IB_150_Notes

1 IB_150-01.19.2023-notes: Explain life as a Fundamentally Energetic Process

1.1 5 Properties of Life

- **Cell:** Composed of Cellular base unit
- **Homeostasis:** Maintain highly ordered internal state. Respond to Environment
- **Metabolism:** Conduct series of biochemical processes to acquire energy; Activity through cellular respiration
- **DNA/Hereditary:** Capable of replicating/reproducing and passing on traits
- **Evolution:** Adapt certain traits as individuals and change as a population

1.2 Explain why all but Evolution require energy

1.2.1 Situation:

Predict observation if a single cell Paramecium is exposed to Cyanide toxin that shuts down its ability to use energy?

1.2.2 Laws of Thermodynamics

0: For $T1 = T3 \cup T2 = T3$, $\therefore T1 = T2$

- If two systems are both in thermal equilibrium with a third system, then they are in thermal equilibrium with each other.
- The zeroth law of thermodynamics provides for the foundation of temperature as an empirical parameter in thermodynamic systems and establishes the transitive relation between the temperatures of multiple bodies in thermal equilibrium.
- An important physical fact is that temperature is one-dimensional and that one can conceptually arrange bodies in a real number sequence from colder to hotter.
- The law allows the definition of temperature in a non-circular way without reference to entropy.

1: $\Delta U_{\text{system}} = Q - W = U1 + U2$

- $E_{\text{total}} = KE_{\text{system}} + PE_{\text{system}} + U_{\text{system}}$
- The conservation law states that the total energy of an isolated system is constant; energy can be transformed from one form to another, but can be neither created nor destroyed.
- In a closed system (i.e., there is no transfer of matter into or out of the system), the first law states that the change in internal energy of the system (ΔU_{system}) is equal to the difference between the heat supplied to the system (Q) and the work (W) done by the system on its surroundings.
- An alternate sign convention is to define W as the work done on the system by its surroundings.
- For processes that include the transfer of matter, a further statement is when two initially isolated systems are combined into a new system, then the total internal energy of the new system, U_{system}, will be equal to the sum of the internal energies of the two initial systems, $U1$ and $U2$.

- Conservation of energy, which says that energy can be neither created nor destroyed, but can only change form. A particular consequence of this is that the total energy of an isolated system does not change.

- The concept of internal energy and its relationship to temperature. If a system has a definite temperature, then its total energy has three distinguishable components, termed kinetic energy (energy due to the motion of the system as a whole), potential energy (energy resulting from an externally imposed force field), and internal energy. The establishment of the concept of internal energy distinguishes the first law of thermodynamics from the more general law of conservation of energy.

- Work is a process of transferring energy to or from a system in ways that can be described by macroscopic mechanical forces acting between the system and its surroundings.

- When matter is transferred into a system, that mass's associated internal energy and potential energy are transferred with it.

- The flow of heat is a form of energy transfer. Heating is the natural process of moving energy to or from a system other than by work or the transfer of matter. In a diathermal system, the internal energy can only be changed by the transfer of energy as heat: $\Delta U_{\text{system}} = Q$.

2: $\delta Q = T \cdot \partial S$

- The natural disorder of the universe will always increase, called entropy. The potential for a system to become more random (Gibbs Free Energy, ΔG) can be calculated by taking the total internal energy of the system (Enthalpy, ΔH) and subtracting from it the quantity of temperature multiplied by the measure of entropy ($T \cdot \Delta S$).

- The second law of thermodynamics can be precisely stated in the following two forms, as originally formulated in the 19th century by the Scottish physicist William Thomson (Lord Kelvin) and the German physicist Rudolf Clausius, respectively:

  - A cyclic transformation whose only final result is to transform heat extracted from a source which is at the same temperature throughout into work is impossible.
  - A cyclic transformation whose only final result is to transfer heat from a body at a given temperature to a body at a higher temperature is impossible.

