BIO 121 Review Session

- By AMS Tutoring (Sambina and Parvin)
Topics after Midterm 2:

- Ecology
  - Different types of ecology
  - Abiotic and biotic factors
  - Survivorship curves and what they represent
  - Population dynamics and factors that regulate population growth
  - Difference between exponential and logistical growth
  - Species interaction
  - Niches and niche differentiation

- More on ecology..
  - Types of succession, characteristics of the different types of succession
  - Biomes and food web
  - Nutrient cycles and ecosystem
  - Speciation
Topics before the Midterm 2: (Already tested material)

- Genetics:
  - Stages of cell cycle
  - Inheritance
  - Pedigrees
- Evolution:
  - How genotype and phenotype frequencies can be affected

Study and cheat sheet tips! (Very important!)
Unit: Genetics
Stages of the cell cycle

- G1 - Growth
- S - DNA synthesis
- G2 - Growth and preparation for mitosis
- M - Mitosis (cell division)
Independent assortment

- Identify when independent assortment takes place in meiosis and explain how this process creates genetic variation among gamete cells.

- Independent assortment takes place during the metaphase of Meiosis I.
- When homologous chromosomes line up against each other in the middle of the cell, the spatial arrangement of paternal and maternal chromosomes (e.g., which goes right which goes left of the metaphase plate) for a given homologous pair is random and independent of the arrangement of all other homologous pairs.
- This results in each daughter cell containing a unique set of chromosomes (and a unique combination of alleles) that is different from other daughter cells.
Crossing over can occur, but the physical distance between genes affects the probability of crossing over.

- Occurs between homologous pairs
- Effect not observable if the cell is homozygous

### Diagram

- **Genes that are far apart**
  - Lots of opportunities for crossing-over

- **Genes that are close together**
  - Less likely to cross-over
A fictional female and male ice spider (2n = 4) were crossed (mated).

The genotype of the parents were:

\[ \text{AABBee (mother)} \times \text{aabbee (father)} \]

a) What would be the genotype of their offspring (F1)

b) Draw the cell of one of their offspring when it is at G1 of the cell cycle

c) In the empty space on the right, draw at cell at Metaphase 1 that would result in the daughter cell shown above.
Solution
Questions?
Inheritance

**Autosomal dominant:**

- Affected person must have at least one affected parent
- Two unaffected parents can only have unaffected offspring
- Typically occurs every generation
- Males and females have the same chance to be affected

**Autosomal recessive:**

- If both parents are affected, all of their offsprings must be affected
- Unaffected parents can have affected offspring
- Males and Females have the same chance of being affected
- Can skip generations
Inheritance

X-linked dominant:

X-linked Dominant - clues

- The daughters (8 or 10) of a male who has this trait (7) will also have this trait (because one x comes from father).

- Sons (3) can only have trait if mother has the trait (1) (receive X from mother)

- No father-son transmission because father only donates Y chromosome to son (7, 9, 11)

https://migr.org/library/sexlinkeddominant.html

X-linked recessive:

X-linked Recessive - clues

- Males are more likely than females to exhibit this trait (only need 1 recessive allele from mother)

- Affected daughters (14) must have an affected father (7) to exhibit this trait.

- Affected daughters (14) - mother may (8) exhibit this trait (rr) or may not (Rr).

https://migr.org/library/sexlinkedrecessive.html
### Inheritance

#### Phenotypic Ratios

<table>
<thead>
<tr>
<th>Offspring Phenotypic Ratio</th>
<th>Parents</th>
<th>Genes</th>
<th>Relationship of Alleles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only one phenotype (F1)</td>
<td>Parents are true-breeding, two different alleles</td>
<td>One gene</td>
<td>Dominant/recessive</td>
</tr>
<tr>
<td>3:1 (F2)</td>
<td>2 heterozygotes</td>
<td>One gene</td>
<td>Dominant/recessive</td>
</tr>
<tr>
<td>1:1 (F1)</td>
<td>heterozygote x homozygous recessive (test cross)</td>
<td>One gene</td>
<td>Dominant/recessive</td>
</tr>
<tr>
<td>9:3:3:1 (F2)</td>
<td>2 heterozygotes</td>
<td>Two genes, unlinked</td>
<td>Dominant/recessive</td>
</tr>
<tr>
<td>1:1:1:1 (F1)</td>
<td>Heterozygote x homozygous recessive (test cross)</td>
<td>Two genes, unlinked</td>
<td>Dominant/recessive</td>
</tr>
<tr>
<td>1:1 (parental phenotypes only) (F1)</td>
<td>Heterozygote x testcross</td>
<td>Two genes, linked (no crossing-over)</td>
<td>Dominant/recessive</td>
</tr>
</tbody>
</table>

