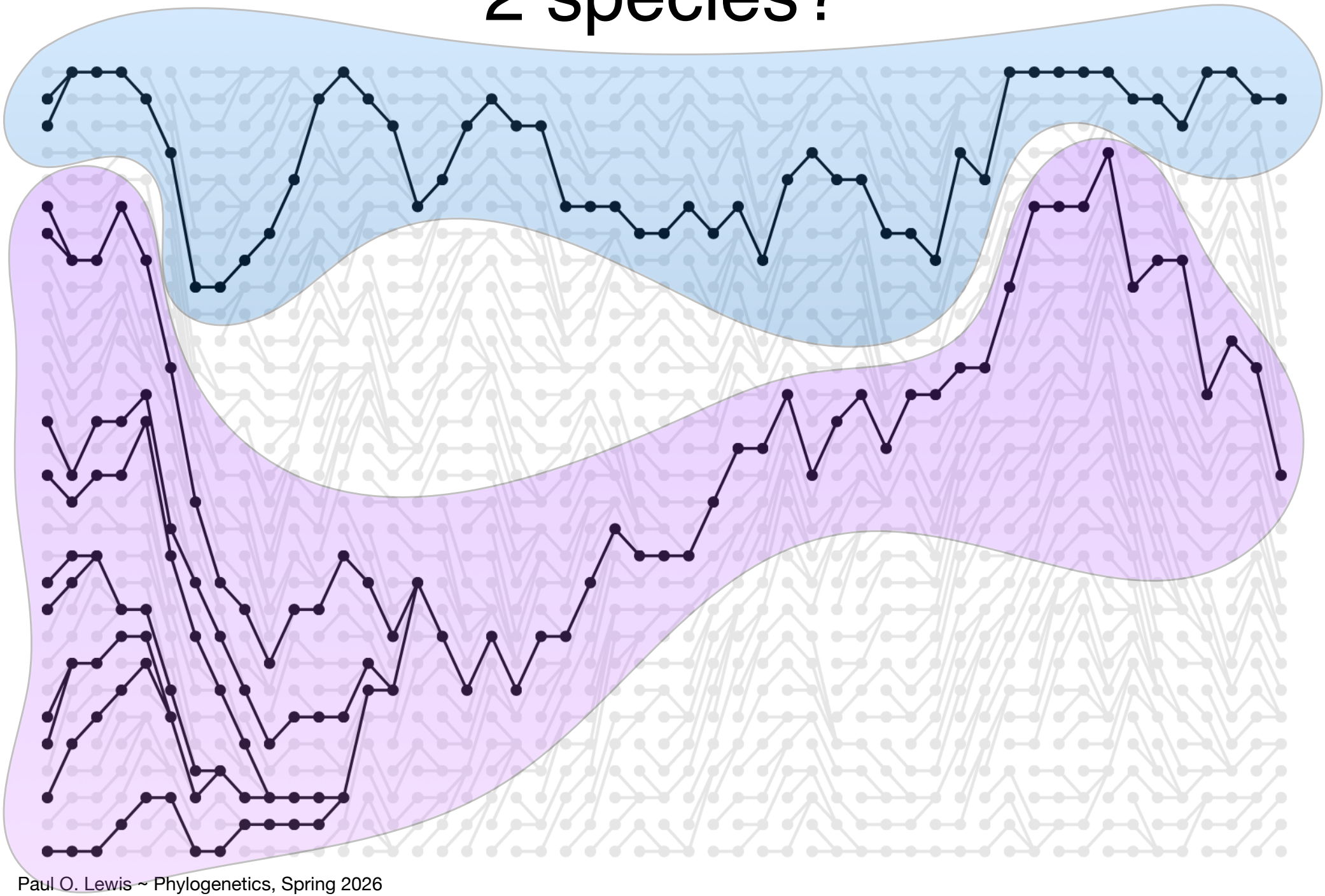
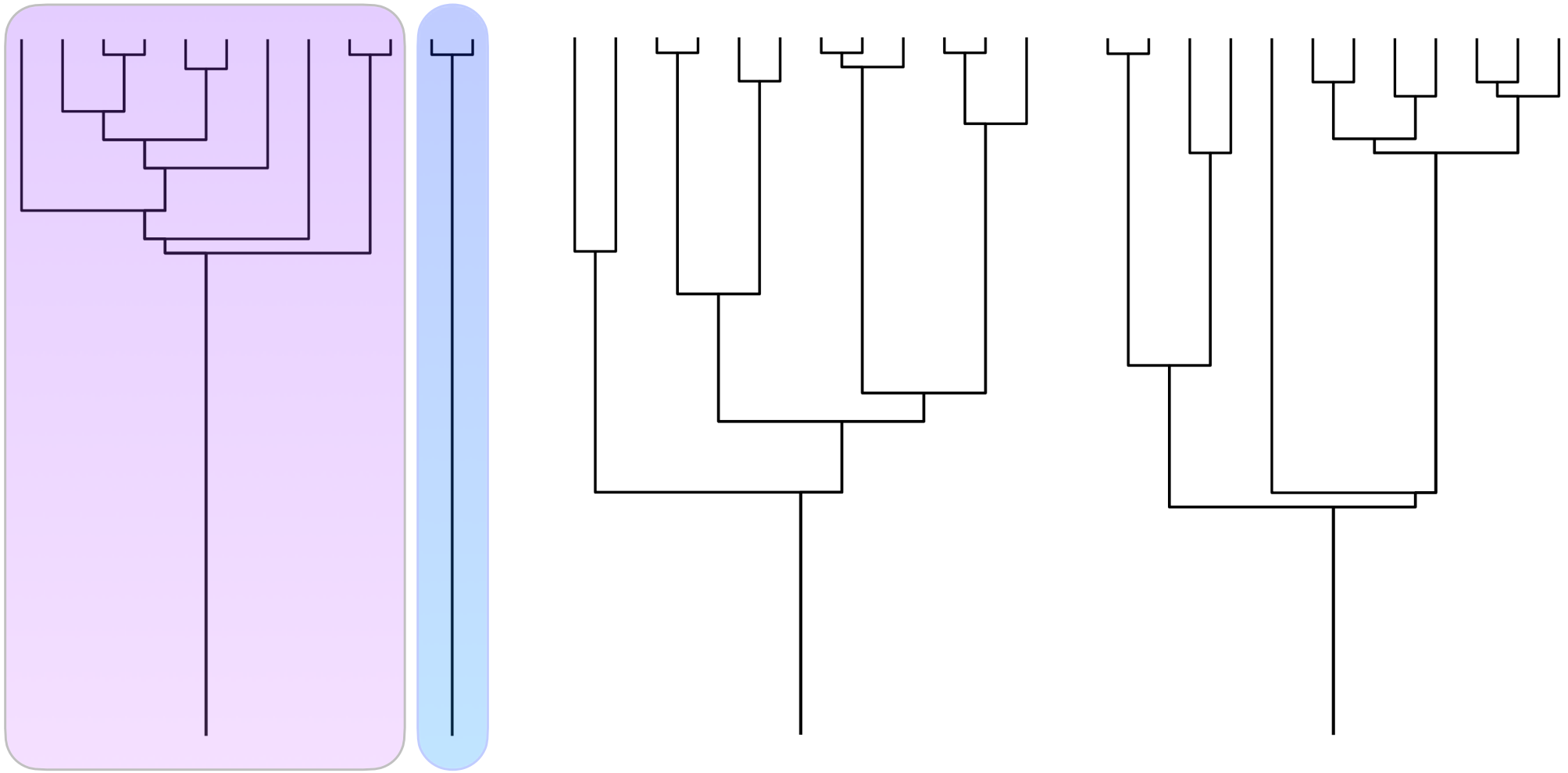
# Bayesian Species Delimitation (BPP software)

