

# Applying Spectral Graph Theory to Microbial Analysis

Zain Jabbar, Monique Chyba

April 29, 2021

# The Importance of the Microbiome



# Waimea Valley



# The Data

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12	Sample 13	Sample 14	Sample 15	Sample 16
Species 1	0	0	0	0	0	0	0	389	23	41	11	0	0	0	0	26
Species 2	157	454	186	0	3	0	0	0	254	475	1040	162	12	75	164	243
Species 3	3	0	0	0	0	12	0	42	0	4	0	34	25	2	58	7
Species 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Species 5	0	0	0	0	0	0	0	0	0	0	6	0	0	4	0	0
Species 6	0	31	0	0	0	0	0	0	0	0	0	0	0	44	0	131
Species 7	0	0	0	0	0	0	0	0	5	0	0	4	0	0	0	0
Species 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Species 9	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0
Species 10	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0
Species 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Species 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Species 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Species 14	128	121	311	0	0	293	0	0	0	0	6	0	355	35	112	0
Species 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Species 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Species 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Species 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Species 19	0	0	0	0	0	0	0	0	67	0	0	0	6	0	0	8
Species 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Species 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Species 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Species 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

## (a) Abundance Table

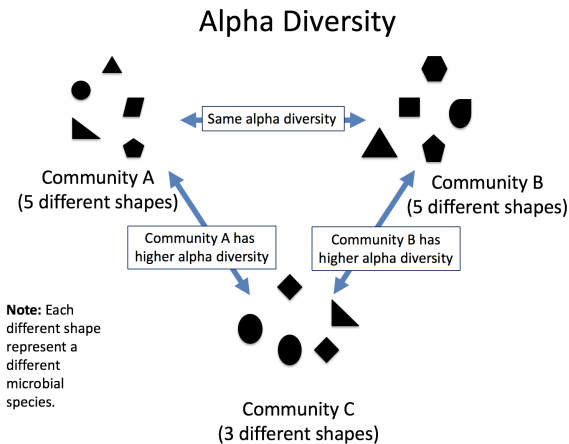
id	run	index	sample_barcode	locus	primer_plate	primer_row	primer_col	extraction_well
105635	Miseq04_165	GACAATTCCGAA	2821	bacterial16S		8 F		12 F12
105634	Miseq04_165	AGCCTGGTACCT	2638	bacterial16S		8 D		12 D12
105633	Miseq04_165	CTAAATACCCCT	2650	bacterial16S		8 B		12 B12
105632	Miseq04_165	TGGGACATATCC	2644	bacterial16S		8 A		12 A12
105631	Miseq04_165	GCCAGGCTTCCT	2750	bacterial16S		8 H		11 H11
105630	Miseq04_165	ATAATCTAATCC	2719	bacterial16S		8 G		11 G11
105629	Miseq04_165	GGAAGCTTAAC	2879	bacterial16S		8 F		11 F11
105628	Miseq04_165	CCTGGTGTCGT	2727	bacterial16S		8 E		11 E11
105627	Miseq04_165	CTCCTGTCCGGA	2722	bacterial16S		8 D		11 D11
105626	Miseq04_165	TACGTTTGCGGA	2647	bacterial16S		8 C		11 C11

## (b) Metadata

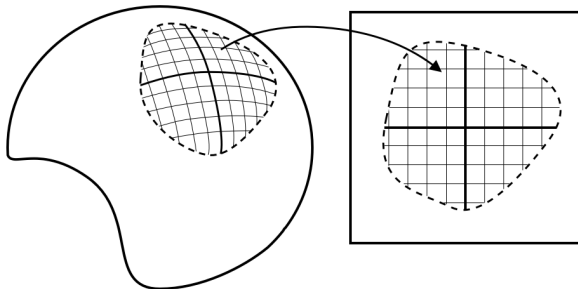
# Problem Statement

Explore!

