Marine Population Ecology & Dynamics

14 OCTOBER 2021

Today

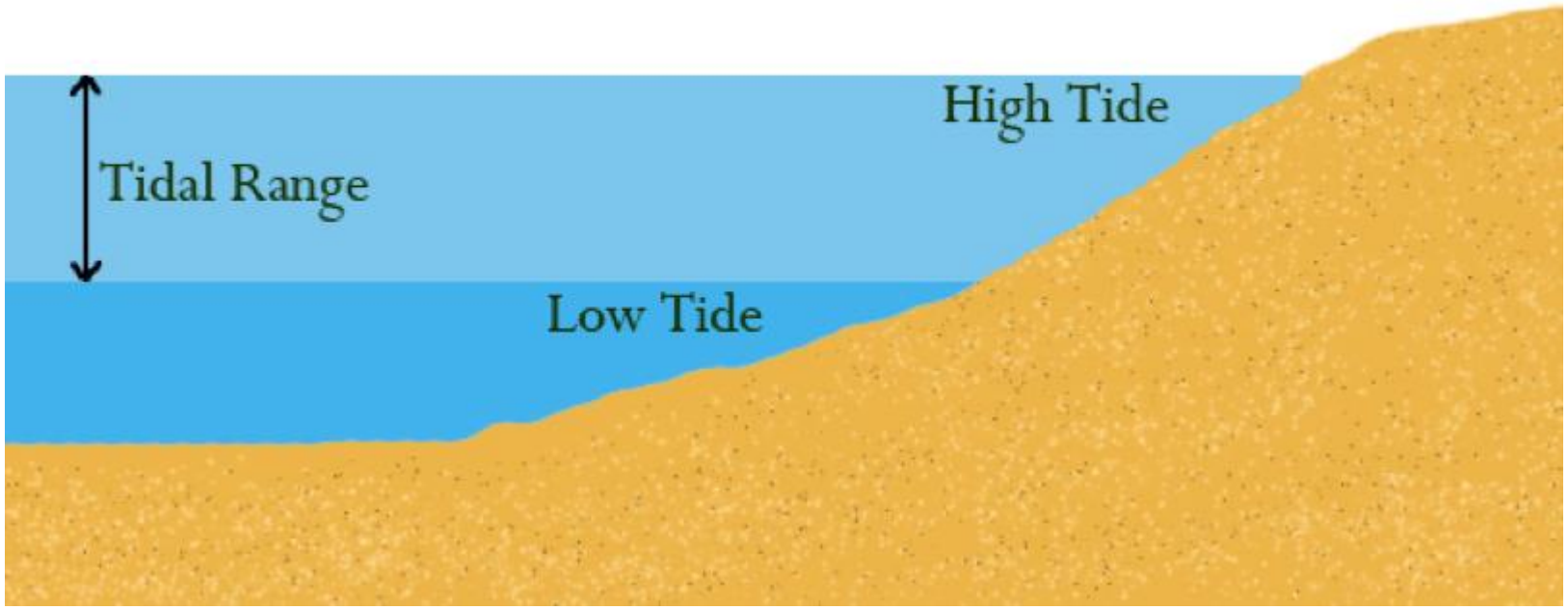
- Rocky intertidal zones as a model system for:
  - Pattern vs process in ecology
  - Niche concept
    - fundamental vs realized
  - Linking ecology and evolution
    - Inter vs intraspecific variability

