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Team Members Present:

PART 1: Review of Key Concepts in Biogeography

1. Briefly define the following terms
    - Biogeography -
    - Endemic -
    - Cosmopolitan -
    - Neutral Model –
    - Occupancy -
    - Abundance -

2. Any clarifications needed or outstanding questions from the lecture? First, help your team members to try to understand any muddy concepts, and ask if no one knows the answer.

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PART 2: Assembling a Community From a "Random" Species Pool: Simulation

Materials needed: A Martian rock microbial community, this worksheet, and environment card, and a pen/pencil. At least one group member should have a laptop to record the final values your group finds.

Instructions: You and your colleagues have characterized the environmental conditions at the Martian rock sites that you previously investigated (in the Microbial Diversity and Subsampling Activity). You expect that these conditions are driving community structure and have received high-level security clearance and permission to test your hypothesis.

You and your colleagues have planted sterile rocks of known composition and can watch real time as microbes colonize these new habitats! Each team will independently and carefully evaluate the microbial diversity of one newly colonized rock community at several time points.

- Each collection of pompoms is a Martian rock microbiome
- Each piece of pompom is individual cell from the microbiome community
- Each type of pompom is an operational taxonomic unit (OTU; i.e., or species of microbe).

EXPERIMENTAL PROCEDURE:

Step A. **Consider your particular Martian environment, decide which OTUs could survive there.**

1. On the Environmental Gradients data sheet, mark the columns relevant to your environment.
2. Each row is an OTU. If there are any "skulls and crossbones" in the relevant columns for that row/taxon, then that taxon will go extinct in your environment.
3. Mark these with **X's** in the Start column of the Community Simulation Table. You will fill in this Table as we work through the exercise.

Step B. Assemble a community from a species pool of Martian microbes.

1. Get a scoop of microbes (pompoms). Sort them out into OTUs by phenotype. Focusing on the abiotic conditions, determine which OTUs can persist in your environment and which go extinct.
2. Return the OTUs that go extinct to a TA and count the population sizes for each of the surviving OTUs.
3. Record your counts in the "Start" column of the Community Simulation Table.

Step B. Account for microbial interactions.

1. Focusing on the biotic conditions, determine which OTUs will survive (or thrive!) in your environment and which will be outcompeted.

2. **Competition.** If your assemblage has two OTUs that exclude one another, identify the dominant competitor. The remaining OTU will go extinct, and the dominant competitor will gain the number of individuals lost by the extinction. Record this information (increases or extinctions) for relevant taxa in the "Interactions" column.
    - OTU 3 cannot survive when OTU 11 is present (competitive exclusion)

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3. **Positive interactions.** If your assemblage has two OTUs that benefit (mutualism or ammensalism), the advantaged OTU will increase by the noted factor. Record this information for relevant taxa in the "Interactions" column.
    - OTU 12 benefits when OTU 4 is present, but OTU 4 does not benefit from OTU 12. *Increase OTU 12 by 1.1.*
    - OTU 15 and OTU 4 mutually benefit. *Increase each by 1.1.*
    - OTU 1 provides a specialized resource to OTU 11 – if both OTU 1 and OTU 11 co-occur, multiple OTU 11 by a *super symbiosis factor of 2!*

Step C. Determine OTU fitness in your Martian environment.

Use the environment gradient sheet to determine the appropriate multiplier for your taxa:

1. For each OTU in your community, look across the 4 columns (one for each pH, salinity, Carbon, and Water) that are relevant to your environment.
2. Whichever of these columns has the lowest number, that number is your multiplier. Put this number into the "Multiplier" Column.
3. Calculate the new size of each OTU's population. To do so, take the START data (or the Interactions correction, when appropriate) times the multiplier value. Record this in the Time 1 column.

    Time 1 = multiplier * Start

Step D. Wind Storm!

1. Put all of your surviving and thriving OTU pompoms back in your take-out box & shake them up.
2. Reach in the box and pull out a handful of ~5-10 random pompoms. In the WindStorm column, add these as negatives to the column labeled WindStorm. (e.g., if you pull out two green pom poms, put -2 in the WindStorm column).
3. Provide the handful of OTUs to the next group (e.g, Team 1 passes to Team 2).
4. With the new microbes that your team receives, use the Environmental Gradient table to determine if any of the new OTUs go extinct in your team's environment. Discard them.
5. For the surviving OTUs, record their new counts in the WindStorm Column.
6. Calculate the new population sizes of the surviving OTUs in the Time Point 2 column.

    Time Point 2 = multiplier * (Time Point 1 + Wind Storm).

Step E. Finale.

