A GENERAL THEORY OF ECOLOGICAL COMMUNITIES I

Housekeeping

Grading contract & meeting

Assignment I


COMMUNITY ECOLOGY
JOHN LAWTON
imgflip.com

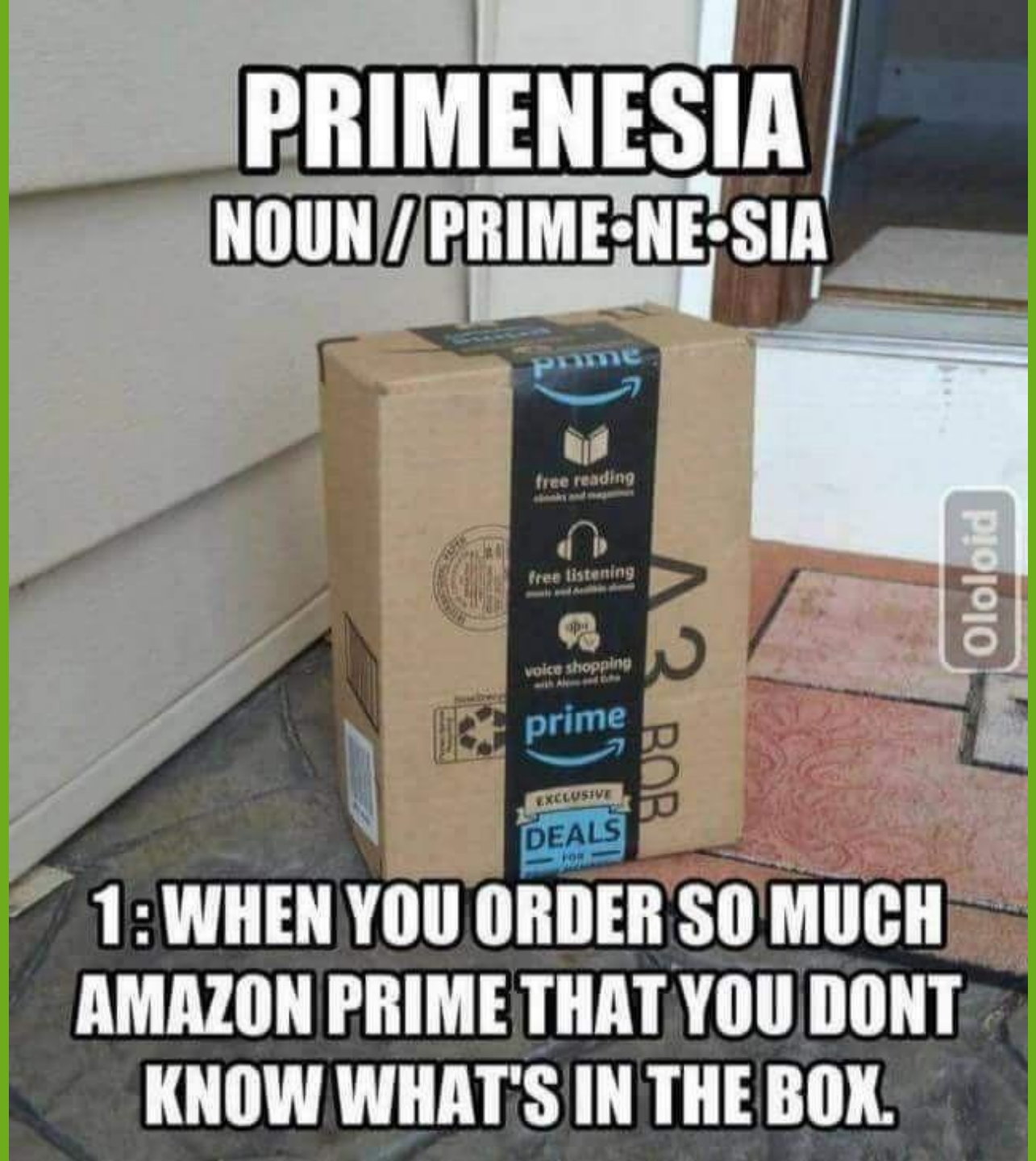

STUFF!

Lose stuff


NOT SURE IF I'M REALLY GOOD AT LOSING THINGS
OR REALLY BAD AT FINDING THINGS
memegenerator.net

Replace stuff

Get stuff


PRIMENESIA
NOUN / PRIME·NE·SIA
free reading
free listening
voice shopping
prime
EXCLUSIVE
DEALS
1 : WHEN YOU ORDER SO MUCH AMAZON PRIME THAT YOU DONT KNOW WHAT'S IN THE BOX.

Create stuff

Get stuff

Lose stuff

Replace stuff

Create stuff

Deterministic replacement

New addition

A general theory of stuff

Transformed item

Involuntary loss

POPULATION GENETICS

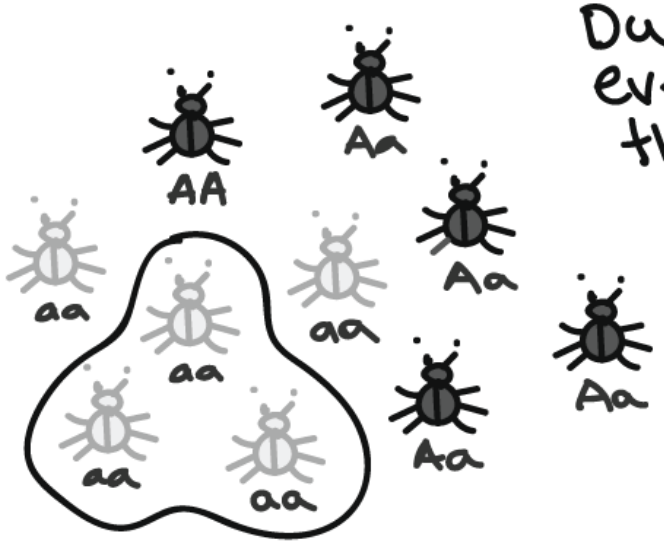
POPULATION GENETICS:
THE BASIS OF EVOLUTIONARY THEORY

A general theory of evolution, based on four high-level processes:

- Genetic drift
- Natural selection
- Migration
- Mutation

Hartl & Clark 1997

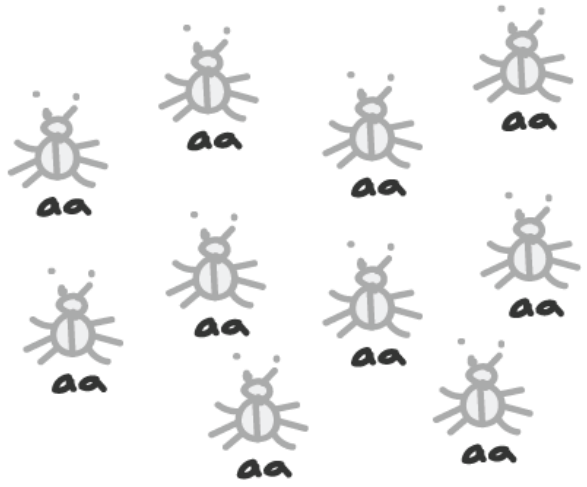
GENETIC DRIFT



Freq. of A = 0.3
Freq. of a = 0.7

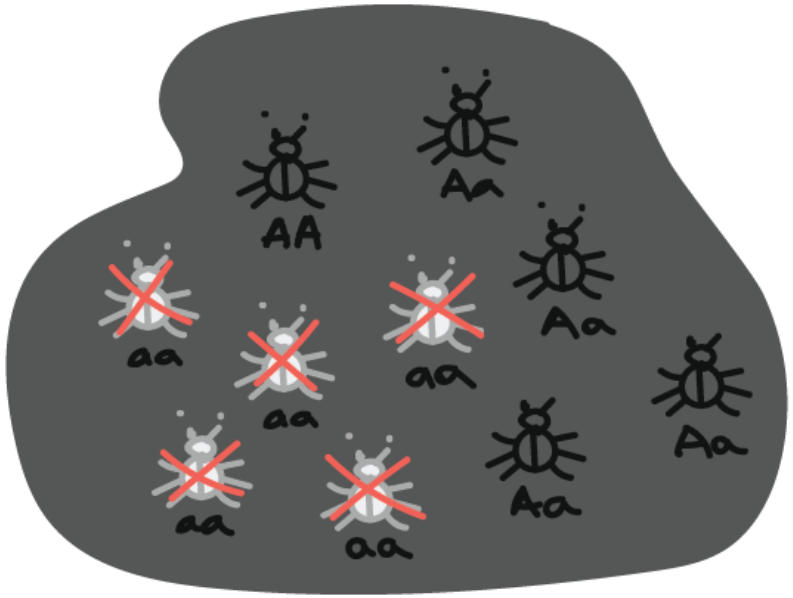
Due to chance events, only these 3 beetles leave offspring

Next generation



Freq. of A = 0.0
Freq. of a = 1.0

NATURAL SELECTION



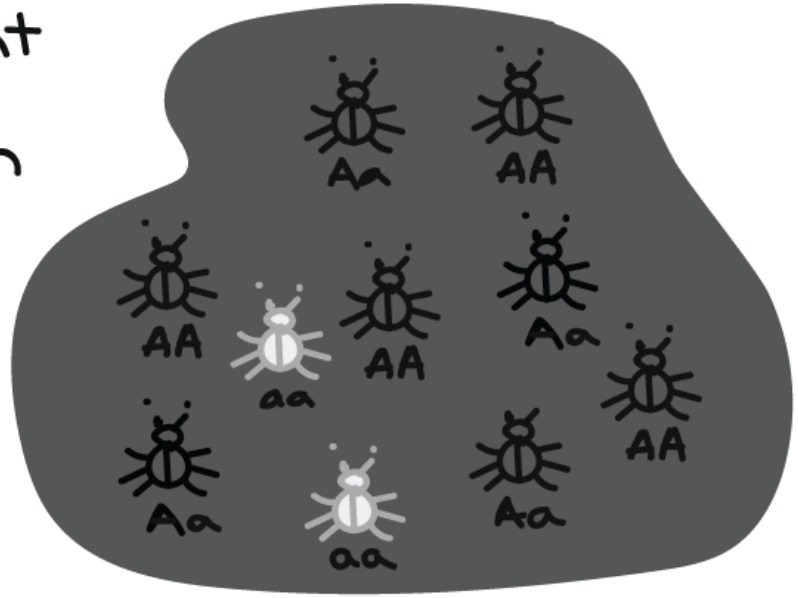
Freq. of A = 0.3
Freq. of a = 0.7

Dark rock environment → light gray beetles are spotted and eaten by birds more often than dark ones

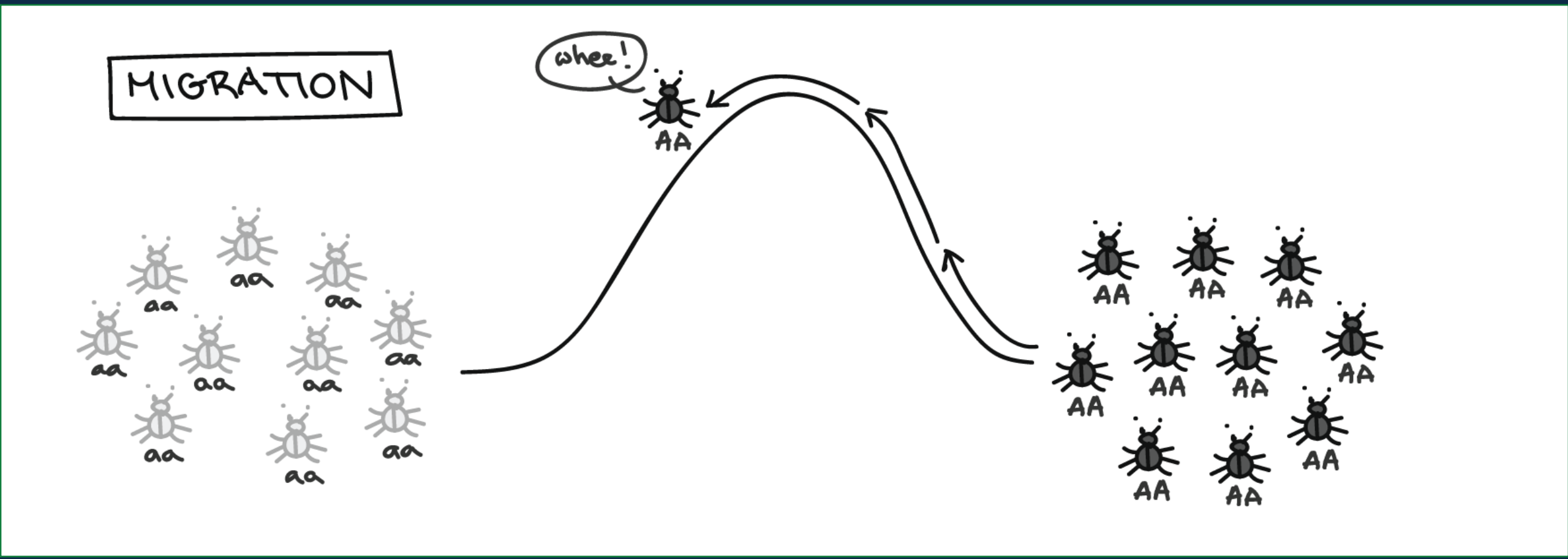
X = eaten by bird

Only survivors reproduce...

