How many chromosomes are in most human cells?

23 46 20,000-25,000

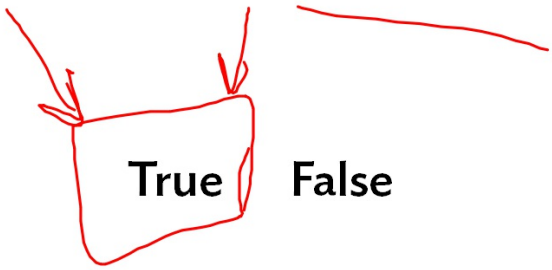
What is produced through the process of transcription?

RNA Protein

What is produced through the process of translation?

RNA Protein

In a human, both bone cells and lung cells have the same genes



False

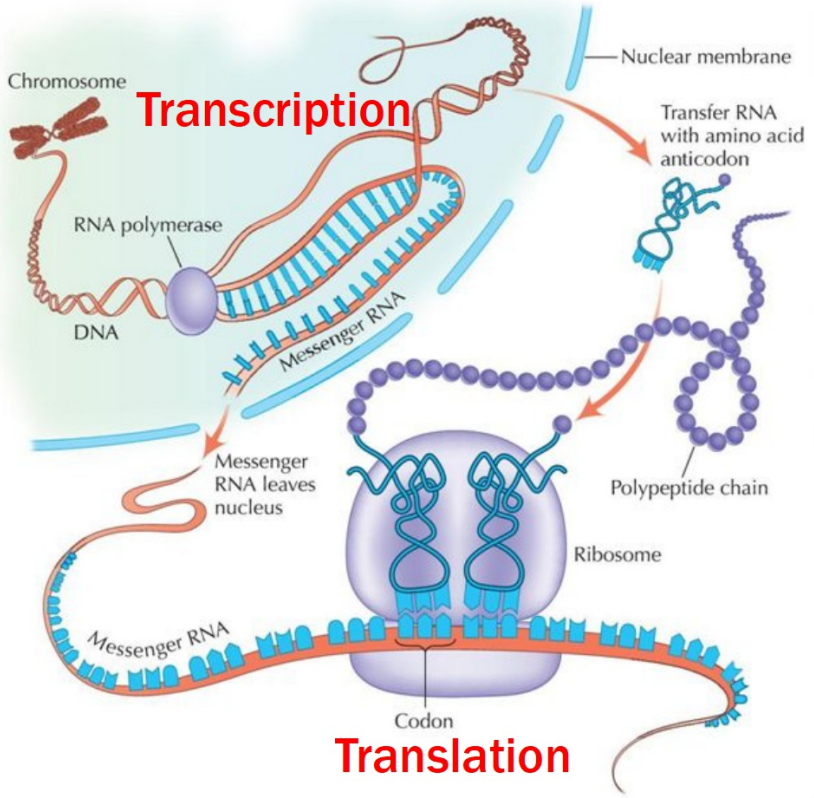
Feb 20, 2020

Objective: The student will identify how different genes are turned on and off in different types of cells and at different times.

Agenda: Warm Up
Gene expression lab

Upcoming:
Thurs/Fri- Gene Expression Lab
Monday: Microarray paper simulation
Tuesday: Mircroarray Wet Lab
Wed: Finish up Labs
Thursday: Lab Open Notes Evaluation

RNA and Transcription



DNA

↓

RNA

↓

PROTEIN

Read the front page of the lab. Highlight and underline important information

Name_____ Period_____ Date_____

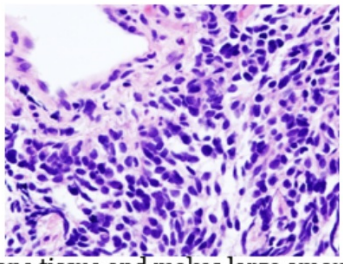
Cell Differentiation and Gene Expression

In most human cells, the nucleus contains a full set of 23 pairs of chromosomes, which carry 20,000-25,000 genes. These genes are identical from cell to cell. Through the process of protein synthesis with transcription and translation is how genes are transcribed to produce Ribonucleic acid (RNA). This RNA is in then translated to produce proteins. If all cells in the same organism have the same genes, why don't they all make the same proteins?