Later today

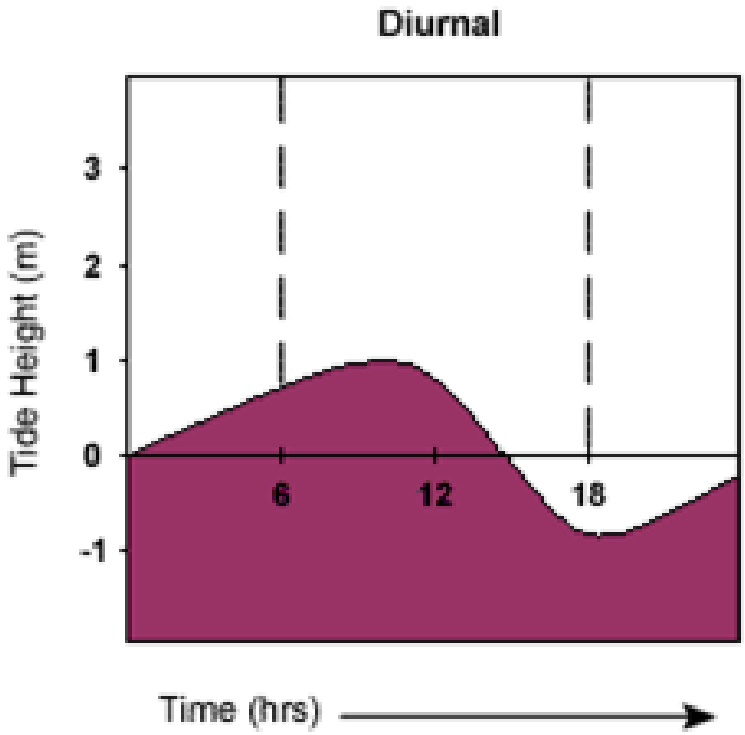
Github tutorial

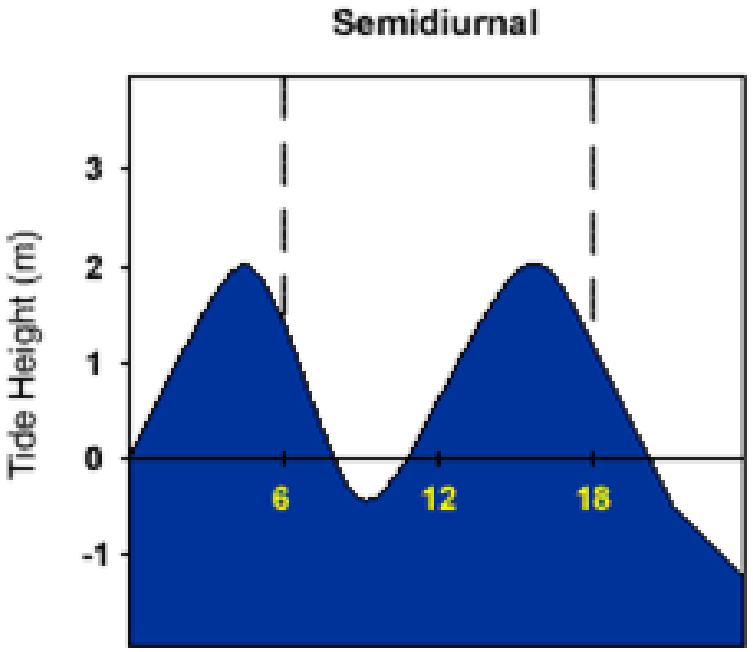
Guest lecture: Shannon Hennessey