- **True Breeding/Pure breeding vs cross breeding:**
  - TRUE BRED ARE HOMOZYGOUS
Inheritance

A female chipmunk with erect ears and a straight tail is crossed with a male chipmunk with floppy ears and a bent tail.

All the F1 chipmunks have erect ears and straight tails.

The F1 chipmunks are self-crossed (5 crosses) and the following F2 data are obtained:

61 female chipmunks with erect ears and straight tails
19 female chipmunks with floppy ears and straight tails
30 male chipmunks with erect ears and straight tails
31 male chipmunks with erect ears and bent tails
9 male chipmunks with floppy ears and straight tails
11 male chipmunks with floppy ears and bent tails

How are the traits of erect and floppy ears and straight and bent tails inherited? Show all of your work. Explain how the mode(s) of inheritance work.
Solution
Pedigrees

***Should include in your cheatsheet

- X linked - difference in chances between different genders
  - Either male or females might have a higher chances
Pedigrees

1. The following pedigrees show the inheritance of a trait known as ACHOO syndrome (or photic sneeze reflex), a condition whereby people break into a sneezing fit upon sudden exposure to bright light.

a) What are the possible modes of inheritance of photic sneeze reflex?

i) For the left pedigree assign genotypes (using A and a) assuming the trait is autosomal dominant. For the right pedigree assign genotypes assuming the trait is autosomal recessive.

ii) Now try to assign alleles assuming the trait is sex-linked (on the X chromosome) for both dominant (left) and recessive (right) inheritance.

- Make hypotheses
  - Autosomal dominant
  - Autosomal recessive
  - X linked dominant
  - X linked recessive

- Test them using the pedigrees
- Unless a hypothesis is disproven, it has chances of being correct
Solution
Questions?
Unit: Population Genetics
Some more assumptions would be:
- No mutation
- No migration
- No selection
- No genetic drift

If the expected genotype frequencies don’t match the observed ones, a population is not in H-W equilibrium.

If any of the assumptions are violated, a population will not be in H-W equilibrium.
Population genetics

All of these affect the frequencies of genotypes:

MUTATION
GENETIC DRIFT
  - Bottleneck
  - Founder effect
GENE FLOW
NATURAL SELECTION
Reproductive isolation

Mechanisms of reproductive isolation

Pre-zygotic = before fertilization
- Spatial isolation (different habitats)
- Spatial isolation (different habitats)
- Behavioural isolation (different mating behaviour)
- Mechanical isolation (different parts)
- Gametic incompatibility

Post-zygotic = after fertilization
- Hybrids are inviable
- Hybrids are sterile

Speciation:
- Basic steps required for speciation
  - No (or very little) gene flow
  - Evolutionary mechanism acting independently in different populations
  - Allele frequencies in different populations diverge
  - Reproductive isolation

- Species concepts
  - Morphological, ecological, biological, phylogenetic
Speciation

**Sympatric vs. allopatric**

**Sympatric populations**
- Exist in the same geographic area
- Individuals regularly encounter one another

**Allopatric populations**
- Found in separate geographic areas
- Populations are physically isolated from one another

**Different ways of defining species:**
- Morphological = specific form & function
- Ecological = specific niche
- Biological = interbreeding populations
- Phylogenetic = smallest possible monophyletic group
Suppose there is a population of brown bears in the mountains of central British Columbia [mountain bears] which form a sister clade to the brown bears of northern coastal British Columbia [coastal bears]. The coastal bears specialize on a marine diet such as whale carcasses, clams and salmon.

Describe the process of a large, single species of BC brown bears becoming two species: mountain brown bears and coastal brown bears. Explain what could happen during each step, each one leading to the next, to cause this result.