Some proteins are made by almost every cell because they are needed for basic cell functions. Other proteins are made by only one type of cell or small groups of cells. Only white blood cells, for example, make antibodies, the proteins that help the body fight infections. Each of the more than 220 kinds of specialized cells in the human body makes a characteristic group of proteins.

Although the two human cells shown have the same genes in their nuclei, they are specialized to make different proteins.

Lung Cells



Bone Cells

The lung cells are specialized for surfactant protein B, a protein found in the lung which is vital for reducing surface tension in the lungs and allowing for the oxygen change in the alveoli to take place.

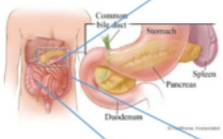
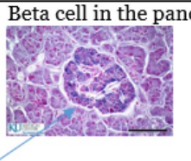
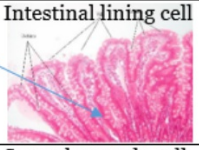
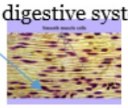
The bone cell is a cell that is responsible for the breakdown of bone tissue and makes large amounts of the protein integrin.

In each cell, only some of the genes are active, or expressed. The activity of genes in a cell is called gene expression. In this activity, you will explore how some genes are turned on and off by molecules called transcription factors. These molecules control the transcription of DNA into RNA.

Identify which person in your group of 4 is which cell.

Part A: Gene Expression in Differentiated Cells

1. Each member of your group will look at gene activity in **one of four kinds of specialized cells** shown below. With your group, decide who will investigate each type of cell.

Location in body	Cell Type	Function	Student Name
	Beta cell in the pancreas 	Beta cells in the pancreas which produce the protein hormone insulin, which regulates cellular uptake and metabolism of sugars and fats	
	Red blood cell (circulatory system) 	Red blood cells produce hemoglobin, a transport protein that carries oxygen to every other cell in the body.	
	Intestinal lining cell 	Intestinal lining cells produce enzymes that contribute to specific steps of digestion	
	Smooth muscle cell in the digestive system 	Smooth muscle cells in the digestive system contract or relax in waves that move food through the digestive tract	

3) You will investigate the expression of only 11 of the approximately 25,000 human genes. Review the proteins these 11 genes produce and their functions in the two tables below.

Determine which of the 11 genes on chromosome 2 and 11 are expressed in your cell.

Genes Expressed in Four Types of Human Cells

Key: + = active gene, - = repressed gene

Chromosomes 2

Protein Produced by the Gene	Beta Cell in Pancreas	Developing Red Blood Cell	Intestinal Lining Cell	Smooth muscle Cell in the Digestive System	Function of the Protein
Ribosome protein S7	+	+	+	+	Needed by ribosomes, which are essential for protein synthesis
Protein synthesis initiator	+	+	+	+	Controls the beginning of protein synthesis
Actin, smooth muscle type	–	–	–	+	Most cells produce actin for cell movement and cell division, but muscle cells produce large amounts of specific types of actin

- = General function

Scan ACROSS the rows. If it is active in ALL 4 cells circle the + in orange

Genes Expressed in Four Types of Human Cells Key: + = active gene, - = repressed gene					
Chromosomes 2					
Protein Produced by the Gene	**Beta Cell in Pancreas**	**Developing Red Blood Cell**	**Intestinal Lining Cell**	**Smooth muscle Cell in the Digestive System**	**Function of the Protein**
Ribosome protein S7	+	+	+	+	Needed by ribosomes, which are essential for protein synthesis
Protein synthesis initiator	+	+	+	+	Controls the beginning of protein synthesis
Actin, smooth muscle type	−	−	−	+	Most cells produce actin for cell movement and cell division, but muscle cells produce large amounts of specific types of actin