# 2 species?

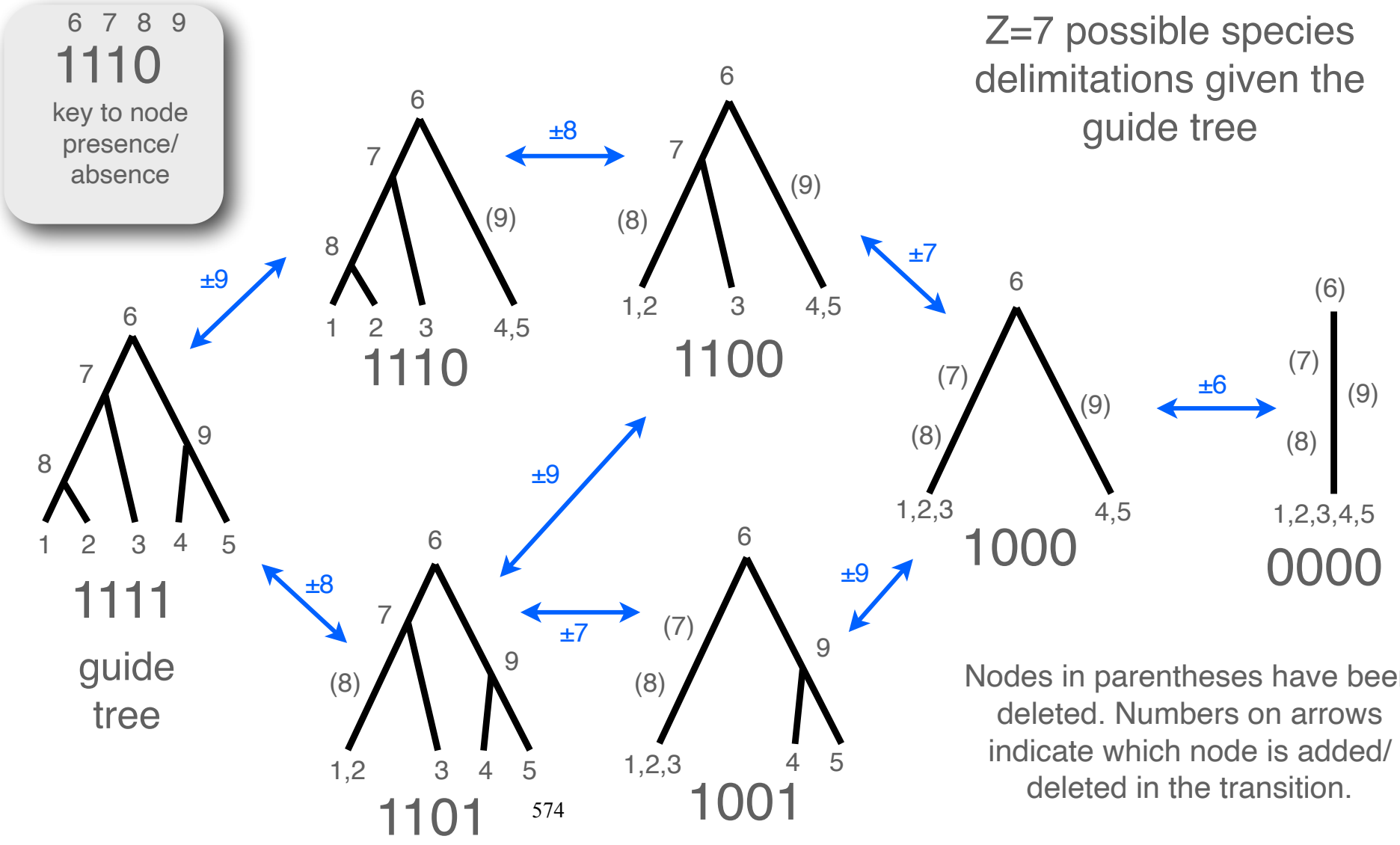


# Maybe just one species after all



gene 1 gene 2 gene 3

# Bayesian Species Delimitation (BPP program)




574

Yang and Rannala (2010)

# Data vs Information

# What is information?

## TAKE AWAY PICKLE JARS

SPECIAL SOURS 10/15
HOT SOUR CUKES 10/15
BIG DILL KOSHER CUKES 10/15
DILLY GREEN BEANS 10/15
CANDY RED BEETS 10/15
SWEET & SPICY CARROTS 10/15
SOUR GREEN TOMATOES 10/15
THYME JALAPENOS 10/15

## PRESERVES TO GO

ORANGE MARMALADE 9
STRAWBERRY JAM 9
SALTED BUTTER 9
MAPLE BUTTER 9
HOUSE MADE SYRUP 9

## BAG OF BISCUITS

4 BISCUITS FOR $11

## GROWLERS

32oz / 64oz

Paul O. Lewis ~ Phylogenetics, Spring 2026

## JACOB'S PICKLES

1 TYPE FOR 5, 4 TYPES FOR 12, 8 TYPES FOR 18

**Special Sours**
**Hot Sour Cukes**
**Big Dill Kosher Cukes**
**Dilly Green Beans**
**Candy Red Beets**
**Sweet & Spicy Carrots**
**Sour Green Tomatoes**
**Thyme Jalapenos**

**Pickled Eggs** Fresh Organic Eggs, Spicy Jalapeno Brine 7

## STARTERS

**FRIED PICKLES** Spicy Red Mayo 11

**BISCUITS & FIXINS** House Strawberry & Orange Preserves, Clover Honey, Salted Butter and Maple Butter 9

**MATZO BALL SOUP** Natural Young Chicken, Noodles, Carrots, Haricot Verts, Onions 12

**GRIT CRUSTED FRIED GREEN TOMATOES** Picnic Sauce 9

**DEVILED EGGS** Pickled Mustard Seed, Smoked Paprika, Micro Arugula 12

**POUTINE** Smothered In Brown Gravy, Cheese, Hollandaise Drizzle 15

**BISCUITS AND GRAVY** Sausage Gravy or Mushroom Gravy 12

**HOMEMADE SLOW COOKED MEATBALLS** Homemade Marinara, Mozzarella14

**OKRA & CHILES** Sliced Pickled Okra, Red Pepper Flakes, Scallions, Liquid Smoke 11

**STREET CORN** Spicy Aioli, Fresh Lime, Crumbled Parmesan 9

## SALADS

Satur Farms Greens From North Fork L.I.

**BUTTERMILK FRIED CHICKEN CAESAR** Romaine, Parmesan Cheese, Biscuit Croutons 18

**GRILLED SALMON SALAD** Baby Greens, Sliced Oranges, Red Onion, Cilantro, Light Orange Vinaigrette 25

**BUTTERMILK FRIED CHICKEN COUNTRY WEDGE** Iceberg, Blue Cheese, Dilly Ranch, Grape Tomatoes, Nitrate Free Bacon 19

**SPICED SHRIMP MARKET KALE SALAD** Toasted Almonds, Dried Cranberries, Raisins, Cherries and Honey-Dijon Vinaigrette With Shrimp 24

Consumer Advisory: Consumption of Undercooked Meat, Poultry, Eggs, or Seafood May Increase the risk of Foodborne Illnesses. Please Inform Your Server If Anyone In Your Party Has A Food Allergy or Any Special Dietary Needs.
Max Split For Credit Card 6 Per Table.
No Substitutions Please.

## SOUTHERN BISCUIT SANDWICHES

Served With Grain Miller Organic Cheese Grits

**HONEY CHICKEN AND PICKLES** Buttermilk Fried Chicken, Hot Sours, Clover Honey 17

**SOUTHERN B.L.T** Buttermilk Fried Chicken, Fried Green Tomatoes, Pickle Slaw, Picnic Sauce, Nitrate Free Bacon 18

**SAUSAGE GRAVY SMOTHERED CHICKEN** Buttermilk Fried Chicken 17

**MUSHROOM GRAVY SMOTHERED CHICKEN** Buttermilk Fried Chicken, Aged Vermont Cheddar 17

**BBQ SMOTHERED PEPPER JACK CHICKEN** Buttermilk Fried Chicken, House Made Creamy BBQ, Vermont Pepper Jack 17

**HOT CHICKEN BISCUIT** Buttermilk Fried Chicken, Nashville Hot Sauce, Hot Sour Pickles 17

**CHICKEN BACON EGG & CHEESE** Buttermilk Fried Chicken, Nitrate Free Bacon, Egg, Picnic Sauce, 2 Year Aged Vermont Cheddar 18

## HOME COOKING

**CHICKEN & PANCAKES** Buttermilk Fried Chicken, Crispy Nitrate Free Bacon, Homemade Syrup 19

**JACOB'S PATTY MELT** Jacob's Beef Burger Blend, Toasted Buttermilk Loaf, melted Cheddar Cheese, Crispy Onions, Lettuce, Pickle Sauce, Big Dill Kosher Cukes, Fresh Cut Fries 17

**CATFISH TACOS** Grilled Catfish, Lime Crema, Cilantro Slaw, Fresh Lime, pickled carrot and jalapenos 21

**SHRIMP & BACON GRITS** Whole Wild Shrimp, Nitrate Free Bacon, Organic Cheese Grits 24

**LOW COUNTRY MEATLOAF** Sweet and Smokey Meatloaf, Whipped Potatoes, Frizzled Onions, coleslaw, Buttermilk Biscuit smothered in Maple Butter 23

**BABY BACK RIBS** Loaded Baked Potato, Pickle Slaw, BBQ Sauce 26

**TURKEY LEG** Whipped potatoes, Home Made Biscuit Stuffing, cranberry compote, turkey gravy 21

**BUTTERMILK FRIED CHICKEN THIGH BASKET** Pork Shoulder Braised Collard Greens, Mashed Potatoes with Turkey Gravy, Buttermilk Biscuit with Sweet Butter 23

