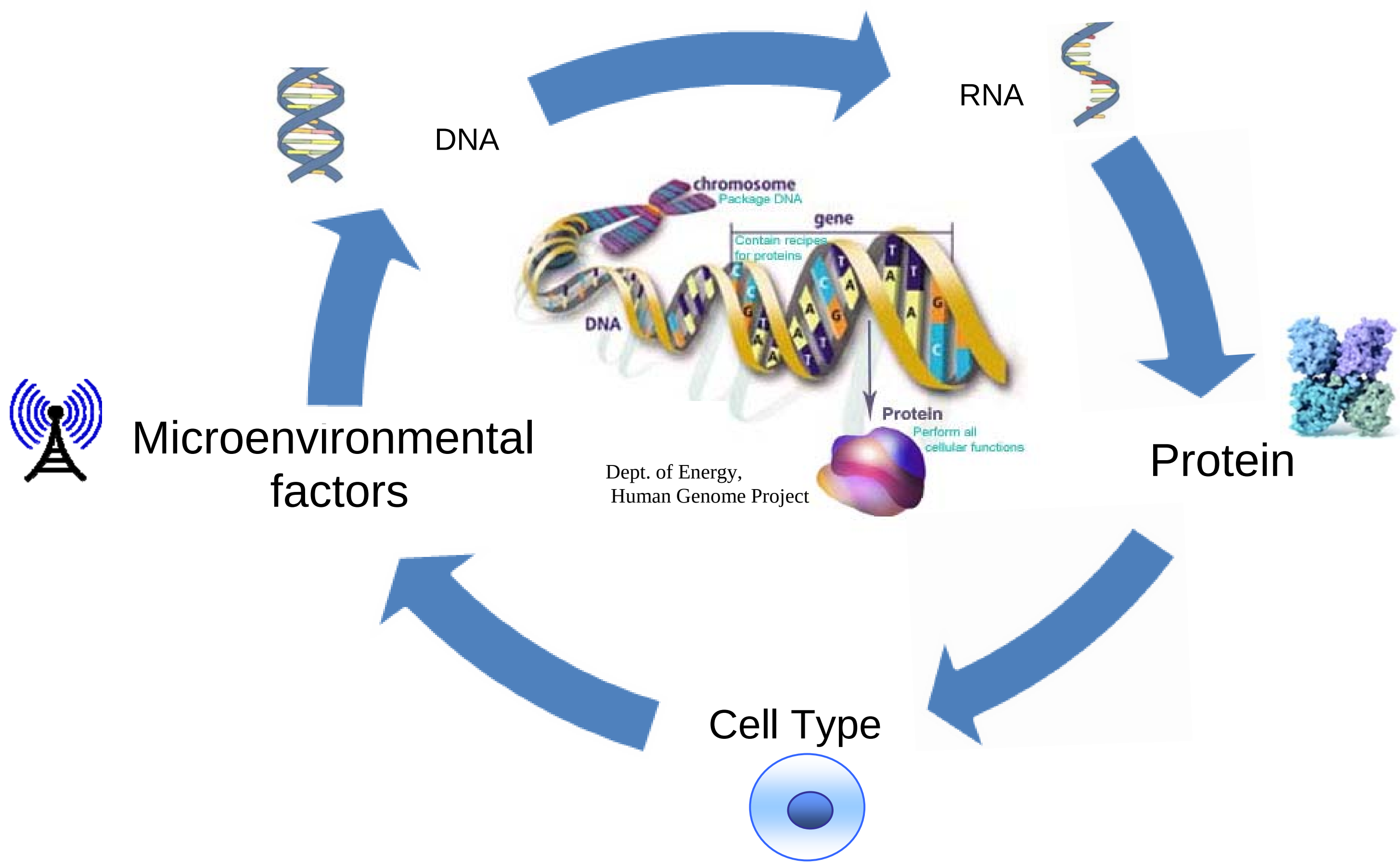
STEM CELL EDU PORTAL

CALIFORNIA INSTITUTE FOR REGENERATIVE MEDICINE

Cell Fate Decision:
Central Dogma of Molecular Biology

All cells that make up a multicellular organism share an identical genotype. However, not all cells are exactly alike. How does this occur? When cells differentiate, how do they “know” to develop into a particular cell with a specific structure and purpose? How does a stomach cell become a stomach cell and not a skin or a liver cell? Researchers believe that the answer at least partially lies in the **central dogma of molecular biology**. Genes that are encoded by DNA are turned “on” or “off” depending upon the proteins that need to be expressed for a specific phenotype. Mistakes or mutations during protein synthesis and gene expression that go unchecked could lead to an atypical phenotype or cancer.



Images courtesy of the National Library of Medicine and National Human Genome Research Institute

Cell Fate Decision

How do cells know what to become? When stem cells proliferate or differentiate, the event is far from random. So, what influences cell fate? The simplistic diagram on the previous page illustrates a flow of events that help determine the fate of a cell. Not only does **gene expression** play an important role in establishing cell type, but also the **microenvironment** in which a cell lives constantly affects the "expression" of genes (remember DNA encodes proteins that do work for a cell). Beginning with the DNA in the nucleus, write a summary that describes the events that occur within each "step" of cell fate decision.

Step	Descriptive Summary
DNA	
RNA ☐ **Transcription (mRNA)** ☐ **Translation (tRNA)**	
Protein (amino acids)	
Cell Type	
Microenvironmental Factors	

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Teacher Version—Cell Fate Decision:
Central Dogma of Molecular Biology

Consider asking students to read the article entitled "Gene Expression Regulates Cell Differentiation" found at the following url.
http://www.nature.com/scitable/topicpage/Gene-Expression-Regulates-Cell-Differentiation-931

Students must also have a strong command of central dogma and the steps that a molecule takes in order to produce a protein.