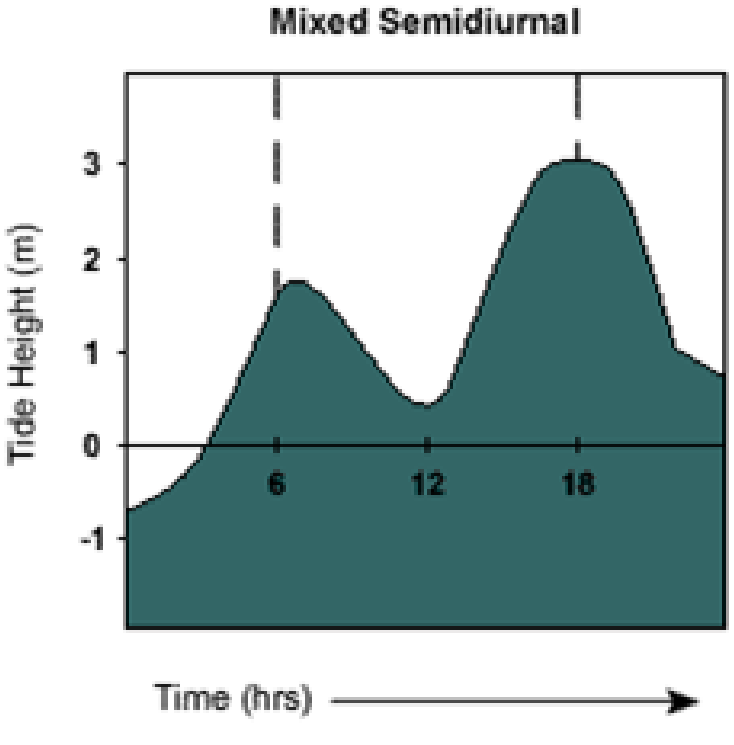
Tidal range



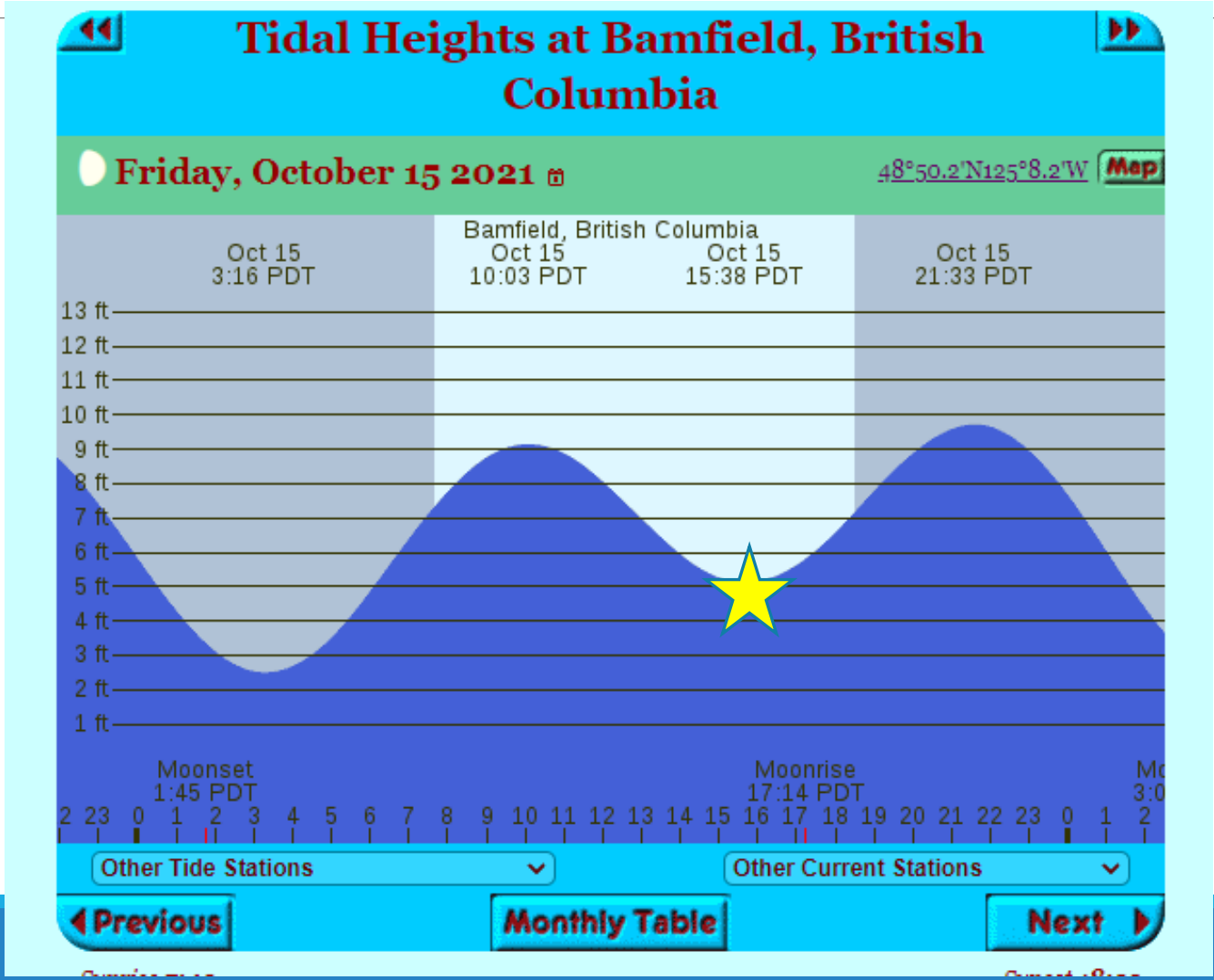
Bay of Fundy (E Canada)
Tidal range: 17 m (55 ft)!


