Geonomics Lab (Part 2)

Anusha Bishop

Lab created by: Drew Terasaki Hart, Natalie Graham, Monica Wilkinson and Keeley Takimoto

Creating a GitHub account

1. Go to https://github.com/
2. Click Sign up
3. Sign up with your **berkeley email**
4. Follow the prompts to create your personal account.
5. Pick your username carefully, you will likely not want to change it (but you can). Some recommendations:
    a. Use part of your real name so it is easier for people to know who you are
    b. Try and keep it short, you may have to type it a lot
    c. Keep everything lowercase. If you really want to separate words, use a hyphen (-) or an underscore (_)

GitHub Codespaces

1. Go to https://github.com/TheWangLab/espm154
2. Click the green "Code" button in the top right
3. Click "Open with Codespaces".
4. Wait for the codespace to load. This will take several minutes.
5. Open the “espm154_lab6” ipynb file
6. When you run a cell you will be prompted to pick a kernel: click “Python environment” and then the first item on the list which has a star next to it (conda)

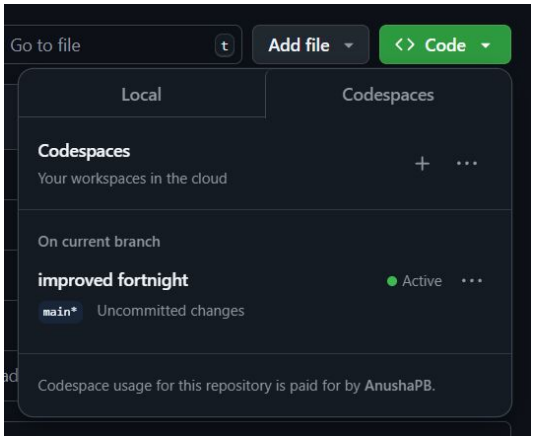
Tips:

1. If you hover over the plots, you can copy the image by clicking this icon:
   This may be useful in answering the lab exercises and keeping track of the simulations.
2. You can download your notebook by right clicking on the file and selecting “Download” (you may have to click “Accept” on a pop-up first)

GitHub Codespaces

To reopen an existing codespace go to here:
https://github.com/TheWangLab/espm154

Click the code button again and click on the listed codespace (it will have a random name)



Evolutionary Simulations in **Geonomics**

Geonomics: Forward-Time, Spatially Explicit, and Arbitrarily Complex Landscape Genomic Simulations

Drew E Terasaki Hart ✉, Anusha P Bishop, Ian J Wang

Molecular Biology and Evolution, Volume 38, Issue 10, October 2021, Pages 4634–4646,
https://doi.org/10.1093/molbev/msab175
Published: 12 June 2021

*Simulation of **local adaptation** and **speciation** across realistic landscapes*

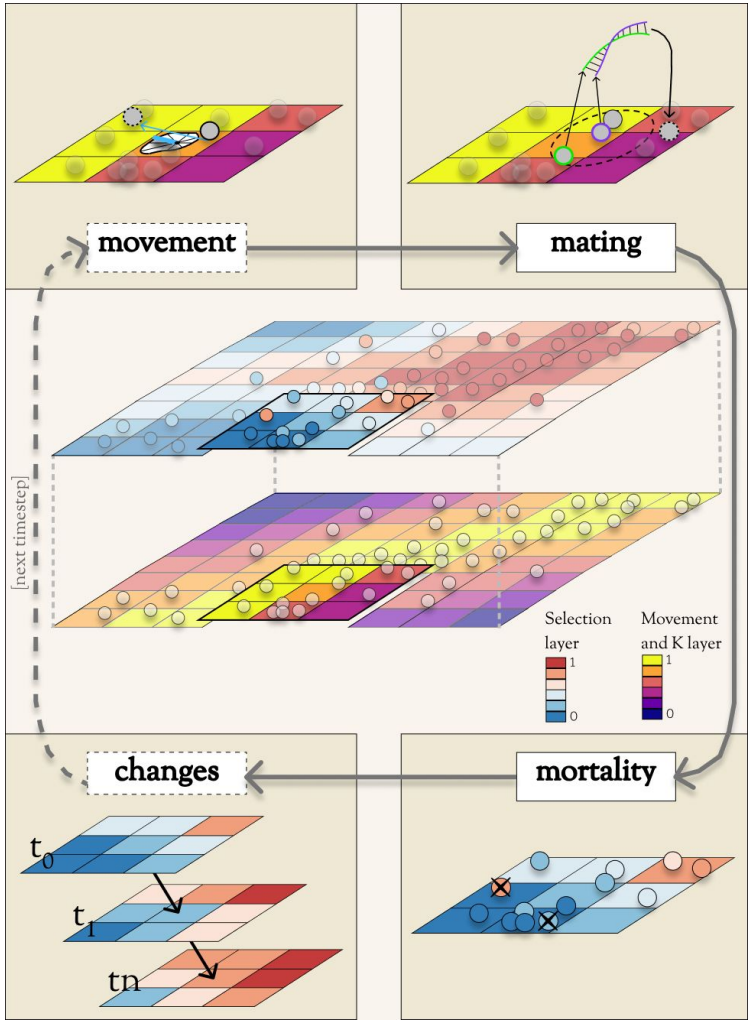
Parameters = Recipe

Brownie in a Mug

- **3** tablespoons sugar
- **3** tablespoons flour
- **1 ½** tablespoons cocoa powder
- **1 ½** tablespoons melted butter
- **3** tablespoons milk
- **¼** teaspoon vanilla extract

