

Gene Expression and Cell Specialization

Learning objective 6.6.A Explain how the same genome can give rise to cells with different structures and functions.

Name: _____

Date: _____

Period: _____

Use the tool **Same Genome, Different Cell**. Part 1 uses **One genome, three cells**, Parts 2 and 3 use **Name that cell**, and Parts 4 and 5 use **How a cell knows**. The question underneath all of it is the one that makes development possible at all: if every cell has the same instructions, what makes them different?

Part 1 · The same genome, three different cells

Select each cell in turn and record what it is doing with its **13** genes. Every one of these cells carries all **13**.

Cell type	Genes in its genome	Genes expressed	Genes silenced	Specialized genes expressed
Red blood cell				
Beta cell				
Neuron				

1. Explain how two cells in the same organism can have identical DNA and completely different structures.

2. State roughly what proportion of its genome each cell is expressing, and explain what that means for the role of gene silencing in differentiation.

Part 2 · Which genes carry information

Switch to **Name that cell**. Put each sample of genes into the tool and record how many of the three cell types still match. Work down the table — the order matters.

Sample: genes detected	What kind of genes these are	Cells still matching	What you have learned
ACTB, GAPDH			
ACTB, GAPDH, RPL13			
INS			
HBB, SCN2A			

3. Distinguish between a housekeeping gene and a specialized gene, and state how you would tell which is which from the expression table alone.

4. Explain why no number of housekeeping genes, however many you detected, would ever identify the cell type.

Part 3 · The genes nobody here is using

Look at the expression table on the second panel of the first tab. Some genes are on in no cell at all.

Gene	What it makes	Which cell type would use it	Is it present in a neuron?
ALB			
CRYAA			
KRT14			
MYH7			

5. Explain why a red blood cell precursor carries an intact, unmutated gene for a lens protein it will never make.

6. The nucleus of a fully differentiated cell, transferred into an egg, can direct the development of a whole organism. Explain what that experiment shows about differentiation.

Part 4 · How a cell knows what to become

Open **How a cell knows**. A signal is released at one end of a row of identical cells. Record the pattern at each setting of the top threshold.

Top threshold	Cells in the first region	Number of distinct fates	Number of boundaries
85			
70			
55			
40			

7. Explain how a single, smoothly falling signal can produce sharply bounded regions of different cell types.

8. Three of your four rows have the same number of fates and one does not. Explain what is different about that row, and state the condition under which “moving a threshold does not change the number of fates” is true.

Part 5 · Structures in the wrong place

Use the homeotic section of the same tab. Each segment's identity comes from which homeotic genes are switched on in it.

Segment	Homeotic genes on	Identity	What it builds
1			
2			
3			
4			
3, with Hox-2 switched off			

9. Explain what a homeotic gene does.

10. The mutant segment builds a perfectly normal structure. Explain why that is what makes homeotic mutations so informative about what these genes do.

What the model simplifies

Thirteen genes stand in for about twenty thousand. The proportion expressed is roughly right in spirit — a differentiated cell uses a minority of its genome — but the real figure varies by cell type and by how expression is measured.

Expression is treated as on or off. Real expression is a continuous quantity, and two cell types often differ in how much of a gene they make rather than in whether they make it at all.

The gene names and their products are real, but the expression patterns are simplified: several of these genes are expressed at low levels in more tissues than the model shows.

The gradient is drawn as a straight line falling with distance from the source. Real morphogen gradients are set up by diffusion and breakdown and are curved, and cells sharpen the boundaries afterwards by signaling to their neighbors — so the edges here appear faster and more cleanly than they would in an embryo.

The homeotic model uses three switches and four segment identities. Real animals have far more homeotic genes, arranged in clusters whose order along the chromosome matches the order of the segments they specify.