3: A system's entropy approaches a constant value as its temperature approaches absolute zero.

- At zero temperature, the system must be in the state with the minimum thermal energy, the ground state.

- The constant value (not necessarily zero) of entropy at this point is called the residual entropy of the system.

- Note that, with the exception of non-crystalline solids (e.g., glasses) the residual entropy of a system is typically close to zero.

- However, it reaches zero only when the system has a unique ground state (i.e., the state with the minimum thermal energy has only one configuration, or microstate).

- Microstates are used here to describe the probability of a system being in a specific state, as each microstate is assumed to have the same probability of occurring, so macroscopic states with fewer microstates are less probable.

- In general, entropy is related to the number of possible microstates according to the Boltzmann principle: $S = k_b \cdot \ln(\Omega)$, where S is the entropy of the system, k_b Boltzmann's constant, and Ω the number of microstates. At absolute zero there is only 1 microstate possible ($\Omega = 1$ as all the atoms are identical for a pure substance, and as a result all orders are identical as there is only one combination) and $\ln(1) = 0$.

2 IB_150-01.24.2023-notes: Aerobic Cellular Respiration: Glucose + O2

When the organism volume reaches a critical point, the diffusion distance L over which oxygen has to diffuse becomes limiting very quickly. The concentration gradient of Oxygen cannot change, neither can that of the cells; therefore, the organism is stuck with whatever oxygen concentration happens to be in the environment.

In measuring Surface Area and Volume of a Cubic Animal, both volume and surface area increase, but volume increases faster. In the Surface Area/Volume graph, as the cubic organism grows, its surface area to volume ratio decreases. The optimal shapes are linear chains of cells of 1 unit width and cubic cell structures for effective surface area of gas exchange, which is the surface area available per unit volume for gas exchange.

Individual cells ALWAYS depend solely on diffusion across their external membrane for gas exchange, yet spherical cells have the lowest surface area to volume ratio of any shape since the SA/V ratio of any shape is high when the object is very small. Since most organisms are not linear/cubic, they survive by dramatically reducing the Length of Diffusion (L), thereby increasing the rate of diffusion in Fick's Law (Q). This is achieved by moving the dissolved gases with "mass flow," a rapid bulk movement of a substance in a current. This Bulk Flow occurs in cases such as water moving over gills, breathing via pulling/pushing air into/from a lung using a diaphragm, and blood flow in a circulatory system.

Spheres have the lowest SA/V Ratio, so they require the least amount of energy/tension to retain their shape.

- Superior/Inferior Vena Cavas ¿ CO_2 ¿ Toward Heart ¿ Right Atrium ¿ Right Ventricle ¿ Pulmonary Artery ¿ Away from Heart
- Pulmonary Capillaries ¡gas exchange¿
- Pulmonary Vein ¿ O_2 ¿ Toward Heart ¿ Left Atrium ¿ Left Ventricle ¿ Aorta (Biggest Systemic Artery) ¿ Away from Heart
- Systemic Capillaries ¡gas exchange¿

Arteries carry deoxygenated blood out of the Right Ventricle.
Artery morphology vs vein - diameter, thickness, tissue composition

- Oxygen concentration does not change within Arteries or Veins
- Arteries are thicker and smaller
  - limit diffusion of oxygen into blood away from the heart
  - withstand high-pressure walls
- Arterioles are between arteries and capillaries
  - Muscular contractions to direct blood through capillary beds, deciding where to pump blood
  - Fight-or-Flight
    - No need to digest food in the moment - no intestinal blood flow required
- Veins are wider and thinner - get blood from capillary tissue with low pressure direct to heart
  - Tend to be packaged between skeletal muscle, moved via contractions
- Tiered Blood Vessel Pressure Differential
  - Large Arteries
  - Small Arteries
  - Arterioles
  - Capillaries
  - Venules
  - Large Veins

