This Module for Interactive Teaching (MINT) may be found online at
https://ivv.rit.edu/gg-mint.php

Gene Expression

- Mutations in coding sequences may affect protein expression without affecting transcription or replication.

Contents:

MINT Learning Objectives

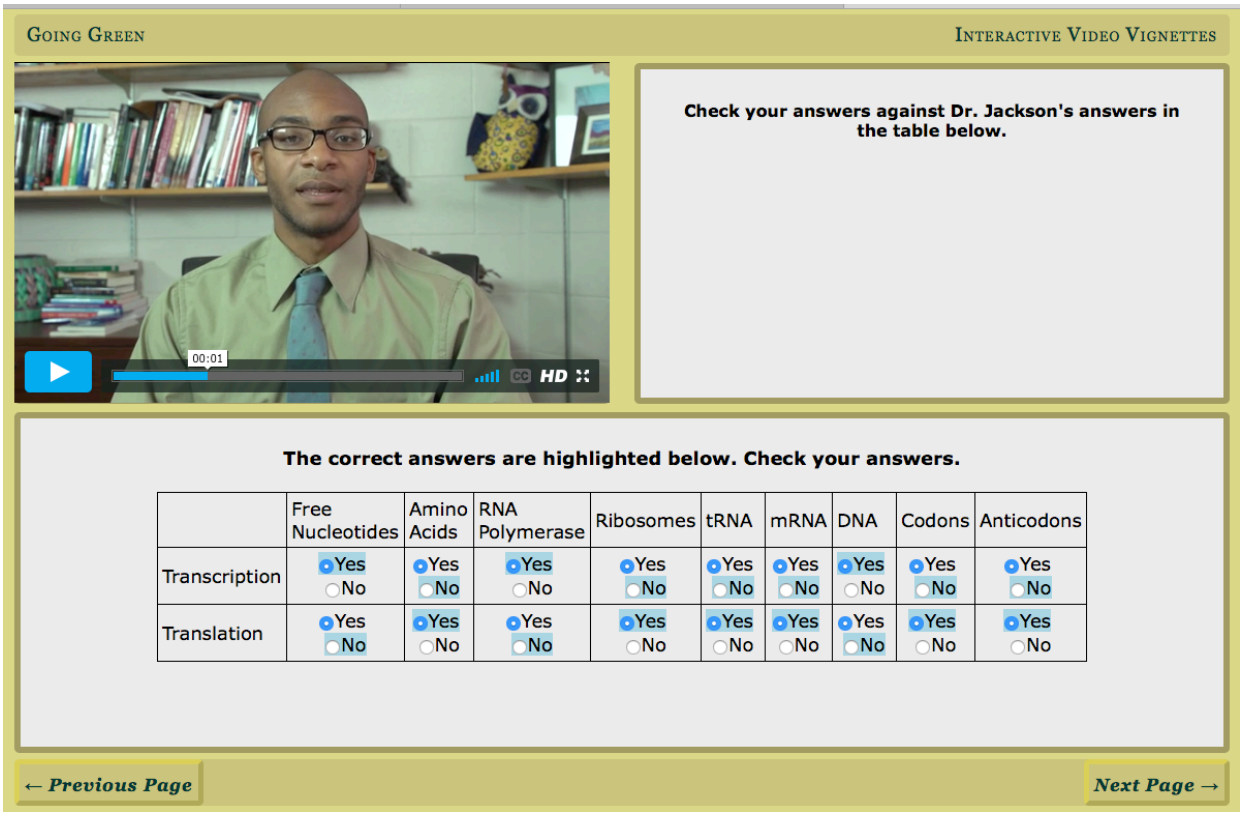
- A mutation in the DNA sequence of a gene may have many different consequences, depending on the position and base change
- Transcription is a molecular process that results in synthesis of a new molecule of mRNA
- Translation is a molecular process that results in the assembly of a polypeptide chain
- A nonfunctional protein can result from mutations other than a stop codon

National Standards Alignments:

- Vision and Change Core Concepts and Competencies (http://visionandchange.org)
  - Core Concept:
    - Information Flow, Exchange, and Storage: The growth and behavior of organisms are activated through the expression of genetic information in context
  - Core Competencies:
    - Ability to apply process of science: Biology is evidence based and grounded in the formal practices of observation, experimentation, and hypothesis testing.
- Biocore Guide (Brownell et al., https://doi.org/10.1187/cbe.13-12-0233)
  - Information Flow: Mutations and epigenetic modifications can impact the regulation of gene expression and/or the structure and function of the gene product. If mutations affect phenotype and lead to increased reproductive success, the frequency of those alleles will tend to increase in the population.