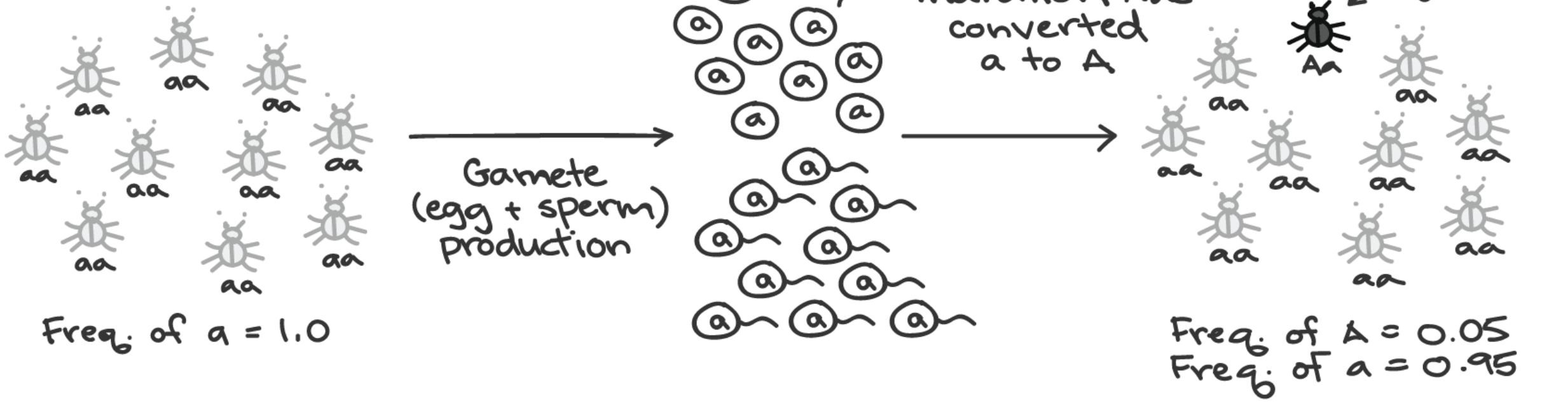
Next generation

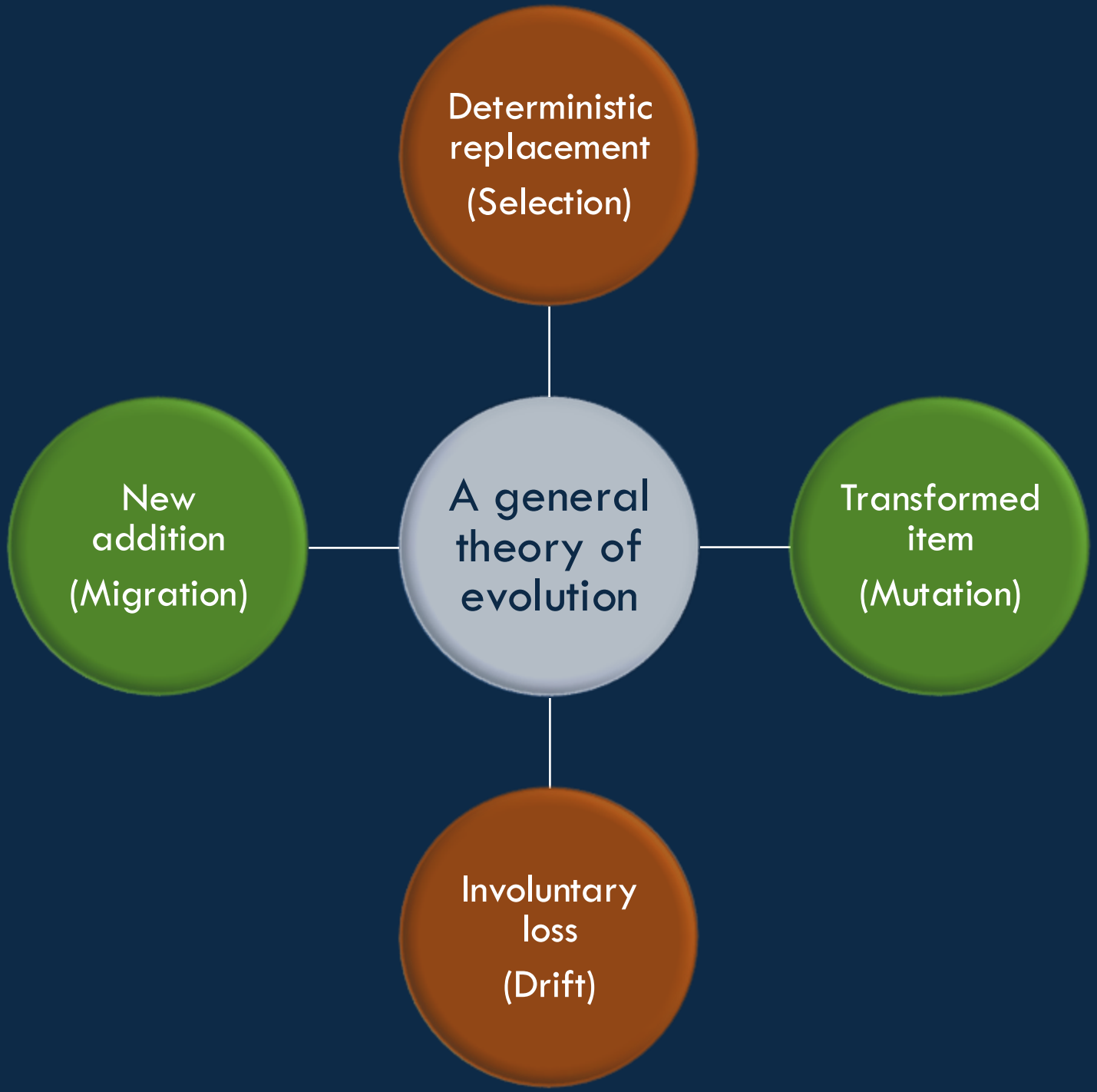


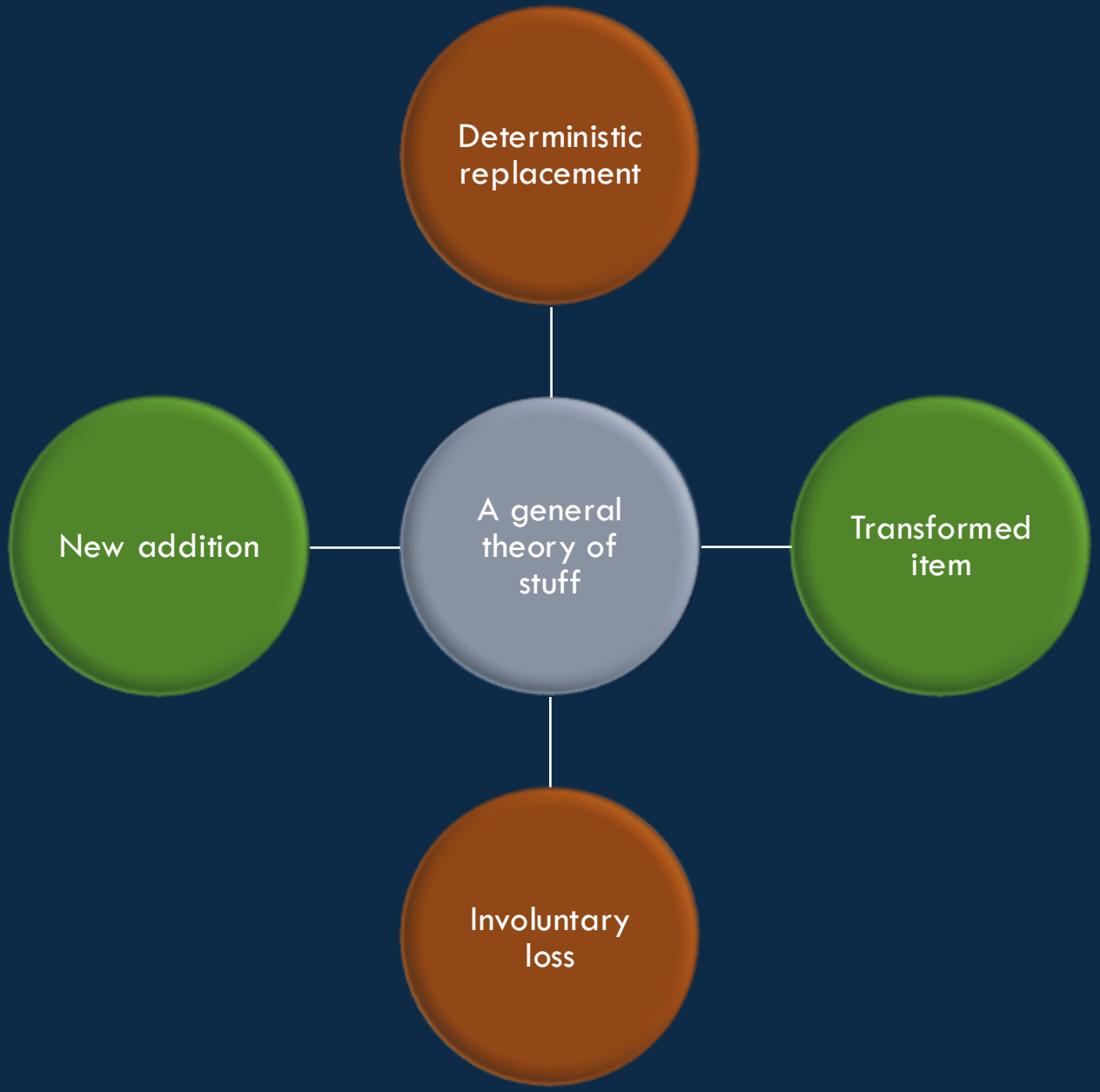
Freq. of A = 0.6
Freq. of a = 0.4


MIGRATION
whee!
AA
aa

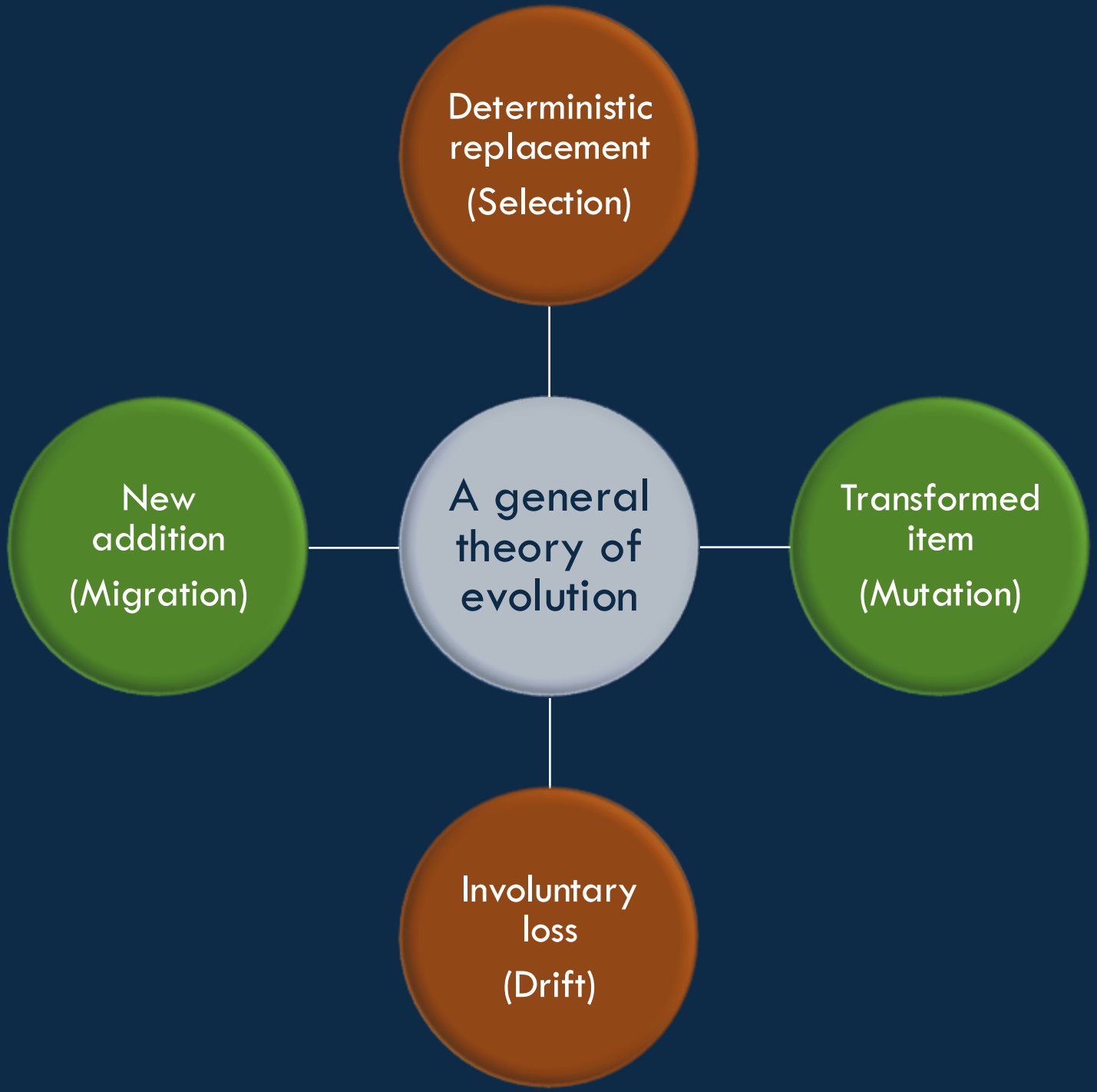
MUTATION


aa
Freq. of a = 1.0
Gamete (egg + sperm) production
A
a
random mutation has converted a to A
new genotype
Aa
Freq. of A = 0.05
Freq. of a = 0.95

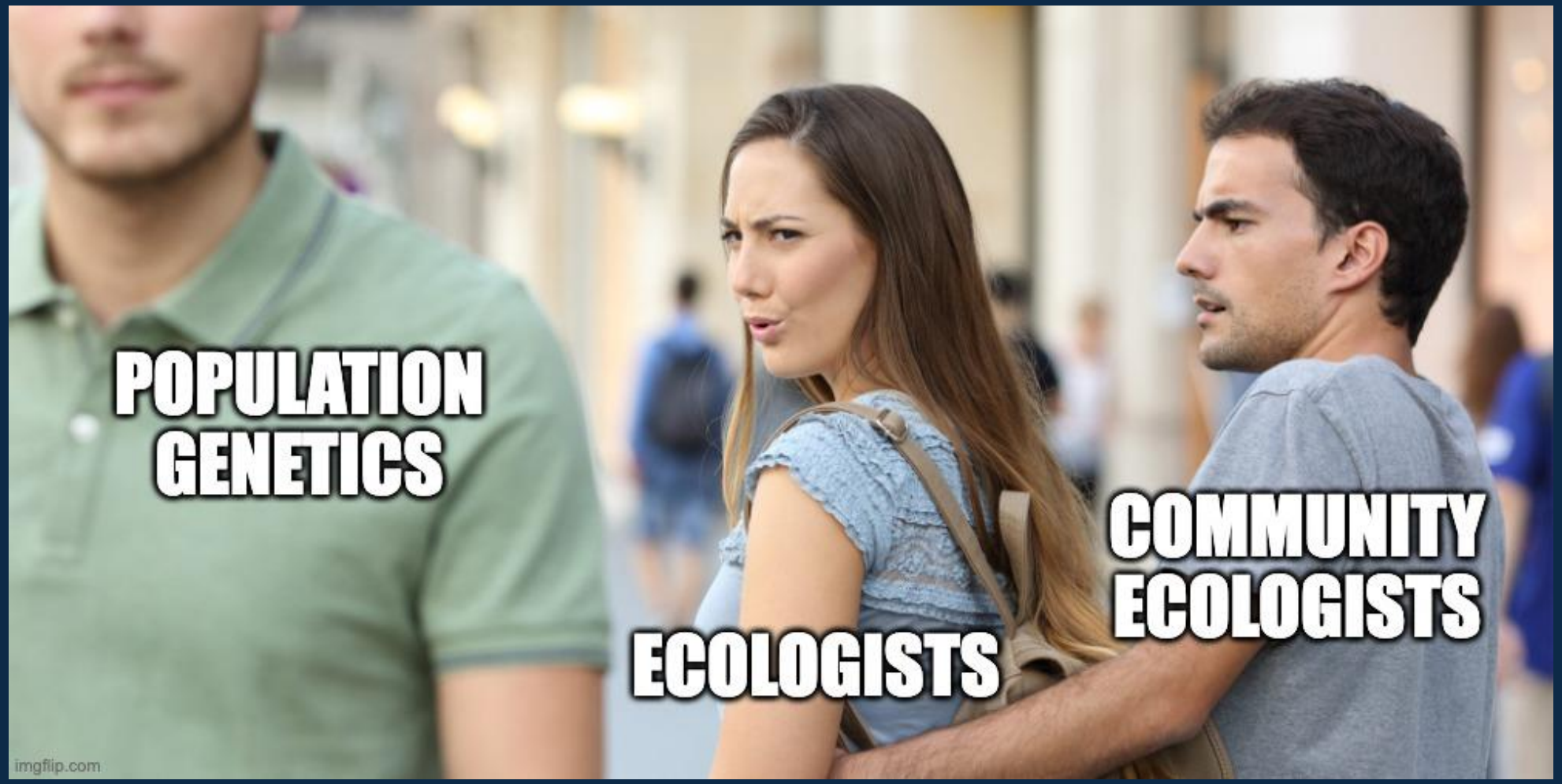

Deterministic replacement
(Selection)
New addition
(Migration)
A general theory of evolution
Transformed item
(Mutation)
Involuntary loss
(Drift)


Deterministic replacement
New addition
A general theory of stuff
Transformed item
Involuntary loss


Haters gonna


Deterministic replacement
(Selection)
New addition
(Migration)
A general theory of evolution
Transformed item
(Mutation)
Involuntary loss
(Drift)

"Unlike population genetics, ecology has no known underlying regularities in its basic processes."