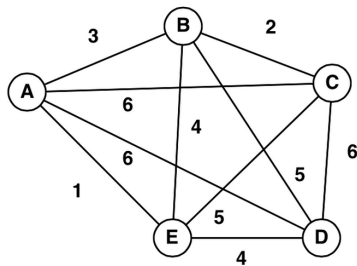
# Previous Microbiology Work



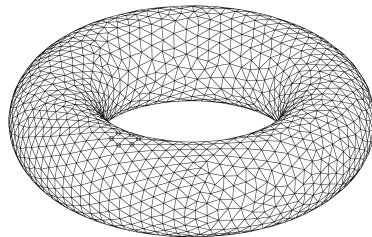
# Manifolds



# Graphs



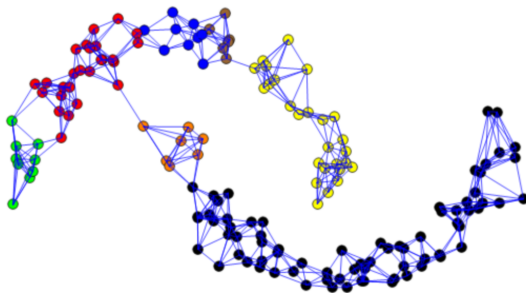
(c) Graphs in General



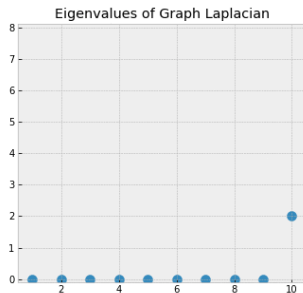
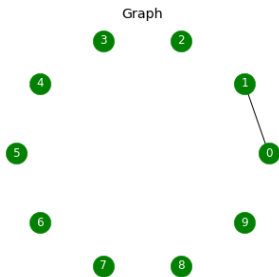
(d) Graphs as Manifolds



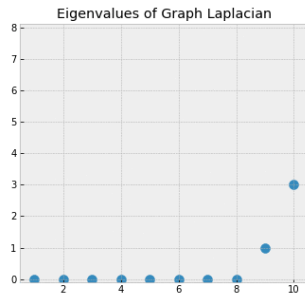
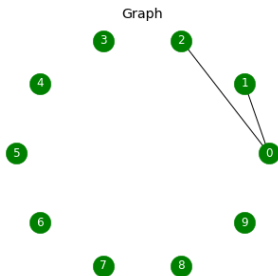
# Compute Adjacency Matrix



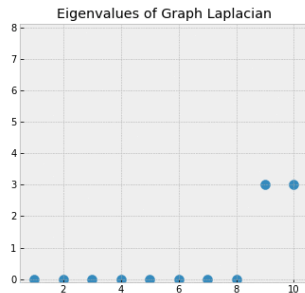
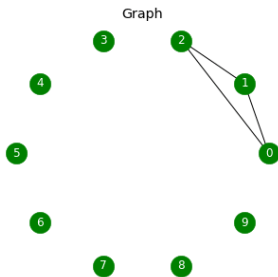
# Compute Graph Laplacian and Eigenvalues



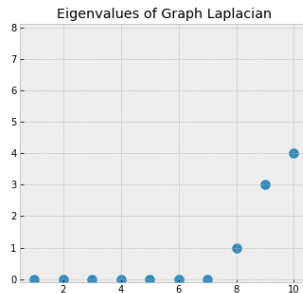
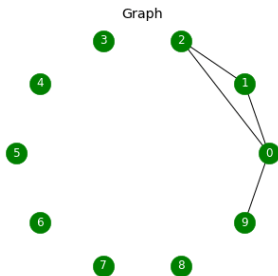
# Compute Graph Laplacian and Eigenvalues



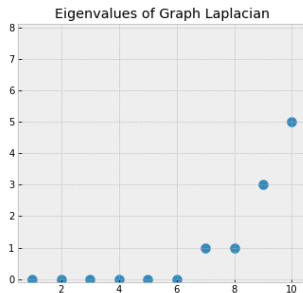
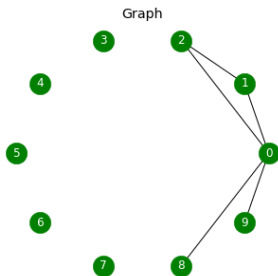
# Compute Graph Laplacian and Eigenvalues