**GUMBO** Cajun Spiced Shrimp, Andouille sausage, carolina rice, Fried Okra 28

## MAC & CHEESE

**CLASSIC MAC & CHEESE** 14 / 21

**BUFFALO CHICKEN MAC & CHEESE** Blue Cheese Drizzle 16 / 24

**CHEESEBURGER MAC & CHEESE** Ground Salisbury Sirloin, Aged Vermont Cheddar Blend, Ketchup 16 / 24

## SIDES

**COLLARD GREENS & BLACK EYED PEAS** With Braised Pork Shoulder 13

**HOUSE FRIES** House Ketchup, Mayo, Pickle Brine 12

**PICKLE SLAW** 8

**HOUSE SALAD** 10

**ORGANIC CHEESE GRITS** 8

**MASHED POTATOES & MUSHROOM GRAVY** 8

## BEER

a selection of american craft brews

## BISCUITS

baked from scratch

## PICKLES

handmade in small batches

## JAMS

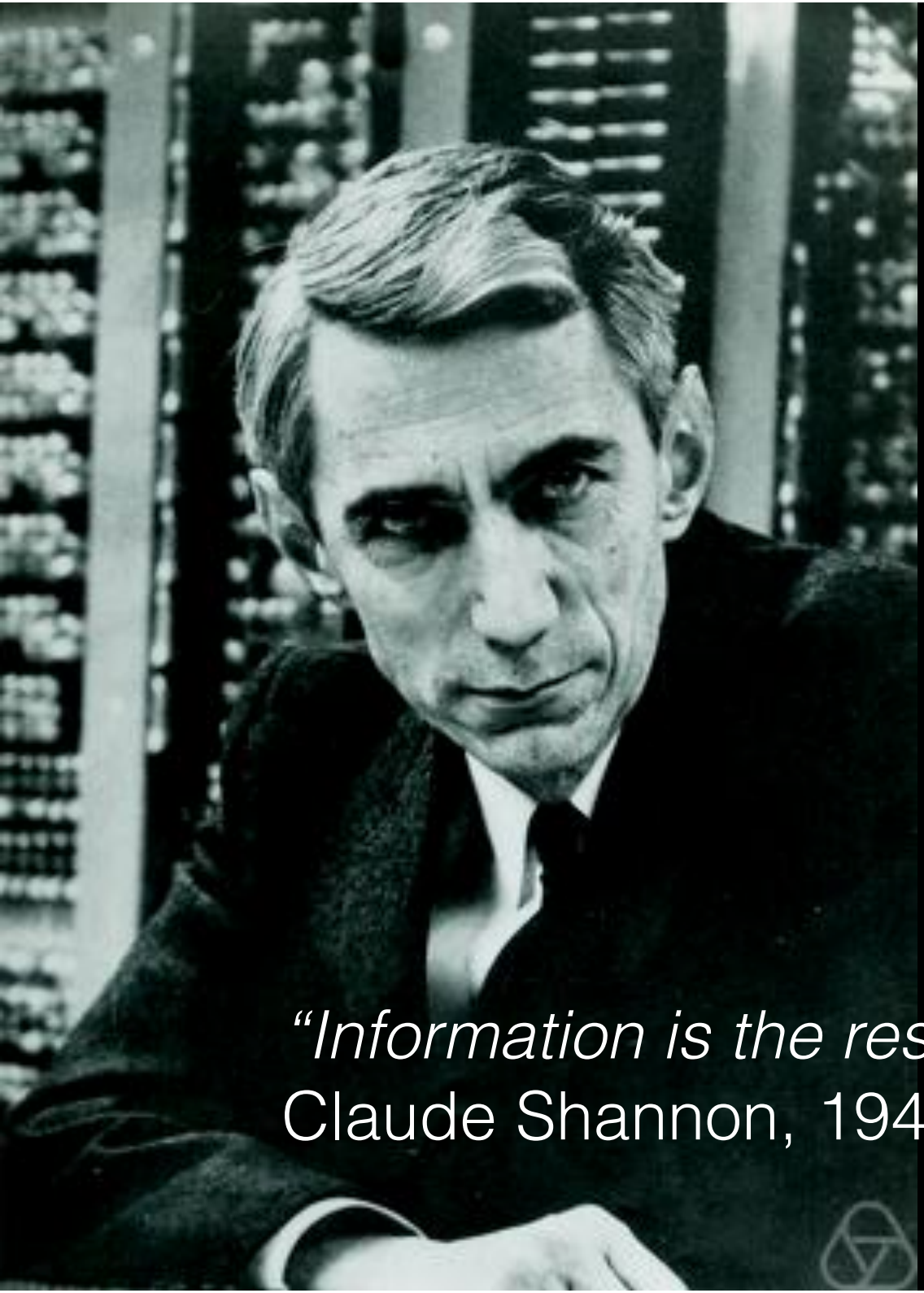
housemade from whole fruits

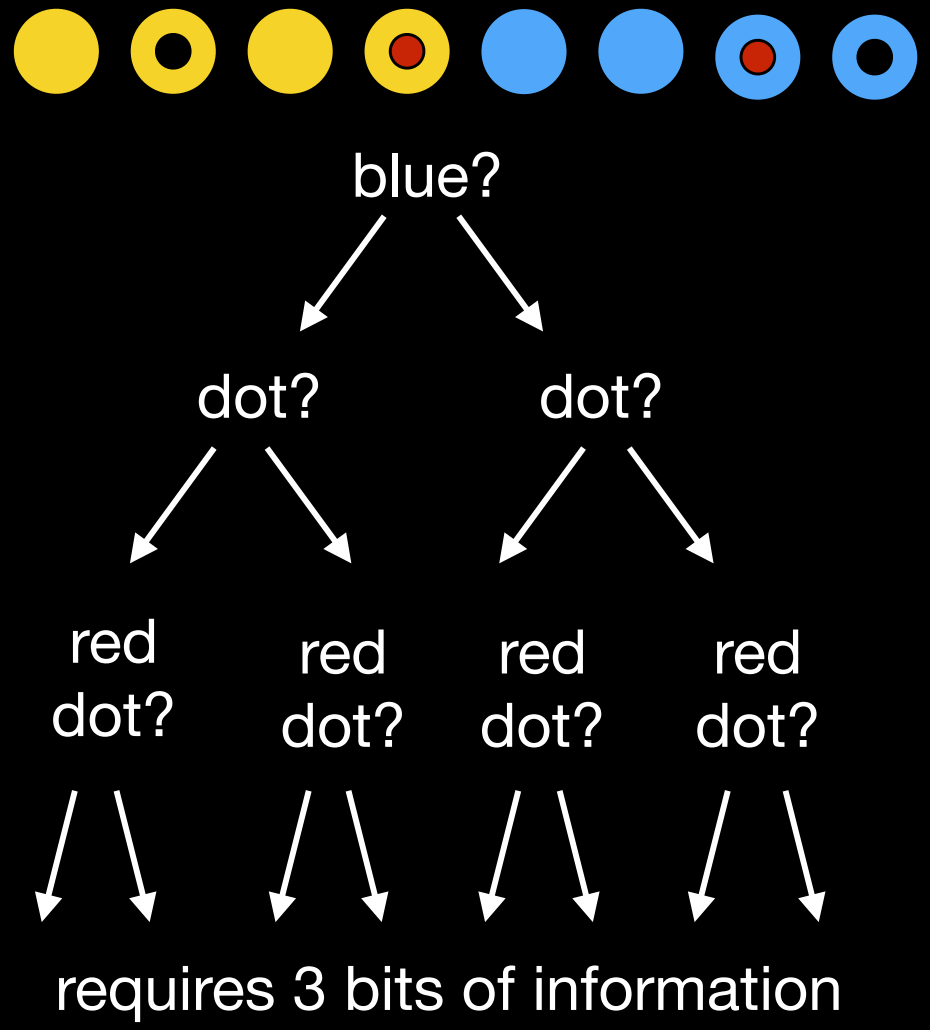
## MEATS

sustainably and humanely raised

JACOB'S PICKLES

509 AMSTERDAM
NYC






*"Information is the resolution of uncertainty"* —
Claude Shannon, 1948

photo: https://geniuses.club/genius/claude-elwood-shann

# Information=Data?

| 14 taxa | 20 characters | 20 characters |
|---|---|---|
| esotericum | 00000000000000000000 | 10000100100001111101 |
| heterosepalum | 00000000000000000000 | 00010111011110101000 |
| kellogii | 00000000000000000000 | 10000100100000111101 |
| majus | 00000000000000000000 | 01001000110000000110 |
| minimum | 00000000000000000000 | 00001100100000000010 |
| montanum | 00000000000000000000 | 01000000110000000110 |
| nuttallii | 00000000000000000000 | 00001000110000000010 |
| paronychioides | 00000000000000000000 | 10101000110000000110 |
| parryi | 00000000000000000000 | 00001111011110101000 |
| polygaloides | 00000000000000000000 | 10000100100001110101 |
| sawatchense | 00000000000000000000 | 00000000110000000110 |
| shastense | 00000000000000000000 | 10101100010000000000 |
| spergulariaeoides | 00000000000000000000 | 00001000110000000110 |
| tenue | 00000000000000000000 | 00001100010000100010 |

# Which has less information?

| 14 taxa | 20 sites | 20 sites |
|---|---|---|
| esotericum | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |
| heterosepalum | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |
| kellogii | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |
| majus | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |
| minimum | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |
| montanum | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |
| nuttallii | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |
| paronychioides | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |
| parryi | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |
| polygaloides | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |
| sawatchense | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |
| shastense | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |
| spergulariaeoides | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |
| tenue | AAAAAAAAAAAAAAAAAAAA | ???????????????????? |