- Arterial Diameter directly relates to Arterial Pressure
  - $P = k \cdot D$
- More capillaries - low diameter - Highest Total Cross-Sectional Area
- Veins have low pressure - nothing to squeeze, so it cannot travel via high pressure
- Blood Velocity (cm/s) steady through arterioles, drops into capillaries
  - some velocity returns from venules due to capillaries dramatically increasing volume
- Rate of Blood Flow in capillaries is slow to give more time for slow Diffusion

Definition: Capillary is a blood vessel that is built 1 cell thick as a site for gas exchange.
Mammalian Lungs optimize the A & L variables of Fick's Laws

- Increase Surface Area for Diffusion via Alveoli
  - "Sac" design allows for High Oxygen Intake and Maximized Diffusion Nodes
- Decrease Length of Diffusion via Implementation of Mass Flow
  - Bronchial+Diaphragm breathing mechanisms
  - Circulatory System's pumping of blood

Not Optimized:

- P_2 (High Partial Pressure)
  - Dead-ended sacs increase SA but result in the need for Tidal Airflow - the need to breathe in and out
  - This results in some "stale" oxygen-depleted air to remain in the lungs after exhalation
  - Any injury to lung-lining results in deflation and "complete" exhalation

Unidirectional flow in Fish Gills

- Water flow through mouth, pushed over Gill Arches, through Filaments, past Slits, out of Opercular Flaps
- Parallel Capillaries
  - Concurrent Flow - Blood and Water Flow in the Same Direction
    - 50% Oxygenation of Blood
    - 100% Oxygenation of passing Water Diffuses towards 0% Oxygenation of Blood in the Capillary of Gill Filament
  - Counter-Current Flow - Blood and Water Flow in Opposite Directions
    - Optimizes the Concentration Gradient by preventing $(P_2 - P_1)$ from reaching Equilibrium

3 IB_150-01.31.2023-notes: Ecology

3.1 Relations of organisms to one another and to their physical surroundings

3.2 Ecosystem

All organisms and abiotic pools of resources with which they interact.

3.3 Ecosystem Processes

The transfers of energy and materials from one pool to another.

3.4 Trophic Levels

The trophic level of an organism is the position it occupies in a food web. A food chain is a succession of organisms that eat other organisms and may, in turn, be eaten themselves. The trophic level of an organism is the number of steps it is from the start of the chain. Trophic level 1 with primary producers such as Plants, Herbivores at level 2, Carnivores at level 3 or higher, and typically finish with Apex Predators at level 4 or 5. The path along the chain can form either a one-way flow or a food "web". Ecological communities with higher biodiversity form more complex trophic paths.

The word trophic derives from the Greek τροφή (trophē) referring to food or nourishment.

3.5 Producers (autotrophs)

Typically plants or algae. Plants and algae do not usually eat other organisms but pull nutrients from the soil or the ocean and manufacture their own food using photosynthesis. For this reason, they are called primary producers. In this way, it is energy from the sun that usually powers the base of the food chain. An exception occurs in deep-sea hydrothermal ecosystems, where there is no sunlight. Here, primary producers manufacture food through a process called chemosynthesis.

3.6 Consumers (heterotrophs)

Species that cannot manufacture their own food and need to consume other organisms. Animals that eat primary producers (like plants) are called herbivores. Animals that eat other animals are called carnivores, and animals that eat both plants and other animals are called omnivores.

3.7 Decomposers (detritivores)

Break down dead plant and animal material and wastes and release it again as energy and nutrients into the ecosystem for recycling. Decomposers, such as bacteria and fungi (mushrooms), feed on waste and dead matter, converting it into inorganic chemicals that can be recycled as mineral nutrients for plants to use again.