1. Round the values in Time Point 2 up to the nearest whole integer (e.g., 1.2 → 2).
2. Calculate the final population sizes:
    Finish = TimePoint2 * multiplier, rounded up.
3. Record these values the final Finish Column.
4. Enter the Finish column values in the shared Google spreadsheet (see the link provided). Find your environment ID (from the environment card) in the top row and record your values in that column. For OTUs that went extinct because of an unfavorable local environment, enter an "X" in the cell. For OTUs that, through the simulation, decrease to 0, record a 0. Every cell of your environment ID column should have a value.

********** **Simulation Complete** **********

Date:

Environmental Gradients

OTU No.	OTU Description	pH															Salinity		Carbon		Water	
		4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	Low	High	Low	High	Scarce	Abundant
1	Small Sparkly Green	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	Small Sparkly White	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2
3	Small Purple ***	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	Small Black	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	☠	2	2	2
5	Small Green	☠	☠	1	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2	2	2	2	2	2	2
6	Small Yellow	2	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1	☠	☠	☠	☠	2	2	2	2	2	2
7	Small Blue	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	Small Red	2	2	2	2	2	2	2	2	1	1	1	☠	☠	☠	☠	2	1	2	2	2	1
9	Small Orange	1.1	1.2	1.3	1.4	1.5	1.6	1.8	2	1.8	1.6	1.5	1.4	1.3	1.2	1.1	2	2	2	2	2	2
10	Small Pink	☠	☠	☠	☠	☠	☠	1	1.5	1.5	2	2	2	2	2	2	☠	2	☠	2	☠	2
11	Small Brown	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	2	2	2	2	2	2
12	Small White	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	☠	2	2	2
13	Large Sparkly Orange	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	☠	2	2	2
14	Large Sparkly Yellow	☠	☠	☠	☠	☠	☠	☠	☠	☠	☠	2	2	2	☠	☠	☠	2	☠	2	☠	2
15	Large Sparkly Green	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	☠	2		2
16	Large Sparkly Pink	☠	☠	☠	☠	☠	☠	2	2	2	2	2	2	2	☠	☠	2	2	☠	2	☠	2
17	Large Sparkly White	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	☠	2	2	2
18	Large Sparkly Purple	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	☠	☠	2	2	2
19	Large Sparkly Blue	☠	☠	☠	☠	☠	☠	1	1	1.5	1.5	2	2	2	2	2	2	2	☠	2	2	2
20	Large Sparkly Red	☠	☠	☠	☠	☠	☠	1	1	1.5	1.5	2	2	2	2	2	2	2	☠	2	2	2

*** CANNOT survive when OTU 10 (Small Pink) is present

☠ Goes extinct

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Tea

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YOUR ENVIRONMENT: _____

Community Simulation Data Table

OTU No.	OTU Descriptor	Start	Interaction ?	Multiplier	Time Point # 1	Wind Storm!	Time Point # 2	Finish
1	Small Sparkly Green							
2	Small Sparkly White							
3	Small Purple							
4	Small Black							
5	Small Green							
6	Small Yellow							
7	Small Blue							
8	Small Red							
9	Small Orange							
10	Small Pink							
11	Small Brown							
12	Small White							
13	Large Sparkly Orange							
14	Large Sparkly Yellow							
15	Large Sparkly Green							
16	Large Sparkly Pink							
17	Large Sparkly White							
18	Large Sparkly Purple							
19	Large Sparkly Blue							
20	Large Sparkly Red							

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Original Martian Survey Data (from Diversity/Subsampling exercise)

OTU No.	OTU Descriptor	Community/Environment														
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**
1	Small Sparkly Green	33	33	34	33	33	34	33	33	34	33	33	34	33	33	34
2	Small Sparkly White	63	6	60	8	56	0	58	6	61	0	60	6	56	4	56
3	Small Purple	9	10	10	12	11	11	10	12	14	0	16	0	14	0	17
4	Small Black	0	20	0	16	0	16	0	18	0	19	0	15	2	22	0
5	Small Green	0	0	1	2	3	4	5	6	7	7	10	13	14	22	30
6	Small Yellow	20	19	18	15	10	9	8	6	6	5	3	0	0	0	0
7	Small Blue	7	9	7	7	7	10	7	10	7	9	7	6	7	8	6
8	Small Red	10	14	22	20	14	24	0	1	0	1	2	0	0	0	0
9	Small Orange	1	2	5	5	7	10	13	14	10	9	8	7	6	2	0
10	Small Pink	0	0	0	0	0	0	0	0	0	28	0	33	0	25	0
11	Small Brown	2	3	4	2	2	2	3	4	1	2	1	2	3	3	2
12	Small White	0	3	0	3	0	1	0	1	0	3	0	4	0	1	0
13	Large Sparkly Orange	0	1	0	1	0	0	0	2	0	1	0	2	0	1	0
14	Large Sparkly Yellow	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0
15	Large Sparkly Green	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
16	Large Sparkly Pink	0	0	0	0	0	0	0	2	0	0	0	3	0	0	0
17	Large Sparkly White	0	0	0	1	0	0	0	1	0	1	0	1	0	0	0
18	Large Sparkly Purple	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0
19	Large Sparkly Blue	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
20	Large Sparkly Red	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