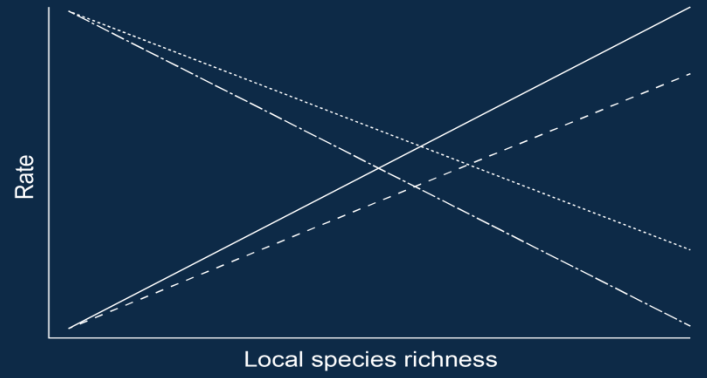


Van Valen & Pitelka 1974

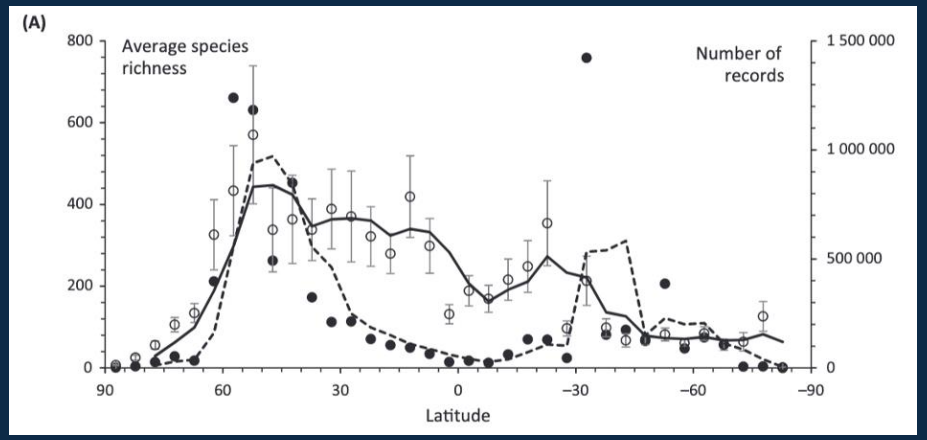
Drivers of community assembly

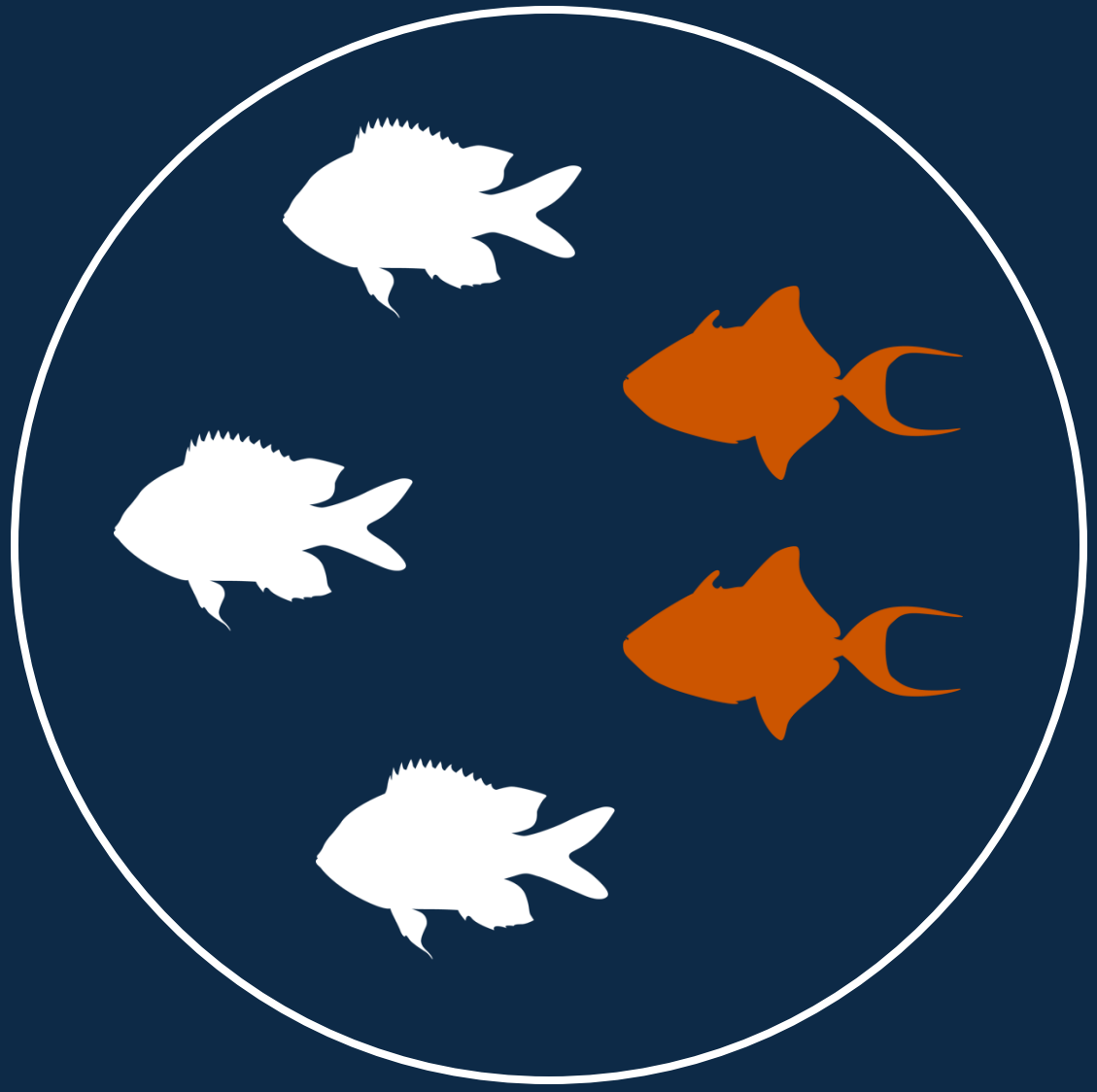
1. Modern coexistence theory

2. Theory of Island Biogeography



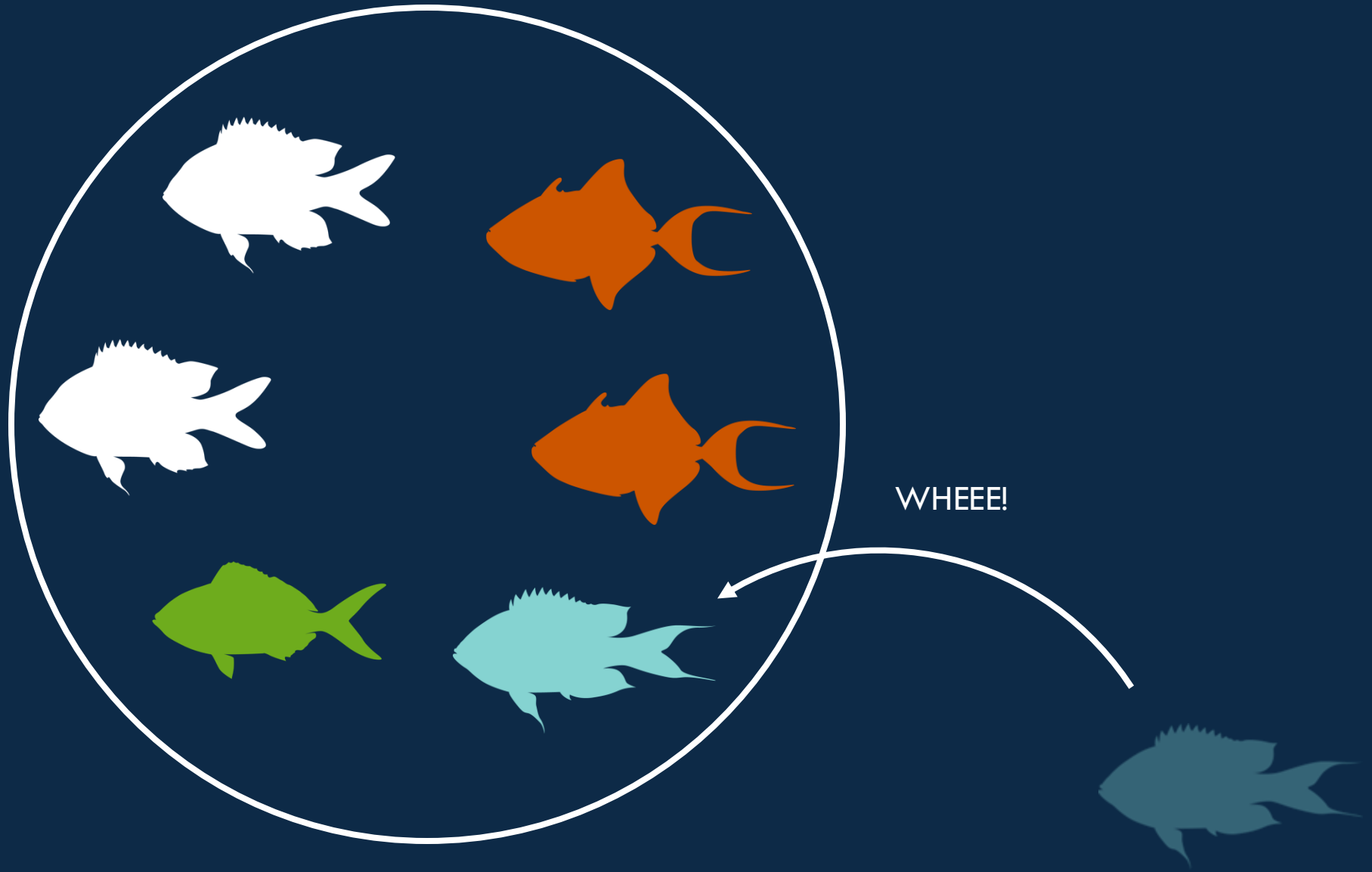
3. Macroecology



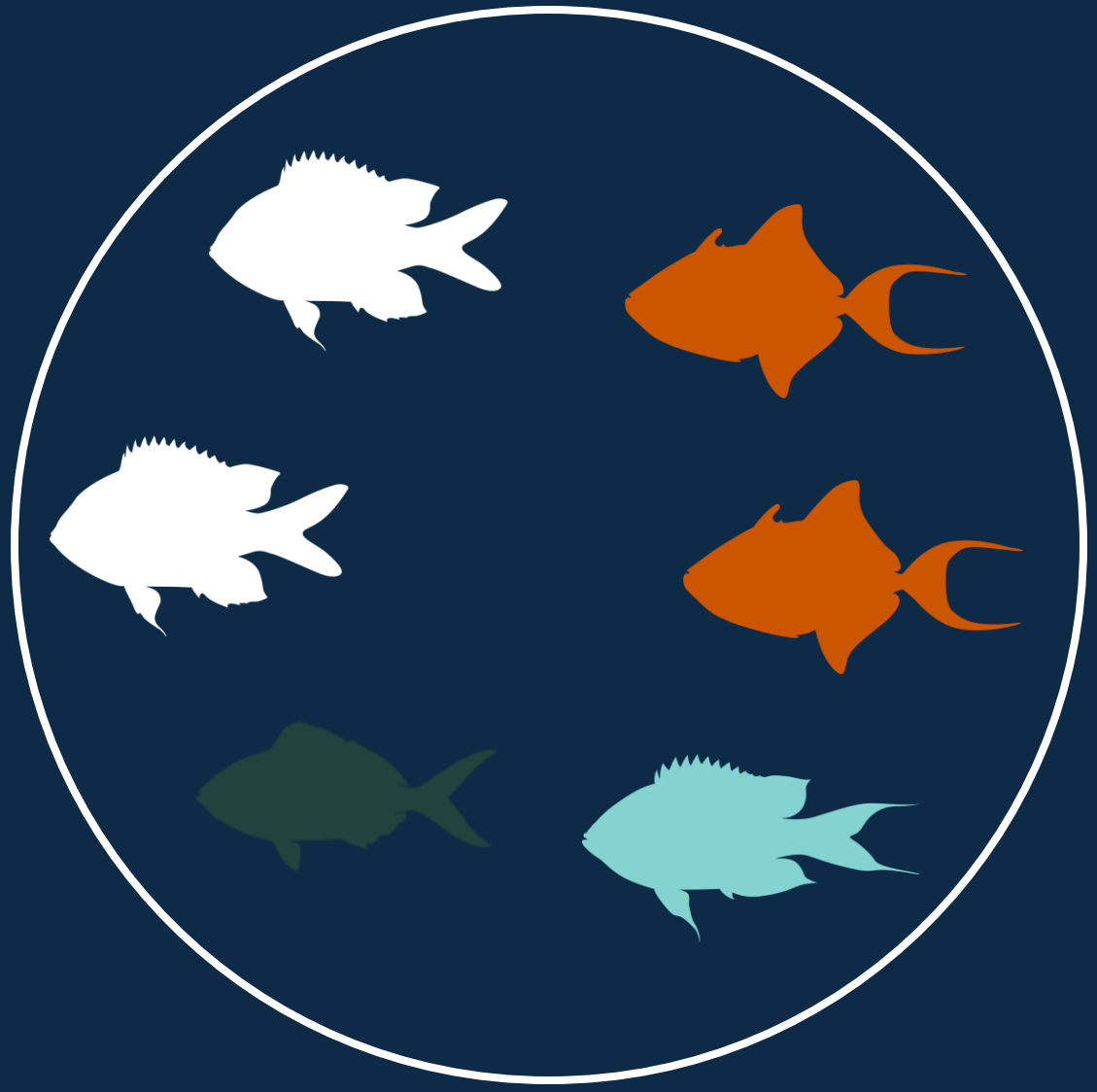


Speciation

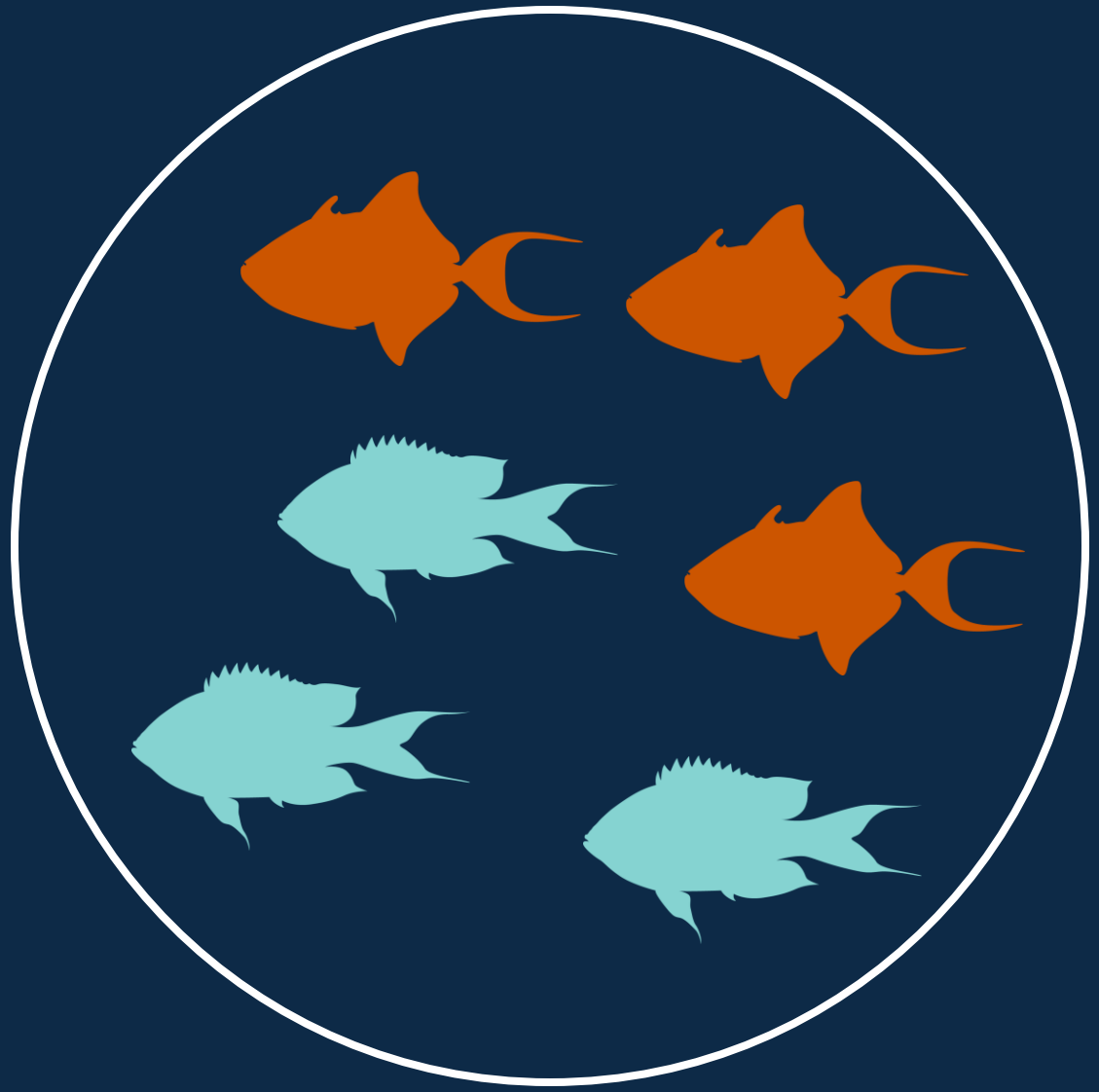
Dispersal

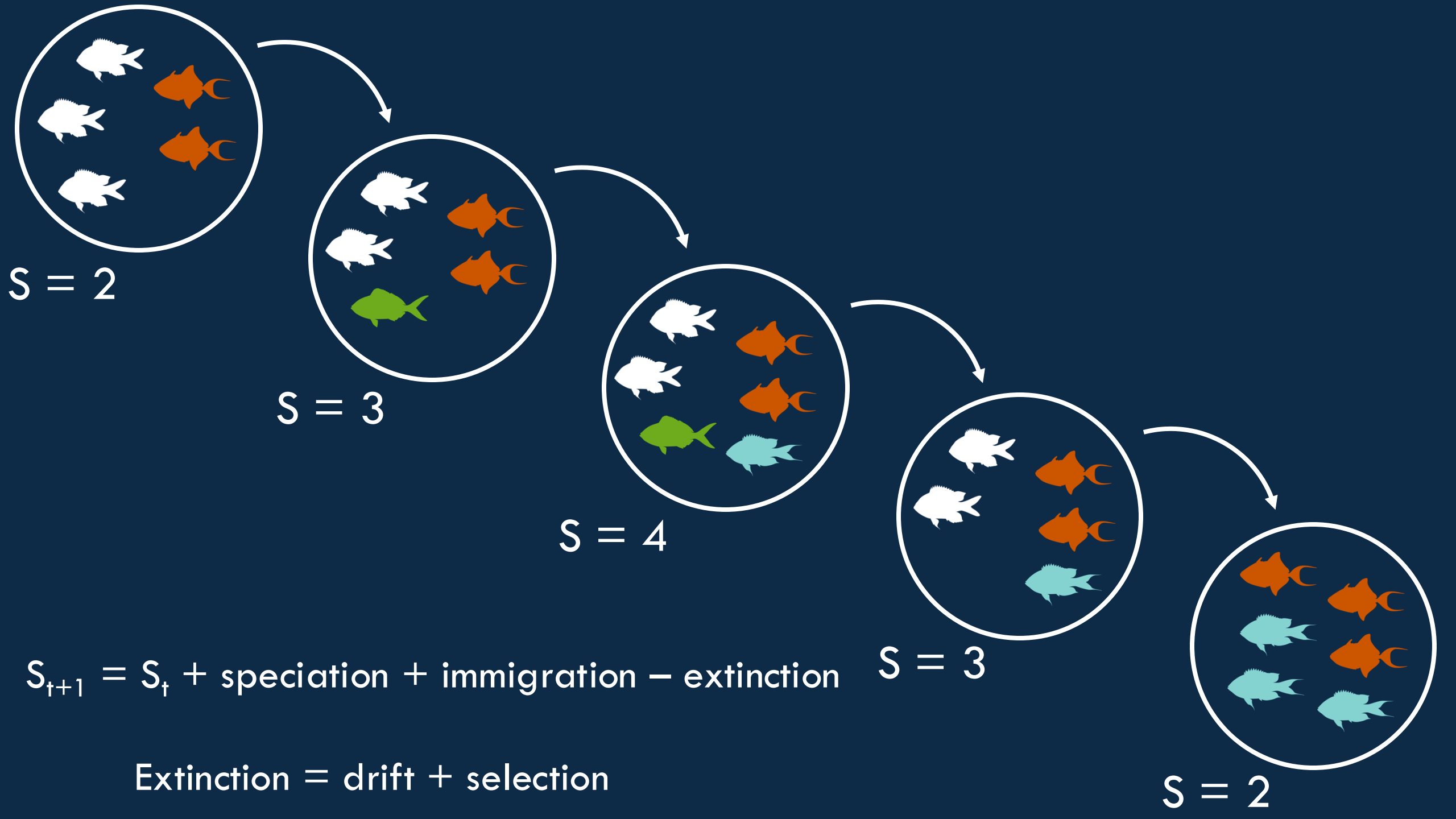


Drift



Selection





$S_{t+1} = S_t$ + speciation + immigration – extinction

Extinction = drift + selection

Deterministic replacement (Selection)

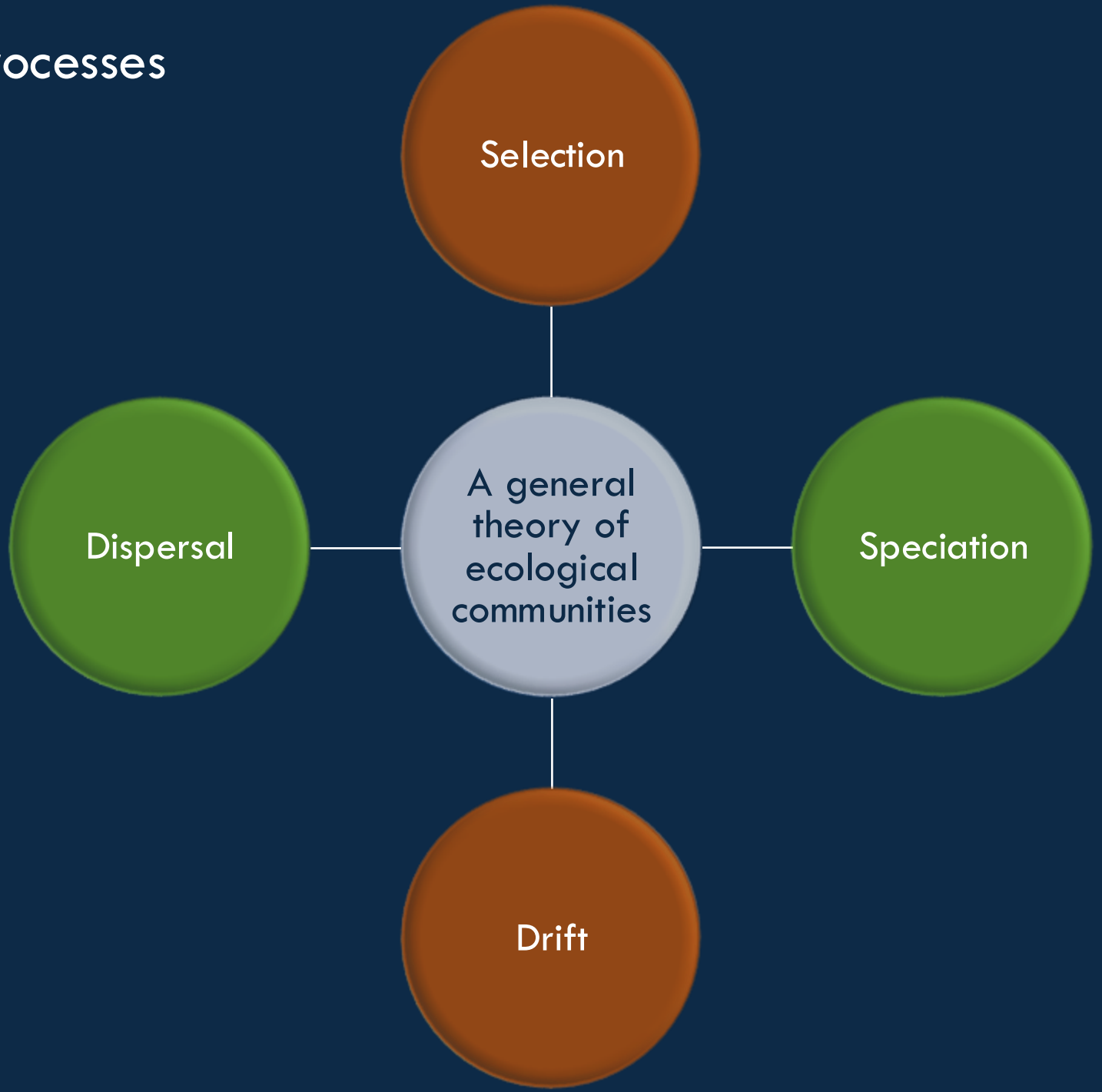
New addition (Dispersal)

A general theory of ecological communities

Transformed item (Speciation)

Involuntary loss (Drift)

Four high level processes



Vellend 2010; 2016

Causes of selection

Competition
Predation
Limiting similarity
Facilitation
Succession
Resource partitioning
Feedback loops
Disturbance
Non-consumptive effects
Alternative stable states
Priority effects
Intransitive competition
Storage effects
Janzen-Connell Effects

Consequences of selection

Selection

CONSEQUENCES

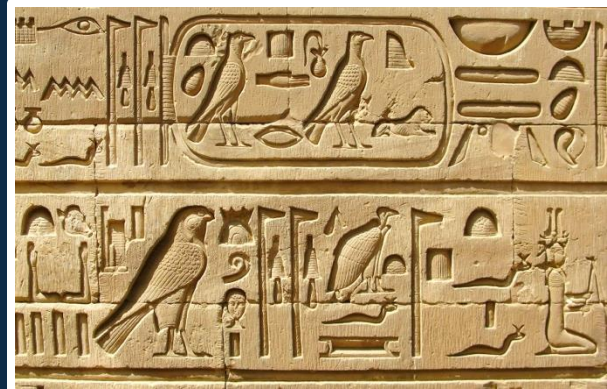
Selection

Movement

A general theory of almost all things

Origination

Stochasticity




DRIFT

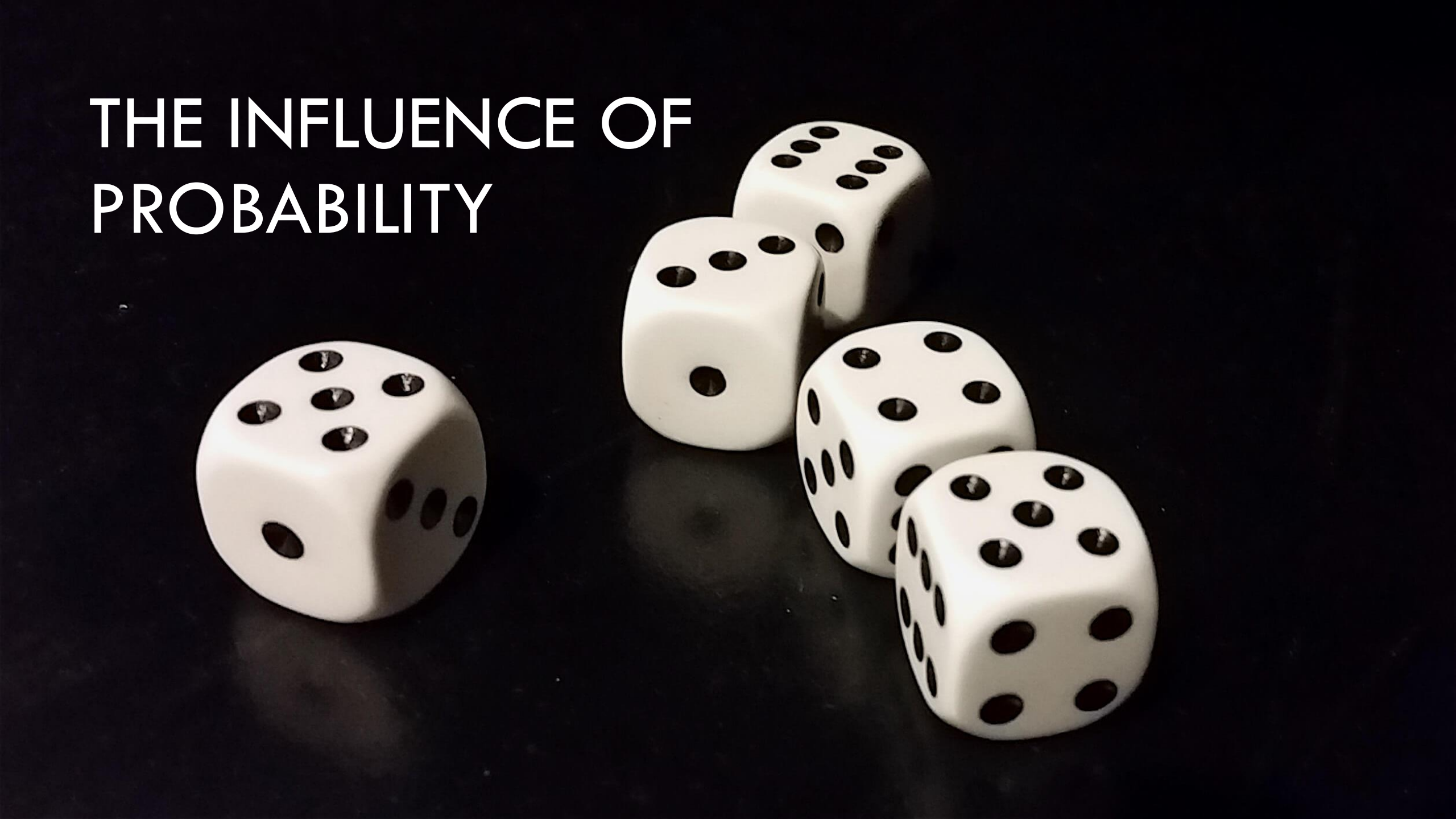

SELECTION


DISPERSAL


SPECIATION


DRIFT

THE INFLUENCE OF PROBABILITY



Chance of survival: 0.5

Chance of survival: 0.4

Chance of survival: 0.5

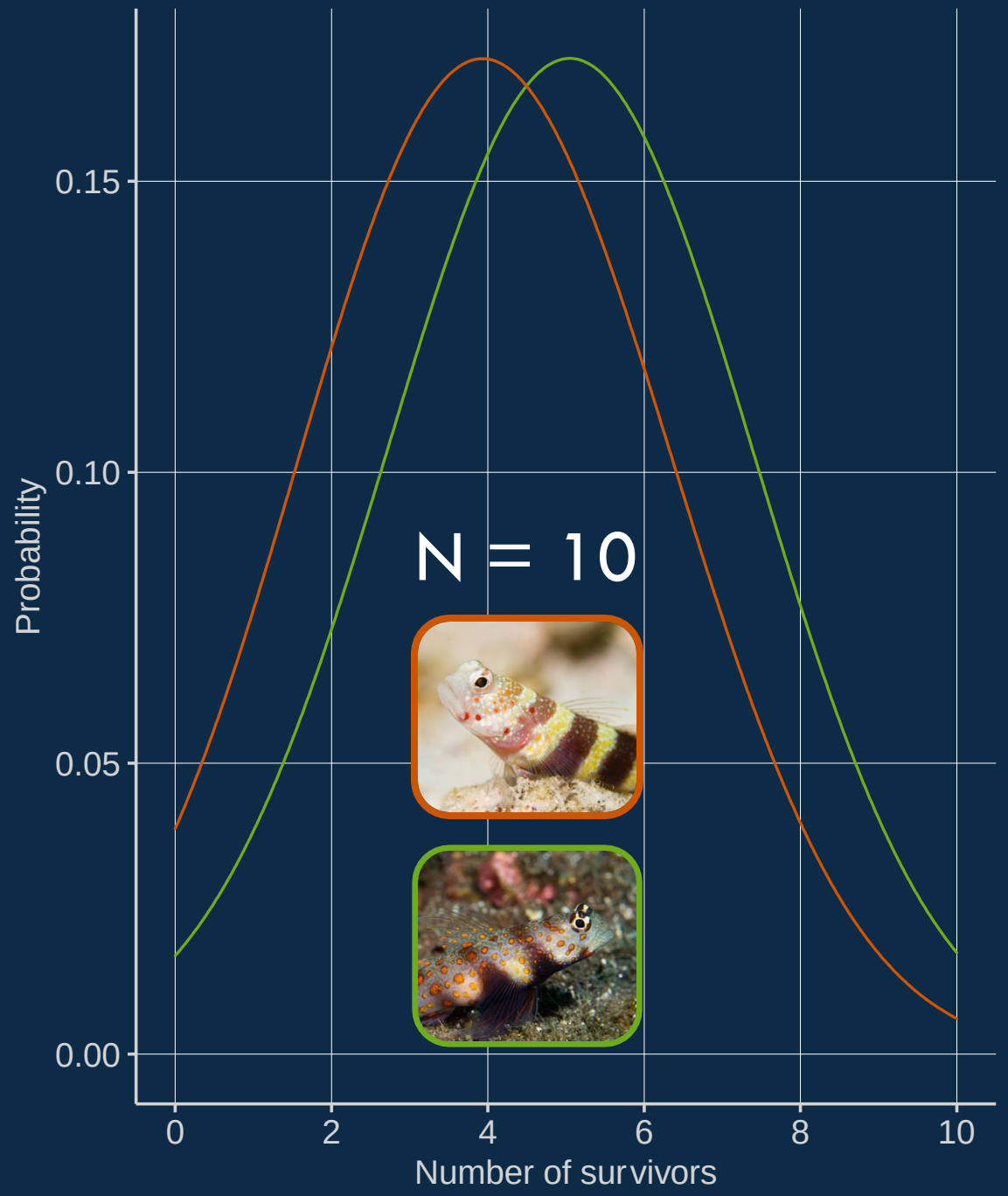
Chance of survival: 0.4

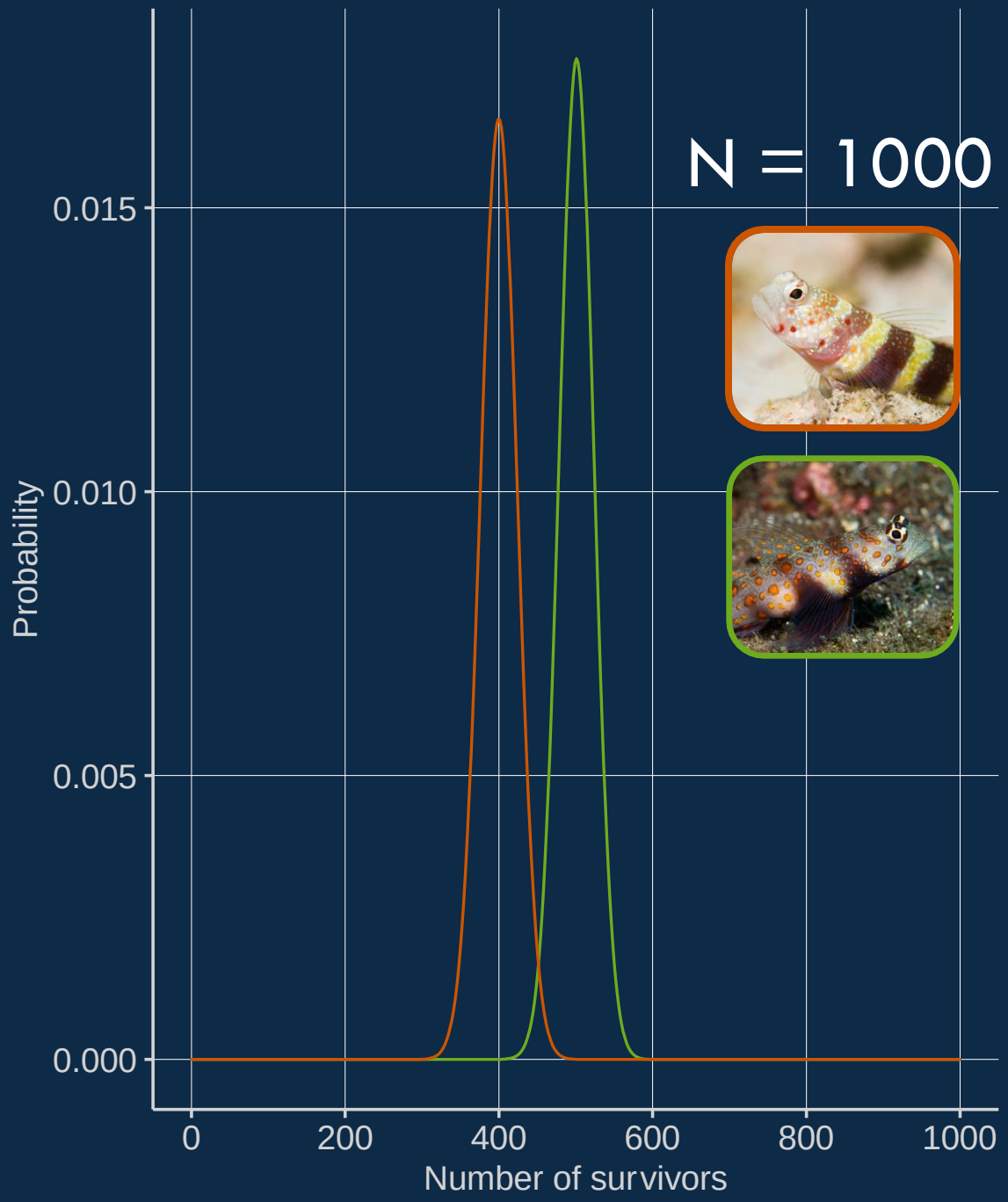
Likelihood of both individuals dying:

