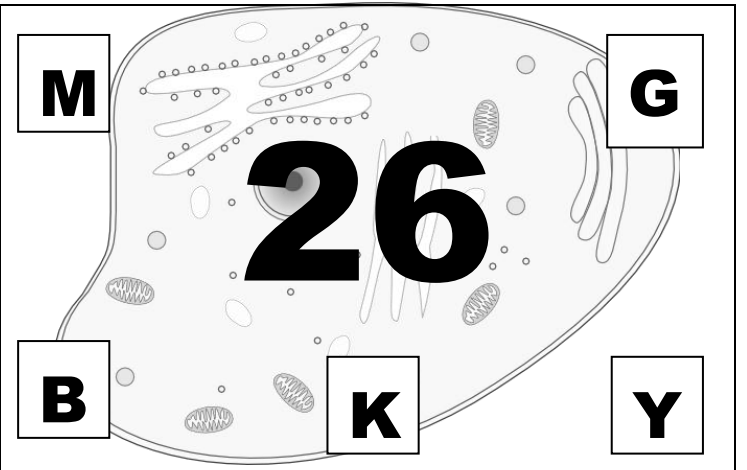
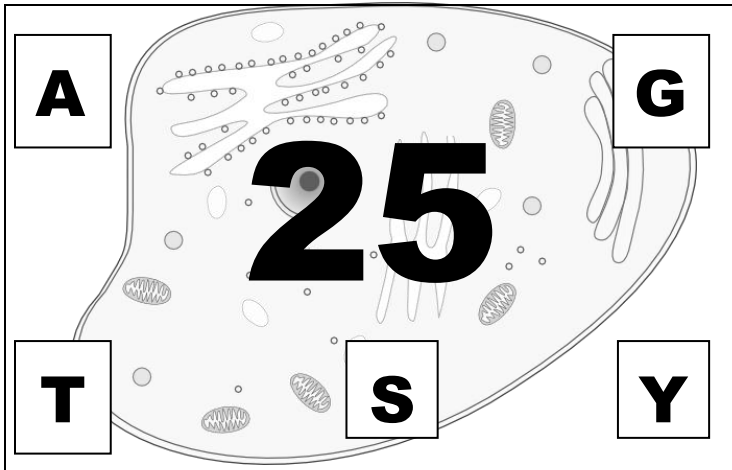
1 Cell 149, May 25, 2012 ©2012 Elsevier Inc. DOI:10.1016/j.cell.2012.05.015

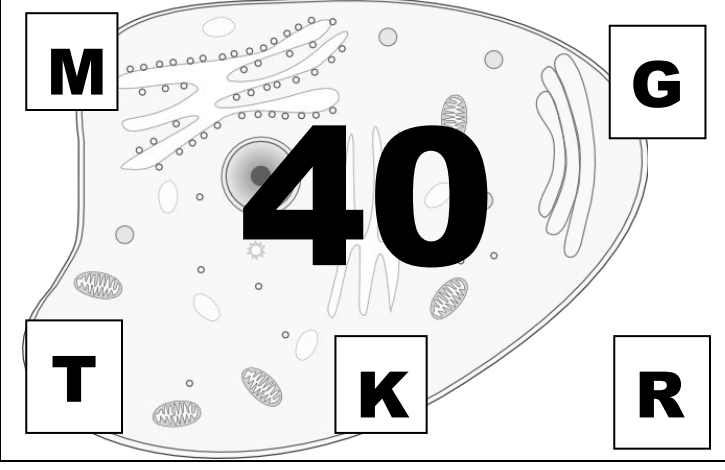
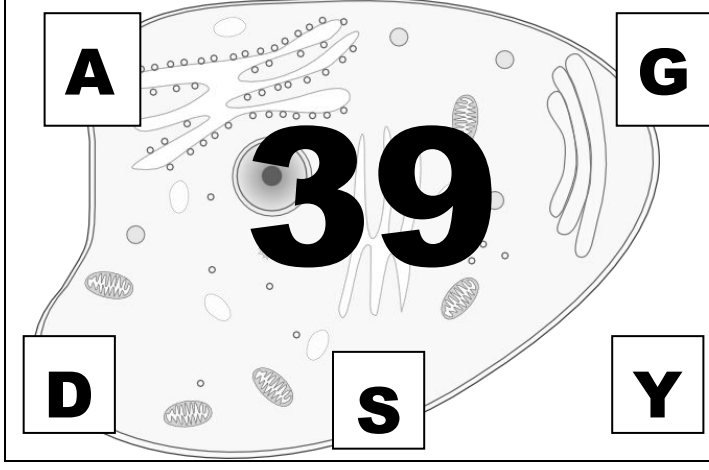
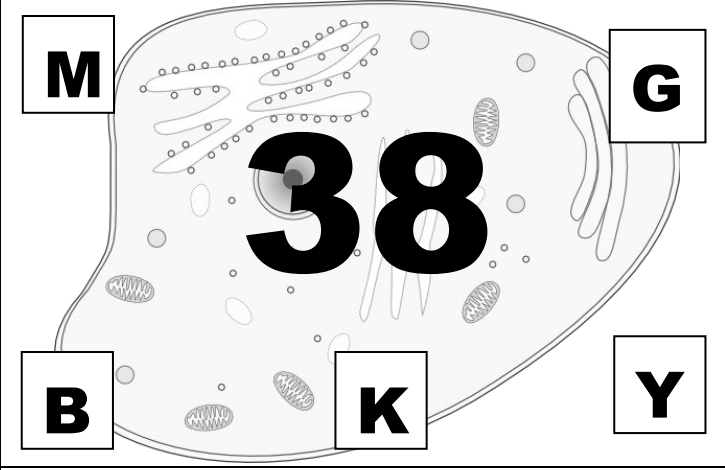
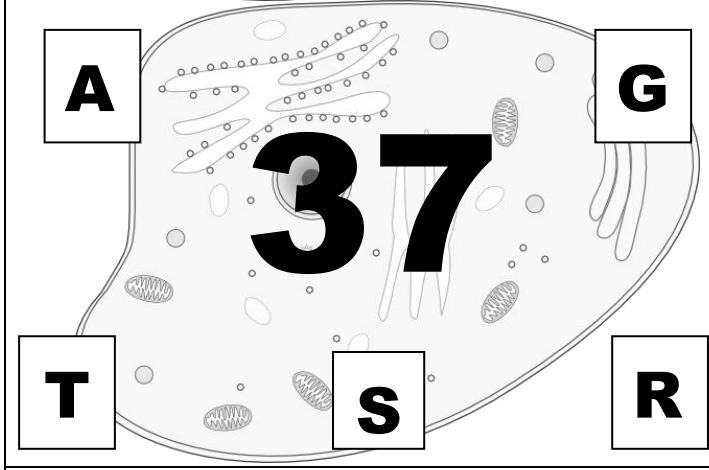
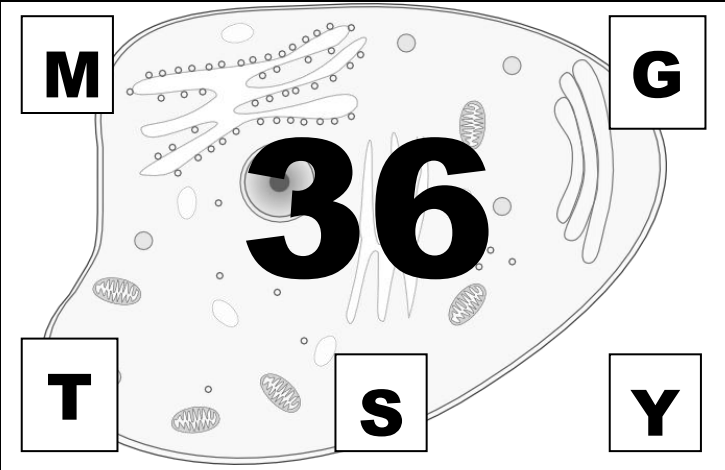
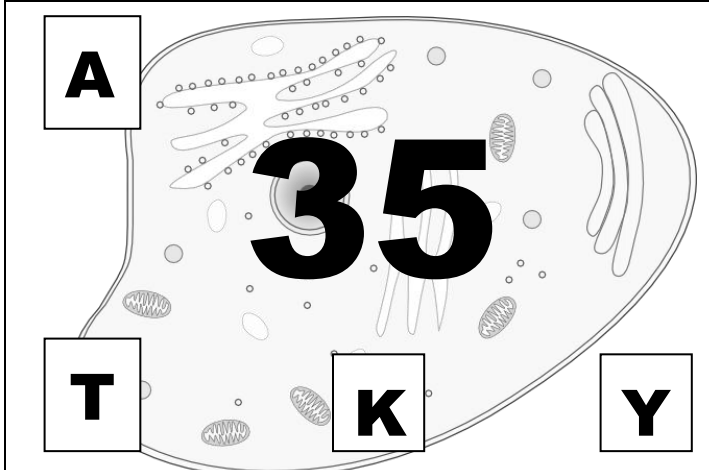
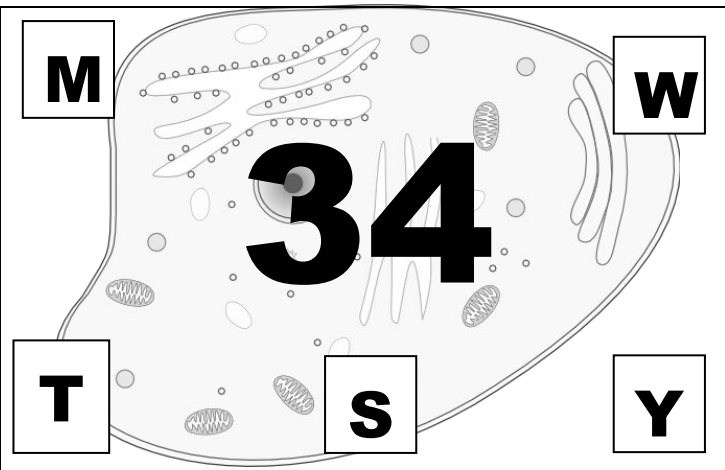
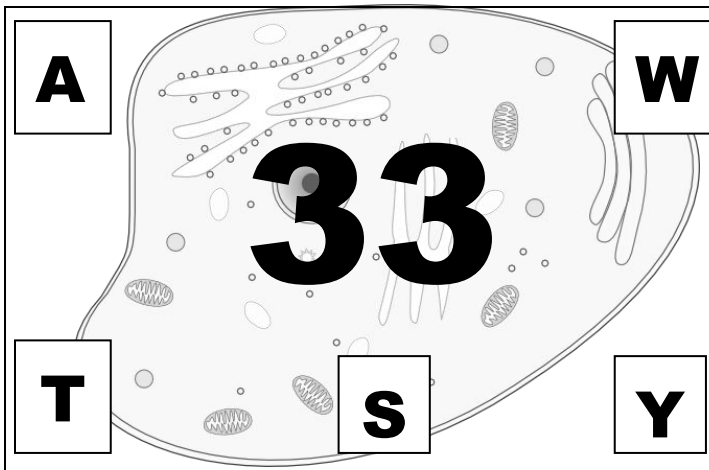
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Online Resources for Epigenetics



VIDEO	Title	Source	Link
	<i>Epigenetics</i>	PBS - NOVA	http://www.pbs.org/wgbh/nova/body/epigenetics.html
	<i>Epigenetics I and II</i>	PBS - NOVA (via youtube)	http://www.youtube.com/watch?v=wFsxVkuChdU (7: http://www.youtube.com/watch?v=Xjq5eEslJhw (6:19)