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PART 2: Analysis & Synthesis

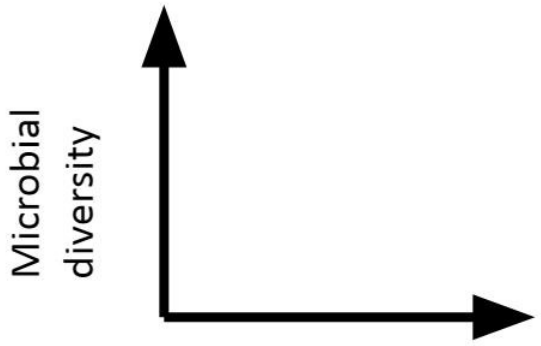
1. Compare the class simulation values in the shared spreadsheet to those you found in the Original Martian Survey Data. Overall, are the general trends in abundance similar or different? Briefly explain.

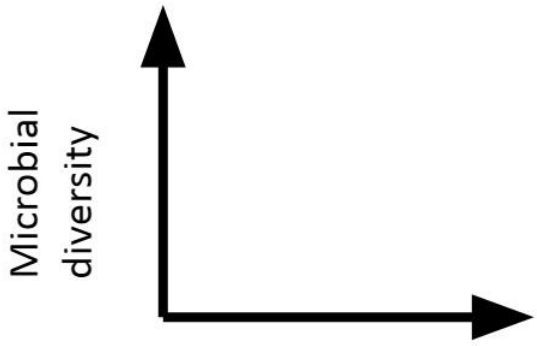
2. In simple terms, what do you think the multiplier represent(s)?

3. What ecological process does the wind-storm simulate?

4. Based on the Environmental Gradients sheet and your experience in Part 1, which two environmental factors do you think are most driving the biogeography of these organisms? Briefly explain.

5. Based on your data and what you learned from the lecture, sketch the general relationship you expect to observe between microbial diversity and the environmental factors you selected. Label your axes!





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6.a. Looking at the **Original Marian Survey data**, place the 20 taxa on the Endemic-to- Cosmopolitan graph below:

6.b. How confident are you in these placements (and do you have higher confidence in some over others?) Why?

6.c. What additional data would increase your confidence in these placements?

7.a. What biogeographical component (e.g., area, connectivity, abundance, occupancy, spatial scale) is described by terms like endemic and cosmopolitan?

7.b. What is the other major component has been used in this class to describe the biogeography of organisms? How does this component relate to how confidently a taxon can be classified as endemic or cosmopolitan?

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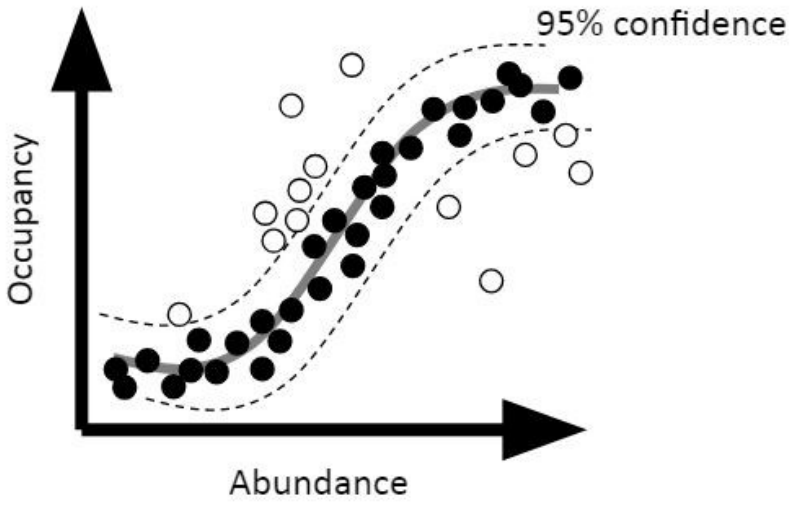
8.a. On the graph below, 1) circle the axis/ axis label that describes endemism/cosmopolitanism, and 2) draw lines designating the regions corresponding to endemic and cosmopolitan taxa.



8.b. From the Martian Survey Data, consider the biogeographical distributions of OTUs 1, 10 and 11. Estimate where these taxa should occur on the Abundance-Occupancy graph above, and place them accordingly (label them by number).

8.c. In the above graph, what does the solid gray line represent?

8.d. What does it mean when taxa are outside the confidence interval (dashed lines)?