=

```
'mug_brownie': {
    'sugar': 3
    'flour': 3
    'cocoa_powder': 1.5
    'melted_butter': 1.5
    'milk': 3,
    'vanilla_extract': 0.25
    }
```


movement
mating
[next timestep]
Selection layer
1
0
Movement and K layer
1
0
changes
mortality
t0
t1
tn

1.) Create and edit a parameters file

parameters file:

```
parameters:{
    landscape: {
        .
        .
    }
    community: {
        species: {
            .
            .
            genomic_arch: {
                .
                .
            }
        }
    }
    model: {
        .
        .
    }
}
```

Optional: *Include paths to raster files and/or directories of environmental-change rasters*

raster file:

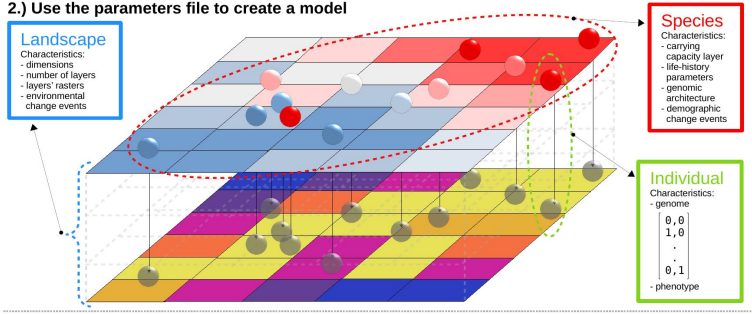
raster directory:

Optional: *include path to a genomic architecture file (.csv)*

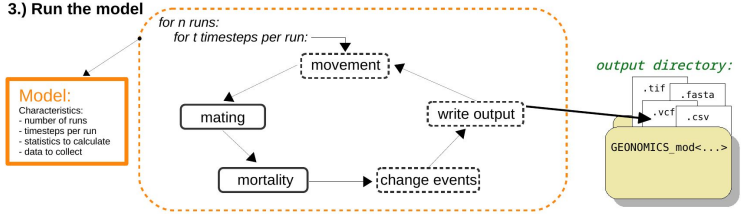
genomic architecture file:

```
loc,   p,  dom,    r,  trait,  alpha,
  1, 0.5,    0,  0.5,      ,      ,
  1, 0.5,    0,  0.5,      ,      ,
  1, 0.5,    0, 0.01,      0,    0.5,
  1, 0.5,    0, 0.01,      1,    0.5,
  1, 0.5,    0, 0.01,      2,    0.5,
  1, 0.5,    0,  0.5,      ,      ,
  1, 0.5,    0,  0.5,      ,      ,
  .   .      .    .        .      .
  .   .      .    .        .      .
```

