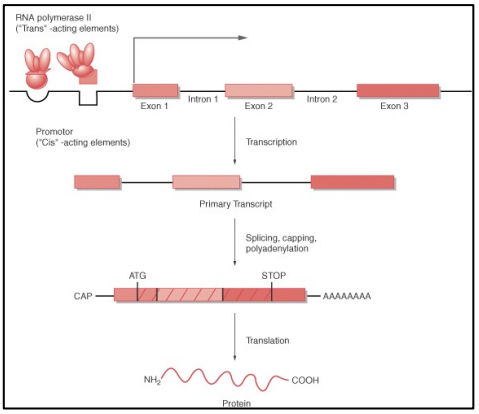
Zach's Exam 1 Review - MCDB4560 Fall 2021

Format: I quiz the students. They provide answers to their peers. Peers check the accuracy of their responses. I guide and fill in the blanks where necessary.

Class 1 – Intro

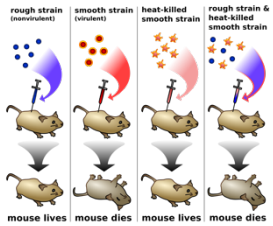
- What is a LUCA?
    - A: Last Universal Common Ancestor
- How is the LUCA useful in understanding divergent evolution?
- Regarding how we understand genes. Define **homolog**, **ortholog**, **paralog**, **analog**.
    - Homolog: Trait related by sharing a common ancestor
        - Ortholog: Shared ancestry (homolog) because of speciation event.
        - Paralog: Shared ancestry (homolog) because of duplication event.
    - Analog: Trait related by having similar function. Not necessarily bc they're related.

    Source:



Class 2 – Genes

- What are the primary components of genes?
- How are genes regulated? What is required for expression of a gene?
- Do all genes code functional proteins? What else could they code?
- What was the first evidence that genetic information is encoded in molecules of DNA?
    - Griffith experiment (1928). Bacteria are capable of transferring genetic information through a process known as transformation.
    - Source: https://en.wikipedia.org/wiki/Griffith%27s_experiment



What is the Lac Operon?

- How is the Lac Operon regulated?
- What is molecular level noise?
    - stochastic fluctuations in genetic circuits
    - Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3348409/
- How does molecular level "noise" allow for proper expression of the Lac Operon?
- What is another example of molecular noise?
    - Pick a signaling system. Point to a place where one part causes a regulatory effect on another part. Noise could be seen when most of the organism does what it's supposed to do at this point, but in a small few of the interactions, the opposite of the desired regulatory function occurs.

Class 3 – Stochastic gene expression

- What is the connection between genotype and phenotype?
- How can two cells of the same genotype have different phenotypes?
- Fluorescent genes CFP and GFP placed under the control of a lac promotor equidistant from the ORI w/in bacterial plasmid (Elowitz et al experiment). Explain how we get green, red, or yellow fluorescence in bacteria. What controls expression? What do these findings suggest?
- What can be done to control "noisy" or "leaky" expression of a gene?
- Under what contexts would it be necessary to have super tight gene regulation?

Class 4 – Quorum sensing & aggregative multicellularity

- How do traits evolve (generally)?
    - Ex) The Texas Blind Salamander lives in deep dark caves. Has eyes, but they're covered by a layer of skin. How did this trait evolve?
- What is quorum sensing?
    - Consider in-class example given of the game of Marco-Polo
- What types of bacterial responses are under the control of quorum sensing?
    - Biofilm formation, Virulence factor expression, motility, etc…
    - Source: https://en.wikipedia.org/wiki/Quorum_sensing
- Define the points of a "dose-response" curve and explain what is happening at each point.
    - Pre-threshold
    - Threshold
    - Post-threshold
    - Saturation
- What might be beneficial about quorum sensing mechanisms being regulated in a threshold response type fashion?

Class 5 – Clonal multicellularity

- What behaviors are seen as "cheating" in transient multicellular organisms?
- Why would it be detrimental to the unicellular colony if all the cells avoided death by "cheating?"
- How do new genes arise? How can gene duplication allow for evolution of traits?
- How can a null mutation produce a dominant phenotype?
    - Consider: WT diploid cell (two alleles of a single gene).
      Phenotypes are produced when the amount of gene product from a gene is sufficient to produce that phenotype.
      A single null, or loss-of function mutation in one allele could lead to a dominant effect due to simply causing not enough gene product to be produced for the desired phenotype.
      Source: https://www.ncbi.nlm.nih.gov/books/NBK22011/ (Loss-of-function mutations)
- What are the benefits of an organism having distinct separation of somatic and germ line cells?

Class 6 & 7 – Cellular polarity and asymmetries

- How can cellular asymmetries be generated?
    - Intrinsic vs induced.
- What could cellular asymmetries produce? Examples?
    - DNA asymmetries? Protein asymmetries?
    - Exs) Establishment of different cell-cell or cell-lumen interfaces, unidirectional movement, asymmetric progeny upon division, control of cellular differentiation, spatial control of organismal contents
- What is cellular chirality?
    - Left or right handedness of the cell
    - A fundamental property of the cell arising from the chiral nature of intracellular macromolecules such as the cytoskeleton and is often observed as biased cell alignment, migration, and rotation as well as intracellular organelle positioning and cytoskeleton dynamics
    - Source: https://www.pnas.org/content/115/50/E11568
- What is an example of an intracellular chiral macromolule?

    - Components of the cellular cytoskeleton: Actin filaments, microtubules.
- How does their chirality affect a developing organism? Consider the interaction btw actin and myosin.
    - Ex) Myosin 1D.

Class 8 – Cell signaling

- Primary components of signaling pathways?
    - Ligand, receptor, effector, target
- What variables affect a particular signaling pathway?
    - Affinity of ligand to its receptor, # of receptors/ligands available, feedback, etc…
- How are cell signaling pathways regulated?
    - Positive feedback? Negative feedback?
- What is the notch signaling pathway?
    - regulates cell proliferation, cell fate, differentiation, and cell death in all metazoans
    - Activity inhibited by Numb to promote neural differentiation
- and why do we care?
    - Notch signaling pathway plays a major role in embryonic development
- What makes it different from other signaling systems?
    - Notch signaling from the cell surface to the genome is direct, linear and devoid of signal amplification
- Predict how mutations can have an effect on signaling systems with feedback mechanisms.

Class 9 – Establishing embryonic axis and HOX genes

- What are Homeobox genes? What are HOX genes? How do they differ?
- What is a homebox? What is a homeobox gene product?
- What is a HOX cluster?
- What evidence do we have that a common ancestor of bilaterian animals all had HOX clusters?
- What tools do we have to determine different expression profiles in different cells?

Remaining Topics

- Model systems
- Frog development
- Zebra fish development