3.8 Biomass Transfer Efficiency

3.9 Energy Pyramid

Diagram of how each trophic level relates to the one below it by absorbing some of the energy it consumes, and in this way can be regarded as resting on or supported by the next lower trophic level. The efficiency with which energy or biomass is transferred from one trophic level to the next is called the ecological efficiency. Consumers at each level convert on average only about 10

3.10 Trophic Level Energy Loss

- Heat flux from Heterotrophs to Environment
- Necrotic mass respiration/decomposition
- Radiation re-emission from photoautotrophs
- Heat and radiation loss from chemoautotrophs
- Kinetic Energy Dissipation from Eddy Fluxes and Turbulent Currents of environmental fluids
- Chemical Potential Energy trapped in Biomass

3.11 Prediction

I predict that the Ecological Efficiency of an ectothermic trophic level is higher than that of an endothermic trophic level. This is due to the increased metabolic efficiency of ectotherms not having to regulate their internal body temperatures, instead being reliant on the environment. Therefore, the same trophic level should sustain a higher population count of ectotherms than endothermic organisms. However, since energy and mass are both conserved in biochemical reactions, I predict that overall biomass and internal system energy will remain constant.

IB_150-02.14.2023-notes: Codons

Hereditary information is encoded in Deoxyribonucleic Acid, or DNA. A polymer composed of two polynucleotide chains that coil around each other to form a Double Helix. Antiparallel sequences, 5'-3' and 3'-5'. DNA is read in 5'-3', and mRNA is also read in 5'-3'. The bases used in DNA are Adenine (A), Cytosine (C), Guanine (G), and Thymine (T). In RNA, the base Uracil (U) takes the place of thymine. DNA and RNA molecules are polymers made up of long chains of nucleotides.

Genotype is the complete set of genetic material, and Phenotype is the set of observable characteristics or traits of an organism. Locus is the "address" of certain genetic information. DNA is wrapped around Histone Proteins to form Chromatin, and Chromatin Fibers are spun into a big, wrapped Chromosome.

Complementary Transcription is mRNA, Messenger Ribonucleic Acid, a single-stranded molecule of RNA that corresponds to the genetic sequence of a Gene. It is read by a Ribosome in the process of synthesizing a Protein. Sets of 3 bases called a Codon. Start Codon sets up Reading Frame for Translation to amino acids, and Stop Codon ends Amino Acid production, halting Peptide Chain formation. Amino Acid strings combine to form Proteins. Redundancy exists, where many Codons code for many Amino Acids.

Codons and Corresponding Amino Acids

AAA	Lys	K	Lysine
AAC	Asn	N	Asparagine
AAG	Lys	K	Lysine
AAT	Asn	N	Asparagine
ACA	Thr	T	Threonine
ACC	Thr	T	Threonine
ACG	Thr	T	Threonine
ACT	Thr	T	Threonine
AGA	Arg	R	Arginine
AGC	Ser	S	Serine
AGG	Arg	R	Arginine
AGT	Ser	S	Serine
ATA	Ile	I	Isoleucine
ATC	Ile	I	Isoleucine
ATG	Met	M	Methionine
ATT	Ile	I	Isoleucine
CAA	Gln	Q	Glutamine
CAC	His	H	Histidine
CAG	Gln	Q	Glutamine
CAT	His	H	Histidine
CCA	Pro	P	Proline
CCC	Pro	P	Proline
CCG	Pro	P	Proline
CCT	Pro	P	Proline
CGA	Arg	R	Arginine
CGC	Arg	R	Arginine
CGG	Arg	R	Arginine
CGT	Arg	R	Arginine
CTA	Leu	L	Leucine
CTC	Leu	L	Leucine
CTG	Leu	L	Leucine
CTT	Leu	L	Leucine
GAA	Glu	E	Glutamic_acid
GAC	Asp	D	Aspartic_acid
GAG	Glu	E	Glutamic_acid
GAT	Asp	D	Aspartic_acid
GCA	Ala	A	Alanine
GCC	Ala	A	Alanine
GCG	Ala	A	Alanine