Circle all repressed genes (-) with a black (pencil) circle

- = never turned on in that cell

Genes Expressed in Four Types of Human Cells Key: + = active gene, - = repressed gene					
Chromosomes 2					
Protein Produced by the Gene	**Beta Cell in Pancreas**	**Developing Red Blood Cell**	**Intestinal Lining Cell**	**Smooth muscle Cell in the Digestive System**	**Function of the Protein**
Ribosome protein S7	+	+	+	+	Needed by ribosomes, which are essential for protein synthesis
Protein synthesis initiator	+	+	+	+	Controls the beginning of protein synthesis
Actin, smooth muscle type	–	–	–	+	Most cells produce actin for cell movement and cell division, but muscle cells produce large amounts of specific types of actin

muscle

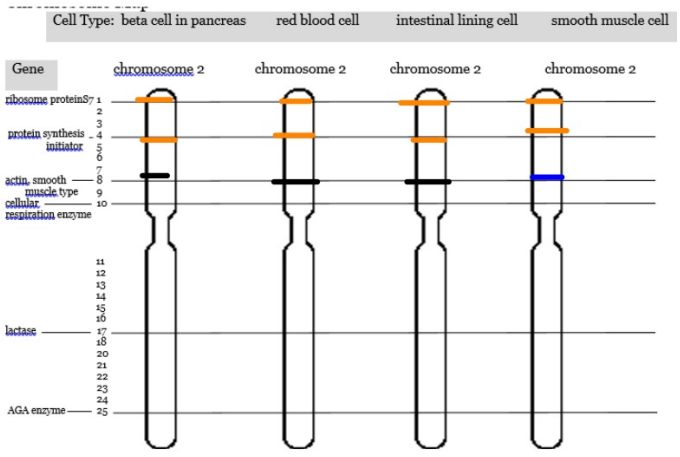
Scan ACROSS the rows. If a gene is active in ONLY 1 type of cell, circle it in Blue

Genes Expressed in Four Types of Human Cells

Key: + = active gene, - = repressed gene

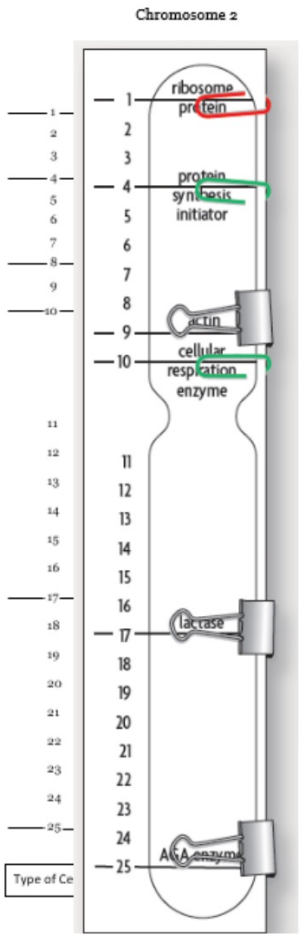
Chromosomes 2

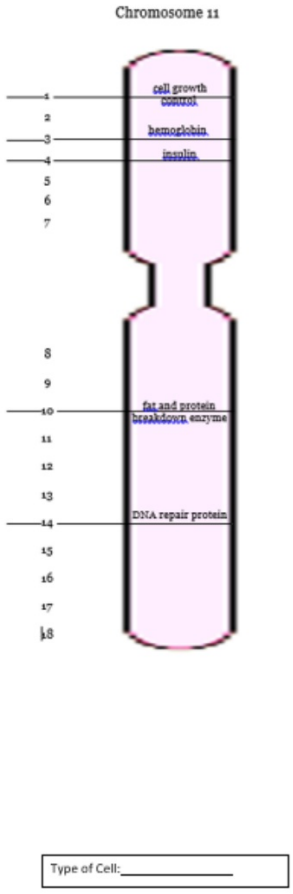
Protein Produced by the Gene	Beta Cell in Pancreas	Developing Red Blood Cell	Intestinal Lining Cell	Smooth muscle Cell in the Digestive System	Function of the Protein
Ribosome protein S7	+	+	+	+	Needed by ribosomes, which are essential for protein synthesis
Protein synthesis initiator	+	+	+	+	Controls the beginning of protein synthesis
Actin, smooth muscle type	–	–	–	+	Most cells produce actin for cell movement and cell division, but muscle cells produce large amounts of specific types of actin



Draw a line on the gene in chromosomes 2 and 11 that match the colors that you used in your chart. If you circled the gene in orange, draw a line in orange on the chromosome.