2.) Use the parameters file to create a model



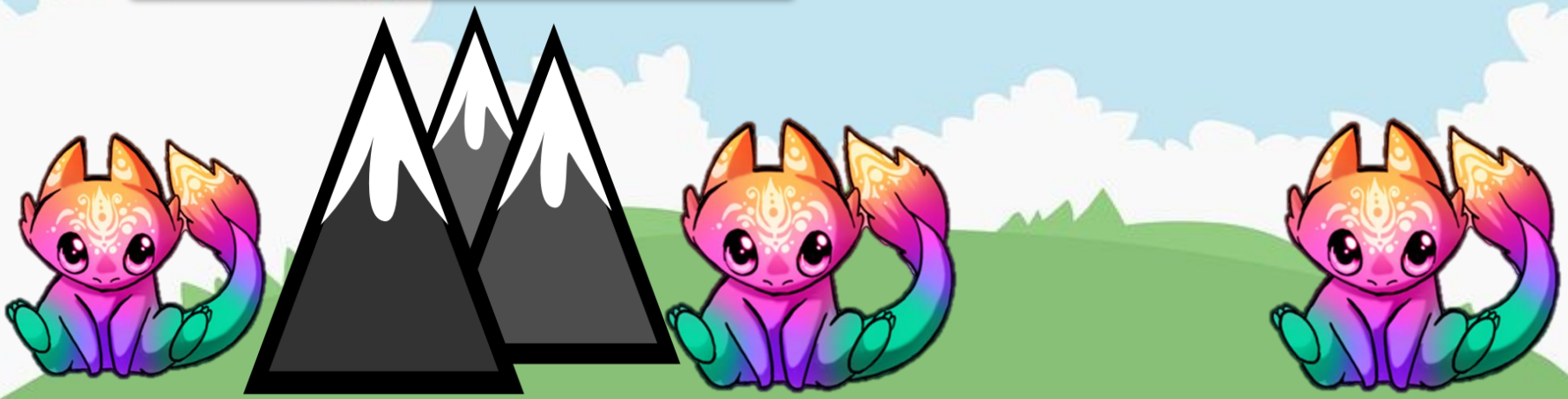
3.) Run the model

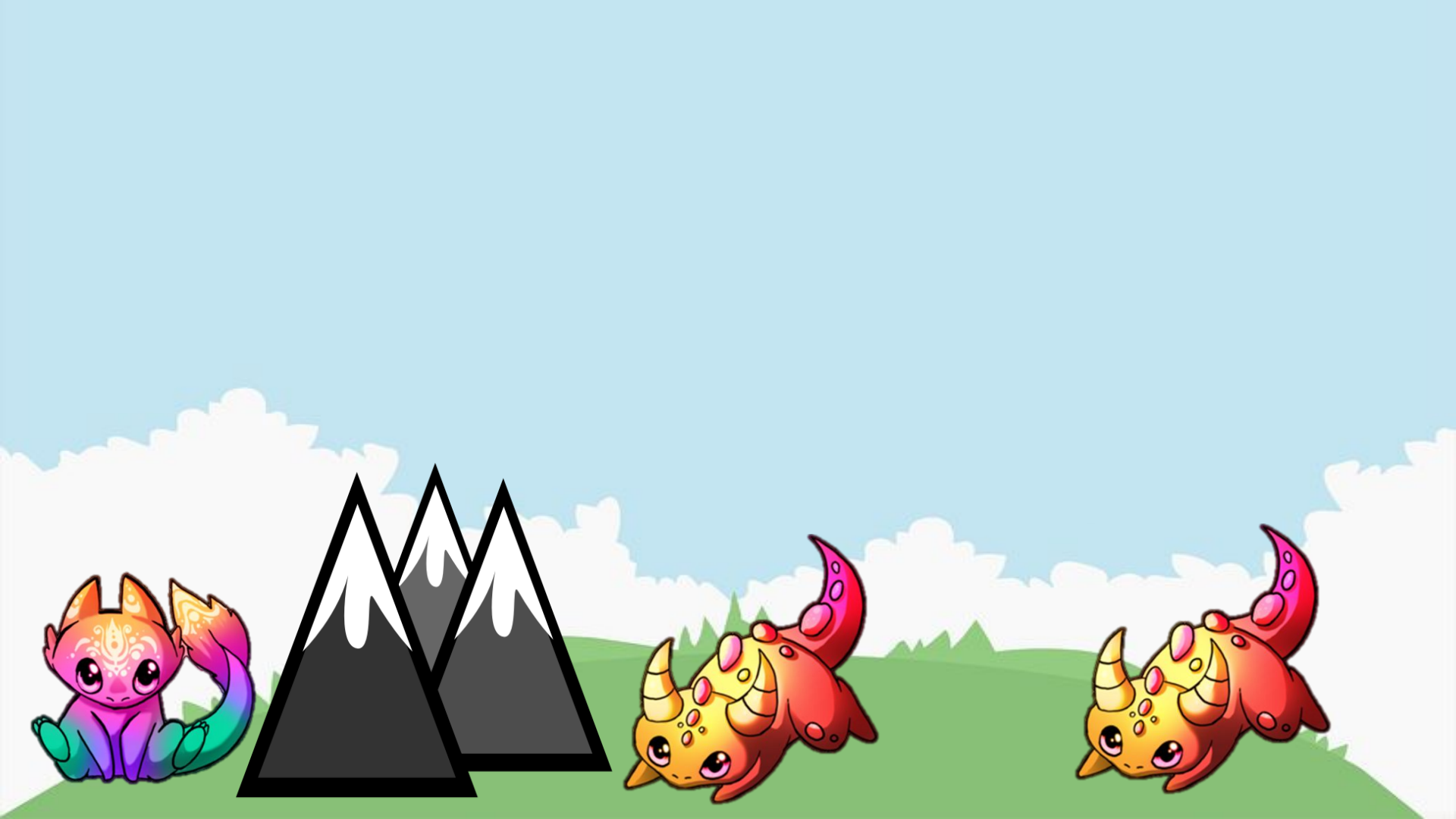


How does speciation occur?