# Which has less information?

| 14 taxa | 20 constant sites | 20 random sites |
|---|---|---|
| esotericum | AAAAAAAAAAAAAAAAAAAA | TAGAGCGCCCAGTCTTCCAG |
| heterosepalum | AAAAAAAAAAAAAAAAAAAA | ATATCACGTACCCGAATTGT |
| kellogii | AAAAAAAAAAAAAAAAAAAA | GGCATTGAAGAGAGGCTTTG |
| majus | AAAAAAAAAAAAAAAAAAAA | TTCTGTGTTGACAAGTTAGT |
| minimum | AAAAAAAAAAAAAAAAAAAA | ATTTCCGAAAATCGTGTGCA |
| montanum | AAAAAAAAAAAAAAAAAAAA | GCATCGCATACTCCCCCTCG |
| nuttallii | AAAAAAAAAAAAAAAAAAAA | ATATTGCTTGAATCAAGAGC |
| paronychioides | AAAAAAAAAAAAAAAAAAAA | GTATTTTACAGGCCGGGCAA |
| parryi | AAAAAAAAAAAAAAAAAAAA | ATGTGATTATGAGAGTTTAT |
| polygaloides | AAAAAAAAAAAAAAAAAAAA | ATGGCAAGTACGAGTTTTCG |
| sawatchense | AAAAAAAAAAAAAAAAAAAA | TTCCGGATCCGTTATGCCAG |
| shastense | AAAAAAAAAAAAAAAAAAAA | CGAATGGGCCACACAATTTA |
| spergulariaeoides | AAAAAAAAAAAAAAAAAAAA | AACCGAATGTGGTATTGGCG |
| tenue | AAAAAAAAAAAAAAAAAAAA | GACGACCCGGGGAACACGAA |

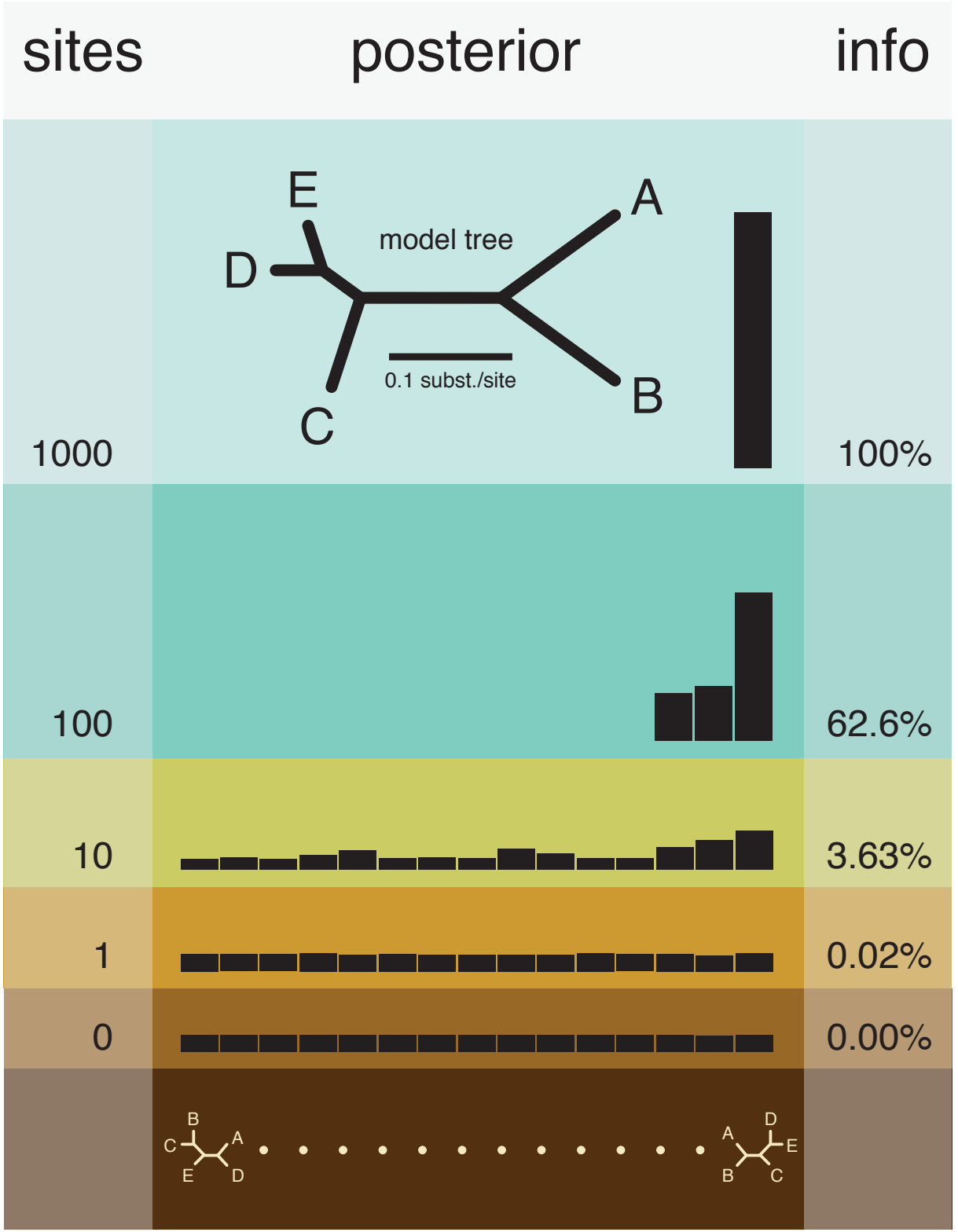
# Overexposed


Underexposed

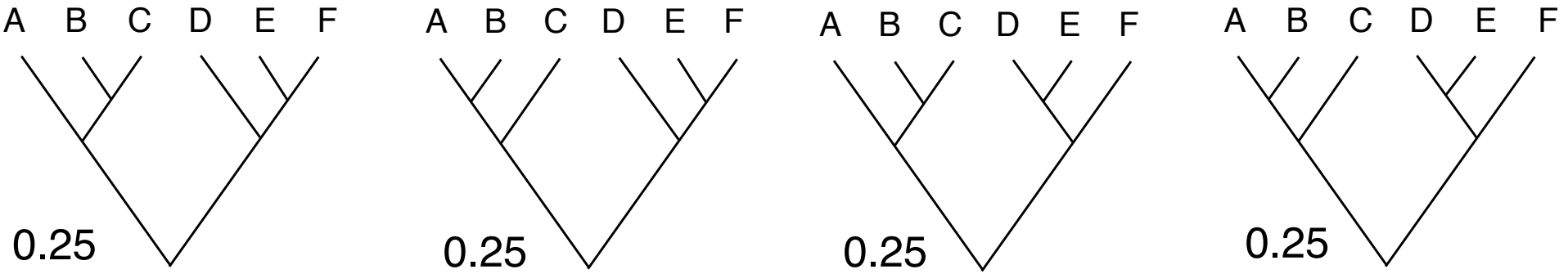
# Just right

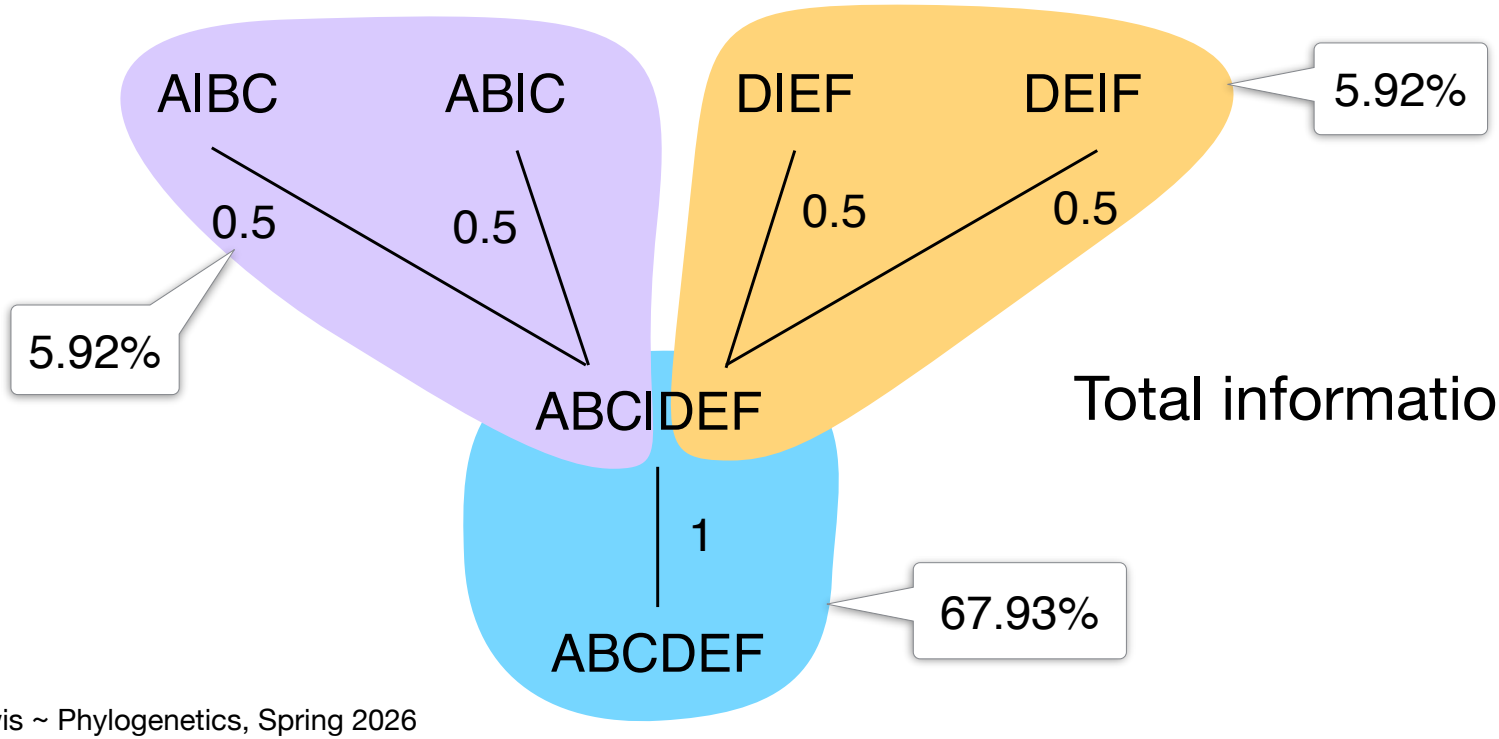
# Bayesian Phylogenetic Information Content

