AP BIOLOGY · UNIT 6 · TOPIC 6.6

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**. Parts 1 and 3 use **One genome, three cells**, Part 2 uses **Name that cell**, and Parts 4 and 5 use **How a cell knows**. The questions ask how cells that have the same genes come to differ from one another.

Part 1 · The same genome, three different cells

Press each cell in turn and record how it uses 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. (a) Calculate the proportion of its genome that each cell expresses.

(b) Explain what this proportion indicates about the role of gene silencing in differentiation.

Part 2 · Which genes carry information

Switch to **Name that cell**. For each row, press Clear, then press each gene in the sample, and record how many of the three cell types still match. Work down the table in order.

Sample: genes detected	What kind of genes these are	Cells still matching	What the result shows
ACTB, GAPDH			
ACTB, GAPDH, RPL13			
INS			
HBB, SCN2A			

3. (a) Describe the difference between a housekeeping gene and a specialized gene.

(b) Describe how a housekeeping gene can be told apart from a specialized gene using only the expression table.

4. A sample contains the products of housekeeping genes only. Explain why detecting more housekeeping genes in the sample could never identify the cell type.

Part 3 · The genes nobody here is using

Click the One genome, three cells tab and look at the Which genes are on where table. Some genes are expressed in none of the three cells.

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

5. A red blood cell precursor carries an intact gene, CRYAA, for a lens protein that it will never make. Explain why the cell carries this gene.

6. Researchers transferred the nucleus of a fully differentiated cell into an egg cell whose own nucleus had been removed. The egg developed into a whole organism. Explain what this result shows about the genes in a differentiated cell.

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. Press each Top threshold button in turn. Count the Head cells in the drawing, and record the number of fates and boundaries from the readouts.

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. In the Part 4 table, three rows have the same number of fates and one row does not.
(a) Explain why the number of fates is different in that row.

(b) Describe the condition under which moving a threshold does not change the number of fates.

Part 5 · Structures in the wrong place

On the How a cell knows tab, open the section Homeotic genes: identity as a set of switches. Each segment's identity depends on 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. Describe the function of a homeotic gene.

10. With Hox-2 switched off, segment 3 builds a normal pair of legs instead of legs and wings. Explain how this result shows that homeotic genes specify the identity of a segment rather than build its structures.

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.