Title: Come with me if you want to live- an "escapist" approach to expression of resistance in e. Coli

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Abstract: This action plan is designed to allow students to investigate various topics from the unit encompassing genetics and biotechnology. This lesson will utilize previous knowledge students have acquired from throughout the year, encompassing specific lessons covering the various bacterial pathogens.(Cells, cell theory, scientific method, etc..)
This lesson is designed to be used by biology students ranging from 9th to 11th grade. This lesson will take students through the process of gene transmission from generational perspective to determination of the presence of resistant genes in given bacteria. Students will "escape" through the use of resistance genes passed through a population in the classroom, through various questions, as well as hands on activities that require students to recall and perform various tasks to survive the use of certain antibiotics. Groups should be set at a maximum of 4 students, varying student levels, accommodations, and language levels, where applicable.

Rationale: This lesson will be designed from a escape room perspective in an effort to get students interested in the areas of science that prove to be more difficult for them to grasp, genetics and biotechnology. Prior to implementation of this activity, students will have examined various pathogens during prior units and prior knowledge will be required for completion of this escape room. This lesson will address all levels, with cooperative learning being utilized in order to successfully complete the activity in class. This activity will support biology EOC standards with some questions designed to be higher order thinking questions intertwined with various hands on activities. In previous years, this topic has shown to be one that students of all levels struggle with in class.
Students will examine topics in gene expression beginning with structures of DNA, RNA, and protein synthesis. Beginning with an examination of the structure of DNA, including nucleotides, students will assemble their own DNA molecule, utilizing nucleic acid pairing knowledge as well as previous information pertaining to the structure of the nucleic acids. The lesson will the progress through processes of replication, transcription, and translation. Students will then differentiate between different types of mutations and how to sequence amino acids using a codon chart. Upon successful completion of this unit, and completion of quiz, topics in biotechnology will then be discussed. Biotechnology topics will include techniques, with examples provided for gel electrophoresis and PCR. Students will complete a virtual lab simulation PCR and gel electrophoresis. Upon completion of this topic on techniques, students will begin investigating genetically modified organisms. The area of genetically modified organisms proves to be one with a great deal of misconceptions for most of our students. Prior to completion of this topic, students will complete readings of case studies as well as participation in an in class debate on pros and cons of "GMO"'s.

Description of teaching unit/module, including expected outcomes:
This unit will cover 10 block days, and will focus on the following standards:

- SC.912.L.16.5: Central dogma of biology (DNA -> RNA -> Protein)
- SC.912.L.16.9: Deciphering types of mutations and possible phenotypic changes, reading codon charts
- SC.912.L.16.10: The impact of biotechnology on society, individuals and the environment

The learning outcomes are as follows:

- Students will identify amino acids using a codon chart.
- Students will determine the type of mutation present in a given nucleotide sequence.
- Students will identify transfer of resistance genes in bacteria
- Students will evaluate pros and cons of genetic engineering
- Students will identify progression of the central dogma in biology

The learning outcomes will be achieved through the following activities:

- Lesson: nucleic acids and gene expression
- Genetics mini escape room review/practice
- Intro/review to nucleic acids, nucleotides, amino acids, and proteins
- Build your own DNA molecule
- Central dogma diagram activity
- Mutation activity (last bacteria standing: salmonella)
- Mutation group activity
- Reading codons practice
- p-GLO transformation activity
- p-GLO extension activity
- Central dogma quiz
- Lesson: Biotechnology introduction
- Examine biotechnology practices: PCR virtual lab
- Celery vs. papaya: examining misconceptions in genetic engineering
- Reading/discussion/debate on genetic engineering in crops
- Gene expression and biotechnology escape room

Data collection:

- Unit pretest on gene expression and biotechnology
- Central dogma quiz
- Escape room team results
- Unit post test
- District unit assessment

Equipment

- Escape room scenarios
- DNA molecule creation materials: pipe cleaners, beads
- Sodium hydroxide tablets
- Liquid culture set up for e.coli
- P.GLO Transformational kit
- p-GLO extension kit

CATALyASES elements specifically included (UF connection):

- Antibiotic resistant bacteria lab
- Modeling an epidemic (adapted to infer antibiotic resistance in e. Coli)
- Topics from *Genetic engineering in crops* by Dr. Barbey
- Topics from *So what is an emerging pathogen* by Dr. Morris
- Topics from *Beyond phylodynamics of infectious disease*

Literature cited

Sujay Chattopadhyaya, Scott J. Weissmanb, Vladimir N. Mininc, Thomas A. Russod,e,f, Daniel E. Dykhuizeng, and Evgeni V. Sokurenkoa, "High frequency of hotspot mutations in core genes of Escherichia coli due to short-term positive selection"
Barbey, Chris. "Genetic engineering in crops"
Salemi, Marco. " Phylogeny of Infectious disease
Guilt, Paul. *"Taking the path of greatest resistance"*