Lewis et al. 2016



# Information can be partitioned by clade




Total information = 79.77%

# Information

| Relative rate | %I |
|---|---|
| 0.01 | 18 |
| 0.1 | 99 |
| 1 | 100 |
| 10 | 64 |
| 100 | 1.5 |

| Percent missing | %I |
|---|---|
| 0 | 100 |
| 50 | 98 |
| 100 | 0 |

| Rate variance | %I |
|---|---|
| 1 | 100 |
| 10 | 97 |
| 100 | 13 |
| 1000 | 0 |

# Morphology vs. molecules in *Polygonella*

## DNA (ITS+rbcL)

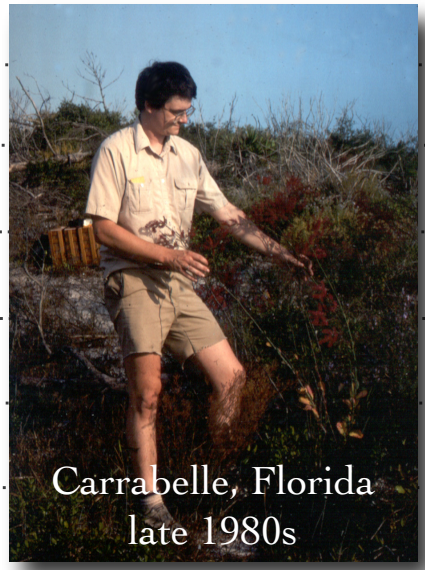
1877 characters

I = **90.4%** (0.048/char.)

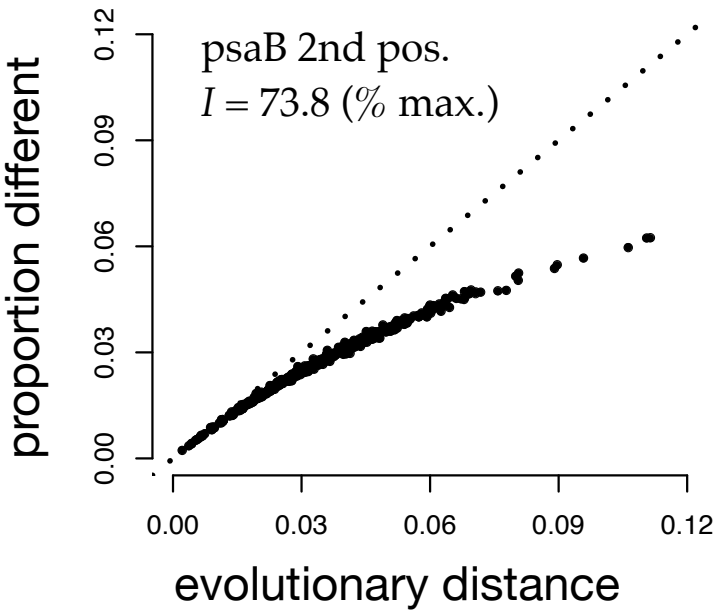
## Morphology

39 characters

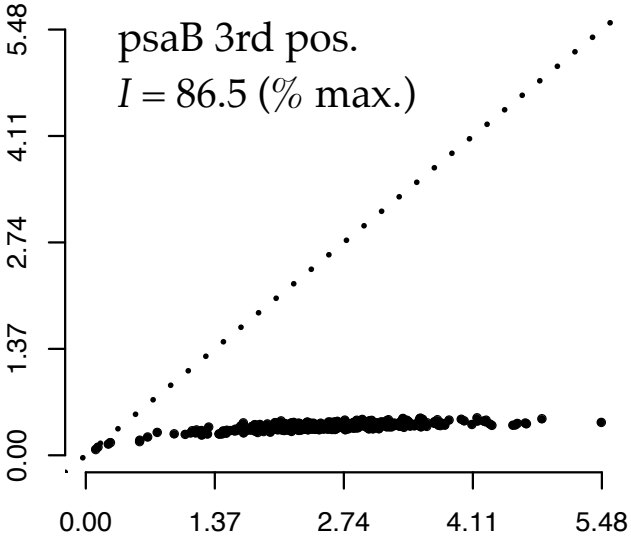
I = **73.6%** (1.887/char.)

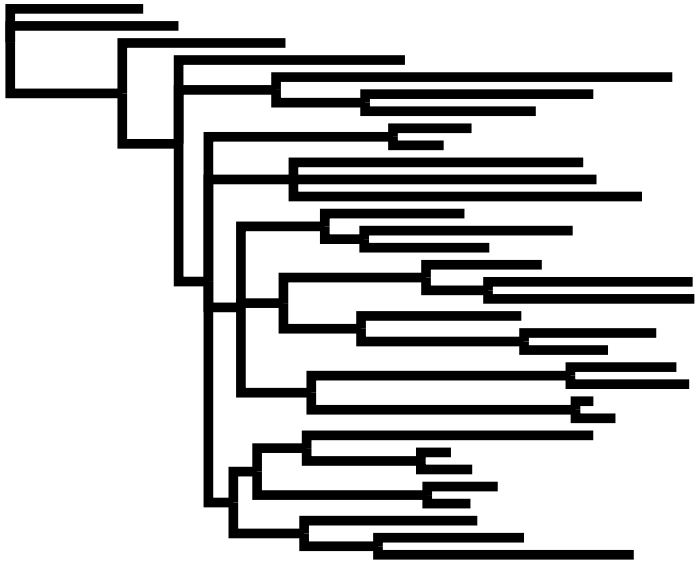



a.



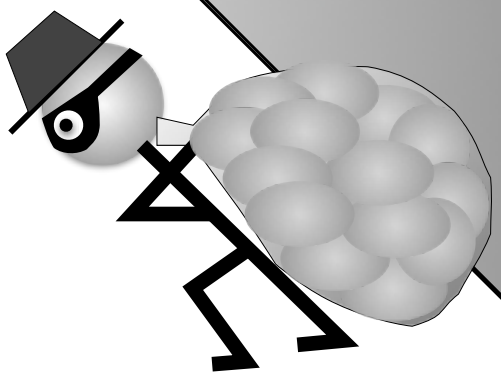

b.