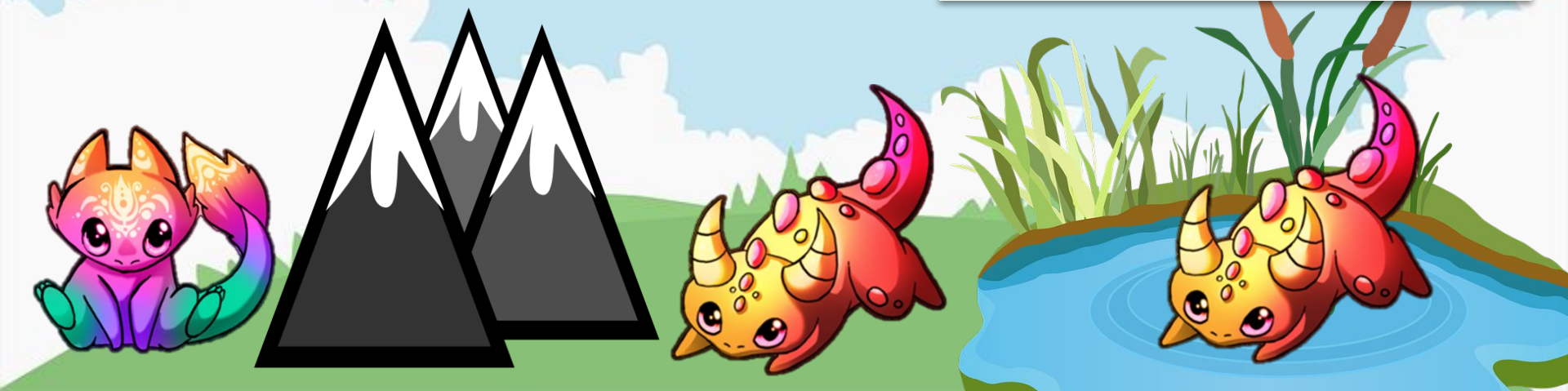
How does speciation occur?

```
'landscape': {
    'layers': {
        <code to make a barrier!>
        }
    },
```

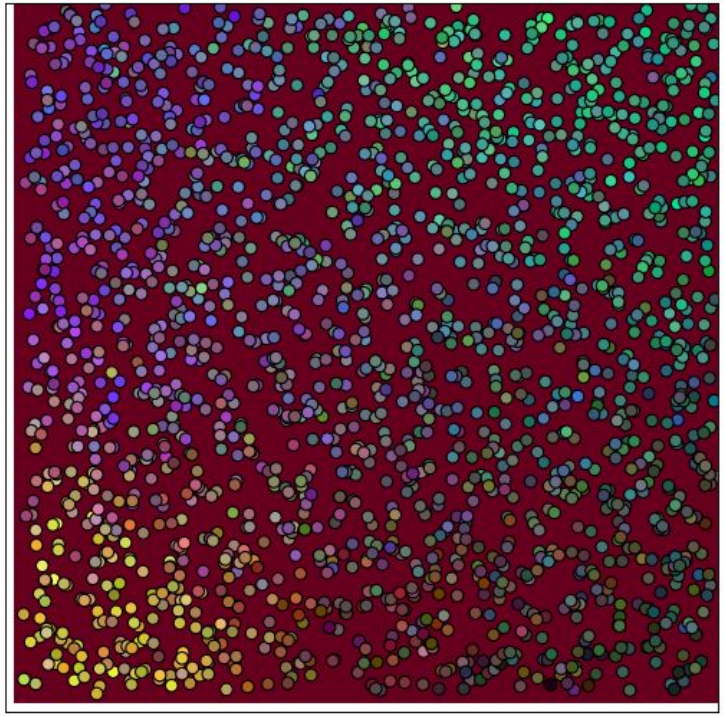




```
'landscape': {
    'layers': {
        <code to make a new environment!>
        }
    },
```

