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| **Title of Unit** | Unit: Molecular gene regulation  Tidbit: Biomedical applications of gene dosage compensation  *Please use a descriptive title that indicates content area* |
| **Date and**  **Location of SI** | June 15-20th  Harvard |
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| **Context** | *What kind of course is unit designed for?*  Sophomore level class of ~50 students  *How long is unit?*  Two weeks  *When will the unit be used in the course?*  Our two-week unit will be the second two weeks of a course, the first two weeks will be: central dogma, transcription and translation. |
| **Abstract**  (< 200 words) | The goal of this teachable tidbit is to have students understand technological applications of gene regulation. The content we have used to address this goal is the mechanism used to balance gene dosage from the X chromosome between human males and females, known as X-chromosome inactivation. The objectives include the ability of students to provide examples of natural mechanisms of gene regulation and biomedical applications thereof, and to propose an experiment and predict the results of that experiment using their understanding of gene dosage compensation. The tidbit is imbedded within a two-week unit on gene regulation in a sophomore-level course in molecular biology or genetics. The tidbit utilizes a number of active learning activities that are designed to progressively increase in Bloom’s level. Students begin with a brainstorming activity to identify natural mechanism of gene dosage regulation, and then progress to the generation of a hypothesis. From there, the students are presented with a set of tools and are asked to predict the results of an experiment and display them graphically. Finally, using clickers, students must predict the experimental results in the event that the experiment does not work as expected. The tidbit addresses diversity in numerous forms including the use of a variety of active learning techniques, the presentation of primary research by female and minority scientists, and a post-assessment reflection on the ethical implications of the featured research study. |
| **Rationale** | *Why was this topic chosen?*  *What misconceptions or difficult concepts are addressed?*  Gene silencing is only an artificial process and not one that is innate  **Not all genes on the X and Y chromosomes have functional roles in gender specification**  Gene dosage: why do we need to control gene expression, why is gene dosage essential on the X chromosome  Repression of gene expression is not the same as gene silencing.  Consequence of gene silencing always cause down-regulation of target  **Gene expression is always binary i.e a gene is always on or off** |

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|  | **Learning Goals:** broad aims of the lesson or unit; what will students understand at end of the unit.  *Example: students will understand the flow of information from DNA to proteins.* | **Learning Objectives:** Specific and measurable statements of what students will be able to do to demonstrate mastery of the learning goals. (You might write multiple objectives for a single learning goal. You could label these as 1a, 1b, 1c, etc.)  *Example: students will be able to predict changes to protein sequence that results from DNA mutations.* |
| 1. | Students will understand why genes are regulated. | Provide examples of why gene expression changes in response to:   * 1. External environmental stimuli   2. Internal developmental stimuli   3. Internal physiological stimuli |
| 2. | Students will understand the various levels at which gene regulation can occur | 2.1 Describe the hierarchical nature of gene regulation  2.2 Provide examples of mechanisms of positive and negative gene regulation, at each hierarchical level  2.3 Predict how a system of gene regulation would respond to specific perturbations |
| 3. | Students will understand technological applications of gene regulation to biomedicine. | 3.1. Describe and explain the experimental tools that allow for the artificial control of gene expression  3.2. Identify a situation where manipulation of the expression of a single gene is appropriate to biomedicine (gene therapy)  3.3. Provide examples of dosage compensation in nature and biomedicine  3.4 Propose an experiment and predict the results of the experiment  3.5 Discuss ethical implications of artificially manipulating gene expression |

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| **Incorporation of Scientific Teaching Themes** | | |
| **Active Learning** | **Assessment** | **Inclusivity** |
| How students will engage actively in learning the concepts *(what types of activities will they engage in?)* | How teachers will measure learning; how students will self-evaluate learning *(what types of assessments are used?)* | How the unit is designed to include participants with a variety of experiences, abilities, and characteristics |
| *Activities outside of class:*  1) watch videos (https://www.youtube.com/watch?v=Y9vXhmI5FXM)  *Activities during class:*  1) Brainstorming  2) Group problem solving with data followed by clicker question  *Activities after class*:  1) Ethical reflection (In one or two paragraphs, identify and discuss two ethical implications raised by this research) | *Pre-assessments:*  Complete a 5-question online quiz  *Embedded Assessments:*  – how do you deal with a problem like an X-chromosome in females?  Clicker question with possible answers revealed after discussions. Then let different groups explain their reasoning.  *Summative assessments:*  Section of subsequent exam (at the end of the two week Teaching Unit) | Ethical assignment will consider all viewpoints.  Groups will be diverse in nature.  Highlighting positive role models in science.  We’re doing several different activity types.  Language will be sensitive to gender issues raised by discussions of sex determination. |

**Class Presentation Plan** (general class schedule with approximate timing for unit)

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| **Session 1** | | | |
| **Time (min)** | **Learning Objectives** | **Activity/assessment** | **Explanation, notes, suggestions, tips** |
| Preclass  assignments /activities  **student time needed**  *enter approximate* | Students will understand the concept of X-inactivation  (less than 30 min total) | Watch video(https://www.youtube.com/watch?v=Y9vXhmI5FXM) ; less than 10min  Complete online 5-question quiz ; 15 min | Can be complemented with reading assignments to reach more students (different learning styles) |
| introductory  material presentation  **class time for this segment** *Enter approx. time.* | Students will understand that the process of X-inactivation occurs naturally and needs to be regulated Students will understand the concept of gene dosage compensation  (3-5 min total) | Brainstorm: Students propose hypotheses on how gene dosage compensation occurs naturally ; 1 min  Card question: Students propose an application of x-inactivation that can be used to address an aberrant gene dosage (ex: Trisomy 21) ; 1 min | Can be extended in real time class |
| learning activity #1 **class time for this segment** *Enter approx. time* | Students will be able to predict the results of an experiment | Students will predict the level of gene expression on different conditions and draw their predicted results on a graph (2 min) | Can be adapted by providing handouts to each students for individual assessment |
| post-activity summing up or transition  **class time for this segment** *Enter approx. time* | Students will learn how to defend their predicted results | Students present and defend their group predicted results and instructor leads the discussion (2-5 min) | Discussion can be extended to address wrong answer to make sure all students understand the reasoning to get the right answer |
| Next activity or class segment  **class time for this segment** *Enter approx. time* | Students will reinforce their understanding of gene dosage compensation | Clicker question: Students predict the results of an additional experiment ; Instructor leads discussion after assessment (1-3 min) | Can be adapted by giving more clicker questions in real time class |
| Additional activities / class segments | Students will consider the ethics of biomedical intervention | Short essay : Students will identify and discuss two ethical implications of biomedical research |  |

*If there are multiple activities or segments or class sessions, add additional rows and activities information as needed*

Resources for Teaching the Unit

*(other files and information needed/helpful to teach the unit, including files for papers from which original data for class activities is taken, supporting information for the instructor, handouts, in class activities materials, assessments with answer keys, homework assignments, etc.)*

Jiang et al., 2013 Translating dosage compensation to trisomy 21. Nature, 500:296-301.

Chromosomal Gene Expression Graph 2014

Chromosomal Gene Expression Graph 2014

**Plans for teaching: Will some members of the team implement this in their teaching? in what context?** *(some team members may not implement this particular unit or activity)*

Natalie Farny will use this tidbit in her genetics class next year (January 2015)

Terence Capellini will use this tidbit in his Primate Functional Genetics and Genomics

Amy Hansen will use this tidbit in her Genetics, Genomics and Evolution

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