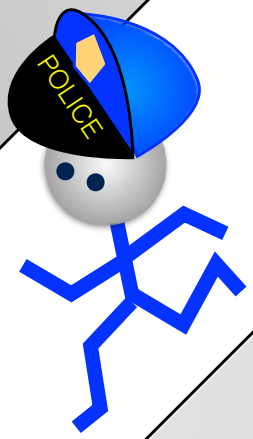


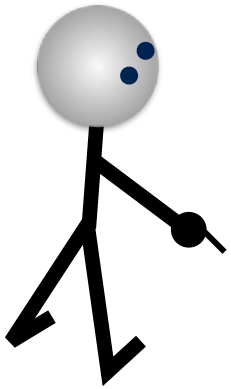



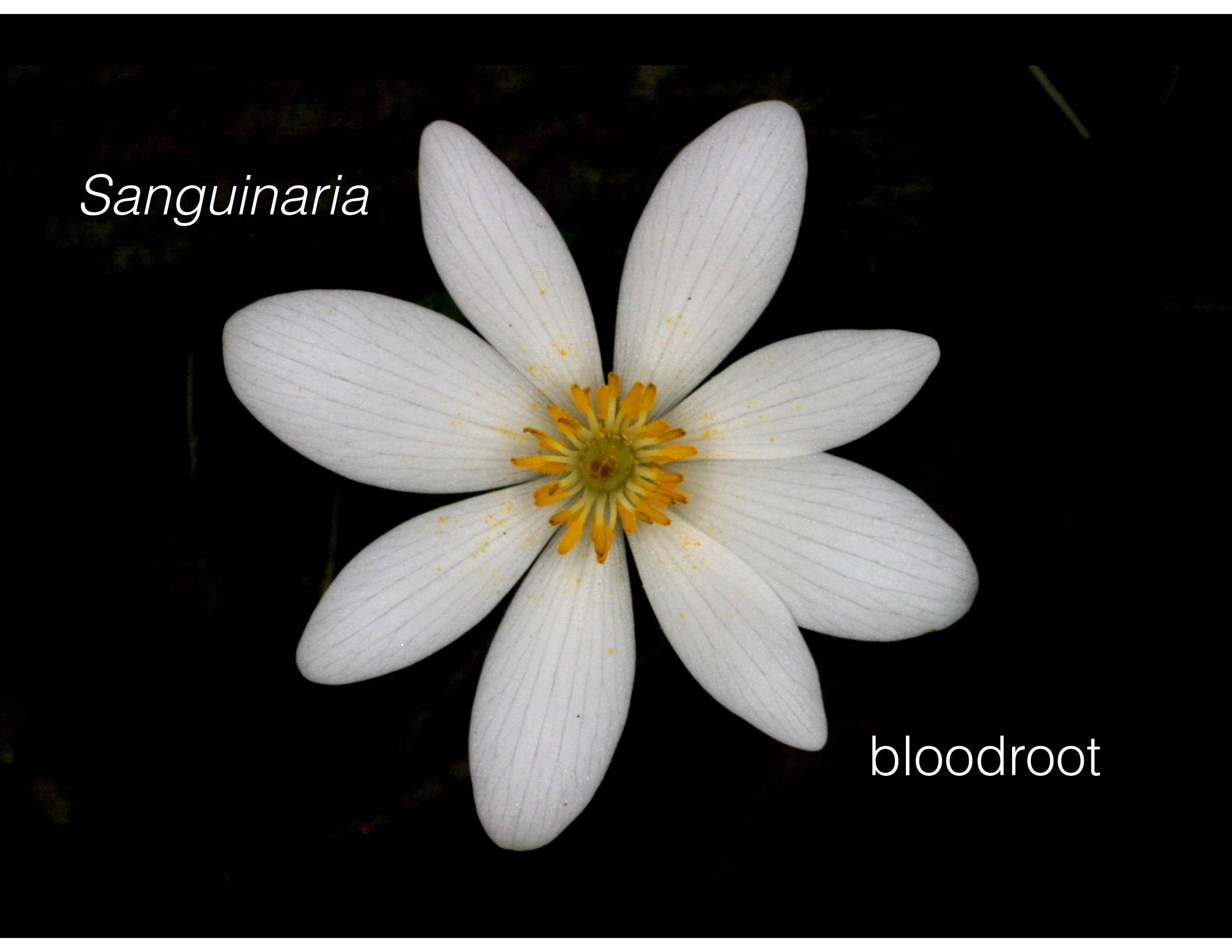
3rd positions have ***more*** information than 2nd positions

# Information can be **false** information!

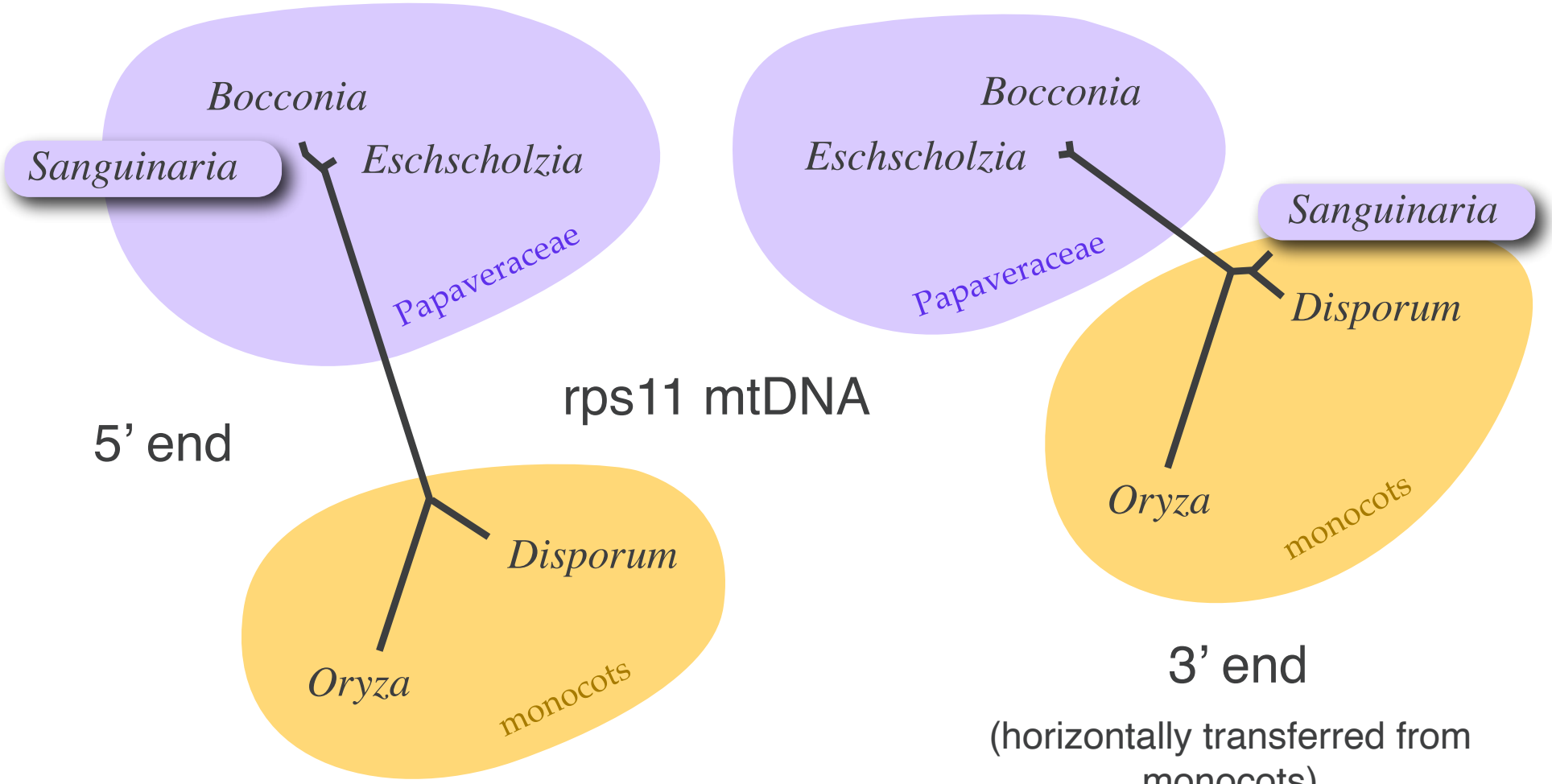





*Sanguinaria*
bloodroot

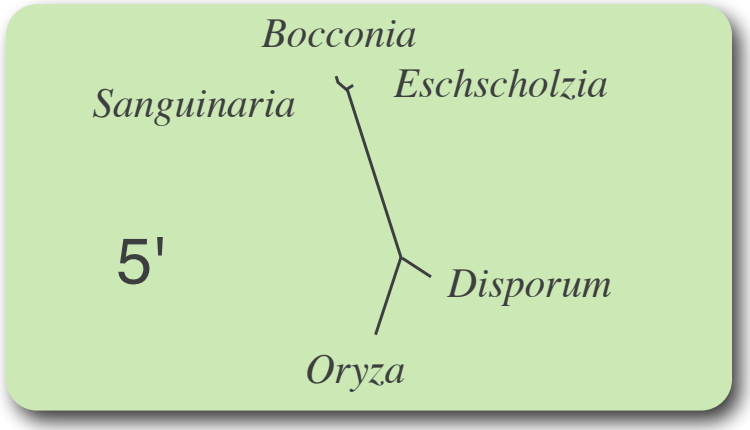
# Horizontal transfer results in conflicting information about the placement of bloodroot (*Sanguinaria*)