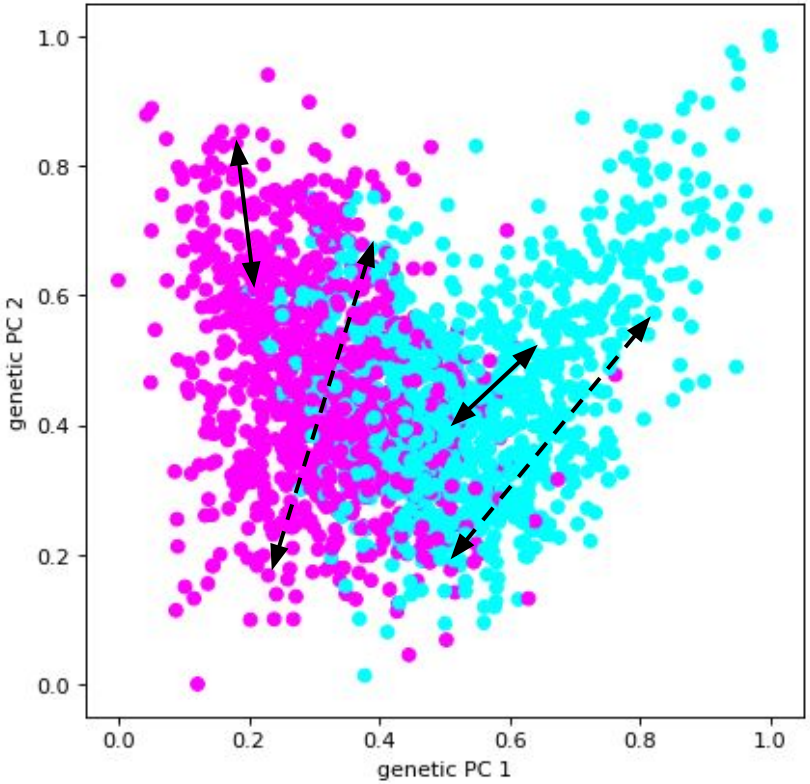


PCA plots



Individuals that have more similar colors are more similar

PCA plots

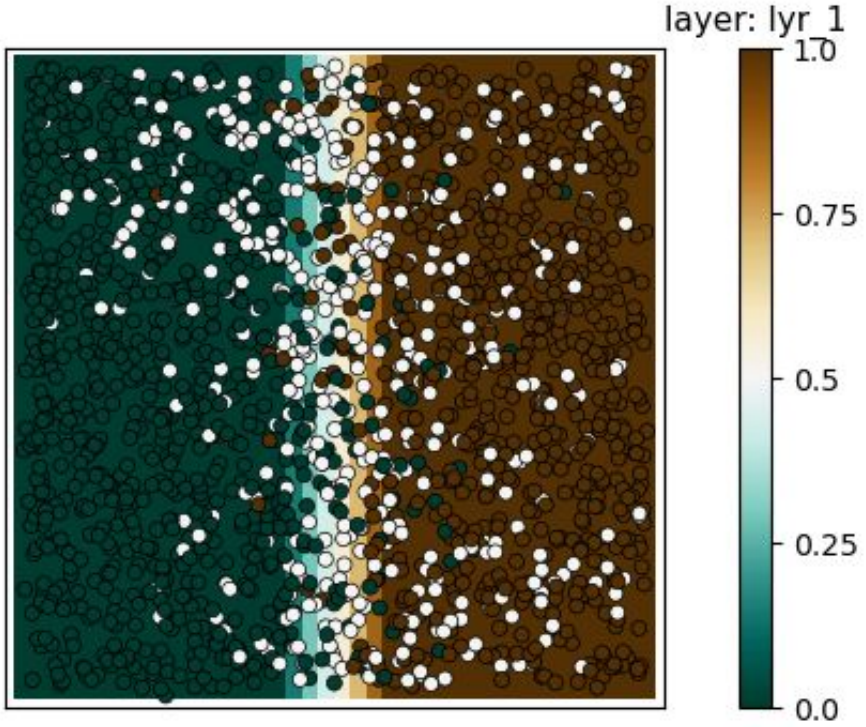


Individuals that are closer on the plot are more similar

Blue = individuals on right side of barrier
Pink = individuals on left side of barrier