$(1 - 0.5) * (1 - 0.5) = 0.25$

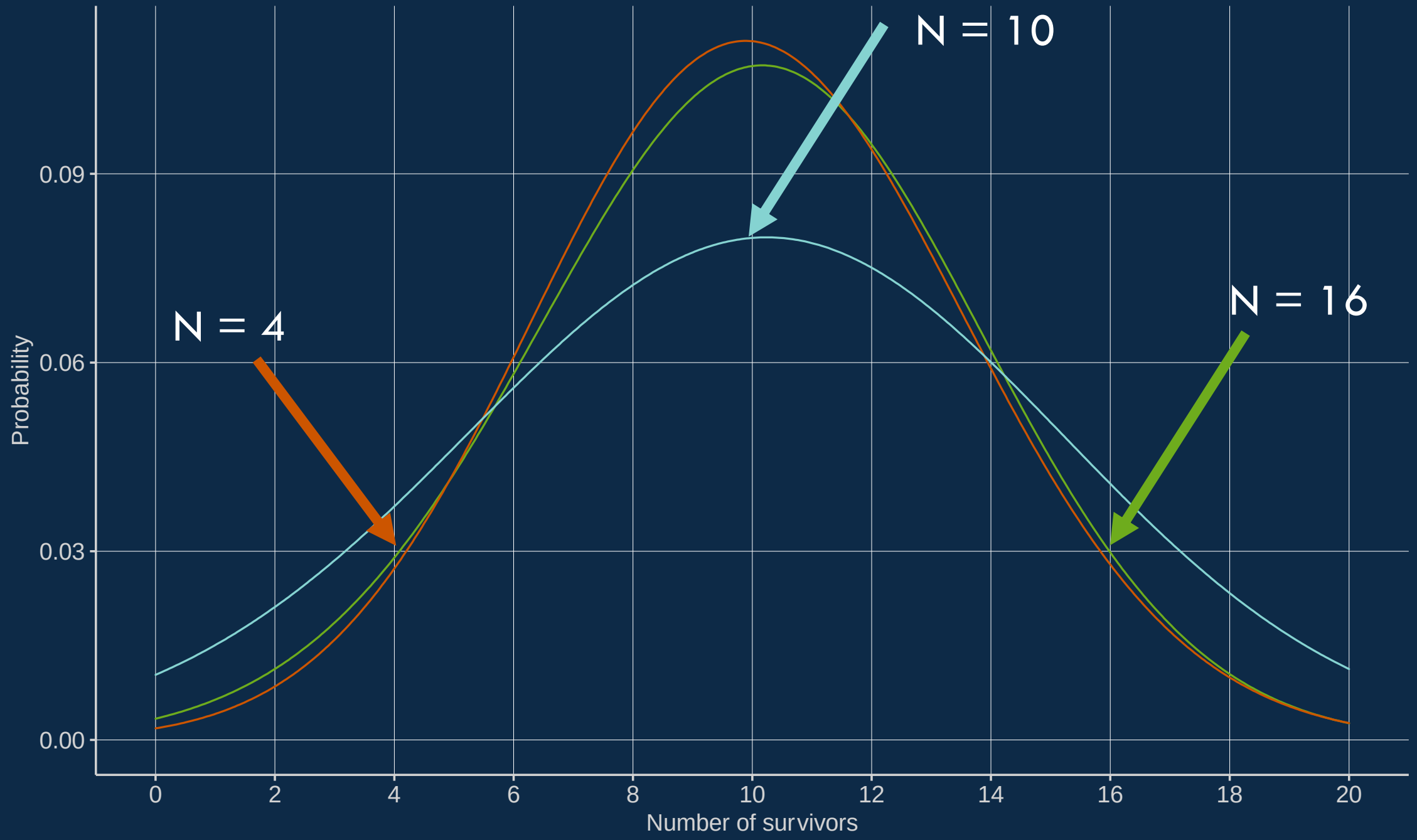
Likelihood of one individual surviving:

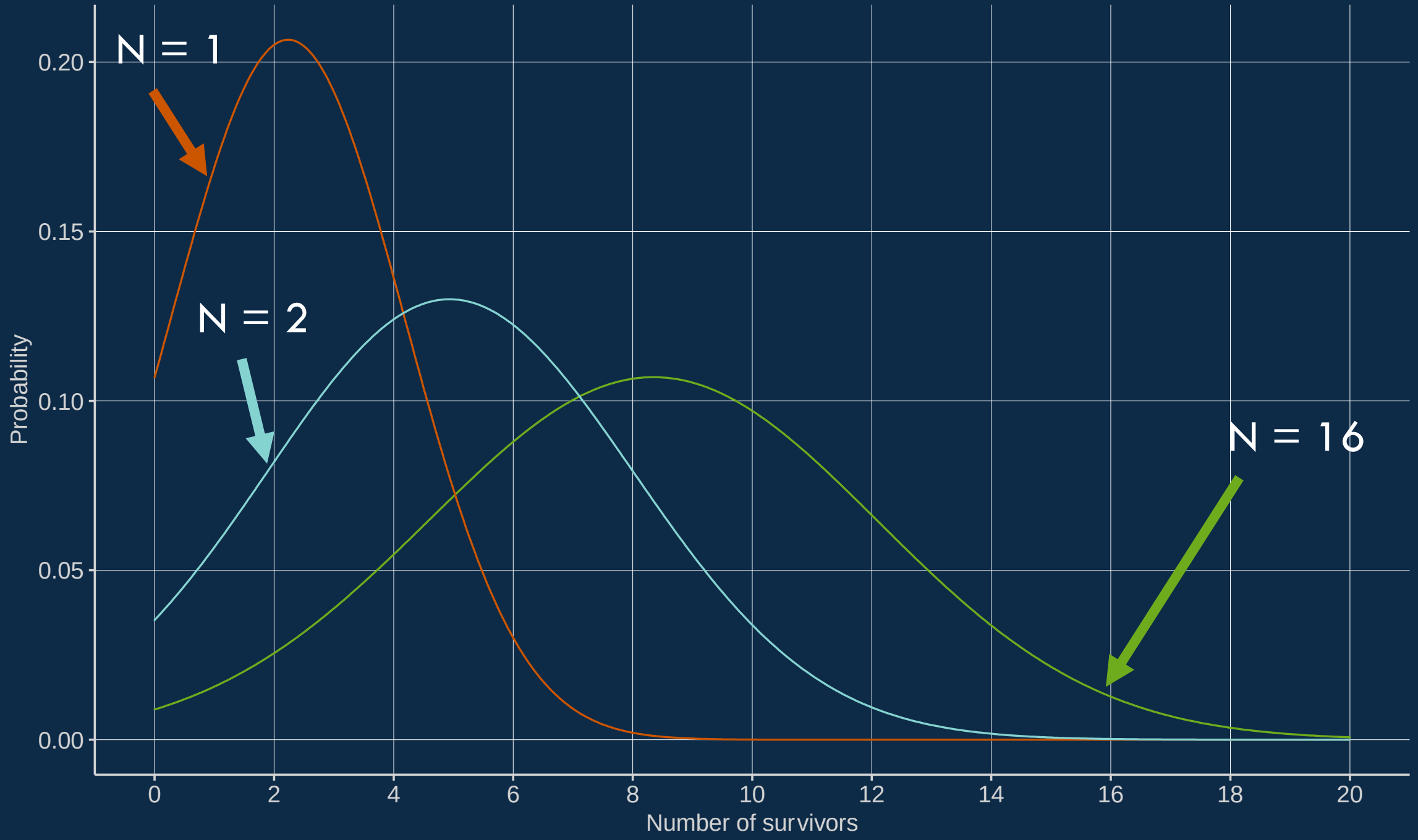
$1 - (0.6 * 0.6) = 0.64$

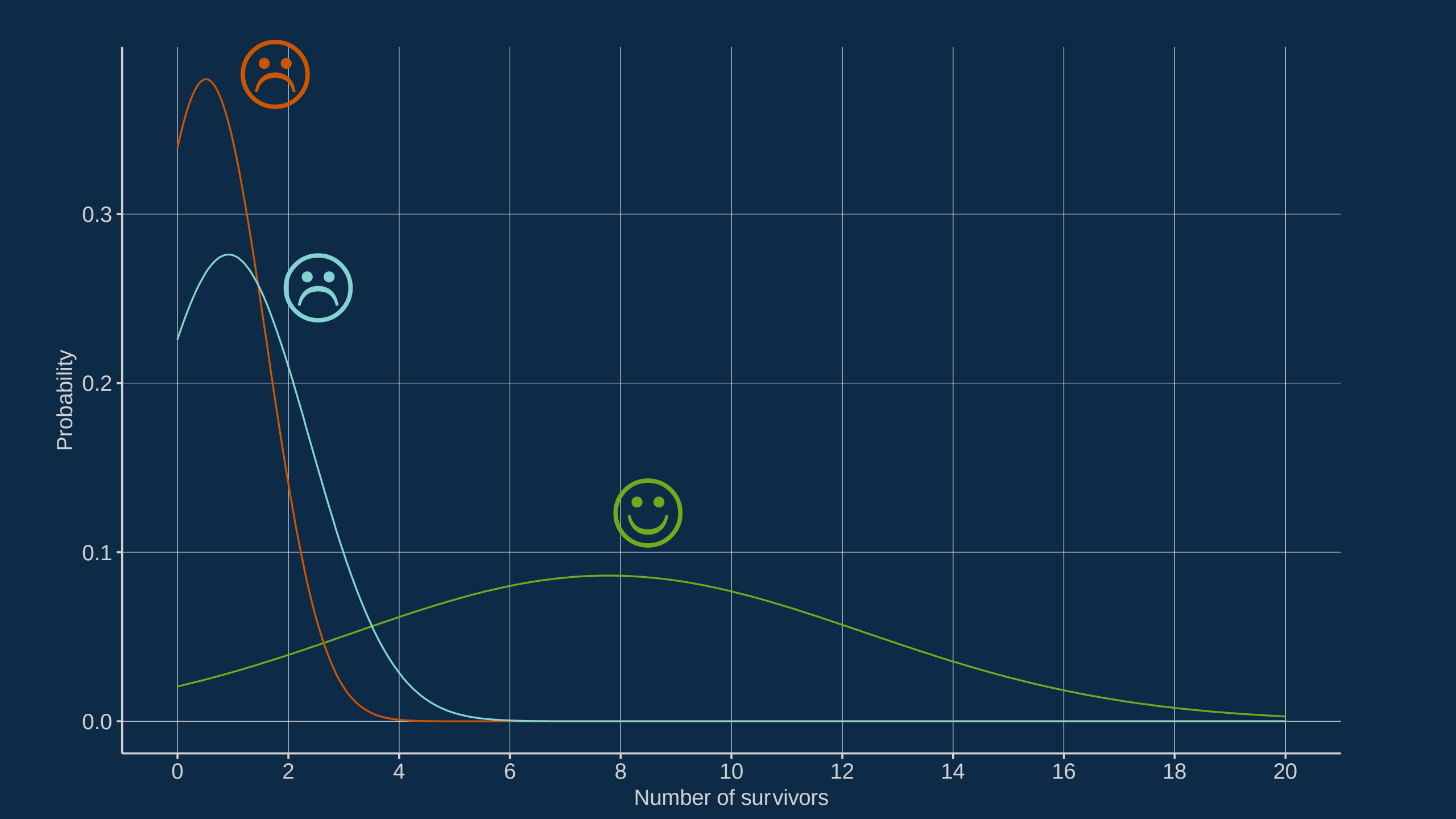

N = 10
0.15
0.10
0.05
0.00
Probability
0
2
4
6
8
10
Number of survivors


N = 1000
0.015
0.010
0.005
0.000
Probability
0
200
400
600
800
1000
Number of survivors

Number of individuals is the critical ingredient for ecological drift!


N = 10
N = 4
N = 16
Probability
0.09
0.06
0.03
0.00
0
2
4
6
8
10
12
14
16
18
20
Number of survivors


N = 1
N = 2
N = 16
0.20
0.15
0.10
0.05
0.00
Probability
0
2
4
6
8
10
12
14
16
18
20
Number of survivors


0.3
0.2
0.1
0.0
Probability
0
2
4
6
8
10
12
14
16
18
20
Number of survivors


What is
randomness/stochasticity?

Drift (population genetics): a demographic event, that occurs independently of the alleles that an individual carries

ECOLOGICAL DRIFT

Takes away species


DRIFT

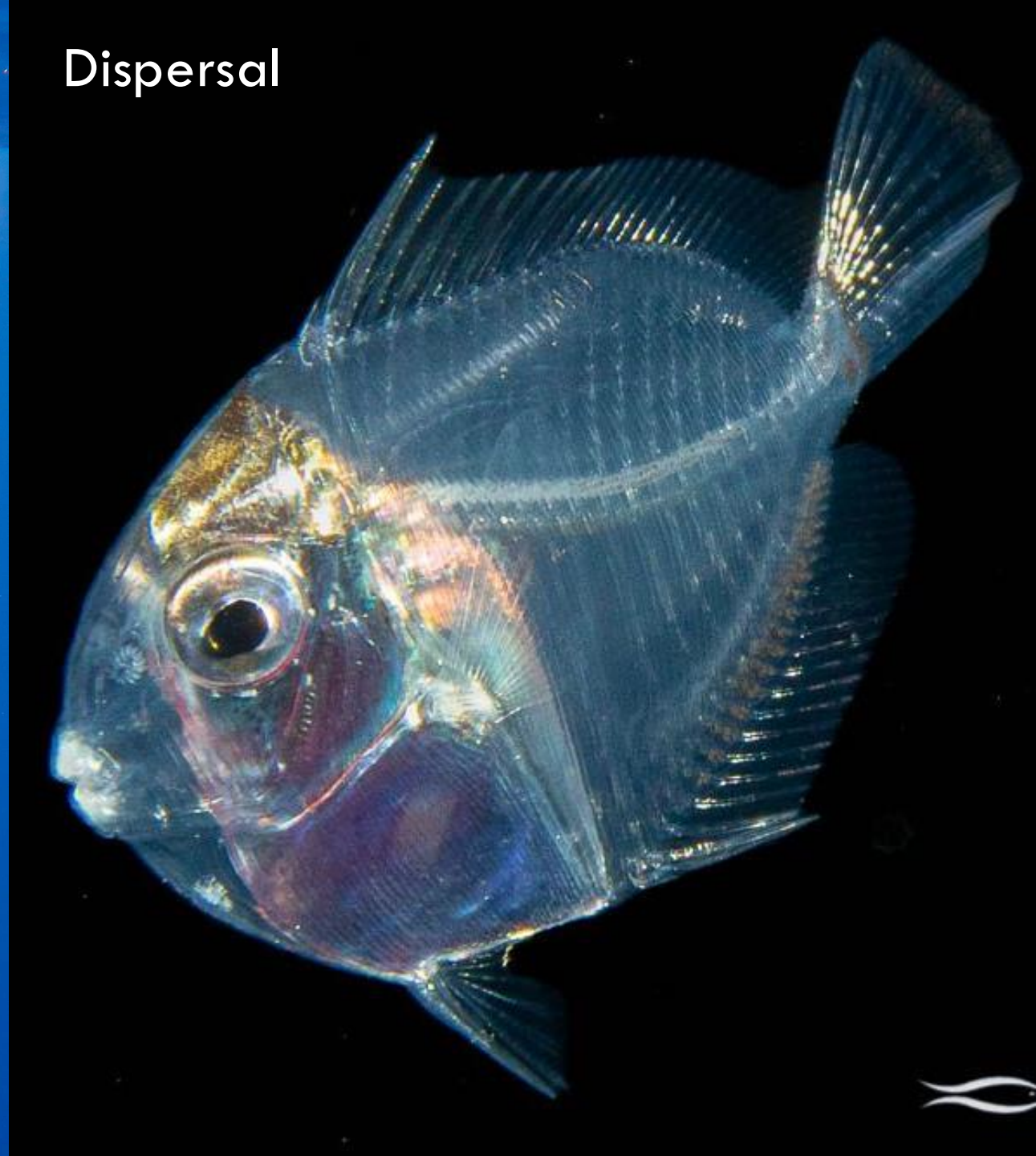

SELECTION


DISPERSAL


SPECIATION

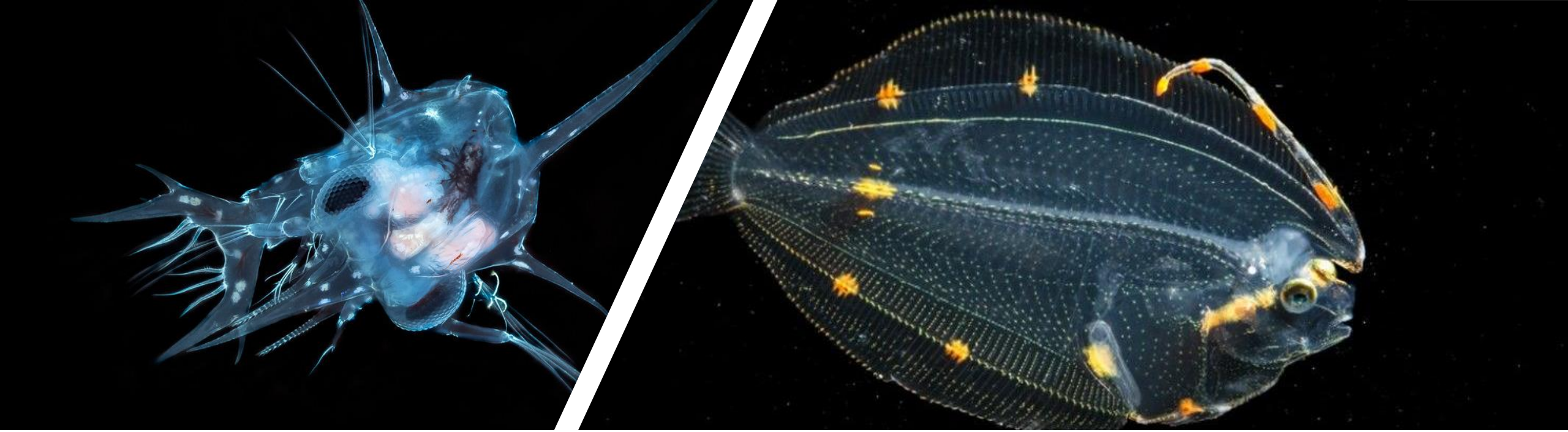

DISPERSAL


Not dispersal

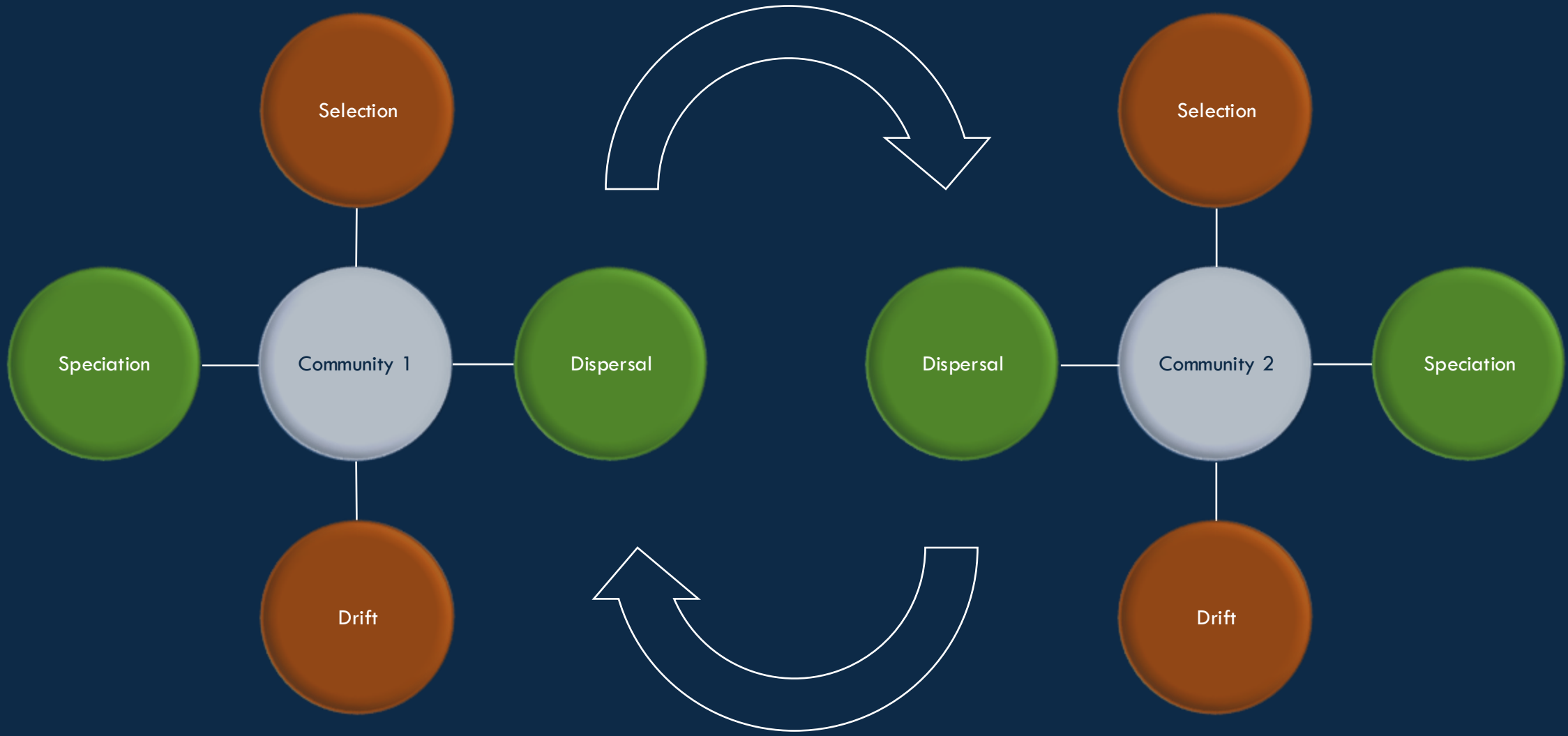

Dispersal

Major difference between terrestrial and marine ecosystems

But why?