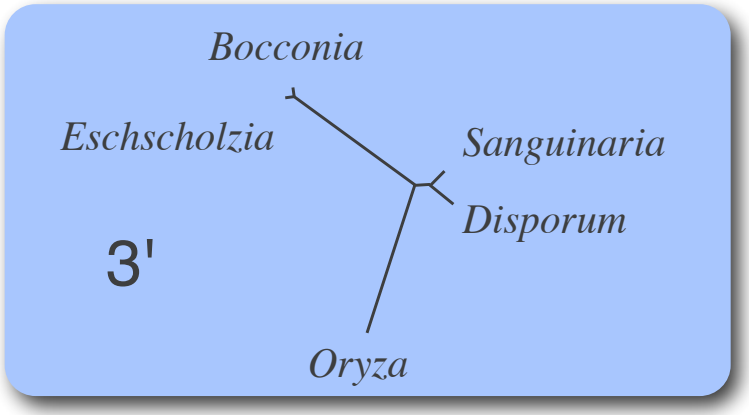





Bergthorsson et al. 2003

# Each data set strongly rejects the other's favorite tree, so a mediocre tree wins everything




| Topology | 5’ | 3’ | Concatenated |
|---|---|---|---|
| **((S,D),O),E,B)** | --- | 0.64 | --- |
| ((S,O),D),E,B) | --- | 0.18 | --- |
| ((O,D),S),E,B) | 0.11 | 0.18 | 1 |
| (O,D,(B,(S,E)) | 0.12 | --- | --- |
| **(O,D,(E,(S,B))** | 0.77 | --- | --- |
| Info | 74.2% | 66.7% | 100% |

# Dissonance is the difference between merged info and average info

| Topology | 5’ | 3’ | Merged |
|---|---|---|---|
| **((S,D),O),E,B)** | --- | 0.64 | 0.32 |
| ((S,O),D),E,B) | --- | 0.18 | 0.09 |
| ((O,D),S),E,B) | 0.11 | 0.18 | 0.14 |
| (O,D,(B,(S,E)) | 0.12 | --- | 0.06 |
| **(O,D,(E,(S,B))** | 0.77 | --- | 0.39 |
| Info | 74.2% | 66.7% | 48.6% |

average info = 70.5

dissonance

21.9

# What if instead of conflicting...

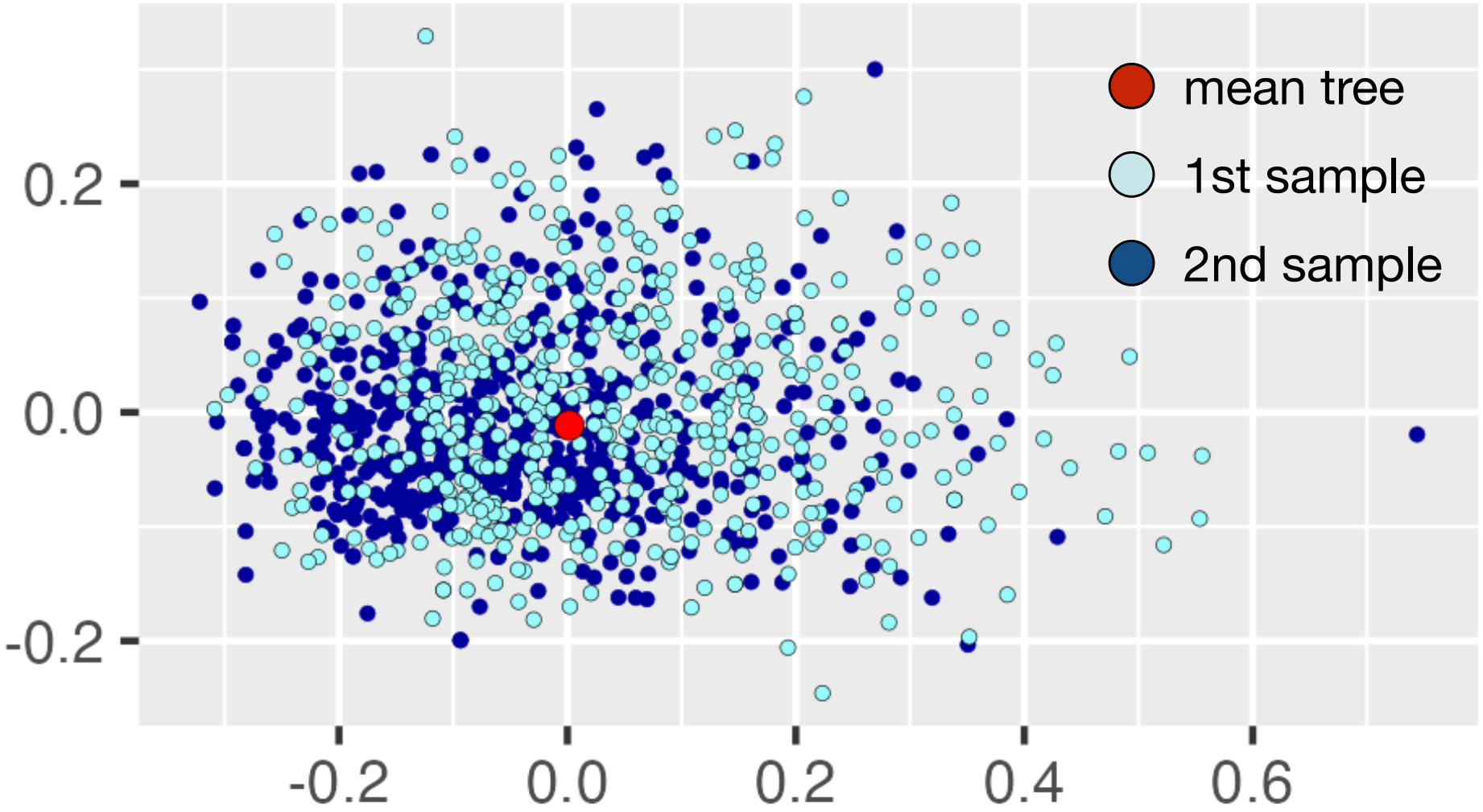
| Topology | 5’ | 3’ | Merged |
|---|---|---|---|
| ((S,D),O),E,B) | --- | --- | --- |
| ((S,O),D),E,B) | --- | --- | --- |
| ((O,D),S),E,B) | 0.11 | 0.18 | 0.145 |
| (O,D,(B,(S,E)) | 0.12 | 0.18 | 0.150 |
| (O,D,(E,(S,B)) | 0.77 | 0.64 | 0.705 |
| Info | 74.2% | 66.7% | 70.1% |

average info = 70.7

dissonance

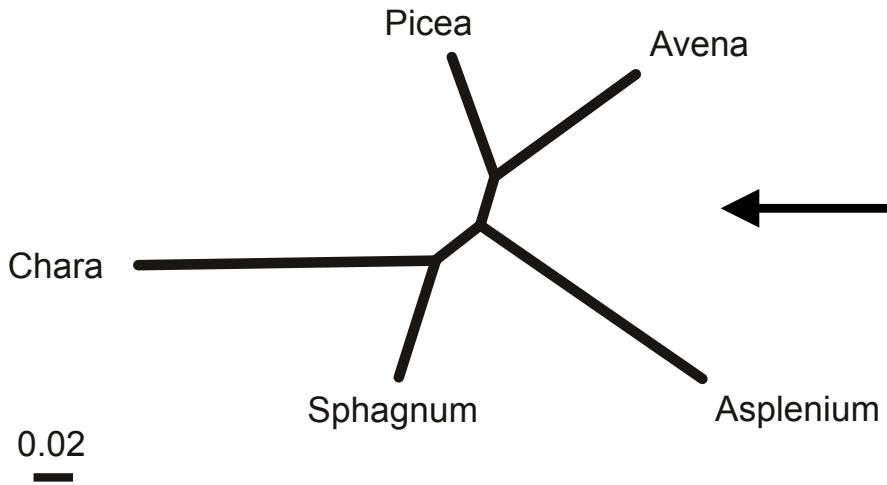
0.06

# New approach using geodesic distances



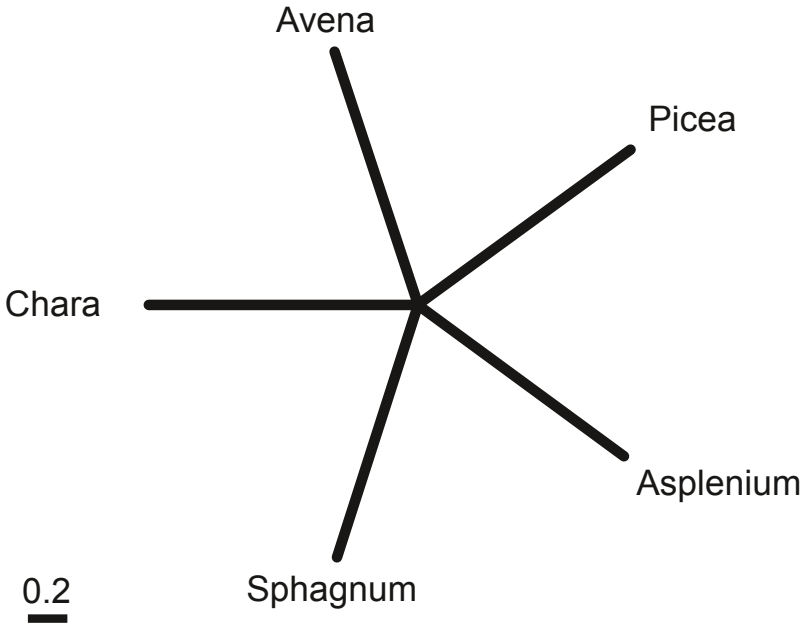

Milkey and Lewis (2026)