GCT	Ala	A	Alanine
GGA	Gly	G	Glycine
GGC	Gly	G	Glycine
GGG	Gly	G	Glycine
GGT	Gly	G	Glycine
GTA	Val	V	Valine
GTC	Val	V	Valine
GTG	Val	V	Valine
GTT	Val	V	Valine
TAA	Stp	O	Stop
TAC	Tyr	Y	Tyrosine
TAG	Stp	O	Stop
TAT	Tyr	Y	Tyrosine
TCA	Ser	S	Serine
TCC	Ser	S	Serine
TCG	Ser	S	Serine
TCT	Ser	S	Serine
TGA	Stp	O	Stop
TGC	Cys	C	Cysteine
TGG	Trp	W	Tryptophan
TGT	Cys	C	Cysteine
TTA	Leu	L	Leucine
TTC	Phe	F	Phenylalanine
TTG	Leu	L	Leucine
TTT	Phe	F	Phenylalanine

Introns and Exons are coding and non-coding regions, both preceded by a Promoter Sequence read by RNA Polymerase, which itself is preceded by a Promoter-proximal Element.

Genetic diversity is driven by random reproduction & Mutation. Individuals differ in the version of the same genes due to sequence changes. Permanent change in DNA leads to new Alleles (versions of genes).

Mutation in gene regulatory regions can affect gene expression: Transcription Factors, Promoter-proximal Elements.

Mutations in the promoter region can cause the loss of all gene expression. RNA Polymerase cannot bind and transcribe DNA into RNA to be translated into eventual Proteins. Mutations in coding regions can lead to changes in the protein product, and mutations in introns can affect mRNA splicing, dramatically affecting the protein product.

Gene - A region of genomic sequence with a specific Locus and function. Allele - one version of the same gene.

Classifying Mutations

By Cause

- SNP - single nucleotide polymorphism.
- Substitution: exchange of a single nucleotide for another.
- Insertion/Deletion (InDels) - additions or deletions of one or more nucleotides.

By Effect

- Missense Mutation - a point mutation wherein a single nucleotide changes codon to encoding for a different amino acid.
- Nonsense Mutation - a point mutation in a sequence of DNA that results in a premature stop codon. A nonsense codon in the transcribed mRNA leads to a truncated, incomplete, and nonfunctional protein.
- Silent Mutation - when the change of a single DNA nucleotide within a protein-coding portion of a gene does not affect the sequence of amino acids that make up the gene's protein.

- Frameshift Mutation - a genetic mutation caused by indels (insertions or deletions) of a number of nucleotides in a DNA sequence that is not divisible by three.

IB_150-02.21.2023-notes: Hardy-Weinberg

Karyotype - Number and Type of Chromosomes

Homologous Chromosomes, i.e., "Homologs" - Two Chromosomes of the same type which share the same genes and same gene loci

Sister Chromatids – Identical molecules of DNA produced during DNA replication

Karyotype? How many Chromatids per Chromosome? Centromere location per Chromosome? Allele differences per Chromosome? Per pair? Gene Locus per Chromosome? Per pair? Autosome differences? Sex Chromosome differences? Karyotype Formulas? Ploidy?

S-Phase, G1, G2 Mitosis Stages Meiosis Stages Dominant and Recessive Importance of Heterozygosity for gene exchange? Carrier Why Asexual Reproduction in important? Pros and Cons?

Sources of Genetic Diversity between Individuals All Organisms: Mutation Sexual Reproduction Only: Independent Assortment of Homologs reshuffles alleles of genes on different chromosome types Recombination via crossing-over reshuffles alleles of linked genes on the same chromosome types Fertilization

Difference between Gamete/Oöcyte Germline cells at stages of each Reproduction Process

Mendel's Laws

Sex Chromosomes SRY gene Sex-linked Genes Males are hemizygous for an X-linked trait Males can only inherit the trait from their mothers (females have two X's, Males have XY i.e. males only have 1 X-linked allele) X-linked red-color blindness is a recessive trait. Females heterozygous for this trait have normal vision. Y-linked genes are always hemizygous - there is only one copy which is passed from a male progenitor to male successors