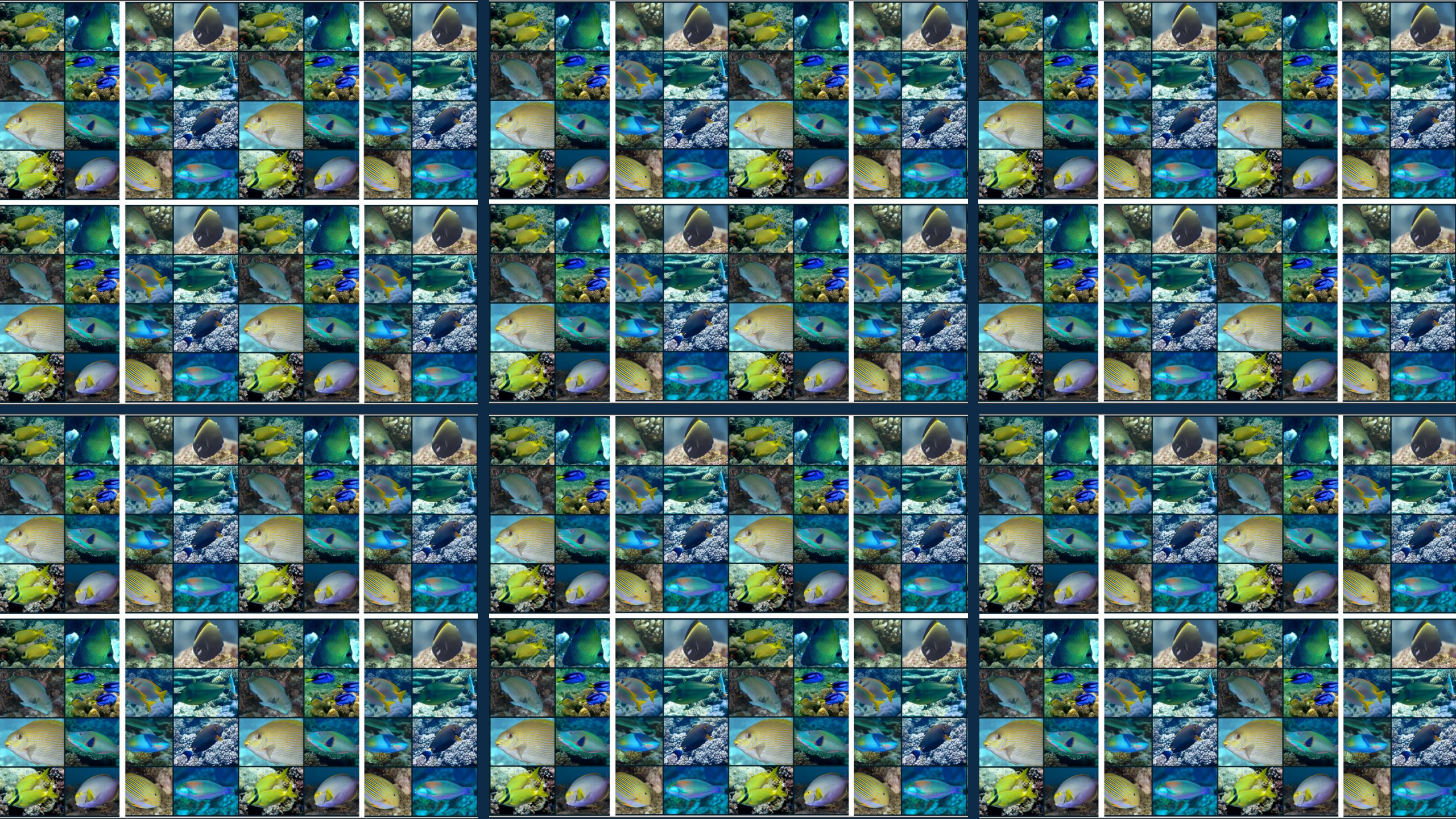


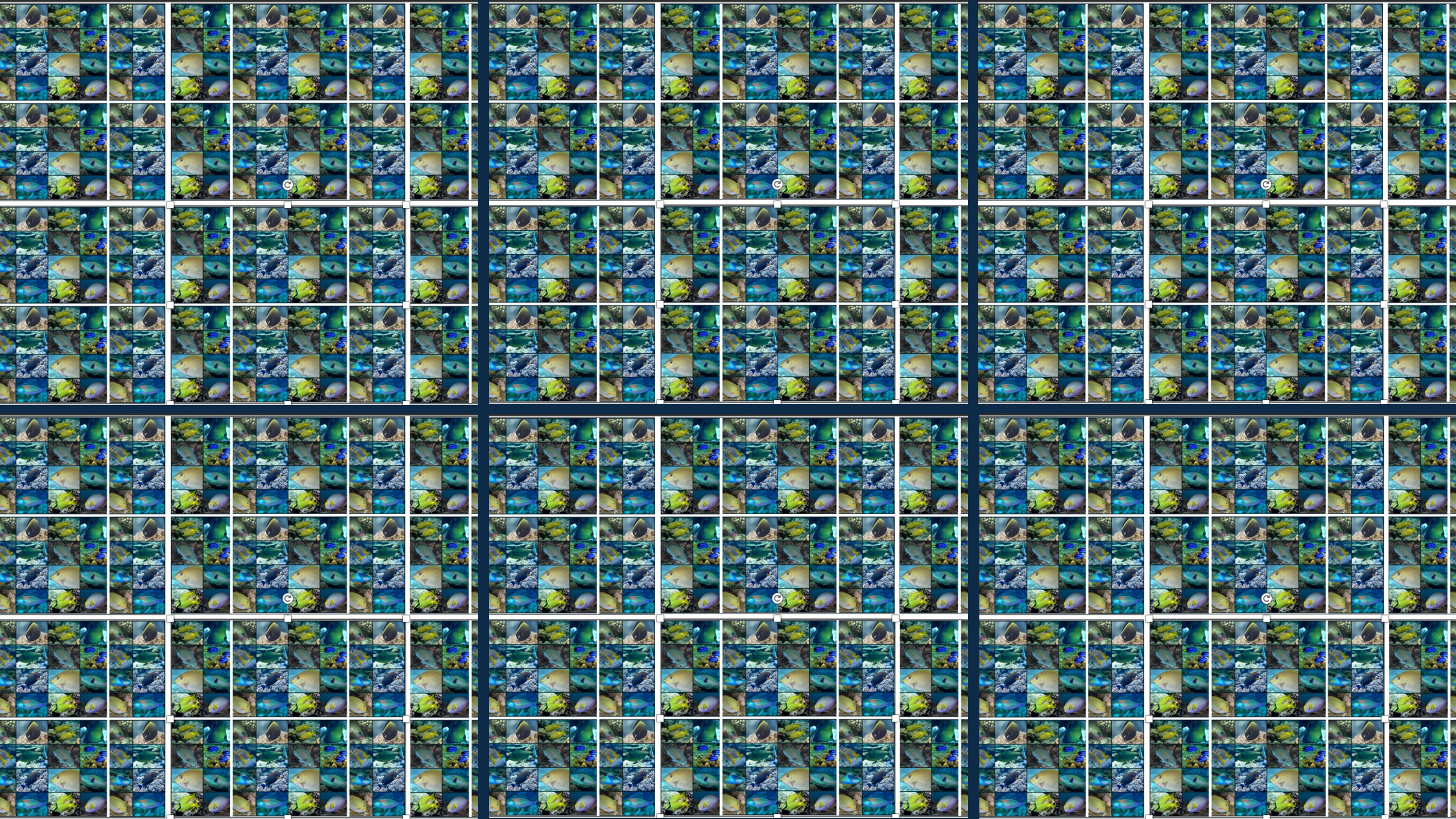
Effects of dispersal magnified in marine environments

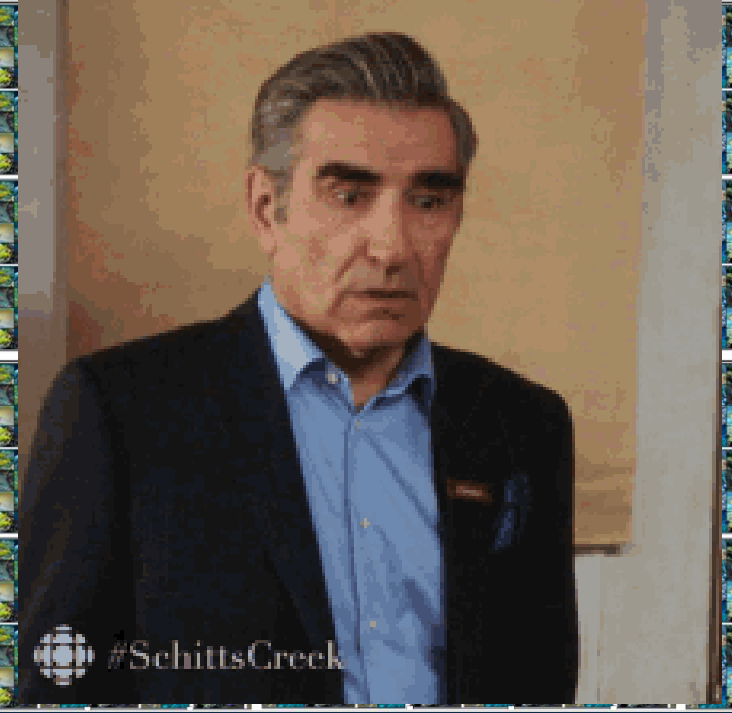

Selection
Speciation
Community 1
Dispersal
Drift
Selection
Dispersal
Community 2
Speciation
Drift


COMMUNITY

META-COMMUNITY






#SchittsCreek

Simple effects on first order properties

Dispersal ↑ local species richness (α-diversity) ↑

Dispersal ↑ community dissimilarity (β-diversity) ↓

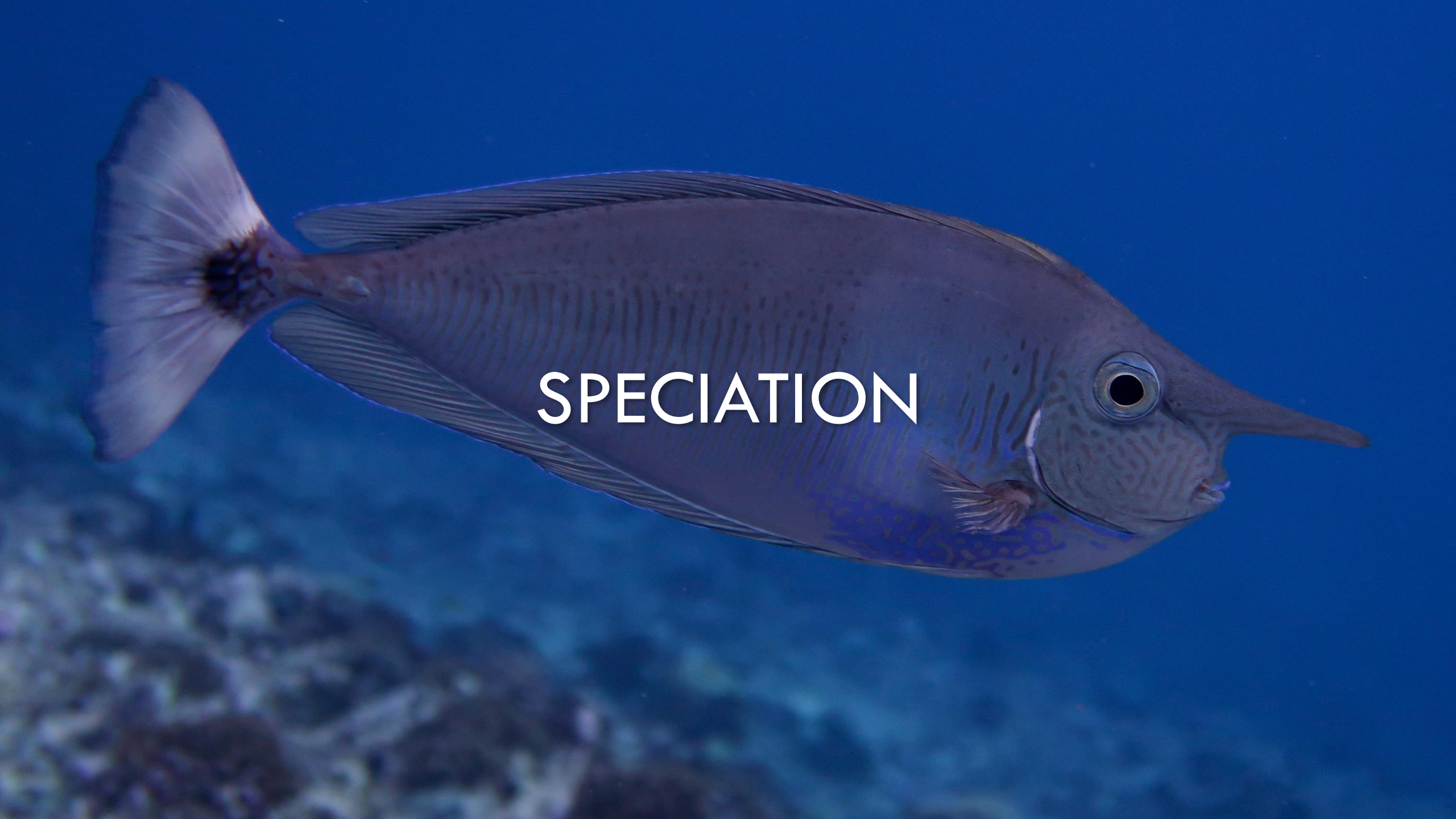
Complicated effects on first order properties

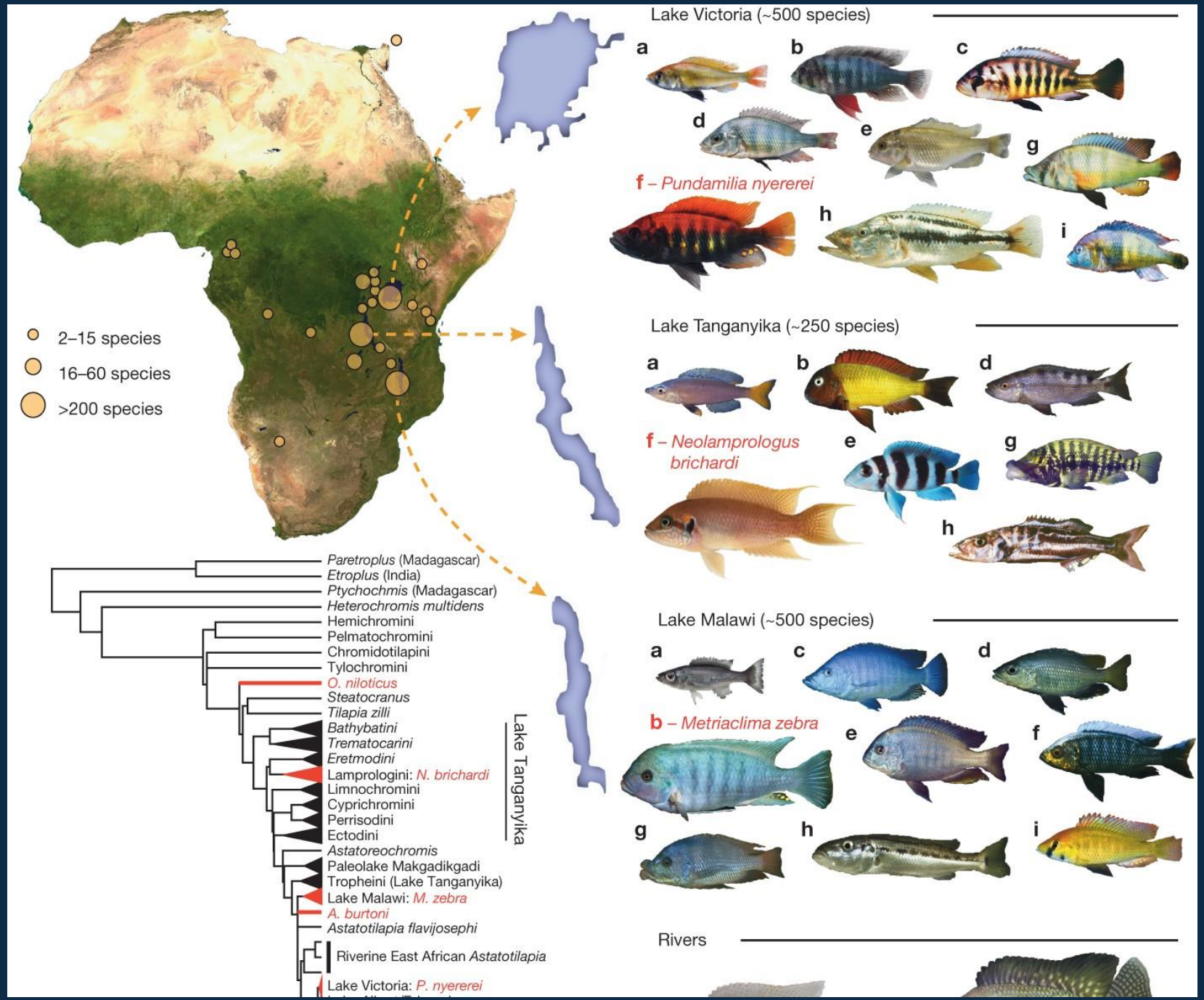
Dispersal ↑ local species richness (α-diversity) ↓

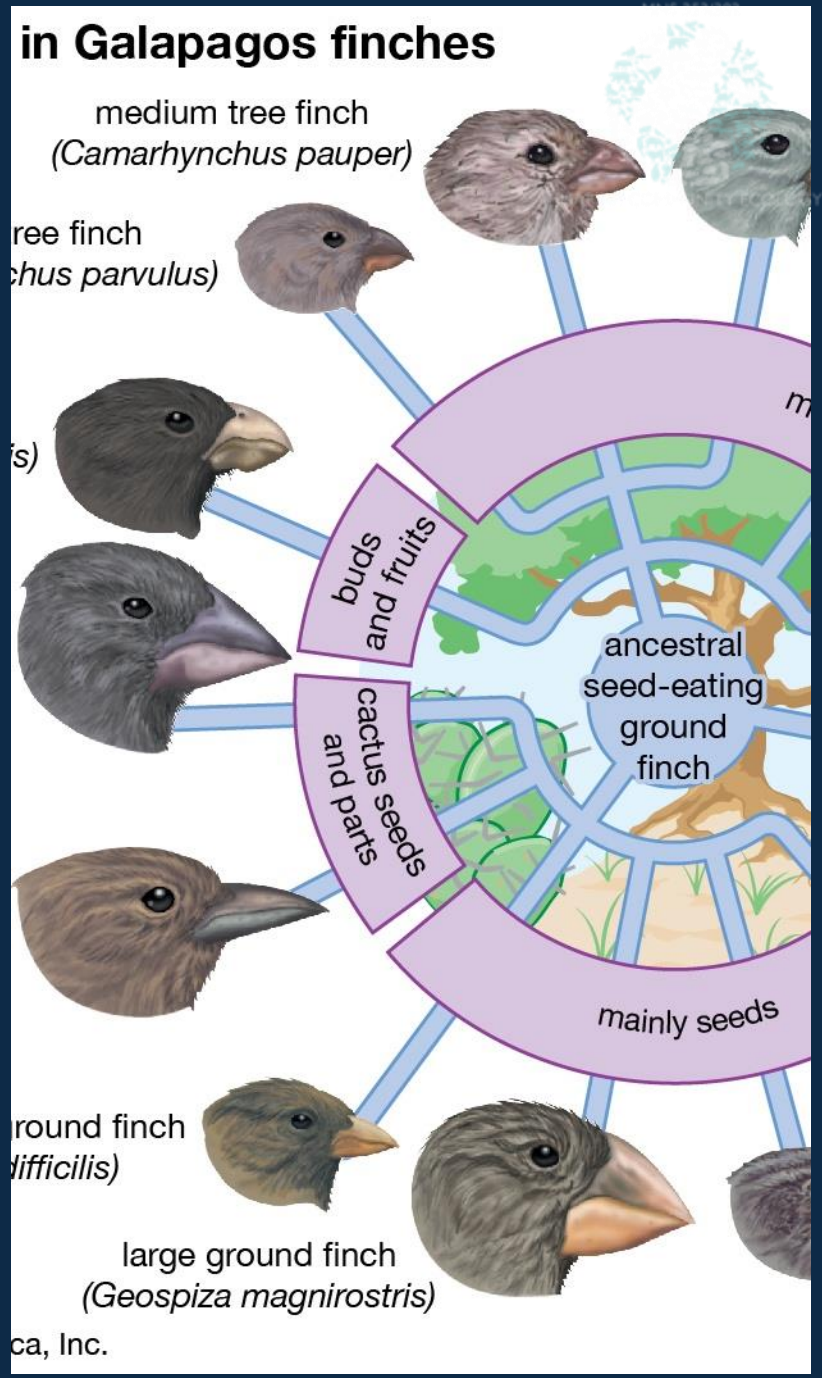
Dispersal ↑ ↓ community dissimilarity (β-diversity) ↑

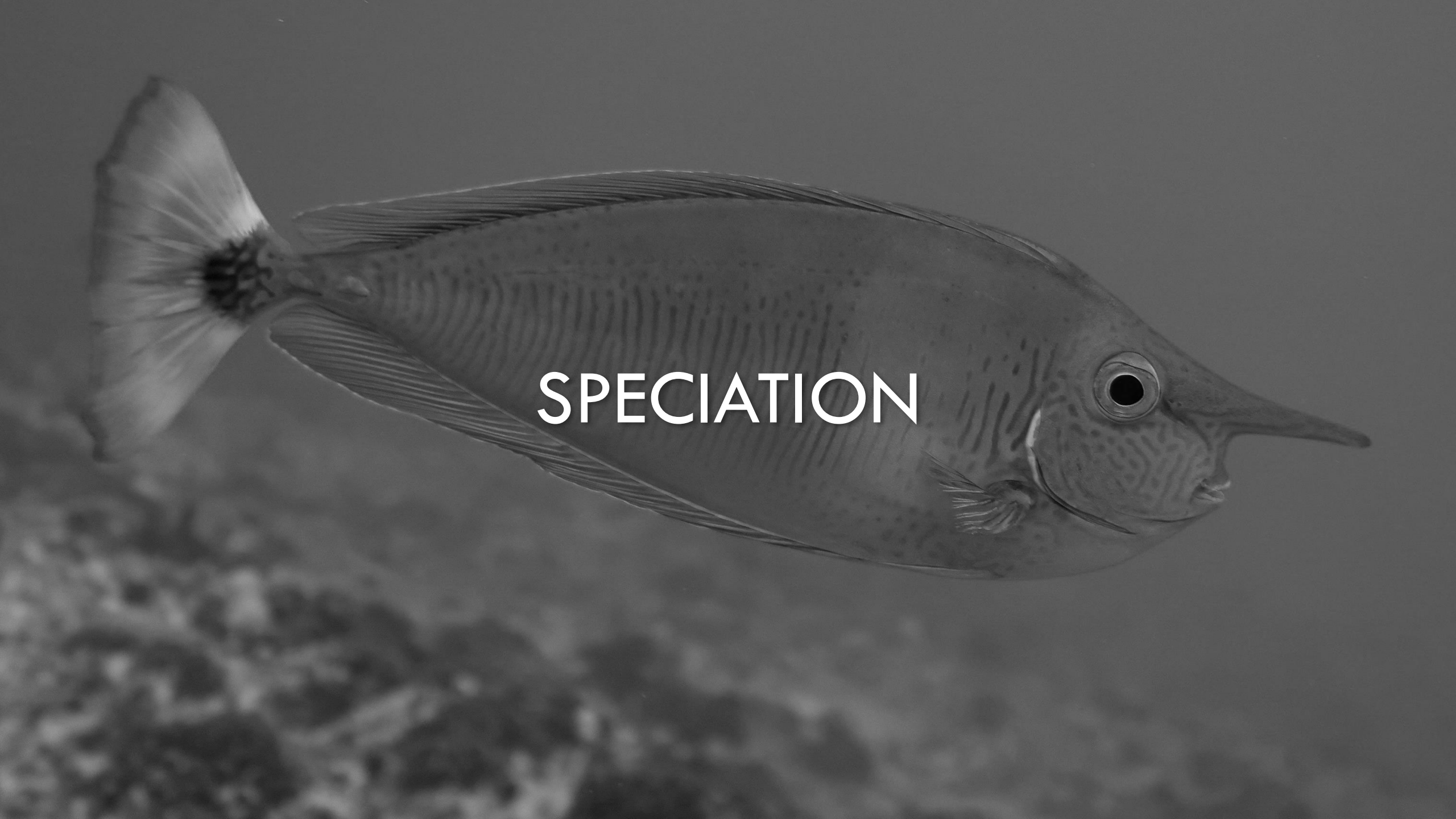
DISPERSAL

Adds species


SPECIATION


2–15 species
16–60 species
>200 species
Lake Victoria (~500 species)
a
b
c
d
e
f – Pundamilia nyererei
g
h
i
Lake Tanganyika (~250 species)
a
b
d
f – Neolamprologus brichardi
e
g
h
Lake Malawi (~500 species)
a
c
d
b – Metriaclima zebra
e
f
g
h
i
Rivers
Paretroplus (Madagascar)
Etroplus (India)
Ptychochmis (Madagascar)
Heterochromis multidens
Hemichromini
Pelmatochromini
Chromidotilapini
Tylochromini
O. niloticus
Steatocranus
Tilapia zilli
Bathybatini
Trematocarini
Eretmodini
Lamprologini: N. brichardi
Limnochromini
Cyprichromini
Perrisodini
Ectodini
Astatoreochromis
Paleolake Makgadikgadi
Tropheini (Lake Tanganyika)
Lake Malawi: M. zebra
A. burtoni
Astatotilapia flavijosephi
Riverine East African Astatotilapia
Lake Victoria: P. nyererei
Lake Tanganyika


in Galapagos finches
medium tree finch
(Camarhynchus pauper)
ree finch
chus parvulus)
s)
buds and fruits
cactus seeds and parts
mainly seeds
ancestral seed-eating ground finch
round finch
difficilis)
large ground finch
(Geospiza magnirostris)
ca, Inc.