    - Information Flow: In most cases, genetic information flows from DNA to mRNA to protein,but there are important exceptions.
    - Information Flow: Information stored in DNA is expressed as RNA and proteins. These gene products impact anatomical structures and physiological function.
- Next Gen Science Standards (http://www.nextgenscience.org/)
    - All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1) (Note: This Disciplinary Core Idea is also addressed by HS-LS3- 1.)
    - All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. (secondary to HS-LS3-1) (Note: This Disciplinary Core Idea is also addressed by HS -LS1-1.)
- American Society for Microbiology Curriculum Guidelines (https://www.asm.org/)
    - Information Flow: The regulation of gene expression is influenced by external and internal molecular cues and/or signals
- Process of Science Skills, Pelaez, N, *et al*. "The Basic Competencies of Biological Experimentation: Concept-Skill Statements" (2017). PIBERG Instructional Innovation Materials. Paper 4. http://docs.lib.purdue.edu/pibergiim/4
    - Posing problems
    - Generating hypotheses
    - Observing nature
    - Interpreting/evaluating data
        - Visual representations used for interpretation of data
    - Determining followup
        - New knowledge incorporated with old to form new hypotheses

Interactive Video Vignette Information



	Free Nucleotides	Amino Acids	RNA Polymerase	Ribosomes	tRNA	mRNA	DNA	Codons	Anticodons
Transcription	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	No	No	No	No	No	No	No	No	No
Translation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	No	No	No	No	No	No	No	No	No

IVV Title: *Going Green*

IVV URL for students: https://ivv.rit.edu/GG/2/
Copy the URL to the Clipboard. Either paste it into an email to your students, or use it to create a link in your course management system.

IVV Description:
An undergraduate is working on a research project where she is trying to express a GFP fusion in a new cell line. She shows that the DNA is incorporated into the genome and the mRNA is expressed, but she does not get green cells. Sequencing reveals that the incorporated gene contained a nonsense mutation, and student revises her ideas about how information is used at each level of gene expression.

Novice Ideas and IVV Learning Goals

Novice Ideas

- Stop codons are found in DNA so they must be used in processes involving DNA (replication and transcription)
- A stop codon mutation will result in a shorter-than-expected DNA molecule
- A stop codon mutation will result in a shorter-than-expected RNA molecule
- Evidence is not required when the experimental result seems obvious

- A lack of a functional cellular protein is always due to failure to transcribe the specific mRNA
- Do not know how to observe products of Central Dogma processes
- If you want to know something about genetics, sequence the whole genome of the organism.

Ideas addressed in the IVV

- Although stop codons are found in DNA they are not used until the process of translation
- A stop codon mutation will not impact the size of the DNA molecule
- A stop codon mutation will not impact the size of the RNA molecule
- Evidence is required to back up all experimental claims
- The absence of a particular functional protein does not always stem from a lack of the particular mRNA
- There are techniques that allow a researcher to quantitatively observe products of Central Dogma processes.

Recommended In-class Curricular Material

Please see the MINT FAQ (https://ivv.rit.edu/FAQ.php) for general information on the use of MINTs and IVVs with your class. The following curricular materials are provided as examples of resources that may be used in class to further student learning towards IVV and MINT learning objectives.

- Wright LK, Newman DL. Using PCR to target misconceptions about gene expression. J Microbiol Biol Educ. 2013. 14(1):93-100. DOI: 10.1128/jmbe.v14i1.539
- DeBruyn JM. Teaching the Central Dogma of Molecular Biology using Jewelry. J Microbiol Biol Educ. 2012. 13(1):62-64.
- Pelletreau KN, Andrews T, Armstrong N, et al. A clicker-based study that untangles student thinking about the processes in the central dogma. *CourseSource*. 2016. https://doi.org/10.24918/cs.2016.15

Assessment Question Information:

The research team has developed multiple select questions for assessing IVV effectiveness. Please contact the research team (https://ivv.rit.edu/about.php) if you are interested in assessing IVV use in your course.

Acknowledgement

This material is based in part upon work supported by National Science Foundation (NSF) grants 1432286 and 1432303. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.