Each person needs 1 cup which contains:
4 binder clips
7 red paper clips
7 green paper clips





Cut out the large chromosomes

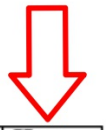
Label your cell type on the bottom of you chromosomes

Place the binder clips on the genes that are permanently turned off in your cell.

(These are the ones that have a black line across them on the smaller model)

Turn to this page in your packet:

Write your type of cell on the top



Type of Cell _____

Cellular event	Affected gene and result	How Does this affect my cell?

Instructions:

8) Shuffle the events card deck. Select one person in your group to start. They will take a card from the top and read the event outloud to the group.

9) Based on the events from the cards, place a Green paperclip over the gene if the gene is expressed (turned on). This means that it is causing the cell to make more of that protein. Place a Red paperclip over the gene if the cell needs less of the protein.

10. Key:

Green paper clip= Protein is needed- increasing the rate of transcription
Red paper clip= Protein is no longer needed- decreasing or turning off transcription
No paper clip= Only small amounts of the protein are needed
Binder clip= The protein is NEVER made in that type of cell

11. **For your cell**, in the data table below, record the cellular event (write card # and underlined words), the affected gene, and the result.

12. The next person, clockwise, in your group selects the next card from the top of the deck. Repeat steps 10-11.

Type of Cell Write your type of cell on the top

Cellular event	Affected gene and result	How Does this affect my cell?
Write under lined event	Write what is happening in body	

Key for my cell:

+ Activator added

++ 2 Activators added

-- Suppressor added

X Nothing happening

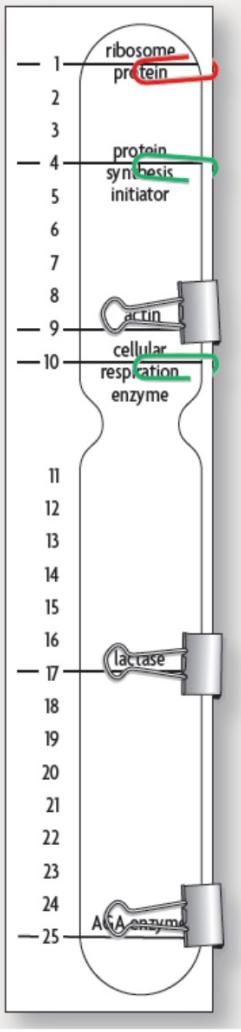
+ Activator removed

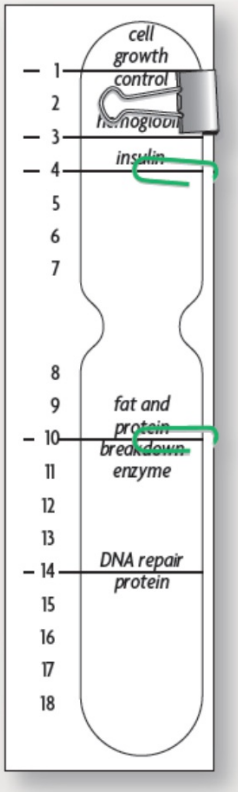
-- Suppressor removed

Ex: #1 All cells require energy, which they obtain by cellular respiration. Attach a green activator to the genefor the cell respiration enzyme in all cell types. This will increase the production of the cellular respiration enzyme. For cellular respiration in smooth muscle, which needs more energy than most cell types, add a second activator.