Use the biological species concept and include references to appropriate evolutionary mechanisms in your answer, and be as specific as possible. (6)
Solution

1) Identify the fact that there would need to be a lack of gene flow between coastal brown bears and mountain brown bear populations.

E.g., The populations have become physically isolated from one another by dispersal or vicariance, like a river forming, which prevents gene flow between coastal and mountain populations and/or allows the populations to diverge from one another.

[Note that they start off as a “large, single species of BC brown bears”, so there has to be something that divides them, can’t start as two isolated populations.]

2) Propose an evolutionary mechanism that would cause the populations’ allele frequencies to diverge from one another.

E.g., If coastal brown bears are a small population, then allele frequencies might change due to genetic drift. Genetic drift is random, so allele frequencies for many different genes could change in different ways for each population, and populations that are isolated from one another could diverge from one another evolutionarily.
3) Describe a specific reproductive isolating mechanism that could evolve between coastal brown bears and mountain brown bears.

E.g., Difference in allele frequencies might lead to gamete incompatibilities / or behavioural differences / between coastal brown bears and mountain brown bears / poor survival and/or fitness of hybrids.

If coastal brown bears and mountain brown bears can no longer mate or produce any viable offspring with members of the other group, then they would be considered separate species according to the biological species concept.
Unit: Ecology
Community Ecology

- Community: all of the population that interact with one another in a given area
- Species interactions
- Ecological niches
  - The function or role an organism plays in a community
    - Physical habitat (where it is found)
    - Resources it uses
    - Interactions with other organisms

- Fundamental niche: theoretical set of conditions an organism has access to in order to survive and reproduce when there are no limiting factors (i.e. competition)

- Realized niche: the set of conditions that is actually used by an animal, after the interaction with other species (i.e. predation and competition) are considered
Community Ecology

Fundamental Niche

Realized Niche

http://www.ecoblender.org/ecological-niche-and-facilitation/
3. Today two species of shore crab, *Hemigrapsus nudus* (the purple shore crab) and *Hemigrapsus oregonensis* (the hairy shore crab) live in the intertidal region around Vancouver. *H. nudus* is widely distributed along the west coast of North America. *H. oregonensis* is common along the coast of Oregon and Washington and its range is expanding northward. 1975 was the first time that these species could be found together on Wreck Beach. Both crab species are scavengers, consuming dead organic material, and both play a similar ecological role in the intertidal area of the marine ecosystem. In 1975 first-year Biology students did a survey of shore crab abundance at Tower Beach as a function of substratum size (e.g. on what size of rocks and pebbles were the crabs found) as seen in graph A. In 2005 another group of first-year students repeated the survey; their data are presented in graph B. (10 marks total)

![Graph A: Hemigrapsus nudus](image1)

![Graph B: Hemigrapsus oregonensis](image2)

**Fig. 1** the relative abundance of *H. nudus* and *H. oregonensis* as a function of substratum size at Tower Beach in 1975 (Frame A) and 2005 (Frame B).
Community Ecology Question

a) Are the curves illustrated in the graph in graph A examples of the fundamental or realized niches of these organisms? Explain your answer. (2 marks)

b) What interaction (be specific) would you expect between the two species where their distribution overlaps in graph A? Why would you expect this interaction to occur? (3 marks)

c) Describe the effect of this interaction on the distribution of the two species in this area over 30 years between 1975 and 2005 (graph B). What is the name of this ecological process (be specific). (3 marks)

d) List one possible characteristic of H. oregonensis and H. nudus that could have led to the results observed and indicate how this characteristic could have led to the results observed. (2 marks)

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**Fig. 1** the relative abundance of *H. nudus* and *H. oregonensis* as a function of substratum size at Tower Beach in 1975 (Frame A) and 2005 (Frame B).
Community Ecology Possible Solutions

a) Fundamental because they illustrate the range where each species can be found.

b) Competition, for resources - space (under rocks), or food (on or under rocks).

c) In the area of niche overlap H. nudus decreases until it is no longer present. Its range is decreased to smaller particles due to competition from H. oregonensis for larger particles. This is called competitive exclusion, resource partitioning or niche partitioning.

d) Larger = better competitor for food, space.
   Better camouflaged = more protection from predators.
Population Ecology

- Population ecology involves making predictions/inferences about how populations will change over time and space.
- Population = group of individuals of the same species, in the same place.