Linkage Mapping? Crossing Over vs Independent Assortment? Differentiate linkage from sex-linkage Predict a crossing-over event given the location of two linked genes on a single chromosome State the null hypothesis of linkage Predict parental and recombinant gamete genotype frequencies given linked/unlinked genes How to set up the necessary crosses to test for independent assortment Chi-Square and p-value in a statistical test From Double Heterozygous Test Cross: Cis or Trans configuration How recombinant frequencies relate to relative mapping distances between two genes (centimorgans)

Hardy-Weinberg: $p + q = 1$ Allele Frequencies $p^2 + 2pq + q^2 = 1$ Genotype Frequencies

If in Hardy Weinberg a population is not evolving Changing Allele freq = evolution If humans are not evolving: Genotype frequencies for HomoDom = p^2, Hetero = $2pq$, HomoRec = q^2 AND will depend on the observed allele frequencies of p and q.

Hardy-Weinberg for 3 alleles? 4? $p + q + r = 1$; $p + q + r + s = 1$

Violations of Hardy-Weinberg Conditions: Change the Allele or Genotype Frequencies Mutation No new alleles will be created Genetic Drift The population that is interbreeding is very large to reduce sampling error Gene Flow No alleles are added or deleted from the population due to immigration or emigration Natural Selection Every allele has an equal likelihood to be passed on to offspring as a gamete ****Not an Evolutionary Mechanism Does not change the Allele or Genotype Frequencies**** Non-random mating Each gamete has the same probability to fertilize any other gamete

If there is equal reproductiveness success and random mating and there is no process to change allele frequencies: Genotype Frequencies can be predicted for the next generation Allele Frequencies will remain constant from generation to generation

H-W principle is the prediction of the Null Hypothesis of Evolution

H-W blood type/antigen examples

Exam 2: Genetics Transcription Direction Mutations

Genotype of Parents for Linkage Test Cross? $AaBb \times aabb$ Crossing-Over Possibility related to CentiMorgan Distance RF children / total children = RF Freq. = separation centiMorgan distance b/w genes each RF genotype is $0.5 \times RF\%$ Sampling Error Cis (AB and ab) vs Trans (Ab and aB) Configuration Parental from F1 Offspring Phenotype Ratios Parental ¿ RF vs RF ¿ Parental True-Breeding? Genotype for True-Breeding test cross? Usage? Pleiotropy vs epistasis vs polygenic inheritance Epistasis is a type of Polygenic Inheritance Genotype and Phenotype Ratios of pleiotropy vs epistasis How many Gametes a parent can make: $AabbCc = 2 \times 1 \times 2 = 4$ $aaBbCc = 1 \times 2 \times 2 = 4$ 4×4 Punnet Square Triploid mutate - a diploid gamete was created during Meiosis 1 or 2 Odd ploidy cannot perform Meiosis 1 - Metaphase 1 checkpoint that ensures all homologs are paired Cannot make gametes Trisomy-21 Individuals are sterile 1 gene undergoes a gene duplication event so 1 of the genes has a pair which allows

for non-sterile affected individuals Seedless plants? Asexual reproduction via cuttings? Monosomy e.g. Turner Syndrome - gonadal dysgenesis 1/2000 females only have 1 X chromosome Penetrance?

https://www.youtube.com/watch?v=m66kBi0ToioYouTube Video Link https://www.youtube.com/watch?v=gQ955N Video Link https://www.youtube.com/watch?v=1gYGeReW8ukYouTube Video Link https://www.youtube.com/watch?v fSn9rY7iwYouTube Video Link https://www.youtube.com/watch?v=v-fSn9rY7iwYouTube Video Link https://www.youtube.com/watch?v=M0MJiO2QnbsYouTube Video Link https://www.youtube.com/watch?v=TmwTg7 Video Link https://ocw.mit.edu/courses/7-014-introductory-biology-spring-2005/resources/quiz1$_s$/$MITOCWQuiz1http$

