**Activity**

Choose how you would like to engage your students in the subject of GMO’s and how that is related to protein production in organisms. We do not suggest that you give them this entire list! You should choose the resources that will best fit your students and your learning outcomes for your course. In our session we will consider how you might fit in these items with your curricular goals and to make the learning process accessible for your students, with a focus on the science of GMO’s and not on the controversy of GMO’s.

**Videos**

Collection of animations from online sources – all are captioned or with transcripts; videos do not require flash to eliminate platform issues

**GMO’s**

1. TED-Ed: Are GMOs Good or Bad? Genetic Engineering & Our Food
   1. <https://www.youtube.com/watch?v=7TmcXYp8xu4&feature=youtu.be>
   2. Terrific introduction video!
   3. Includes questions for thought and discussion on the TEDEd page (<https://ed.ted.com/featured/0HAnxvLF#watch>)
2. Scientific American: What Is a Genetically Modified Food?
   1. <https://www.youtube.com/watch?v=JMPE5wlB3Zk>
   2. Good information on how GMO’s are produced; includes a good introduction to artificial selection
   3. The article on the Scientific American page is a good source of additional information and citations (<https://www.scientificamerican.com/video/what-is-a-genetically-modified-food2013-07-24/>)
3. The Royal Society: What is genetic modification?
   1. <https://www.youtube.com/watch?v=rx953M-tpp4>
   2. The Royal Society has produced an animation to explain the basic science of GM, compared to conventional plant breeding.
   3. Great section on exploring GM plants (<https://royalsociety.org/topics-policy/projects/gm-plants/>)

**TRANSCRIPTION**

1. HHMI Biointeractive
   1. <https://www.biointeractive.org/classroom-resources/dna-transcription-basic-detail>
   2. Good introduction video
   3. Includes curriculum connections
2. Virtual Cell Animation Collection
   1. <http://www.vcell.science/project/transcription>
   2. Good animation – clear coverage of the process – advanced terminology (acronyms)
   3. Instructors can register to download the videos
3. DNA Learning Center – Cold Springs Harbor
   1. <https://dnalc.cshl.edu/view/15510-Transcription-DNA-codes-for-messenger-RNA-mRNA-3D-animation-with-basic-narration.html>
   2. There is a “sound effects” only version – instructors could use this in class and show the video and add their own commentary (sign) so that everyone would have the same experience
   3. More advanced videos are available on the site if the instructor is interested (<https://dnalc.cshl.edu/resources/animations/>)

**TRANSLATION**

1. HHMI Biointeractive
   1. <https://www.biointeractive.org/classroom-resources/translation-basic-detail>
   2. Good introduction video; “advanced” videos also available - <https://www.biointeractive.org/classroom-resources/translation-advanced-detail>
   3. Includes curriculum connections
2. Virtual Cell Animation Collection
   1. <http://www.vcell.science/project/translation>
   2. Good animation – clear coverage of the process – advanced terminology (acronyms)
   3. Instructors can register to download the videos
3. DNA Learning Center – Cold Springs Harbor
   1. <https://dnalc.cshl.edu/resources/3d/15-translation-basic.html>
   2. There is a “sound effects” only version – instructors could use this in class and show the video and add their own commentary (sign) so that everyone would have the same experience
   3. More advanced videos are available on the site if the instructor is interested (<https://dnalc.cshl.edu/resources/animations/>)

**TERMINOLOGY**

**Terms for GMO’s**

* Genetics
* Genetic modification
* Genetic engineering
* Bioengineering
* DNA
* Gene
* Agricultural biotechnology
* Biopharming
* *Bacillus thuringiensis* (Bt)
* Bt crops
* Chromosome
* Artificial selection
* Cross pollination
* Gene expression
* Gene flow
* Genome
* Genomics
* Genotype
* Phenotype
* Hybrid
* Resistant crops
* Mutation
* Organic agriculture
* Recombinant DNA
* Selective breeding
* Traditional breeding
* Transgene
* Transgenic organism
* Protein