Budget and justification

Item	**Vendor/source**	**Cost**
Biology escape room	Teachers pay teachers	$50.00
pGLO™ Transformation and Inquiry Kit for AP Biology 1660335EDU	Bio rad	179.00
Total cost		**$229.00**

Science lesson plan
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Title: come with me if you want to live….an "escapist approach to bacterial antibiotic resistance "
Key question: How have antibiotics contributed to the increase in antibiotic resistance?
Subject: biology
Grade and ability level: 9^{th} -11^{th}, regular and honors
Science concepts: gene expression and biotechnology
Overall time estimate: 10 block days, each block class 90 mins. Module will cover 2 units (DNA replication, translation, transcription, biotechnology units)
Learning styles: visual, auditory, and kinesthetic
Vocabulary: transcription, translation, E. Coli, genetic engineering, electrophoresis, PCR

Lesson summary: During this multi day lesson, students will be introduced to the central dogma in biology , learning the progression from DNA to protein synthesis, and learn to differentiate between different types of mutations and how they occur. Students will also be introduced to different types of biotechnology techniques. Students will participate in a discussion on the pros and cons of genetically engineered crops. To summarize all topics, students will participate in an escape room set up in the classroom. Students will be asked to answer various questions and participate in a variety of hands on activities to "escape" from our host cell (our classroom).

Students learning objectives with standards:
SC.912.L.16.5 Differentiate between the cellular processes of DNA replication, transcription, and translation
SC.912.L.16.9 Identify gene and chromosomal mutations and/or state that mutations may or may not result in a phenotypic change
SC.912.L.16.10 Explain the possible impact of biotechnology on the individual, society, and the environment.

Materials:
Required: 1 laptop/computer per group
Supplemental: pen/ pencil

Advance preparation:
- Highlight important areas from readings on genetic engineering in plants
- Print all cards for escape room stations
- Set all hands on stations
- Prepare sodium hydroxide solution, set up and label cups for students.

Procedure and discussion questions with time estimates:
Day one: Genetics escape room practice, gene expression and biotechnology pretest, DNA structure, function, base pairing, create DNA molecule, replication
Day 2: transcription, RNA structure, function, types, base a pairing with DNA, protein structure review, RNA types, functions, central dogma diagram
Day 3: central dogma quiz, review quiz, protein synthesis, translation, mutations, differences between types, reading codons, gene expression activity.
Day 4: reading codons activity, mutations group activity

Day5/6: pGLO transformation lab
Day 7: introduction to biotechnology, gel electrophoresis, PCR techniques, virtual lab on PCR and gel electrophoresis
Day 8: examining genetic engineering in crops, celery vs papaya activity reading discussion, debating pros and cons.
Day 9: introducing escape room activity, students exchange genes,
Day 10: post test, discussion of results, address any misconceptions or gaps in learning prior to district assessment.

Assessment suggestions:
For all objectives listed, students will participate in a variety of hands on activities, diagrams, and cooperative learning activities, as well with a short quiz built into assess content knowledge on the central dogma prior to beginning subsequent topics. Student data will also be collected from district assessment as it relates to this topic.

Extensions:
Activity: conduct a research project on an emerging pathogenic issue.
Literature:
Bacteria learn a new trick by Stephen Ornes
What is genetic modification and how is it done? RoyalScociety.org

Literature cited

Sujay Chattopadhyaya, Scott J. Weissmanb, Vladimir N. Mininc, Thomas A. Russod,e,f, Daniel E. Dykhuizeng, and Evgeni V. Sokurenkoa, "High frequency of hotspot mutations in core genes of Escherichia coli due to short-term positive selection"
Barbey, Chris. "Genetic engineering in crops"
Salemi, Marco. " Phylogeny of Infectious disease
Guilt, Paul. *"Taking the path of greatest resistance"*

Additional articles for literacy and cross curriculum support, where applicable
http://www.jbc.org/content/281/38/27806.full Escherichia coli Transcriptome Dynamics during the Transition from Anaerobic to Aerobic Conditions*
https://academic.oup.com/cid/article/45/8/1025/344528 Theodor Escherich: The First Pediatric Infectious Diseases Physician?
https://www.cell.com/trends/biotechnology/pdf/S0167-7799(10)00199-X.pdf Decorating microbes: surface display of proteins on Escherichia coli
https://micro.magnet.fsu.edu/cells/bacteriacell.html Bacteria Cell Structure
https://m.youtube.com/watch?v=4873Tcjll70 E.coli binary fission
https://m.youtube.com/watch?v=yybsSqcB7mE mega plate video
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5506381/pdf/mgen-3-108.pdf genetics unit
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2718352/pdf/zpq12412.pdf gene expression
https://www.biointeractive.org/classroom-resources/how-pathogenic-e-coli-infection-begins How a Pathogenic E. coli Infection Begins
https://www.biointeractive.org/classroom-resources/superbugs-resist-antibiotics-can-evolve-11-days Superbugs That Resist Antibiotics Can Evolve in 11 Days