Part 2: Natural Selection

Selection plots

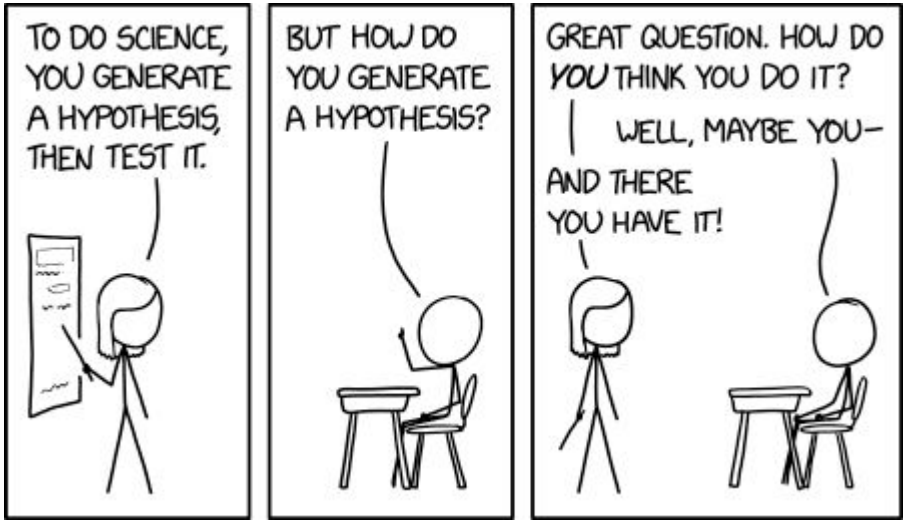


Individual color = trait
Landscape color = env

Individual color matches the background color = local adaptation

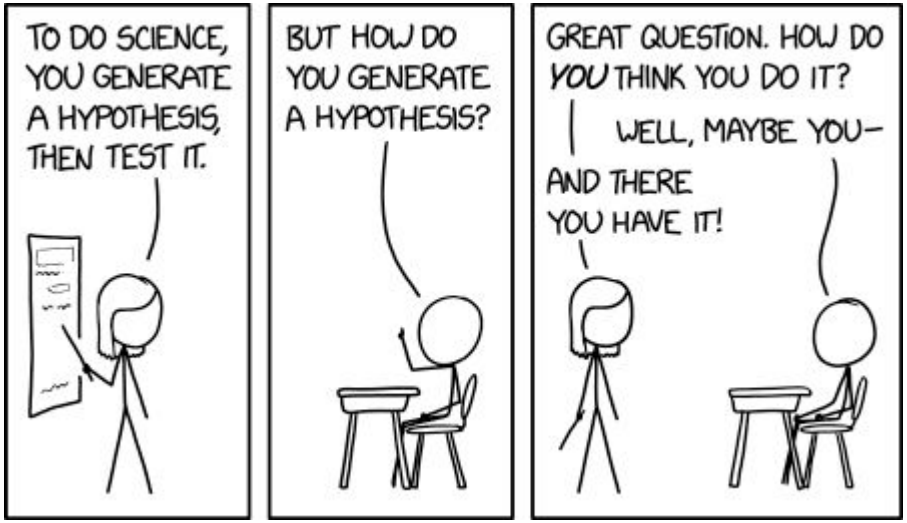
Part 3: Hypothesis Testing

Generating Hypotheses



If we [parameter change], then [outcome with evidence] because [justification]

Generating Hypotheses



If we [parameter change], then [outcome with evidence] because [justification]

If we add a barrier to our landscape, then we will observe differentiation of the populations on either side of the barrier in our PCA plot because of drift

Think-pair-share

1. THINK [5 minutes]: Pick one of the parameters listed in the lab to change and generate a hypothesis.

For ex: if we [increase/decrease parameter X] then we will observe that [mismatch increase/decreases] because [justification]

2. PAIR [5 minutes]: Share your hypothesis with the person next to you. See if you agree with each others expected outcomes.

3. SHARE: Be prepared to share one of your hypotheses with the class.

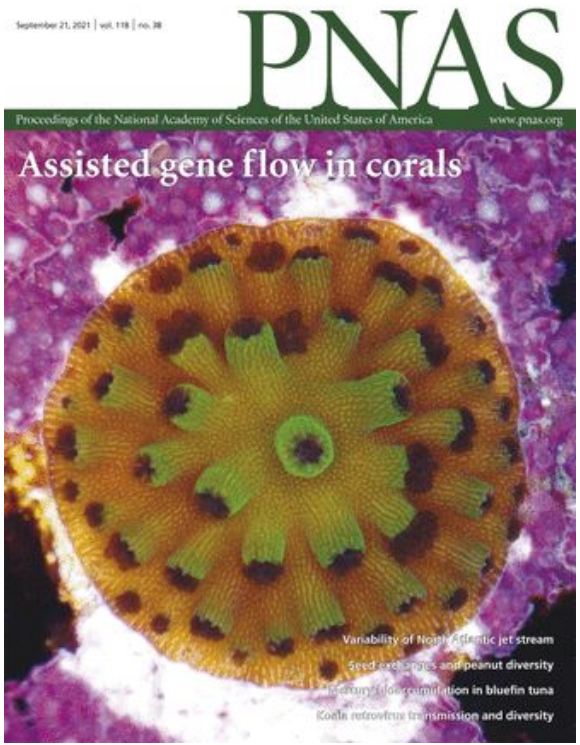
(Before you start running you simulations, answer Question 2)

Why does this matter?

Real world conservation question:
Is gene flow always good?

Testable question:
What is the effect of movement distance on phenotype-environment mismatch?

CLASSROOM POLL: Do you hypothesize that increasing movement distance will increase or decrease phenotype-environment mismatch in our simulations?



https://www.pnas.org/doi/full/10.1073/pnas.2110559118

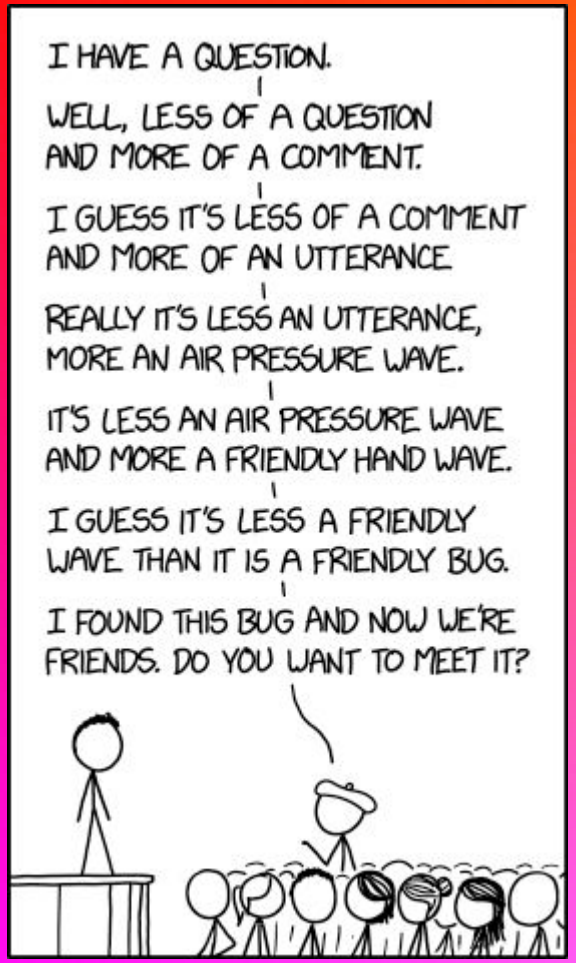
Why does this matter?