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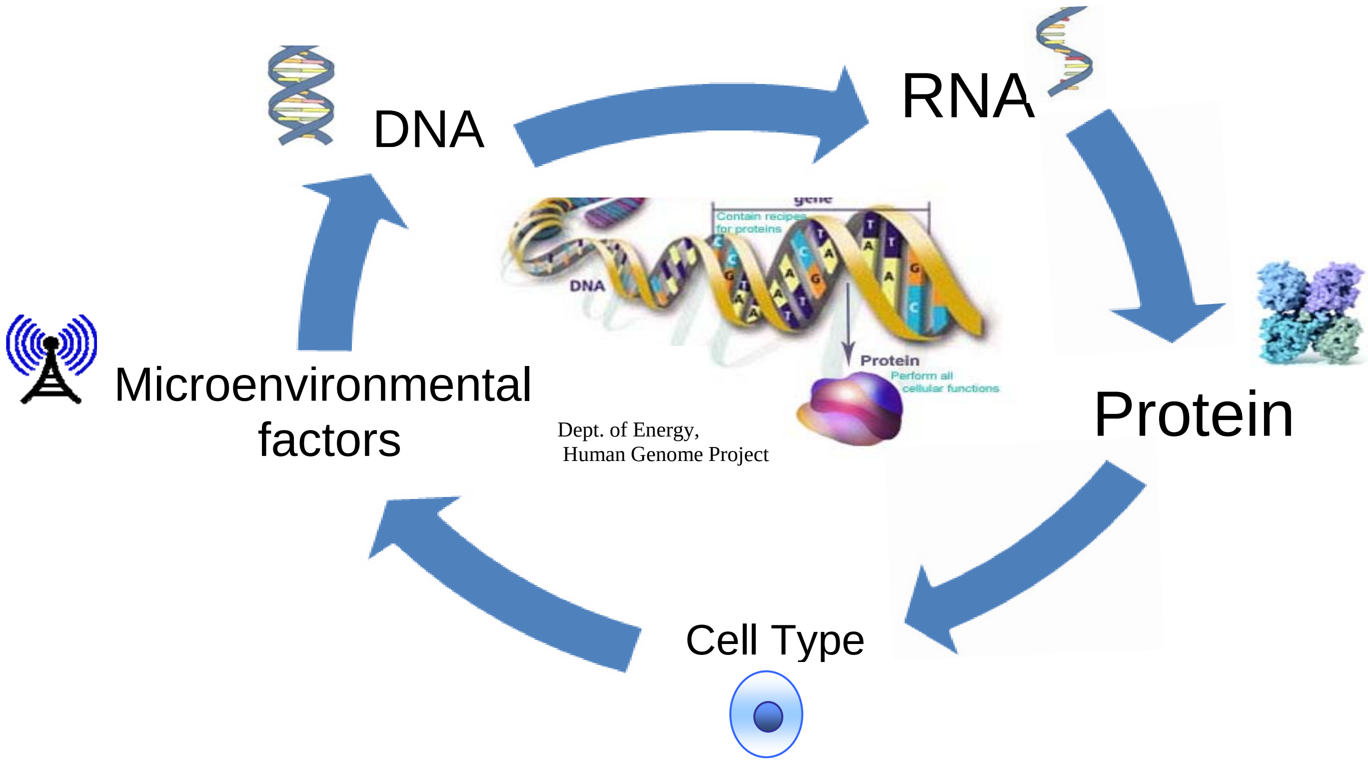

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Step	Descriptive Summary
DNA	The genotype is stored in the nucleus encoded by the nucleic acid polymer DNA (genes). The gene(s) that is (are) to be expressed into a particular phenotype will receive a cellular signal to "unzip." A process of transcription describes how genetic information is copied into complementary mRNA base pairs.
RNA ☐ **Transcription (mRNA)** ☐ **Translation (tRNA)**	During transcription, RNA polymerase ligates the complementary mRNA nucleotides to the DNA template strand of the gene that is expressed into the protein. An mRNA complementary strand forms from the 5' end to the 3' end. When complete, the mRNA codon strand leaves the nucleus through a nuclear pore and travels to a ribosome in the cytoplasm. During translation, the ribosome attaches the corresponding tRNA anticodon containing the attached amino acid to the corresponding triplet codon. Peptide bonds develop between the amino acid monomers, forming a polypeptide chain that finally folds into a protein.
Protein	The primary protein structure is released into the rough endoplasmic reticulum where the protein is molded into the secondary and tertiary structure and wrapped within a vesicle. The vesicle is then sent to the Golgi where the final quaternary structure is constructed and the protein is transported to where it needs to go.
Cell Type	As the proteins that are produced during protein synthesis form the appropriate structure and perform specific functions, the cell that contains these proteins develops into its destined cell type. As the differentiated cell undergoes its metabolic activities, it will send and receive microenvironmental signals that will, in turn, affect the cell's DNA.
Microenvironmental Factors	The microenvironment in which a cell resides provides a constant supply of cell signals that stimulate a response in that cell. Cell-to-cell communication in the form of hormones, cytokines, neurotransmitters, and growth factors is detected by receptors on the cell surface. These ligand-receptor interactions are essential to the process of cell signaling in the ability to inhibit or stimulate an action by a cell. Cells send out signals which, in turn, can turn genes in *other* cells "on" or "off," affecting *those* cells' structure and function—and "feeding back" on the original signal senders.

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