You should understand and know:
- Types of factors that regulate population growth
  - birth/deaths
  - immigration/emigration
- Types of survivorship curves (and what they represent)
Case Study: Northern Spotted Owls Activity

In 2012, biologists estimate that there are only about 10 breeding pairs left in BC, and that about 250 are necessary for the population to survive. In other words, these species are endangered. The reason behind is that their habitat (old growth forest) is disappearing.

Provide one example of an event that could influence each of the factors with respect to Northern Spotted Owl populations on the next slide.
Case Study: Northern Spotted Owls Activity

Birth

Death

Emigration

Immigration
Case Study: Northern Spotted Owls Survivorship

Based on the data below, which survivorship curve likely applies to the Northern Spotted Owl?

- 13 adult owls in captive population, all survived
- Three owlets born in 2012, only one survived

A. Type I  
B. Type II  
C. Type III
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A. Type I  
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C. Type III  

![Survivorship Curve Diagram]
Per capita growth rate (r)

\[ r = \text{birth rate} - \text{death rate} \]

Populations size

<table>
<thead>
<tr>
<th>Population size is:</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing</td>
<td>&gt; 0</td>
</tr>
<tr>
<td>Not changing</td>
<td>0</td>
</tr>
<tr>
<td>Decreasing</td>
<td>&lt; 0</td>
</tr>
</tbody>
</table>

Exponential growth:
- \( r \) is constant

Logistic growth:
- \( r \) is decreasing to 0
Intrinsic per capita growth rate ($r_{\text{max}}$)

- $r_{\text{max}}$ = rate at which population grows when not limited
- Limited by
  - Density-dependent variables: Competition over resources, Predation, Disease
  - Density Independent: Environmental disasters

**Carrying capacity limits population size**

Factors that contribute to a **low** intrinsic per capita growth rate:
- long generation times (individuals take a long time to reach reproductive age)
- few offspring produced per individual (low per capita birth rate)
- relatively high per capita death rate compared to per capita births

Factors that contribute to a **high** intrinsic per capita growth rate:
- short generation times (individuals reach reproductive age quickly)
- many offspring produced per individual (high per capita birth rate)
- a relatively low per capita death rate compared to per capita births.
3. *Paramecium* is a unicellular eukaryotic organism that can be easily grown in the lab in a liquid medium. Figure 3A below represents a typical growth curve for *Paramecium*.

![Figure 3A. Paramecium population growth](image)

a. On the graph in figure 3A, what does K indicate for this culture of Paramecium? (Note: answering “carrying capacity” would not be sufficient)

b. What are two density-dependent factors that could influence the carrying capacity in this scenario?
Growth Rate Question Solution

a. It indicates the maximum number of Paramecium cells that the habitat studied (in this case, probably a test tube filled with medium) can sustain for a prolonged period of time.

b. Competition among Paramecium cells for food
   Competition among Paramecium cells for space
   Presence/production of harmful metabolic waste from the Paramecium cells.
Ecological Succession

- Ecological succession: building a community over time
- Ecological disturbance = any event that moves biomass from a community
- Biomass = mass of living organisms
**Ecological Succession**

**Early successional communities:**
- Soil with few nutrients and little water retention
- Little shade
- Little protection from the elements (wind, sun, rain)
- Abiotic factors are more important here
- Pioneer: high dispersal, fast growing, hardy

**Late successional communities:**
- Resources (nutrients, water) and shelter (shade, protection from wind/erosion) will be plentiful
- Competition (biotic factor) will also increase for resources and niche space
- Climax: low dispersal, long-lived, good competitors

Cyclic process between early and late successional communities. Why?

Climax communities may not be able to sustain themselves forever, given intense competition for resources.
Primary vs. Secondary Succession

Primary succession: no soil

Disturbances:
- Volcanic eruptions
- Glaciers
- Floods
- Landslides

Lichens will always be the first organisms present at the beginning of this succession.