A real world conservation question: **Is gene flow always good?**

Testable question: **What is the effect of movement distance on phenotype-environment mismatch?**

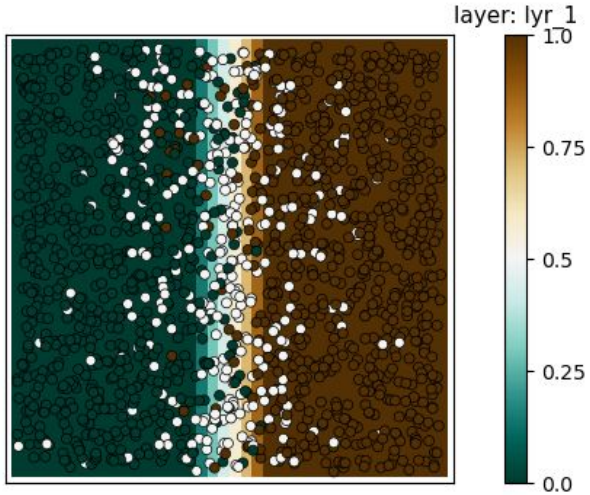
Hypothesis A: If we have more movement, then adaptive alleles can spread more easily through the population, increasing fitness/decreasing mismatch

Hypothesis B: If we have more movement, then alleles that are not adapted to the local environment (i.e., maladaptive alleles) can spread more easily, decreasing fitness/increasing mismatch

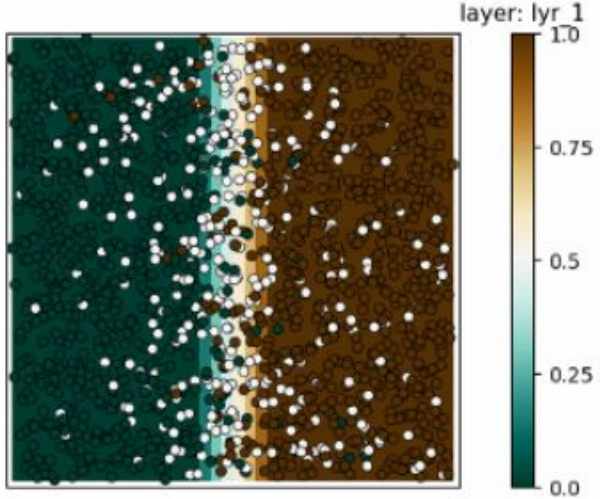


Thanks! Questions?

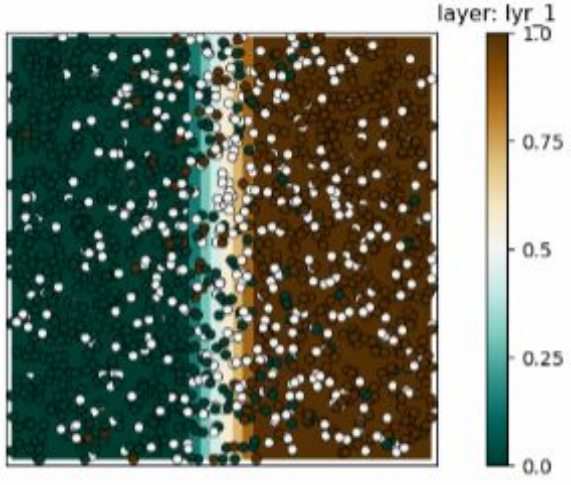
Original (move distance = 0.5)



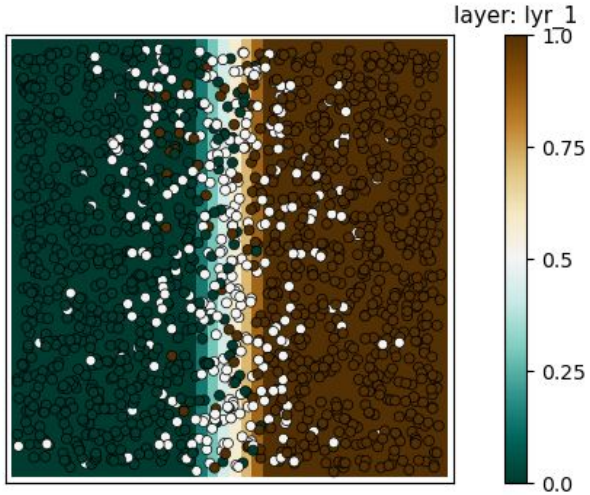
Morgan (new value = 1)