SPECIATION

Scale: a few local seagrass beds

Scale: seagrass beds within a region

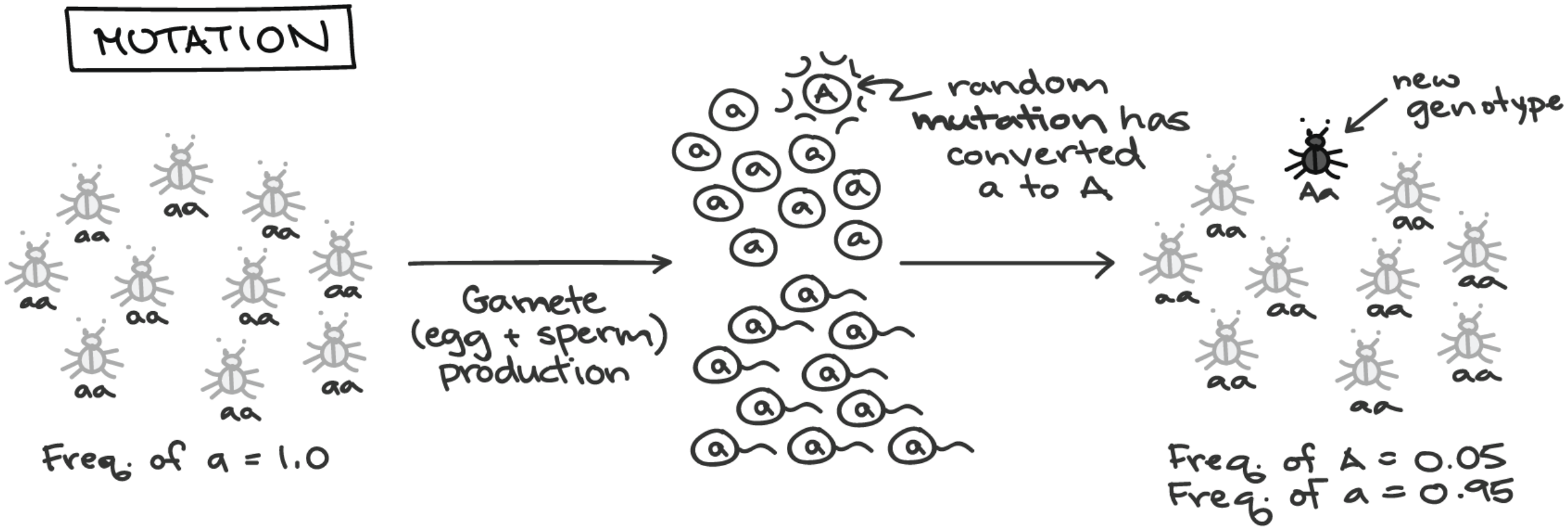
Scale: seagrass beds across many regions

Genus *Trimma*: extreme microallopatry

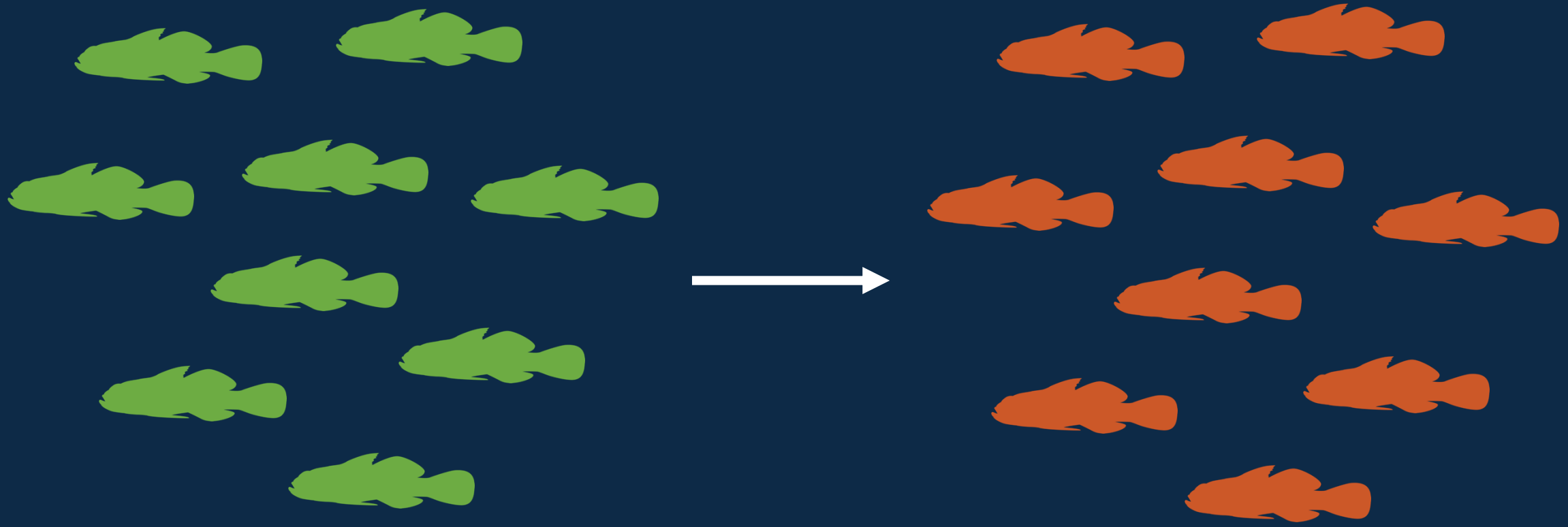
Winterbottom et al. 2014


Speciation = Mutation?

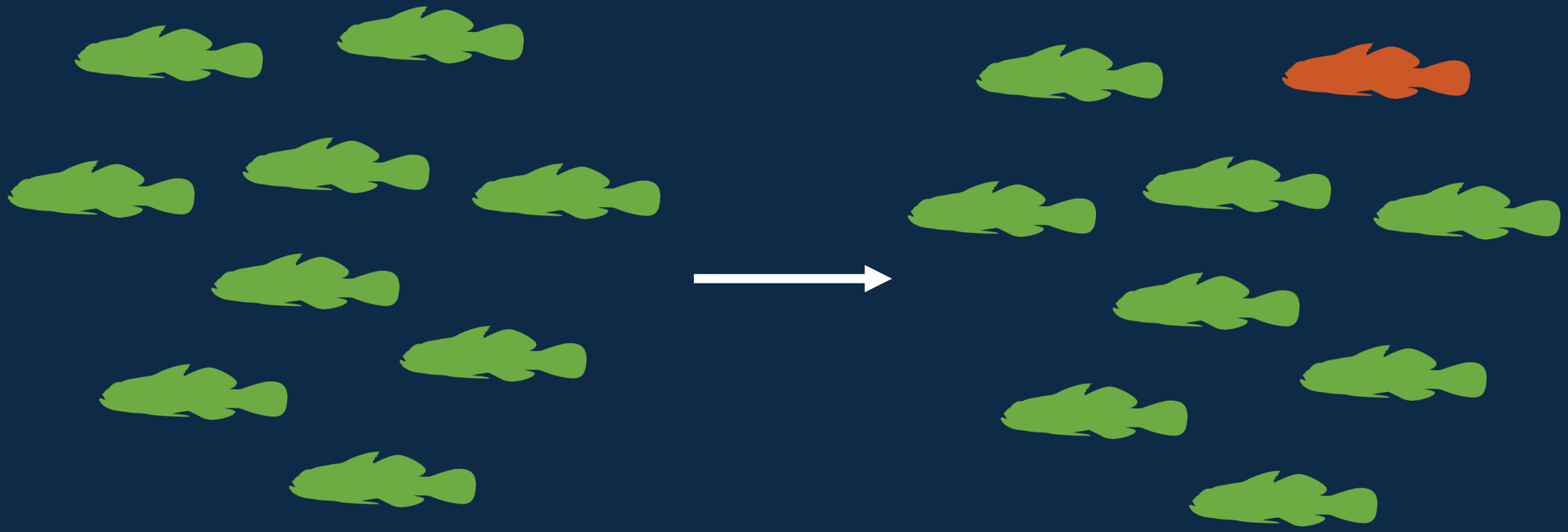
Speciation = mutation?