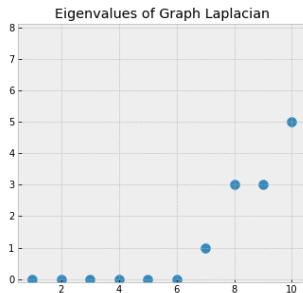
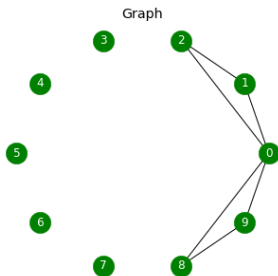
# Compute Graph Laplacian and Eigenvalues



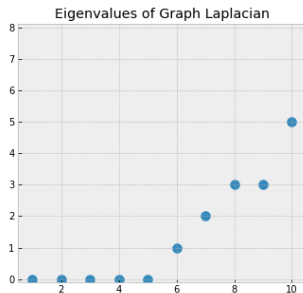
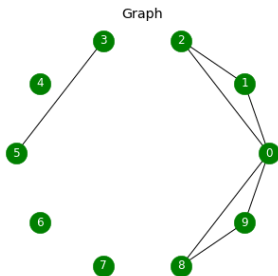
# Compute Graph Laplacian and Eigenvalues



# Compute Graph Laplacian and Eigenvalues

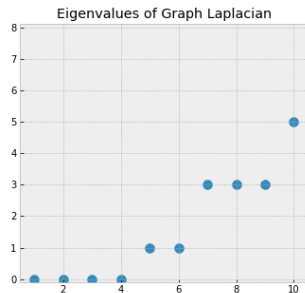
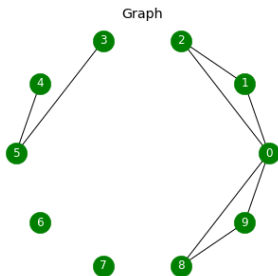


# Compute Graph Laplacian and Eigenvalues

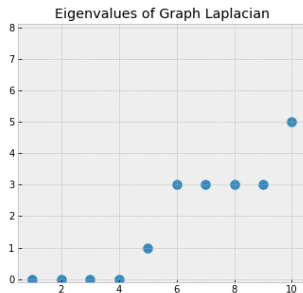
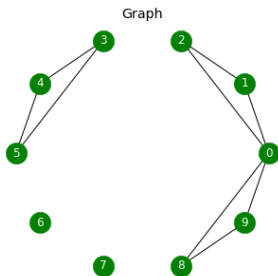




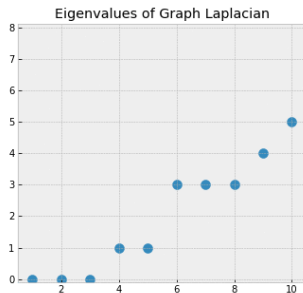
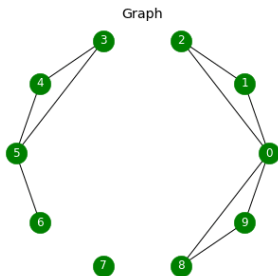
# Compute Graph Laplacian and Eigenvalues



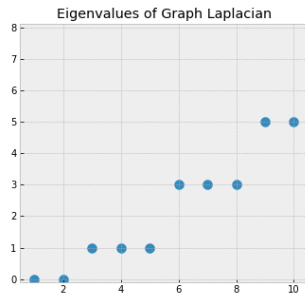
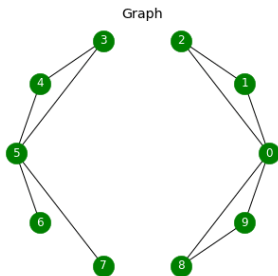
# Compute Graph Laplacian and Eigenvalues