Secondary succession: soil remains

Disturbances:
- Forest fires
- Logging
- Construction
- farming
Abiotic Factors and Biomes

- Abiotic factors have a greater impact on the distribution of biomes
- These include precipitation, topography, temperature, sunlight, wind, nutrients
- Biomes represent distinct niches
- Ex. Tropical rainforest have to tolerate moisture and heat
  Temperate rainforests have to tolerate temperature variation
Nitrogen

- Nutrients influenced by both biotic and abiotic factors
- Nitrogen is an essential nutrient -> required for growth and reproduction
- Organisms can only use fixed nitrogen and most are incapable of fixing it
- Prokaryotes can only fix it
**Scenario:** A particular invasive plant species grows very rapidly, and has nitrogen-fixing bacteria associated with its roots. The figure below shows the relative biodiversity and biomass of two areas in the same forest: Site A (which has none of the invasive species), and Site B (which has the invasive species).

<table>
<thead>
<tr>
<th>Biodiversity (number of species)</th>
<th>Biomass (g/m²/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site A (no invasive)</td>
<td>Site B (invasive)</td>
</tr>
<tr>
<td>20</td>
<td>120</td>
</tr>
<tr>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>120</td>
<td>120</td>
</tr>
</tbody>
</table>

a. Briefly describe the results shown in the figure.
b. What is a possible explanation for these results?
Nutrient Question Answer

a. Site B has a higher total biomass (100 g/m$^2$/year) than Site A (80 g/m$^2$/year) but less biodiversity (Site B has about 37 species vs Site A about 47 species)

b. Nitrogen is likely a limiting nutrient for this ecosystem. Adding nitrogen increases the biomass.

OR

The invasive species outcompeted the local species. Growth of the invasive decreased Biodiversity.

OR

Most of the extra biomass belongs to the invasive species. Site B has a higher total biomass despite having fewer species.
Carbon Cycle
Ecosystems

- Interacting system composed of biotic and abiotic factors
- Autotrophs can produce their own food using light or chemical energy
- Heterotroph cannot produce their own food (relies on autotroph for food)
- Net primary productivity = rate at which producers make energy available to ecosystem
Why is the biomass of producers generally greater than that of consumers?
Ecosystem Question

5. The following species are found in a forest ecosystem: (14 marks total)

- *Felis concolor* (cougar)
- *Lepus capensis* (brown hare)
- *Odocoileus virginianus* (white-tailed deer)
- *Trifolium repens* (white clover)
- *Boletus edulis* (king bolete)

a. Use a diagram to illustrate the different trophic levels represented by these species. Use arrows to indicate the direction of flow of energy through this community.
b. Which species would have the most biomass? Give one reason why.
c. Explain what would happen to each of the trophic levels in (a) above, if brown hares were removed from the food web.
Ecosystem Solution Part A

Diagram:
- **King bolete (decomposer)**
- **Hare**
- **Deer**
- **Cougar**

Arrows indicate predatory relationships:
- King bolete preys on Hare and Cougars.
- Hare preys on Deer.
- Deer preys on Cougars.

Labels:
- **Primary producer**: Clover
- **Primary Consumers**: Hare, Deer
- **Secondary Consumers**: King bolete, Hare, Deer
b. Clover because they are the lowest trophic level, and are able to photosynthesis and harness energy from the sun, etc.

c. Cougars may decrease (due to lack of food) OR they may consume more deer to compensate, therefore decreasing the number of deer.

If cougars do not consume more deer (perhaps they are harder to catch), deer will increase since there is less competition for the clover (no more hares to compete).

Therefore, clover may increase if hares are gone (less herbivores present) OR may decrease if deer increase (more deer = more clover eaten).

Bolete may stay the same (if other biomass stays the same) or decrease (if total biomass decreases)
Questions?
Study Plan

- Start studying lecture slides from post midterm 2
- Then go back and review the first two sections
- Solve the past exam and understand key words and the approach to solving the questions
- Make a good cheat sheet! (even if the exam is open book, don’t pour down everything from lecture slides!). You will not have enough time!

CHEAT SHEET TIPS:

- Important diagrams (eg cycles, survivorship curves)
- Approach to questions, how you should go about solving inheritance materials, etc
YOU CAN DO IT
I BELIEVE IN YOU
Acknowledgement:

- The lecture slides (including some images) are taken from slides our respected lecturers gave us during our class!
- The solutions in the slides are taken from official mark schemes, so none of the materials presented here are answers from the AMS Tutors