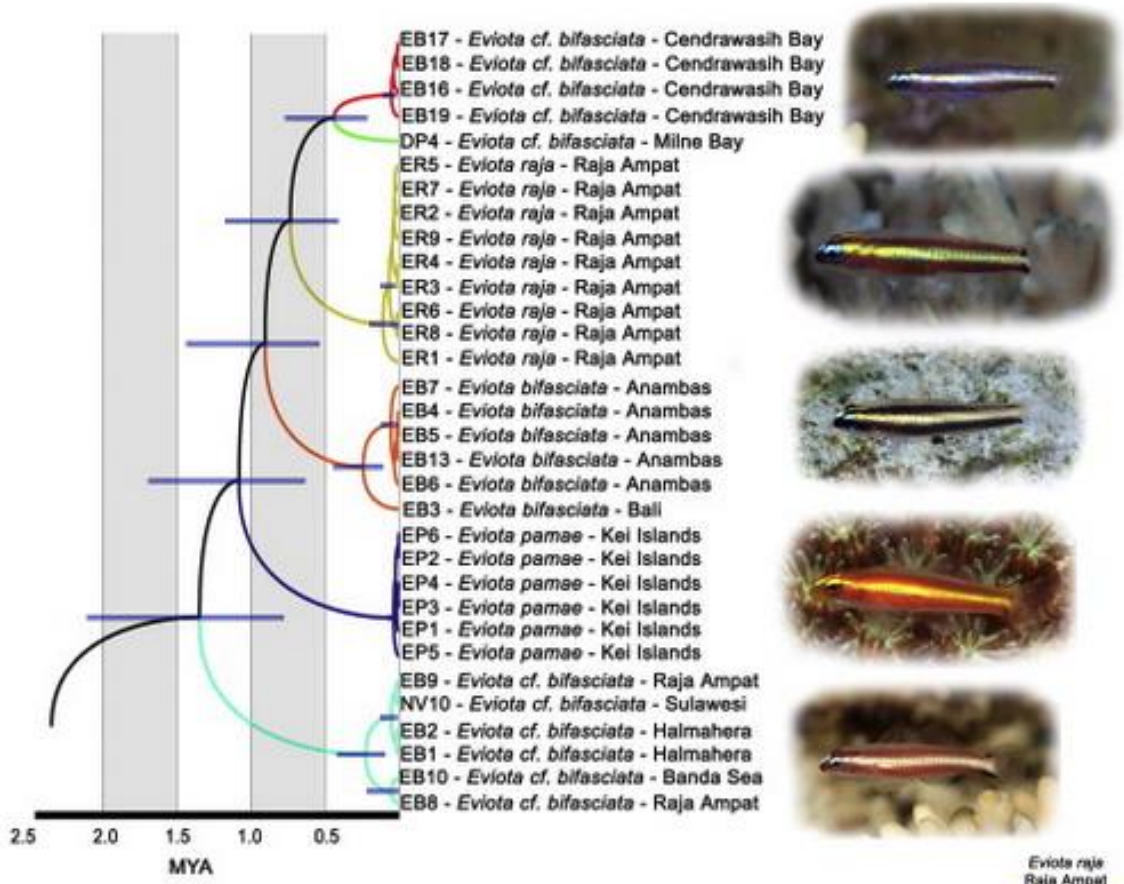


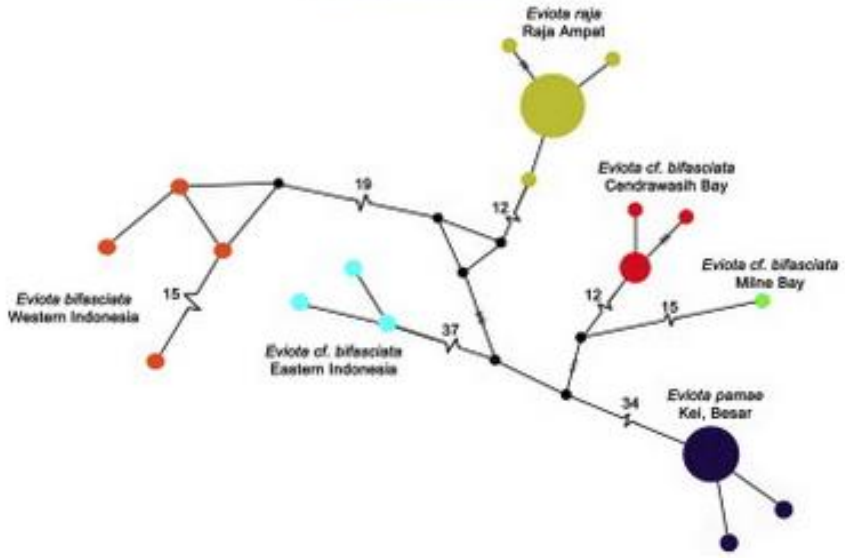
Allopatric speciation



Sympatric speciation

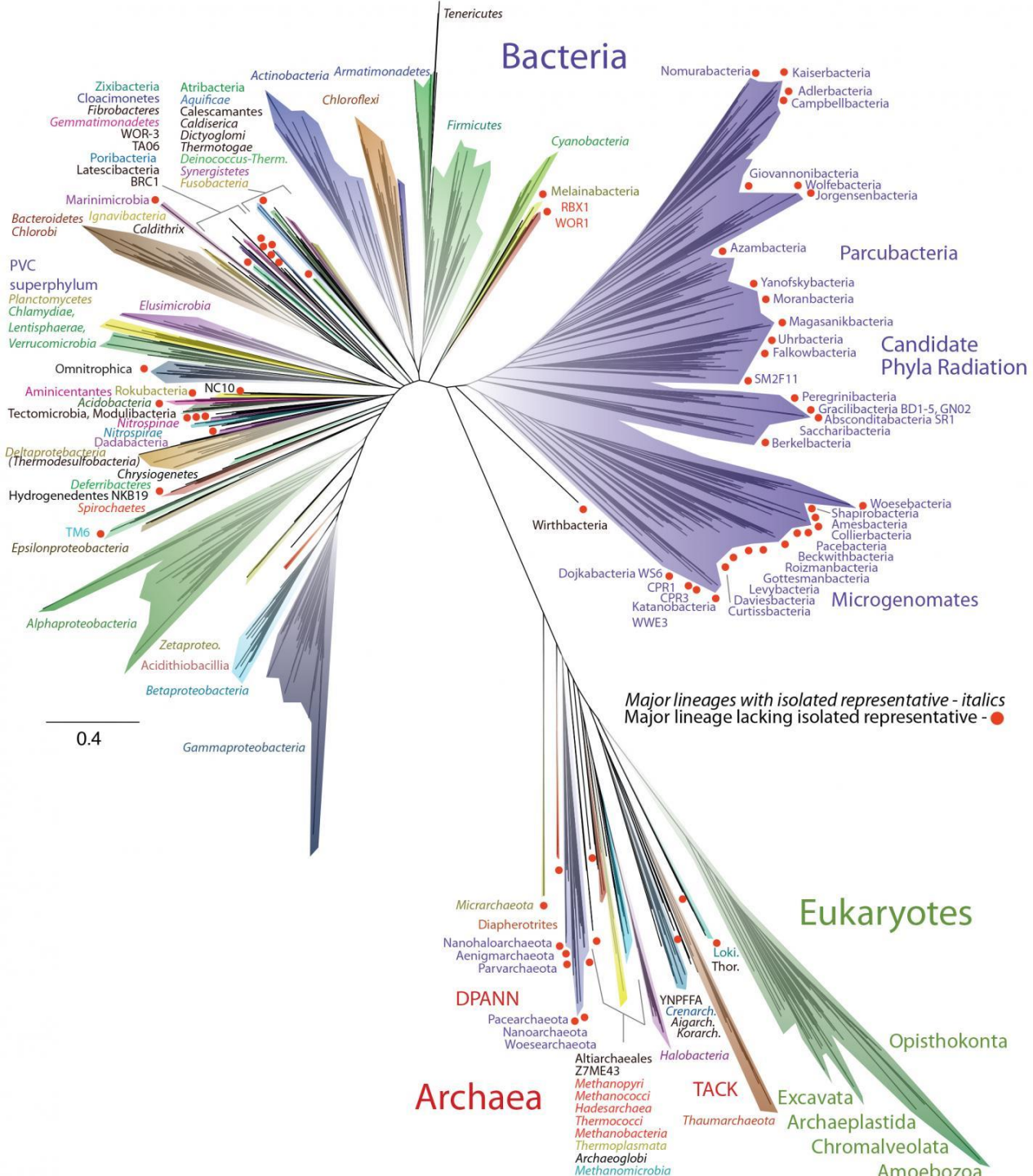


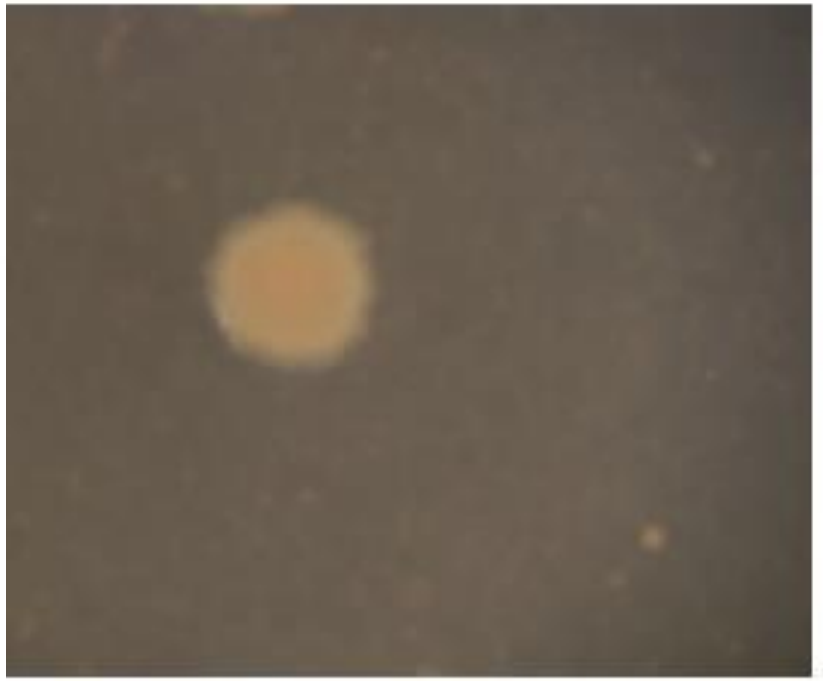


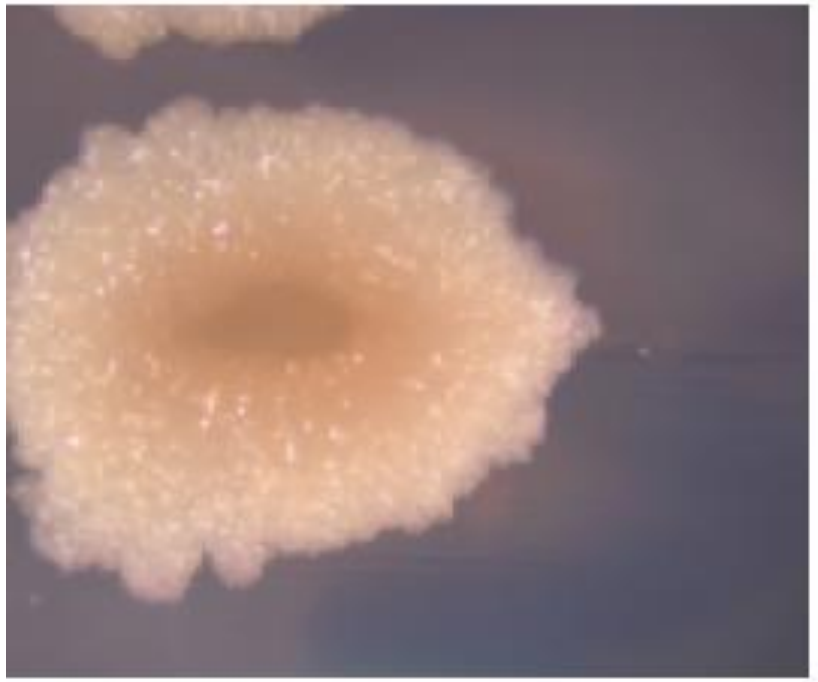


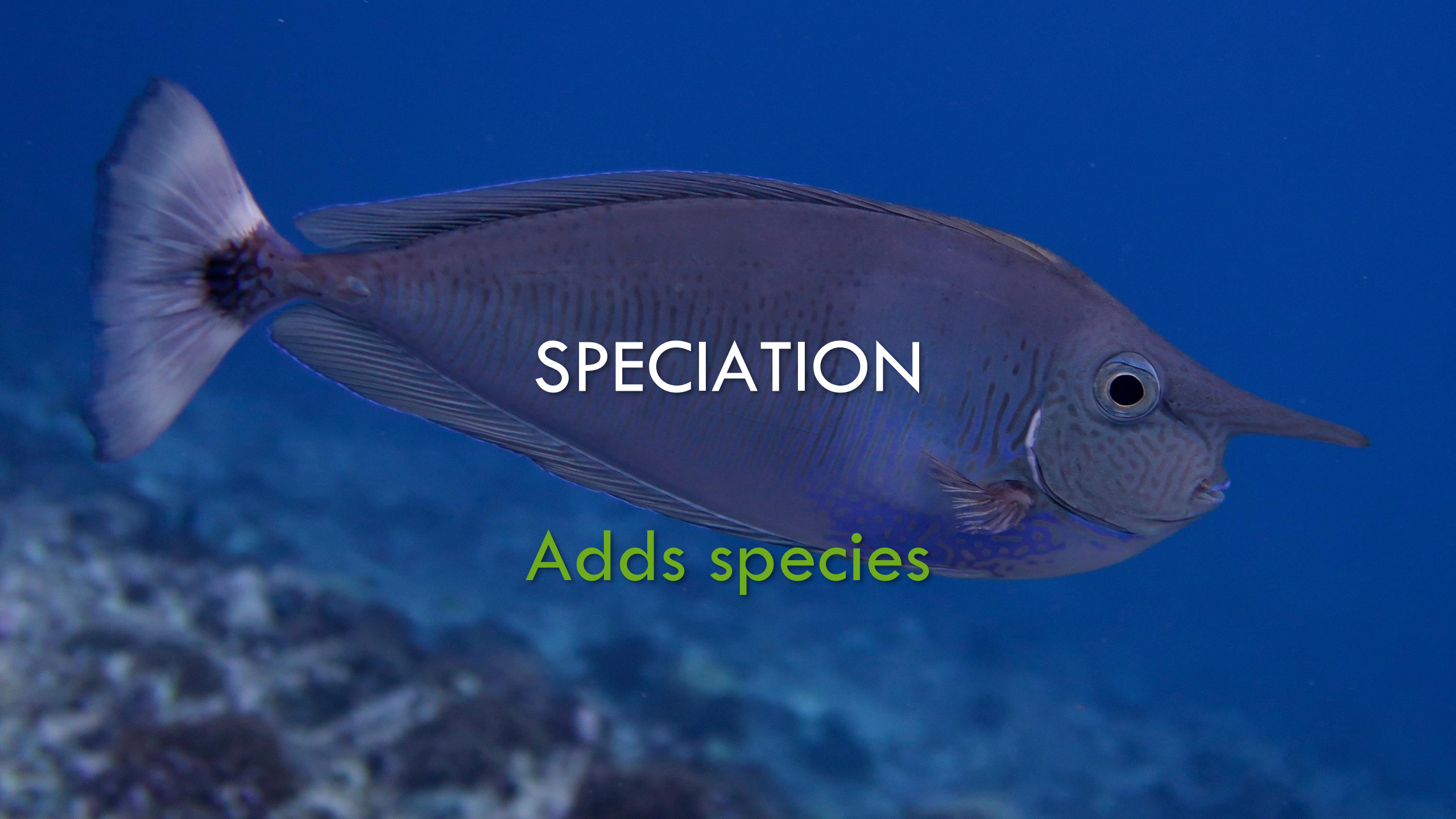
Speciation during mid Pleistocene (150,000 years ago)

Tornabene et al. 2015


Bacteria
Tenericutes
Actinobacteria
Armatimonadetes
Chloroflexi
Firmicutes
Cyanobacteria
Zixibacteria
Cloacimonetes
Fibrobacteres
Gemmatimonadetes
WOR-3
TA06
Poribacteria
Latescibacteria
BRC1
Atribacteria
Aquificae
Calescamantes
Caldiserica
Dictyoglomi
Thermotogae
Deinococcus-Therm.
Synergistetes
Fusobacteria
Marinimicrobia
Bacteroidetes
Chlorobi
Ignavibacteria
Calditrix
Melainabacteria
RBX1
WOR1
PVC
superphylum
Planctomycetes
Chlamydiae,
Lentisphaerae,
Verrucomicrobia
Elusimicrobia
Omnitrophica
Aminicentantes
Rokubacteria
NC10
Acidobacteria
Tectomicrobia, Modulibacteria
Nitrospinae
Nitrospirae
Dadabacteria
Deltaprotebacteria
(Thermodesulfobacteria)
Chrysiogenetes
Deferribacteres
Hydrogenedentes NKB19
Spirochaetes
TM6
Epsilonproteobacteria
Alphaproteobacteria
Zetaproteo.
Acidithiobacillia
Betaproteobacteria
Gammaproteobacteria
0.4
Nomurabacteria
Kaiserbacteria
Adlerbacteria
Campbellbacteria
Giovannonibacteria
Wolfebacteria
Jorgensenbacteria
Azambacteria
Parcubacteria
Yanofskybacteria
Moranbacteria
Magasanikbacteria
Uhrbacteria
Falkowbacteria
SM2F11
Candidate
Phyla Radiation
Peregrinibacteria
Gracilibacteria BD1-5, GN02
Absconditabacteria SR1
Saccharibacteria
Berkelbacteria
Wirthbacteria
Woesebacteria
Shapirobacteria
Amesbacteria
Collierbacteria
Pacebacteria
Beckwithbacteria
Roizmanbacteria
Gottesmanbacteria
Levybacteria
Daviesbacteria
Curtissbacteria
Dojkabacteria WS6
CPR1
CPR3
Katanobacteria
WWE3
Microgenomates
Major lineages with isolated representative - italics
Major lineage lacking isolated representative -
Micrarchaeota
Diapherotrites
Nanohaloarchaeota
Aenigmarchaeota
Parvarchaeota
DPANN
Pacearchaeota
Nanoarchaeota
Woesearchaeota
Altiarchaeales
Z7ME43
Methanopyri
Methanococci
Hadesarchaea
Thermococci
Methanobacteria
Thermoplasmata
Archaeoglobi
Methanomicrobia
Archaea
YNPFFA
Crenarch.
Aigarch.
Korarch.
Halobacteria
TACK
Thaumarchaeota
Loki.
Thor.
Eukaryotes
Opisthokonta
Excavata
Archaeplastida
Chromalveolata
Amoebozoa







SPECIATION

Adds species


SELECTION

Causes of selection

Competition
Predation
Limiting similarity
Facilitation
Succession
Resource partitioning
Feedback loops
Disturbance
Non-consumptive effects
Alternative stable states
Priority effects
Intransitive competition
Storage effects
Janzen-Connell Effects

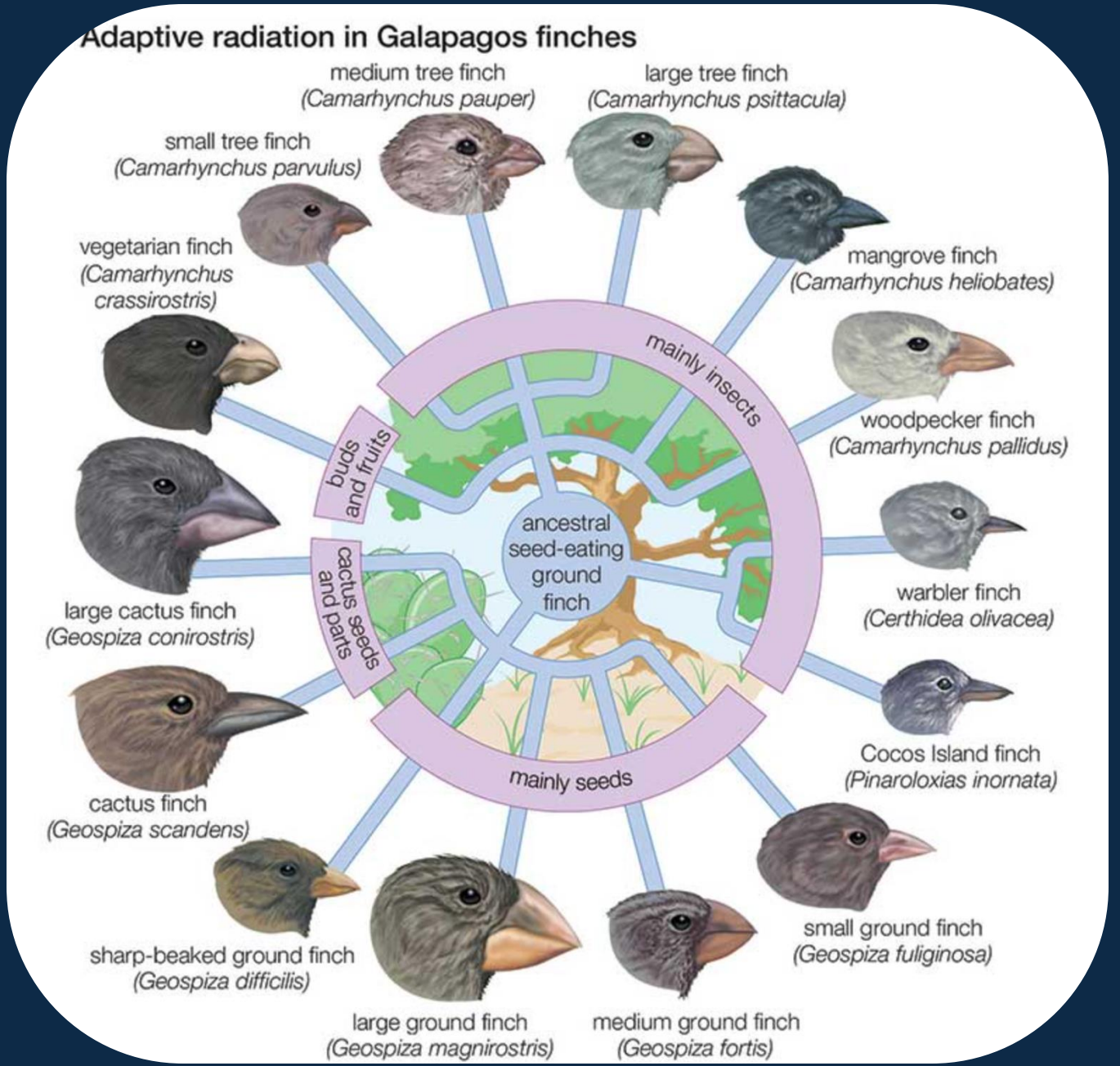
Consequences of selection

Selection

CONSEQUENCES

"… the operation of selective forces on populations, which cannot be understood in terms of nor reduced to the principles of physics or chemistry."

Applies to evolution, ecology, economics, genetics, social science, medicine, etc.



Bell 2009

Fitness


Expected quantity of offspring produced by an organism per unit time

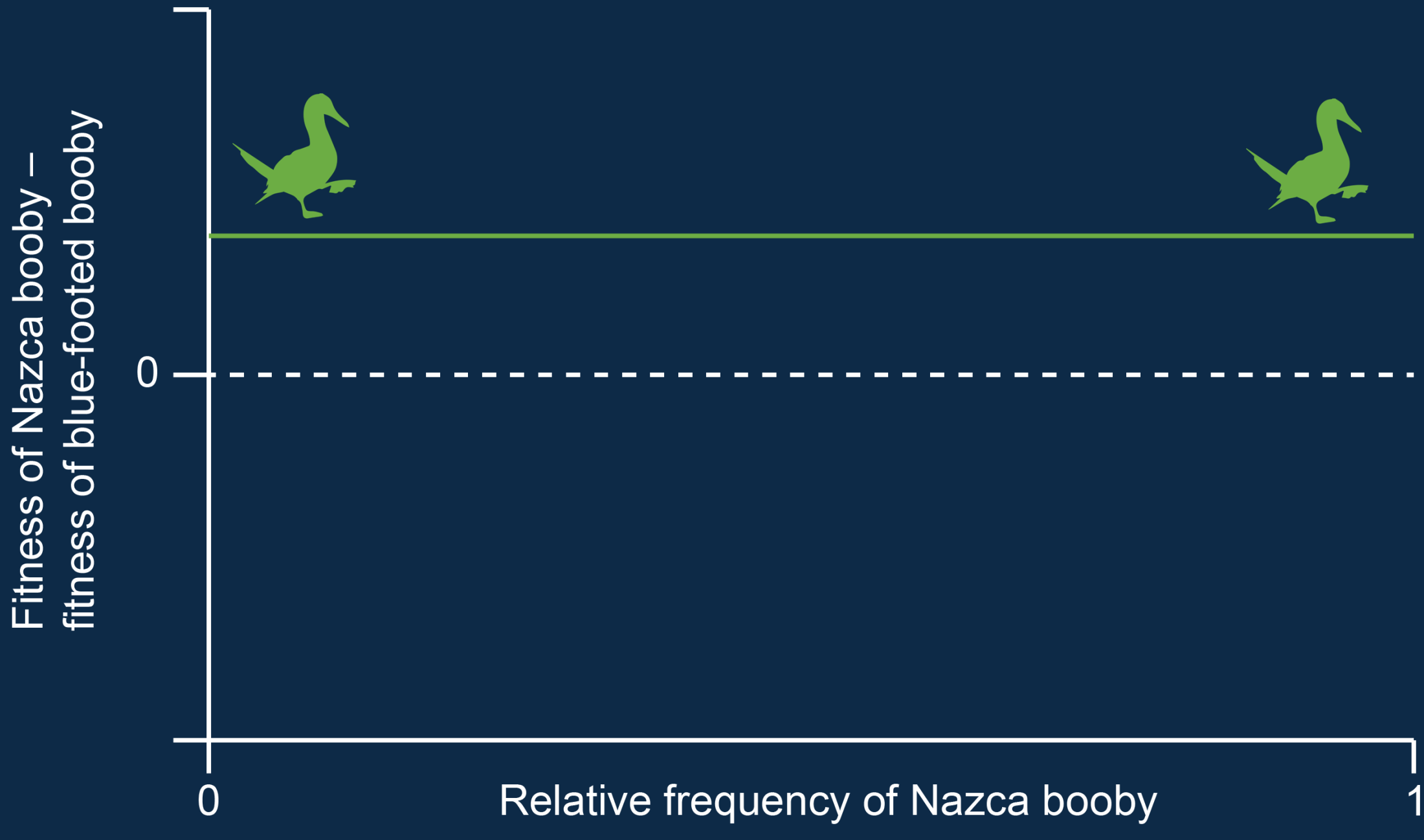
FORMS OF SELECTION

Townsend et al. 2002

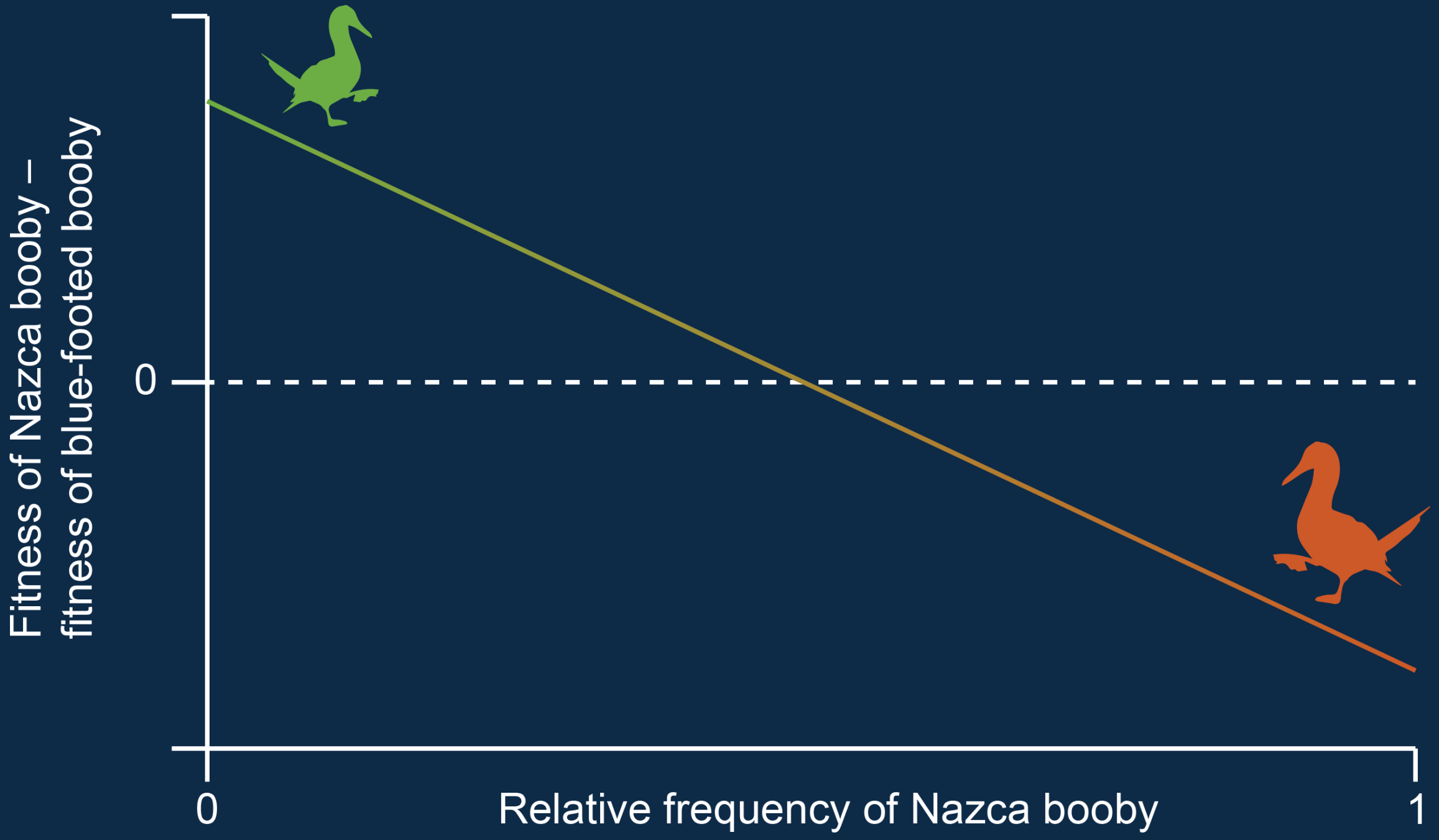
Five main forms of selection

1. Constant selection
2. Negative frequency-dependent selection
3. Positive frequency-dependent selection
4. Spatially-variable selection
5. Temporally-variable selection

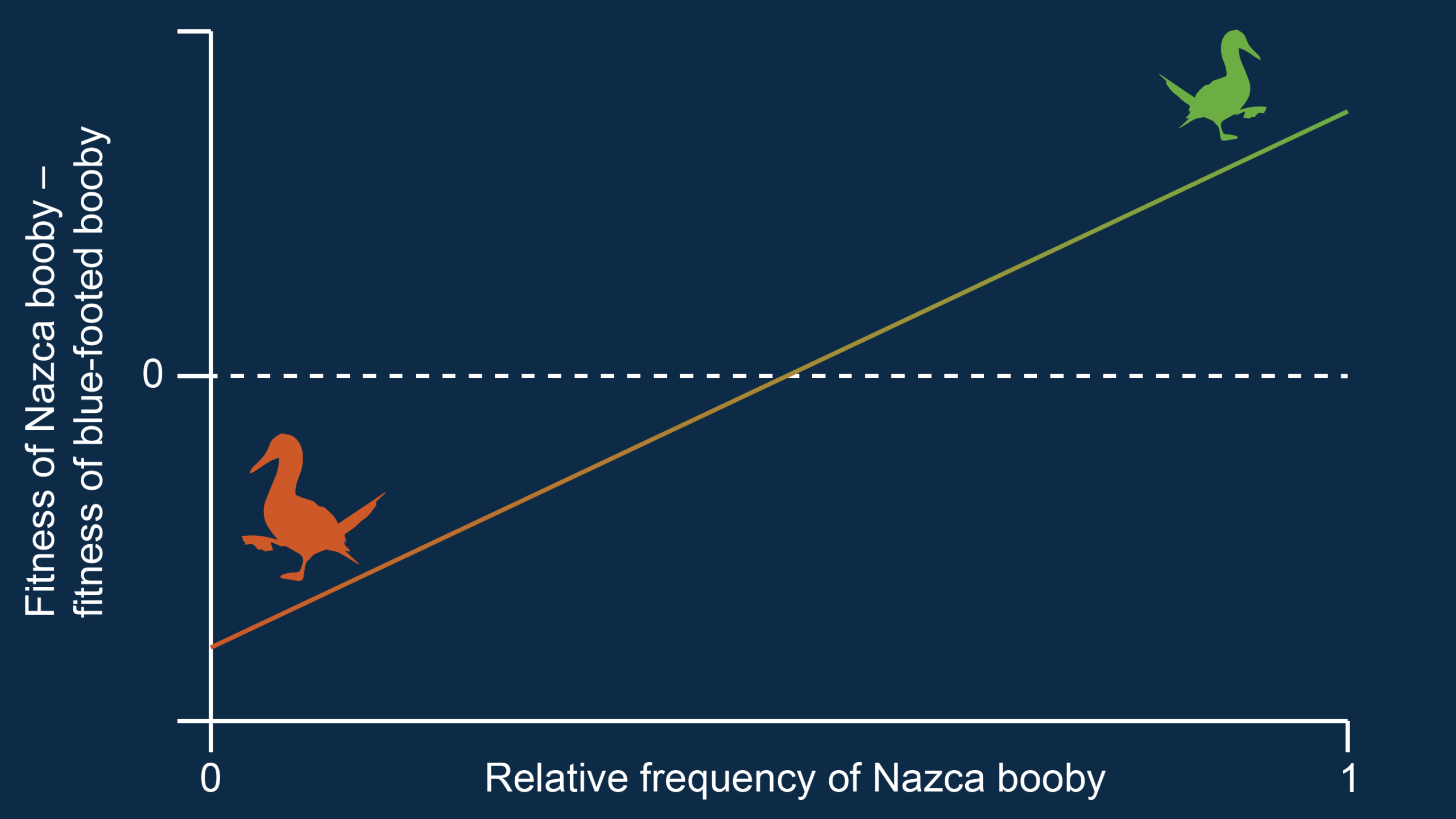
1. Constant selection


Fitness of Nazca booby –
fitness of blue-footed booby
0
0
Relative frequency of Nazca booby
1

2. Negative frequency-dependent selection


Fitness of Nazca booby –
fitness of blue-footed booby
0
0
Relative frequency of Nazca booby
1

3. Positive frequency-dependent selection


Fitness of Nazca booby –
fitness of blue-footed booby
0
0
Relative frequency of Nazca booby
1