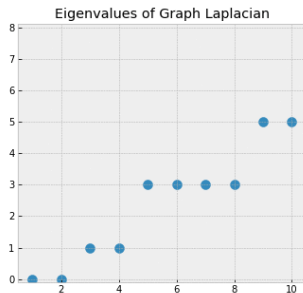
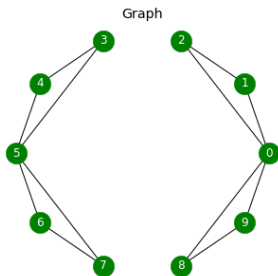
# Compute Graph Laplacian and Eigenvalues

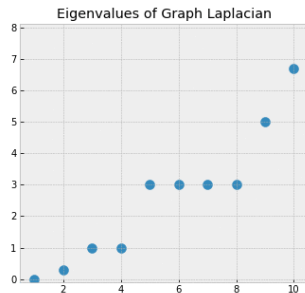


# Compute Graph Laplacian and Eigenvalues

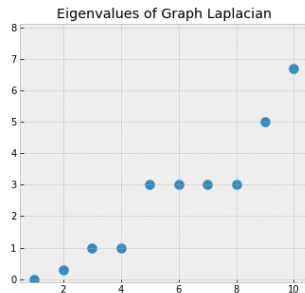
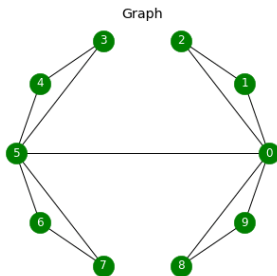


# Compute Graph Laplacian and Eigenvalues

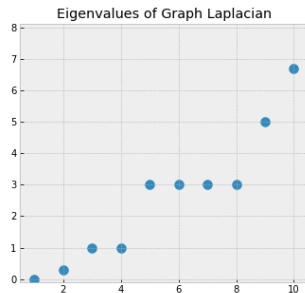
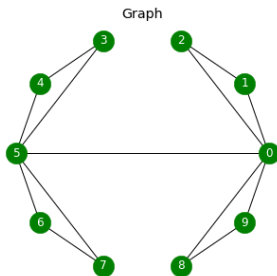




# Compute Graph Laplacian and Eigenvalues

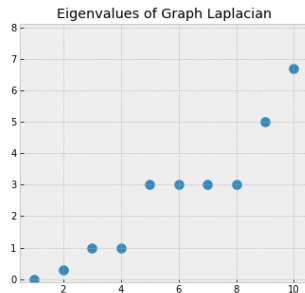
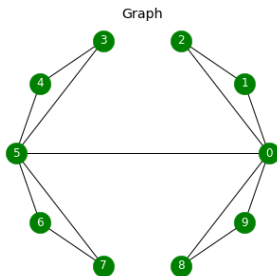


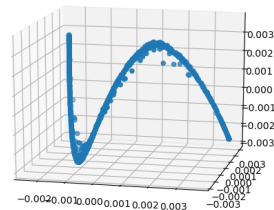
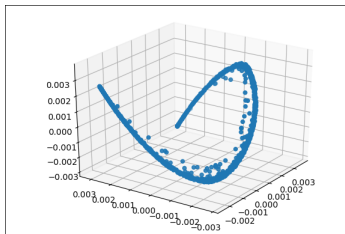
# Compute Graph Laplacian and Eigenvalues



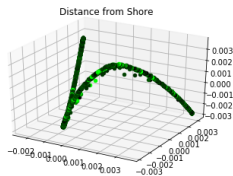
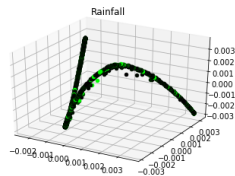
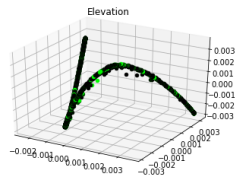


# Compute Graph Laplacian and Eigenvalues





**Figure:** The plots are a representation of the dimensionality reduction procedure and display a one dimensional submanifold in  $\mathbb{R}^3$ .



Thank you for listening!