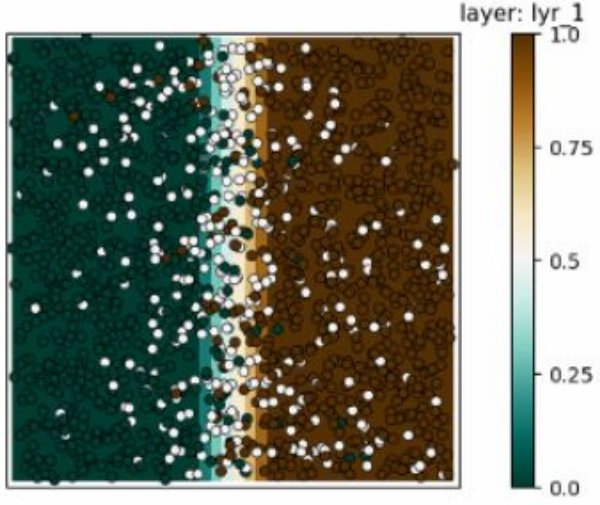
Nathan (new value = 2)



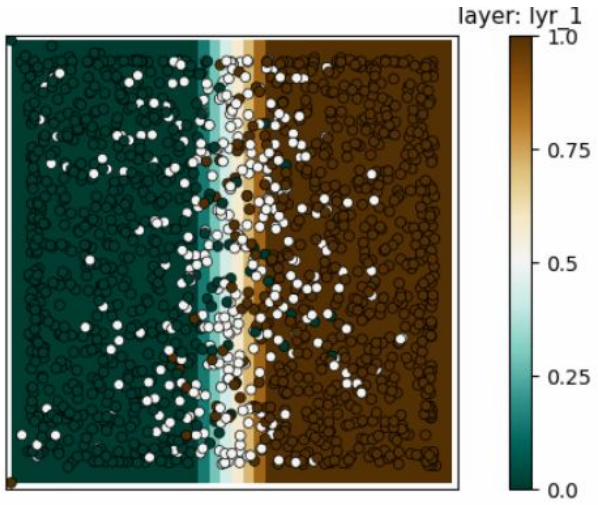
Original (move distance = 0.5)



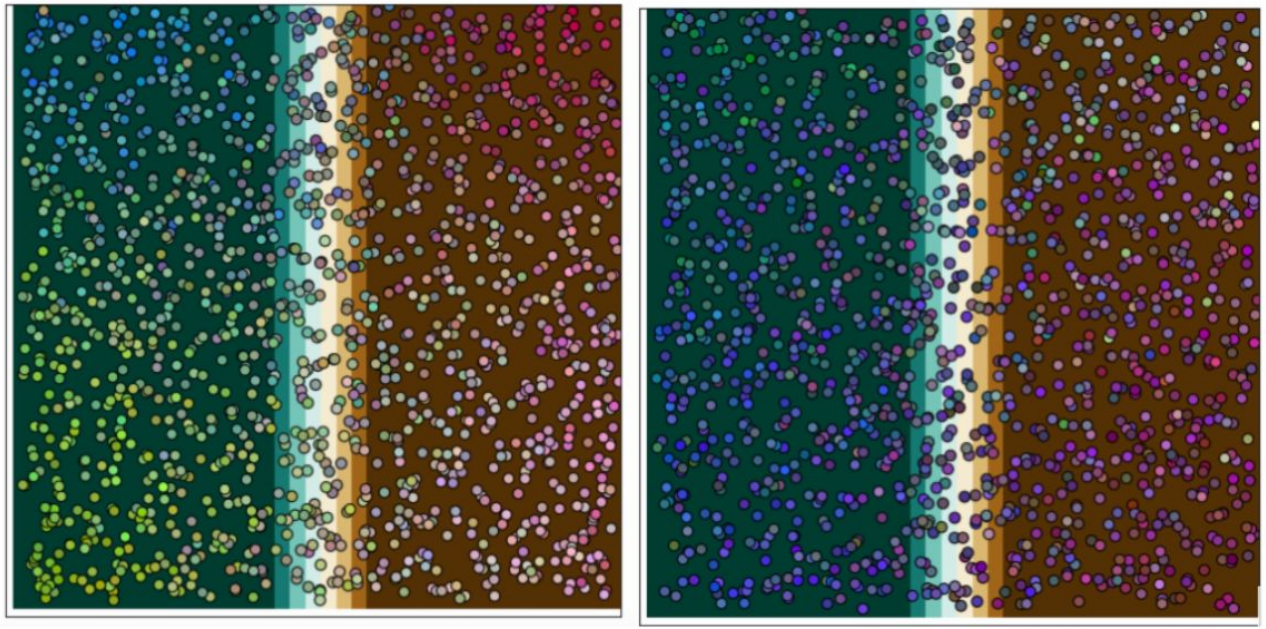
Morgan (new value = 1)



Nathan (new value = 0)



Namrita



mating radius 10 vs 100