	<i>Epigenetics</i>	scishow (via Youtube)	http://www.youtube.com/watch?v=kp1bZEUgqVI&feature=youtube_gdata_player
	<i>Epigenetics makes you unique: Courtney Griffins at TEDxOU</i>	TEDxTALKS (via Youtube)	http://www.youtube.com/watch?v=JTBg6hqueTg
	<i>(Audio slide show) A Tale of Two Mice</i>	PBS – NOVA	http://www.pbs.org/wgbh/nova/body/epigenetic-mice.html Audio slide show and supporting web page about the aguti mice and epigenetics.
	<i>Utah Twins</i>	The University of Utah - Genetic Science Learning Center	http://learn.genetics.utah.edu/content/epigenetics/twins/
ARTICLES	Title	Source	Link
	<i>How the First Nine Months Shape the Rest of Your Life</i>	<u>Time Magazine</u> - By Annie Murphy Paul	http://www.time.com/time/magazine/article/0,9171,2021065,00.html#ixzz2Wn5nO1wE
	<i>Why Your DNA Isn't Your Destiny.</i>	<u>Time Magazine</u> - By John Cloud	http://www.time.com/time/magazine/article/0,9171,1952313,00.html
	<i>Beyond DNA: Epigenetics - Deciphering the link between nature and nurture.</i>	Natural History - By Nessa Carey	http://www.naturalhistorymag.com/features/142195/beyond-dna-epigenetics
	<i>Epigenetics: Tales of Adversity.</i>	<u>Nature</u> - International Weekly Journal of Science	http://www.nature.com/nature/journal/v468/n7327_supp/full/468S20a.html
WEB SITES	Title	Source	Link
	<i>Learn Genetics and Teach Genetics</i>	The University of Utah - Genetic Science Learning Center	http://learn.genetics.utah.edu/content/epigenetics/