4. Spatially-variable selection

5. Temporally-variable selection

Five main forms of selection

1. Constant selection

2. Negative frequency-dependent selection

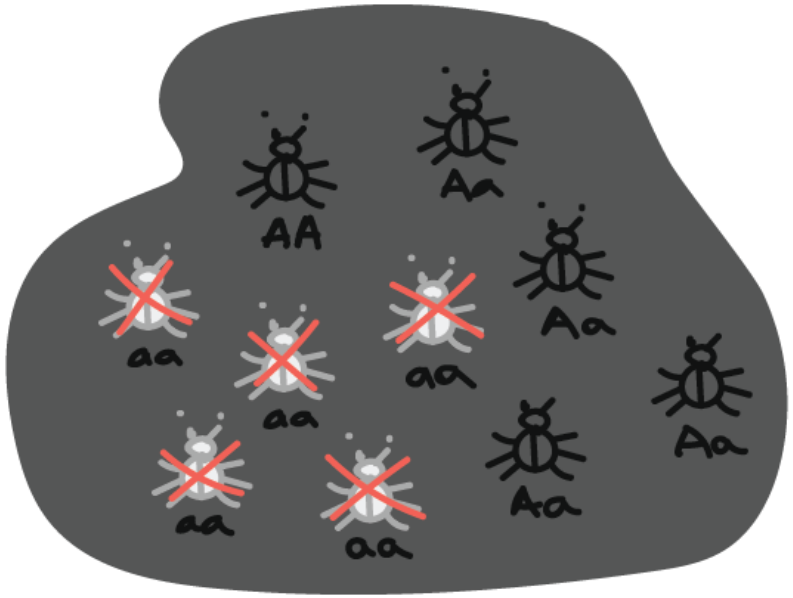
3. Positive frequency-dependent selection

4. Spatially-variable selection

5. Temporally-variable selection


Species are affected by selection, which results in one species gaining a competitive advantage

NATURAL SELECTION



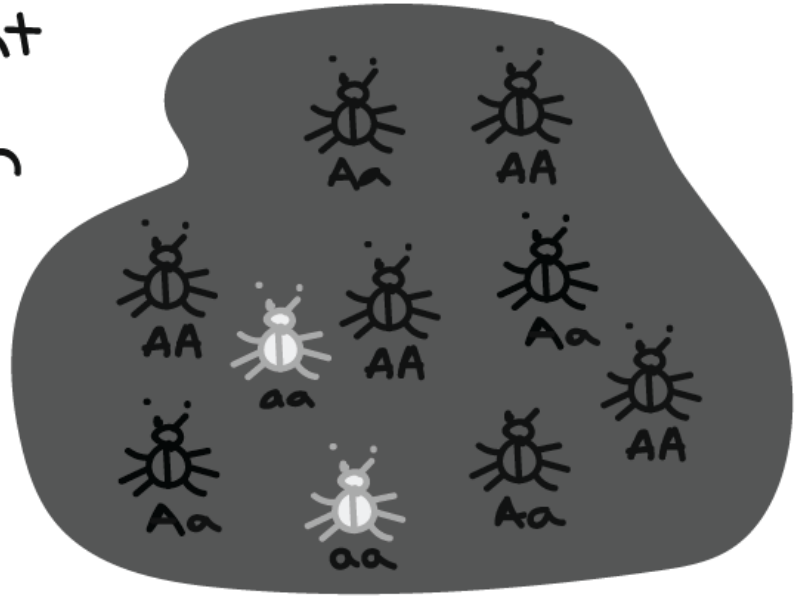
Freq. of A = 0.3
Freq. of a = 0.7

Dark rock environment → light gray beetles are spotted and eaten by birds more often than dark ones

X = eaten by bird

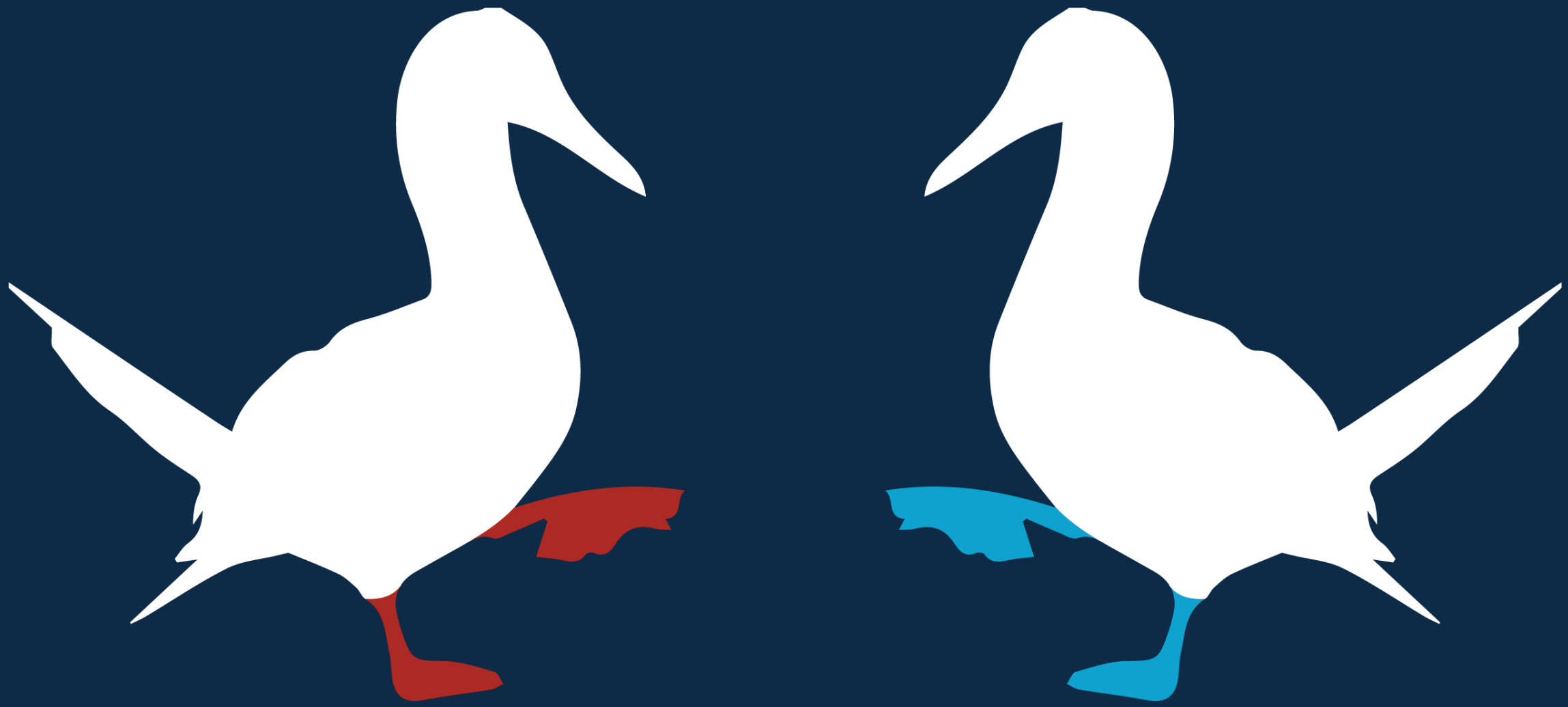
Only survivors reproduce...

Next generation

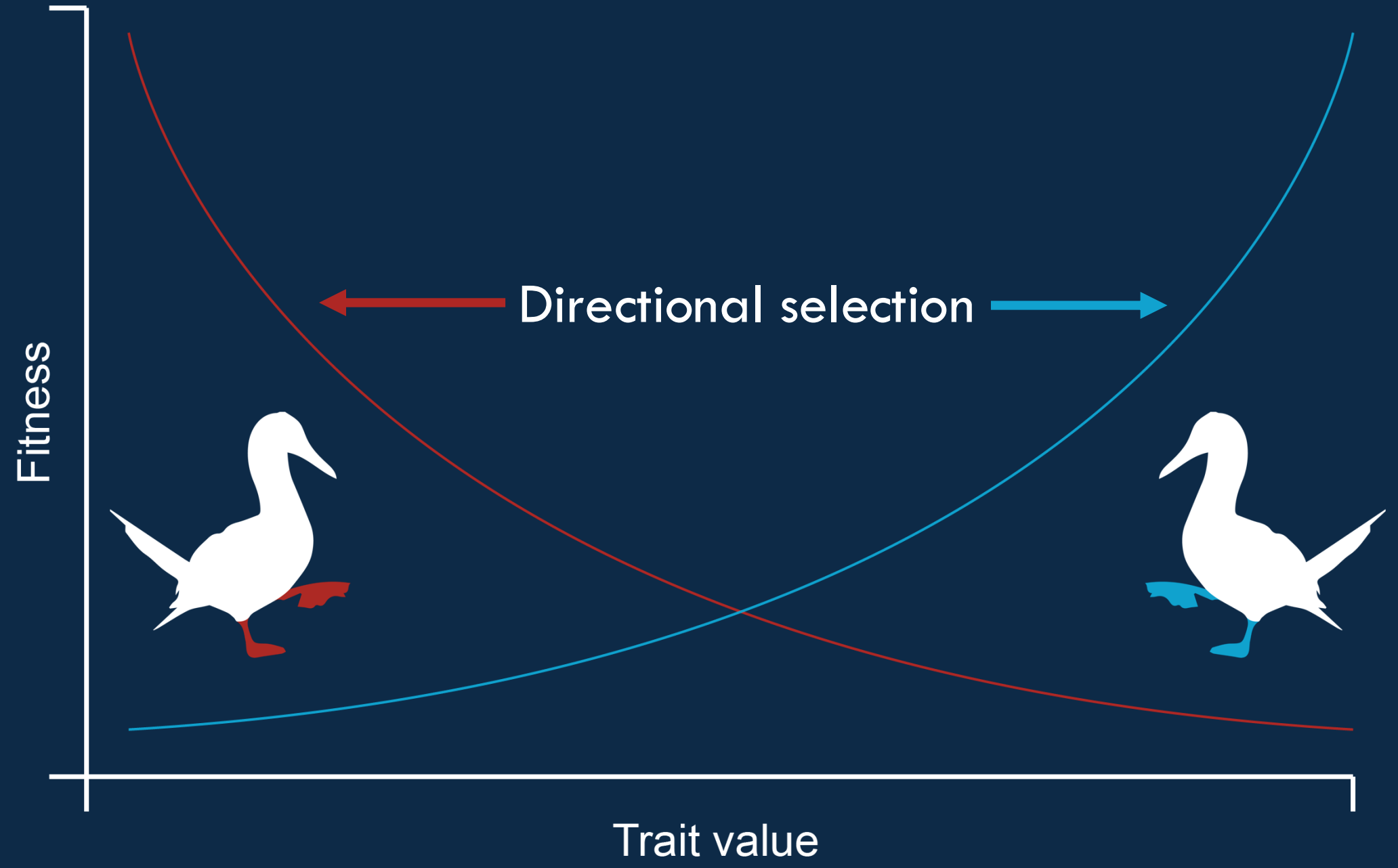


Freq. of A = 0.6
Freq. of a = 0.4

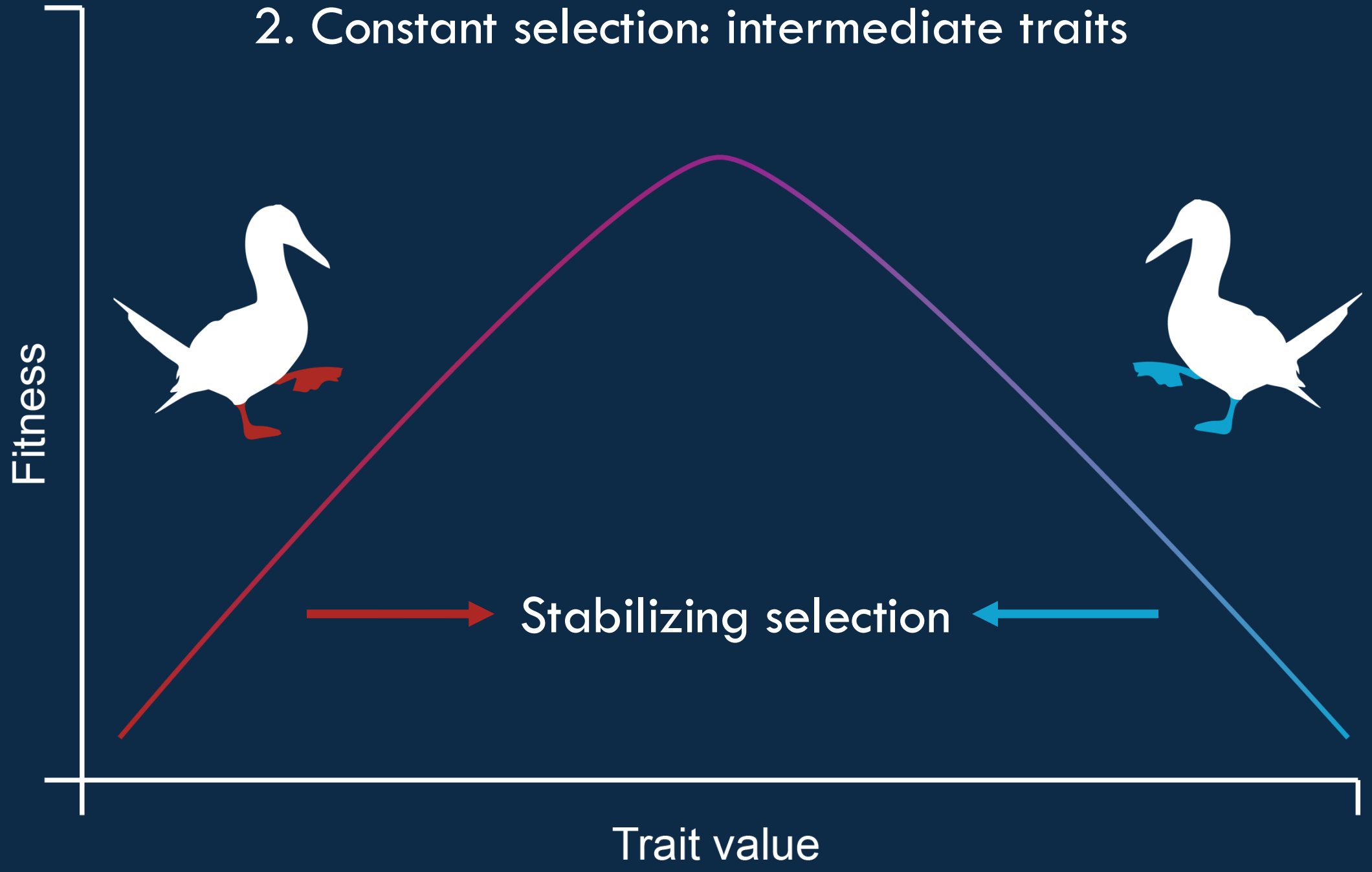
Trait-based selection



1. Constant selection: extreme traits



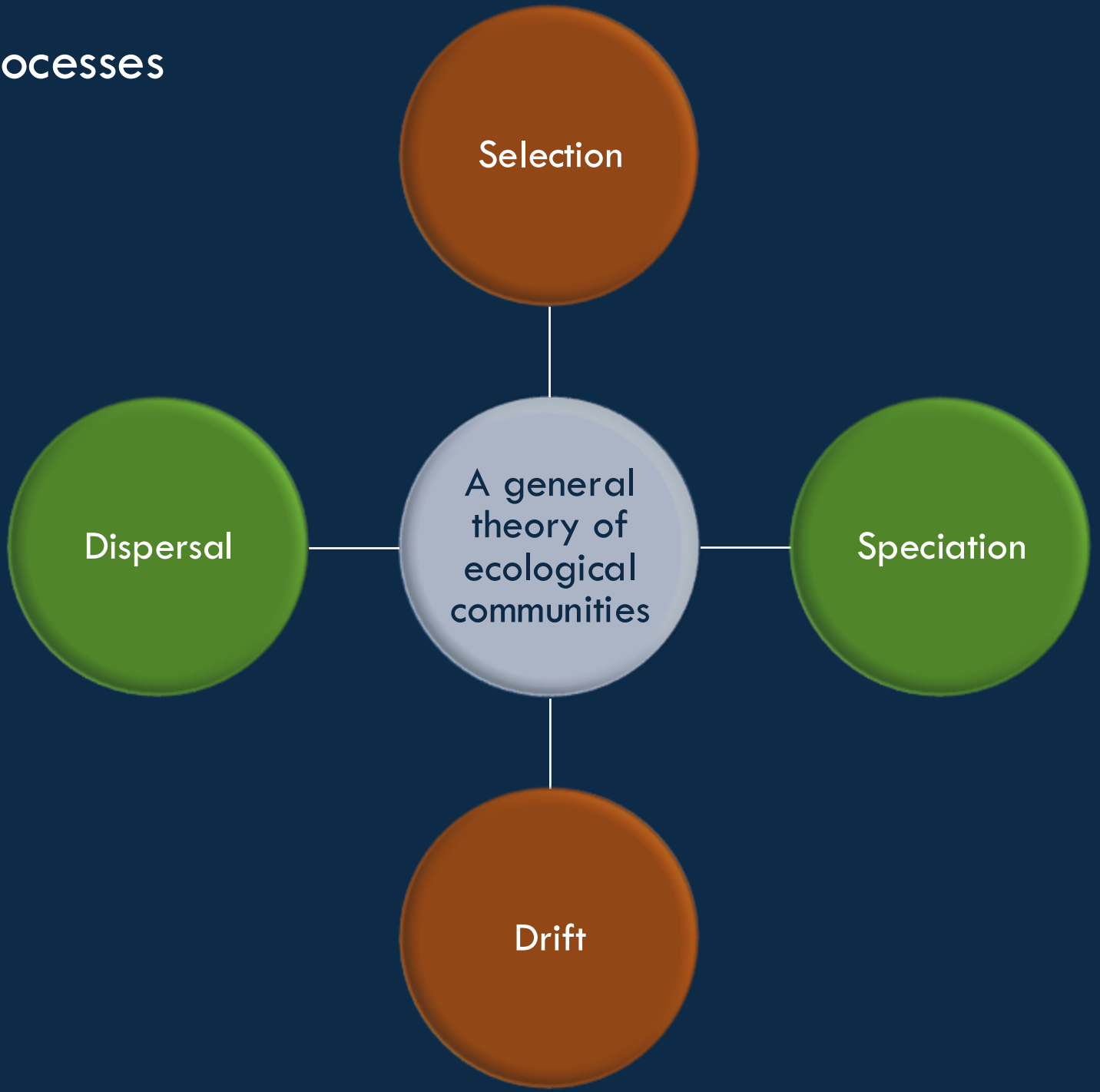
2. Constant selection: intermediate traits



(Imagine purple-footed booby here)


ECOLOGICAL SELECTION
Takes away species

Four high level processes



Vellend 2010; 2016

Four main processes

Selection

Drift

Dispersal

Speciation

Five lower-level processes of selection

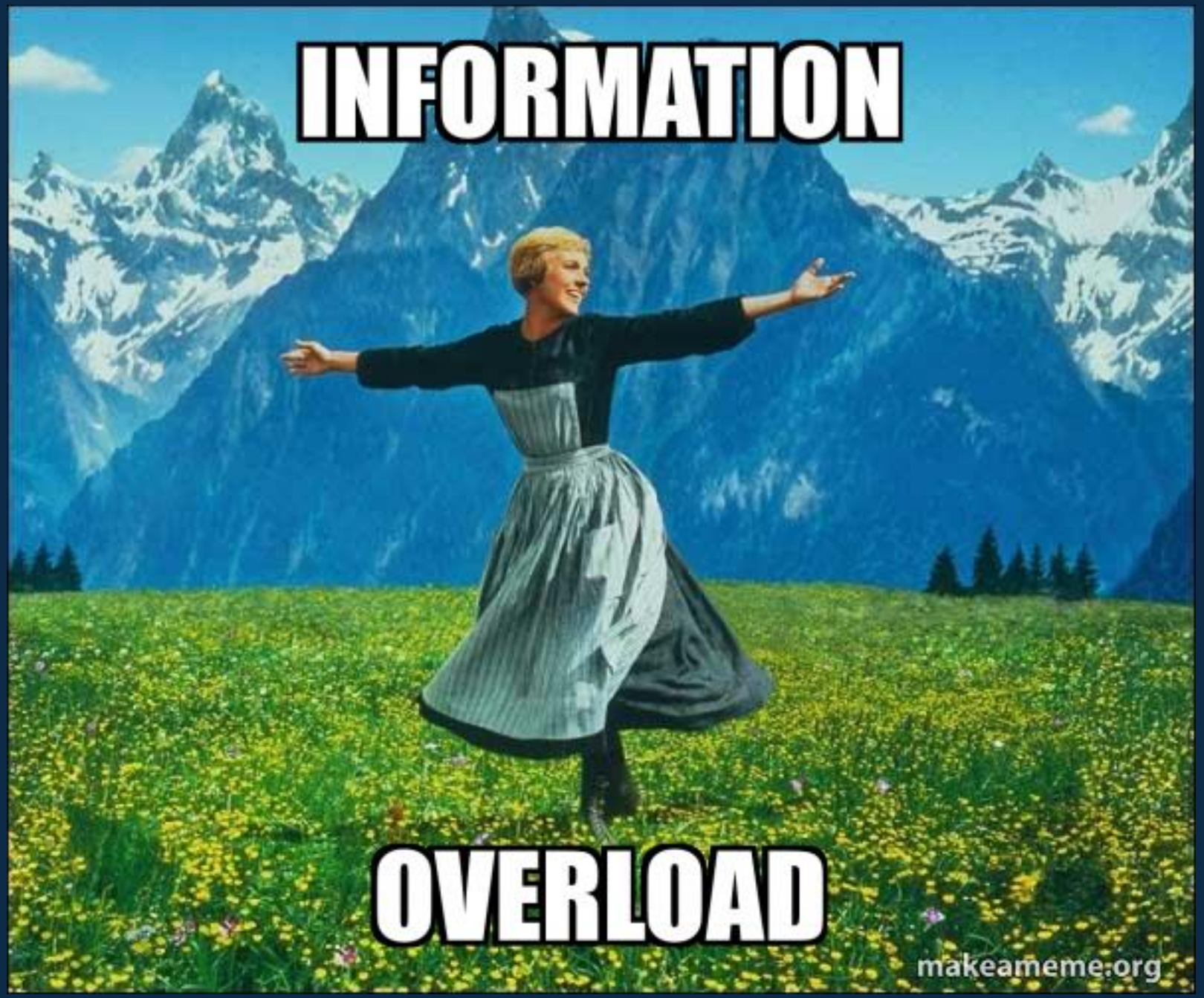
Constant selection

Negative frequency-dependent selection

Positive frequency-dependent selection

Spatially-variable selection

Temporally-variable selection


INFORMATION
OVERLOAD
makeameme.org

Homework

Briefly (1-2 sentences) describe the four main processes (dispersal, drift, speciation, selection) and the five main forms of selection (constant, negative frequency-dependent, positive frequency-dependent, spatially variable, temporally variable) and their role in structuring ecological communities using your own words.

E.g.: Ecological drift: a stochastic process that describes species' random walks to extinction. Drift removes species from a community and depends strongly on a species' population size.