Type of Cell Smooth Muscle

Cellular event (underlined)	Affected gene and result (what is happening in body)	How Does this affect my cell? (result in my cell)
#1) All cells require energy	Cell respiration enzyme activated in all cells	+ +





Sample Student Response: Cellular Events Affecting All Cell Types

Cellular event	***Affected gene and result***
Cell needs energy (Card 1)	*Cell respiration gene is activated to start cellular respiration.*
Cells have enough ribosomes for now (Card 2)	*A repressor is attached to the ribosomal protein to decrease production of the ribosome protein.*
A full meal of protein and fat (Card 3)	*An activator is added to the gene for fat and protein breakdown enzymes.*
Proteins are needed (Card 6)	*The protein synthesis initiator gene is expressed.*
Meal high in carbohydrates, low in protein and fat (Card 13)	*Activator is removed from the fat and protein breakdown enzyme gene.*

Sample Student Response: Cellular Events Specific to the Pancreatic Beta Cell

Cellular event	***Affected gene and result***
Beta cell released its insulin and now needs more (Card 7)	*The insulin gene is activated to make more insulin.*
The beta cell has enough insulin (Card 8)	*The insulin gene is repressed.*

Sample Student Response: Cellular Events Specific to the Intestinal Lining Cell

Cellular event	***Affected gene and result***
Milk is present in the small intestines (Card 4)	*The lactase gene is expressed to increase production of lactase enzyme.*
There is no milk in the small intestines (Card 5)	*The lactase gene is repressed to decrease production of the lactase enzyme.*
No more intestinal cells are needed (Card 10)	*The cell cycle control gene is activated, and prevents the cell from dividing.*

Leave the green/red activators on your chromosome after you place them on until you are told to take them off.

Rotate who is reading the cards and complete at least 7 cards.

Each person in the group records the event in their chart and makes changes to their chromosomes.

Key for my cell:

+ Activator added

++ 2 Activators added

– Suppressor added

X Nothing happening

+ Activator removed

– Suppressor removed

This page contains the cards used in the activity which describes various cellular events, each student in the group must complete what is instructed by the action of each card.

14. The smooth muscle cell is mature and only needs to produce small amounts of actin to help with muscle contractions. Remove all activators or repressors from this gene, which will continue to direct production of small amounts of actin.

13. The person's last few meals were high in carbohydrates, but moderate in fat and protein. In all cells, remove any green activators from the gene for the fat and protein breakdown enzyme. The cell will continue to produce small amounts of the enzyme.

12. The developing red blood cell must make a large amount of hemoglobin. Attach two green activators to the gene for hemoglobin to indicate that this gene must be highly expressed.

11. The smooth muscle cell is growing and must produce actin. Add a green activator to the actin gene of the smooth muscle cell.

10. The intestinal lining cell and the maturing red blood cell do not need to divide ever again. Add a green activator to the cell-cycle control gene, which will produce a protein that prevents the cell from dividing.

9. The smooth muscle cell is about to start a new cell cycle, when it will replicate its DNA and divide. Add a green activator to the DNA repair protein gene and a red suppressor to the cell growth control gene.

8. The pancreatic beta cell currently has enough insulin. Remove any green activators, and add a red repressor to the insulin gene of the beta cell.

7. The pancreatic beta cell has released its insulin, and more is needed. Remove any red repressors, and add a green activator to the insulin gene. This will turn on production of insulin.

6. Proteins are needed for a cell to function. The protein synthesis initiator gene is expressed in all cells. Add a green activator to this gene for all cell types.

5. There is no milk in the small intestine. The lactase gene is repressed in the intestinal lining cells. Remove any green activators, and attach a red suppressor to the gene for lactase. This will decrease production of the lactase enzyme.

3. After a meal full of protein and fats, a person's body needs more enzymes to break down the fat and protein. Add a green activator to the gene for the fat and protein breakdown enzyme in all the cells.

2. Your cell has enough ribosomes for now. Attach a red repressor to the gene for the ribosomal protein. This will decrease production of the ribosome protein.

4.There is milk, which contains lactose, in the small intestines. The lactase gene is expressed in the intestinal lining cells. Remove any red suppressors, and attach a green activator to the lactase gene. This will increase production of the lactase enzyme.

1. All cells require energy, which they obtain by cellular respiration. Attach a green activator to the gene for the cell respiration enzyme in all cell types. This will increase production of the cell respiration enzyme. For cell respiration in smooth muscle, which needs more energy than most cell types, add a second activator to the gene.