

MCDB 4650 (Fall 2021) EXAM #1 review questions

Introduction

What are the core components of the cell theory?

According to cell theory, each cell in your body is how old, approximately?

Why do we believe that LUCA exists and what can we know about LUCA?

What kinds of evidence suggest that different types of animals share a common ancestor?

When is a cell an organism?

What does it mean that unicellular organisms (and cells within a multicellular organism) are social? How can cells be social without forming (or being part of) a single organism?

Explain why the connections between genotype and phenotype are generally complex.

Genes, experimental methods & outcomes.

What is the evidence that genetic information is encoded in molecules (of DNA)?

How is it recognized within a cell, how can it be "hidden"?

Where does genetic information come from (originally)?

What is the role of gene / genome duplication in evolutionary change?

What are the possible fates of a newly generated gene?

What is meant by the terms homolog, ortholog, paralog, and convergence in the context of genes?

What is a null mutation, an antimorphic, hypomorphic, hypermorphic, or a neomorphic mutation?

How could a null mutation produce a dominant phenotype?

What are common features (parts) of a gene? What are common aspects of polypeptide/protein structure? How do they help you predict the effects of a mutation?

What are the common characteristics of a molecular machine?

Stochastic gene expression: sampling phenotypic space with a single genotype

How might changing the number of lac repressor molecules in a cell influence the expression of the lac operon?

How might the cell benefit by turning the lac operon on stochastically, even in the absence of lactose? Why isn't the lac operon always (constitutively) expressed?

What (generically) determines the threshold concentration of a cellular response?

What is meant by the "half-life" of a molecule? What factors influence it?

How does it differ from the half-life of an isotope?

How does the half-life of key regulatory molecules influence cellular response behaviors?

How (and why) do stochastic effects influence molecular and cellular systems?

What is monoallelic expression and what is the evidence that it exists?

In the Elowitz et al experiment, what processes determine which fluorescent proteins are expressed: are these reversible or irreversible events?

How would your answer change if instead of fluorescent proteins, they used transcription factors?

How might gene expression events become (effectively) irreversible?

Quorum sensing & aggregative multicellularity

What is meant by evolutionary "costs and benefits"?

How do social factors influence such costs and benefits?

What is quorum sensing and why is it useful?

What types of bacterial responses might be under the control of quorum sensing control and why?

What, if anything, is the value of stochastic decision making?

Why is a typical biological response curve not linear?

How is the threshold for a quorum (signal) response set?

How might a mutation in the receptor change quorum sensing responses? For example, if the mutation reduced ligand-receptor binding affinity?

What is a (social) cheater, how does selection influence their prevalence in a population?

Clonal multicellularity

Why would (scientific) people come to think that humans, sponges, and unicellular choanoflagellates share a common ancestor?

What kind of behavior(s) emerged when *Chlorella vulgaris* was exposed to the predator *Ochromonas vallescia* and why? (Borass et al)

How would you determine, experimentally, whether a multicellular structure was a colony or a single organism?

What distinguishes a somatic cell from a germ line cell?

What processes are involved in cell differentiation?

Cellular polarity & asymmetries

Are cells inherently asymmetric? what does that mean?

How can cellular asymmetries be generated?

What happens once they are generated - how do they effect sibling cells?

How do, generally, asymmetries arise in multicellular organisms?

What could asymmetric determinants be? In what situation(s) could there be problems with these determinants and how would that affect the early embryo?

How might asymmetries arise from DNA replication? DNA modification? Cell division plane?

Centrosome inheritance? Sperm entry site?

What types of cellular systems display chirality (left-right handedness)?

How might we visualize cellular asymmetries, experimentally?

Establishing Asymmetries / Left-Right

How might different myosins have arisen molecularly (evolutionarily)?

Why does muscle contract rather than expand (or both)?

Does the microfilament system have a handedness?

What does it mean that a "phenotype is 100% penetrant and is specific to Myosin1D"?

What is a "chimera"? What is a chimeric protein (polypeptide)?

Why (from a protein structure perspective) are "functional" chimeric proteins possible?

What is the implication that myoD1 has a similar role in L/R determination in *Drosophila*, zebrafish and *Xenopus*?

Signaling systems

How does the Notch signaling pathway differ from other signaling pathways?

What is the molecular machine behind Notch signaling?

How do feedback networks work?

Generate plausible predictions (and explanations) for the effects of mutations or inhibitors on the outcomes of various signaling pathways (when you are given the pathway - no memorization).

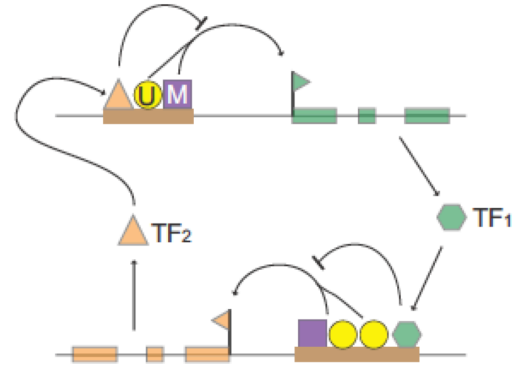
What is going on (what is described) in this picture (→)? Which interactions might be cooperative?

How would you find the enhancers of a gene & determine which were active in a particular cell?

Be able to provide plausible predictions (and explanations) for how changes in a transcription factor binding motif lead to changes in response to a morphogen gradient?

How is the response of a cell to a morphogen gradient similar to or different from a bacterium's quorum sensing response?

Beside the distribution of the morphogen, what other factors might influence the behavior (read out) of a morphogen gradient?



Establishing embryonic axes and HOX genes

What is a homeobox? How is a gene/protein with a homeobox different from a HOX gene/protein?

Consider the role of Hox genes in anterior-posterior axis specification: what evidence suggests that the common ancestor of all bilaterian animals had a HOX cluster.

How might changing the orientation of a gene in a Hox cluster influence gene expression?

If a particular HOX gene is mutated to a null phenotype, what might you expect to be the effect on neighboring HOX genes to be?

Xenopus and Zebrafish

What is genome diminution and how does it emerge from cellular asymmetry?

How does it influence cell behavior?

How can nuclear transplantation (cloning) be used to determine whether genome diminution is occurring in a species? What factors might limit the ability of a somatic nucleus to support the development of a "normal clone"?

Why do some organisms rely on maternal gradients to pattern the early embryo?

How can you tell (experimentally) that sperm entry leads to a microtubule-dependent reorganization of vegetal components to produce a dorsal-ventral asymmetry?

What does Li⁺ induced dorsalization tell you about the potential fates of embryonic blastomeres?

How does the ability to ventralize or dorsalize a (Xenopus or other type of) embryo make it possible to screen for polypeptides that influence embryonic patterning?

What does a morpholino do? How does it influence (maternal versus zygotic) gene expression, compared to CRISPR Cas9?

more to come on Thursday the 30th of October (depending upon how far we get).