**Terms for Transcription**

* Initiation of Transcription
* Elongation of Transcription
* Termination of Transcription
* DNA
* Gene
* Gene expression
* RNA polymerase
* Transcription factors
* Promoter DNA
* Splicing
* mRNA
* Terminator DNA
* Inhibitors
* Gene regulation
* Reverse transcription

**Terms for Translation**

* Initiation of Translation
* Elongation of Translation
* Termination of Translation
* mRNA
* tRNA
* rRNA
* ribosomes
* Rough Endoplasmic Reticulum (RER; Rough ER)
* Nuclear pore
* Amino acid
* Codon / Anti-codon
* RNA
* Protein / polypeptide
* Amino acid sequence
* Primary protein
* Genetic code
* Start codon
* Stop codon
* Peptide bonds

**LEARNING TERMINOLOGY**

Kahoots already made (by others):

1. GMO Fact or Fiction?
   1. <https://create.kahoot.it/details/gmo-fact-or-fiction/394a486d-74b4-45c2-9287-31ca90cd853a>
   2. 12 questions
   3. Introduction to GMO’s; students would have to have some scientific reading and knowledge before taking this quiz; could be used as a “let’s see what you think” to get the conversation started in the classroom
2. GMO
   1. <https://create.kahoot.it/details/gmo/7ed8502e-25ff-46e6-a6e6-298dadaf094b>
   2. 15 questions
   3. Overview of GMO’s but with a focus on very “street level” knowledge of GMO’s and has specific questions about number of GMO’s currently in production, etc. which are not up to date
3. Biology Protein Synthesis
   1. <https://create.kahoot.it/details/28238a17-23ca-4b2d-8e1f-d7771d81de38>
   2. 15 questions
   3. Covers transcription and translation
4. Biology: IB Biology – Translation
   1. <https://create.kahoot.it/details/e092266c-b415-469f-8cf1-1da7599c981d>
   2. 12 questions
   3. Focus on translation but not overly advanced
5. IB Biology: Transcription
   1. <https://create.kahoot.it/details/ib-biology-transcription/bf4af224-373a-478b-a154-5fd255a49811>
   2. 11 questions
   3. Focus on transcription – good level
6. DNA Transcription and Translation
   1. <https://create.kahoot.it/details/dna-transcription-and-translation/22553b96-fa0e-468a-8296-b7f51f4d7c90>
   2. 47 questions
   3. Some of these questions may be too advanced, focusing on leading/lagging strands, etc.
7. DNA/RNA/Protein Synthesis
   1. <https://create.kahoot.it/details/dna-rna-protein-synthesis/53b515c5-2d37-45d7-8c59-5e5f85442c0d>
   2. Terrific overview of DNA, RNA, and protein structure and production
8. DNA. Protein Synthesis, and Mutations
   1. <https://create.kahoot.it/details/dna-protein-synthesis-and-mutations/01222281-662a-409f-b338-062ad2e40936>
   2. Really like the addition of some mutation questions here without going over the top as far as detail

Quizlet already made (by others)

*Need to be careful with some Quizlet’s – they are very advanced for an introduction to protein production. These are more “simple” examples.*

1. Kahoot GMO
   1. <https://quizlet.com/182933651/kahoot-gmo-flash-cards/>
   2. 18 flash cards
   3. High-level detail
2. GMO
   1. <https://quizlet.com/tw/386345679/gmo-flash-cards/>
   2. 9 flash cards
   3. Good introduction overview
3. Transcription / Translation Bio Quiz
   1. <https://quizlet.com/3276173/transcriptiontranslation-bio-quiz-flash-cards/>
   2. 46 flashcards
   3. Mid-level detail
4. Transcription Biology
   1. <https://quizlet.com/6112030/transcription-biology-flash-cards/>
   2. 13 flashcards
   3. Would be a good primer before class (following a reading or video assignment)
5. Translation
   1. <https://quizlet.com/389806090/translation-flash-cards/>
   2. 15 flashcards
   3. Good overview before or after a lecture