# Mean trees




posterior mean tree

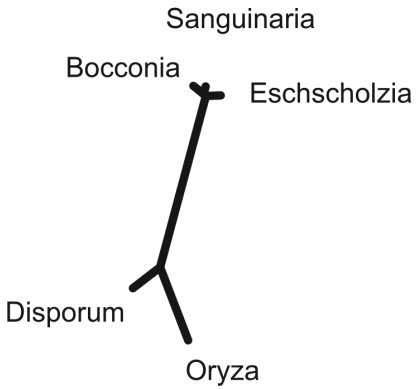
prior mean tree



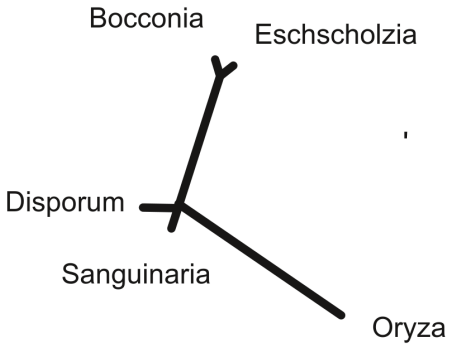
# Information

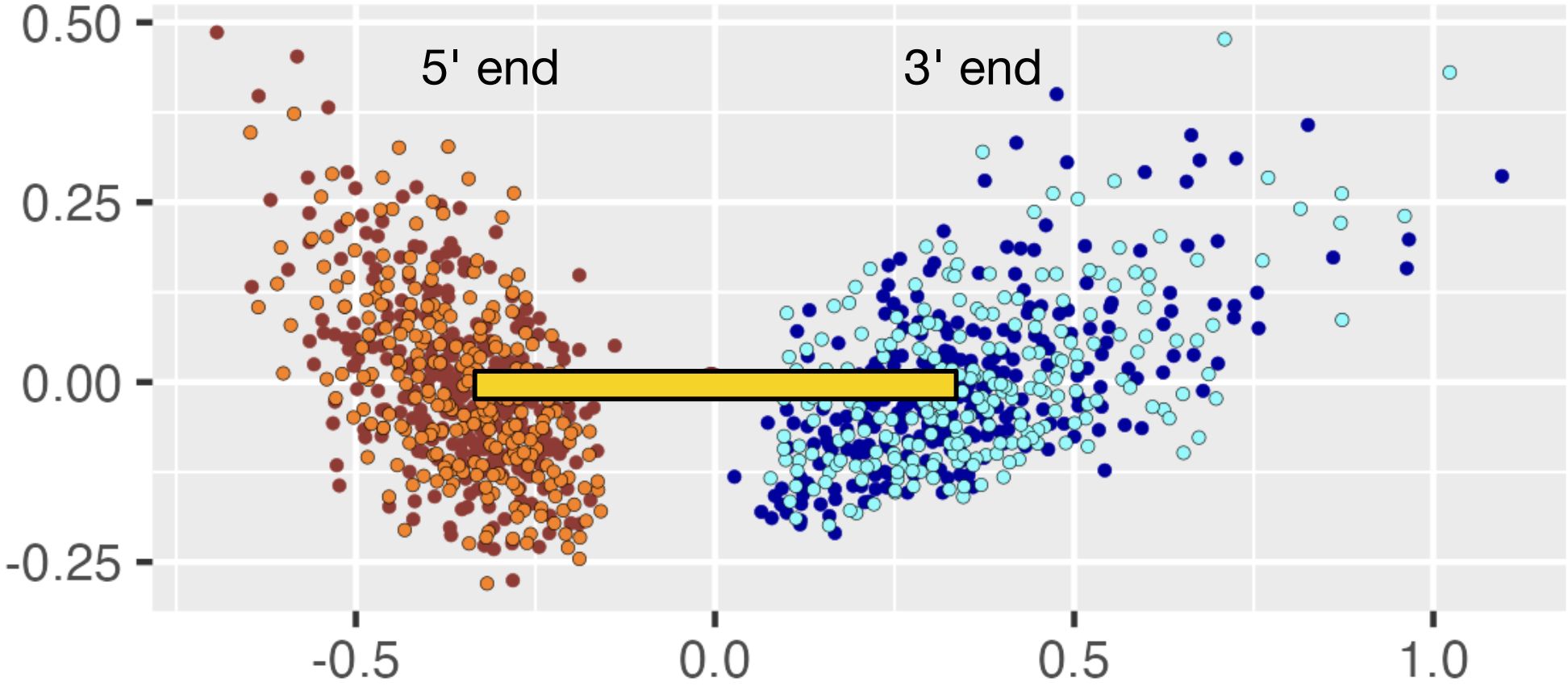
$$I = 100 \left( \frac{V_{\text{prior}} - V_{\text{post}}}{V_{\text{prior}}} \right)$$

$$I = \begin{cases} 100 & \text{if } V_{\text{post}} = 0 \\ \\ 0 & \text{if } V_{\text{post}} = V_{\text{prior}} \end{cases}$$



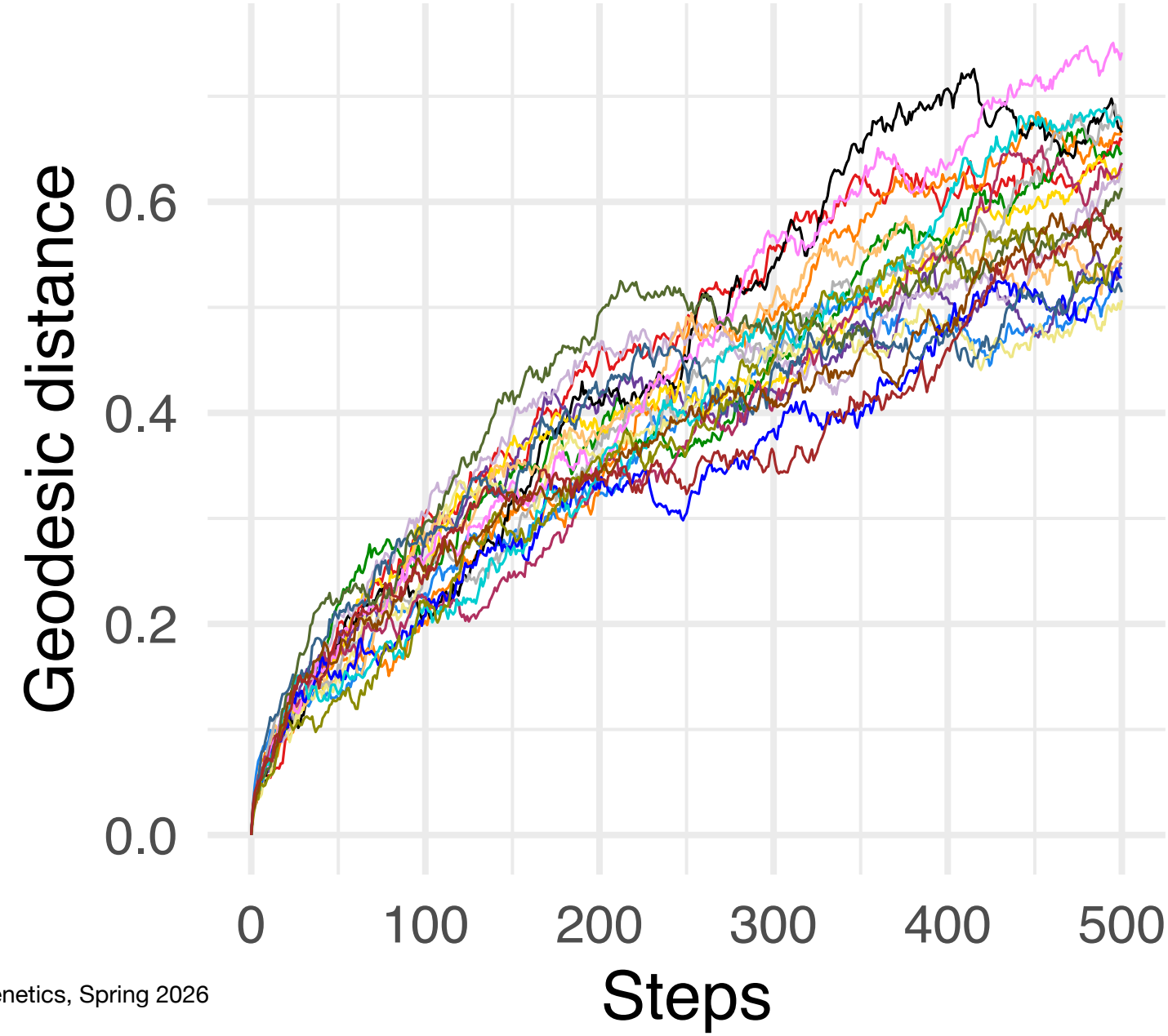

# Dissonance




dissonance = distance between mean trees scaled by pooled standard deviation

# 20 random walks through treespace



# Dissonance increases with distance