Ω

Pronghorn Speed, Relatives, Location, & Natural Selection

#Prompt - https://www.phind.com/Phind Website Write high-level explanation notes about the following:

Define biological evolution Differentiate between different sources of phenotypic diversity among individuals in a population, including heritable variation and environmentally induced variation due to phenotypic plasticity. Define "Gene Pool" in regards to genotype and allele frequencies Identify variation that is of evolutionary significance Define biological evolution with respect to allele frequencies Explain the Hardy-Weinberg Principle and how it applies to genetic traits. Explain how to calculate genotype and allele frequencies from numbers of diploid individuals State the two assumptions that must be true for a population to be in Hardy-Weinberg Equilibrium Explain the three conditions under which genotype frequencies of the next generation can be predicted Explain why only if phenotype frequencies are known can we use the Hardy-Weinberg principle to estimate allele and genotype frequencies Explain how to test whether a population is evolving using the Hardy-Weinberg Principle as the prediction of the Null Hypothesis for evolution, and comparing observed and expected genotype frequencies for a population of known allele frequencies

Explain the relationship between populations and genetic diversity In what sense the expected genotype frequencies of the Hardy-Weinberg Principle represent the prediction of the null hypothesis of biological evolution? Explain the biological implications of either rejecting or failing to reject the null hypothesis based on results from using the Chi-Square statistic to compare expected and observed genotype frequencies of a population to determine whether a population is in HWE Illustrate why testing for HWE is often more powerful or useful than observing changes in allele frequencies between generations as a test for evolutionary change in a population Identify which generational timestep was tested for evolutionary change when testing the current generation for HWE

Understand the effect of each Hardy-Weinberg violation on a population's genetic structure Processes that can change allele genotype frequencies within a population are evolutionary mechanisms. What are 4 Violations of Hardy-Weinberg? What processes can change genotype frequencies within a population without necessarily violating Hardy-Weinberg? Define Mutations, "Genetic drift", "Gene Flow", "Natural selection", and "Non-random Mating" in regards to evolution When does Genetic Drift become an important evolutionary force and why? Identify the founder effect and bottleneck events as two different scenarios that cause rapid declines in population size, resulting in elevated contribution of drift to evolutionary changes What is allele fixation? How does an allele become 'lost' in a population? Why are Mutation and Genetic Drift two evolutionary forces that are inevitable? Define Dispersal in the context of Gene Flow. Relate Immigration and Emigration of individuals How does gene flow act to homogenize allele frequencies between populations? Will gene flow cause each to diverge from HW proportions? Define metapopulation Define and give examples of the two assortative types of Nonrandom mating. Explain how mating can be random with respect to some traits, while nonrandom with respect to other traits in the same population of individuals Define Inbreeding Depression and explain how some populations enter a 'death spiral' How does Inbreeding enhance Selection and 'expose' rare recessive alleles? How does Natural Selection differ between positive assortative and negative assortative mating? Derive a statistical proof that shows that ALL natural populations will evolve Support the statement that evolution would not be possible without mutations, but that mutations are unlikely to be responsible for statistically significant deviations from HWE Describe the concept of "random sampling of alleles" in genetic drift making specific reference to the parental gene pool and the fraction of gametes contributing to offspring genotypes. Predict the relative effects of genetic drift in large vs. small populations and predict the relative time to allele fixation for large vs. small populations undergoing drift Explain how gene flow influences effective population size, allele frequencies, and genetic divergence between populations living in different regions

Challenge Problem - Dr. Clegg's family - 45 yr old likely to die of cancer, no children Recessive is less likely to get eliminated than Dominant Alleles More Persistent Common in diseases Human Growth Stop 40, stop producing children Late-in-life diseases start - no affect on general reproduction, offspring

already born Example: Cancer, no evolutionary advantage for Natural Selection to stop or select against it