Diurnal
Tide Height (m)
3
2
1
0
-1
6
12
18
Time (hrs)


Semidiurnal
Tide Height (m)
3
2
1
0
-1
6
12
18


Mixed Semidiurnal
Tide Height (m)
3
2
1
0
-1
6
12
18
Time (hrs)

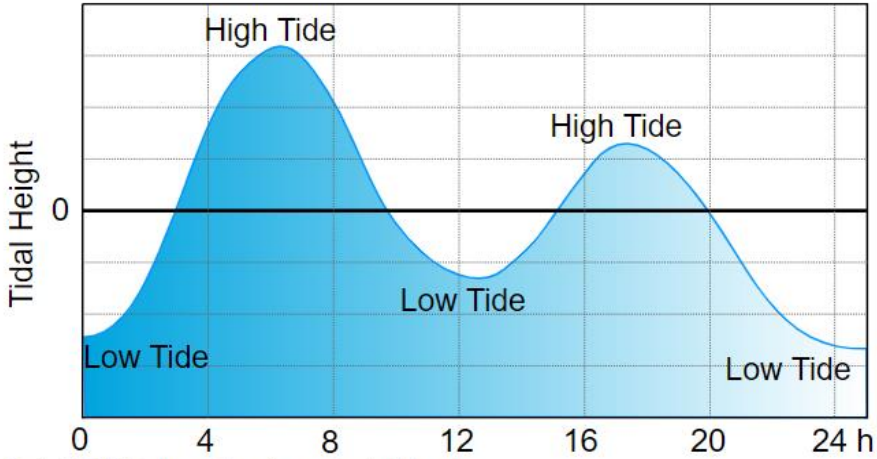
Tides at BMSC- http://www.dairiki.org/

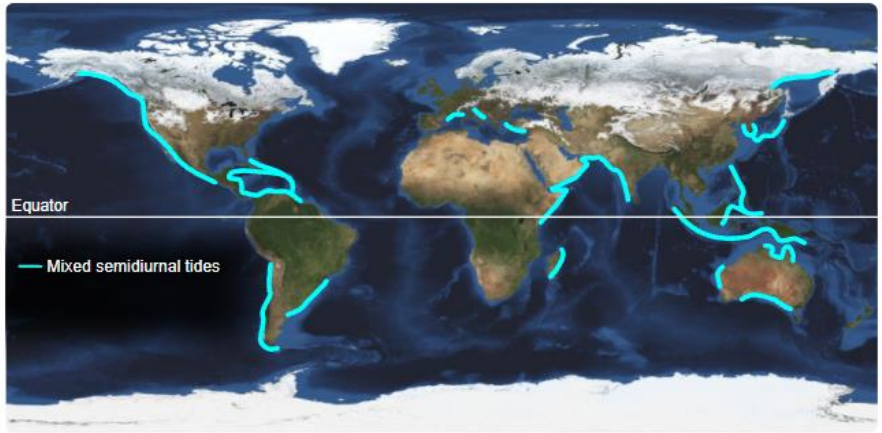


Bamfield MSC

Mixed Tidal Cycle

A *mixed tidal cycle* is a cycle with two high and low tides with different sizes each lunar day. The difference in height between successive high (or low) tides is called the diurnal inequality. Areas with a mixed tidal cycle can be found alongside the West cost of the USA, in parts of Australia and in South East Asia.





Right: Tidal Height vs. Time for a mixed tidal cycle.

Left: Global distribution of mixed tides.

Rocky shore intertidal ecology

- similar patterns worldwide (vertical zonation)
- the vertical range is small (< 5 m)
- many species are specialized for life on rocky shores
- most common species are a convenient size (1 - 30 cm)
- predators & prey are often slow and so easy to manipulate, “seastars are like little wolves”

R. T. PAINE
G. CHANG
C. HARLEY
M. WONHAM
E. SOULANILLE
J. RUESINK
A. SUN
D. SECORD
D. BRUMBAUGH
T. WOOTTON
C. PFISTER
R. KVITEK
A. HARPER
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R. Cowen
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G. LAMBERT
C. BIRKELAND
K. MAUZEY
J. DRESCHER ?
G. VAN VLIET ?
B. MENGE / J. LUBCHENCO
A. Olson
W. Rice
S. Gaines
L. West
C. Gavanaugh
M. Patterson

The “keystone” scientist

“I just sat around and gawked. The place was a wonderland of pattern.” – Bob Paine describing his first visit to Tatoosh Island

“A note on trophic complexity and community stability,” was only three pages long, but it set off a revolution — and, for a time, a battle — within the field of ecology.

Tatoosh Island

Ecological Phenomena

Pattern- what we see. Ecologist often attempt to fit ecological data to a pattern, however, a pattern in itself is not meaningful

Process- what we want to understand. Ultimately what we actually use patterns for is to understand processes and mechanisms

Specifically, one goal of ecological science is to “predict” what will happen to a population, or community under a specific set of conditions or circumstances

If you are a conservation scientist, you can then use this to create management outcomes.

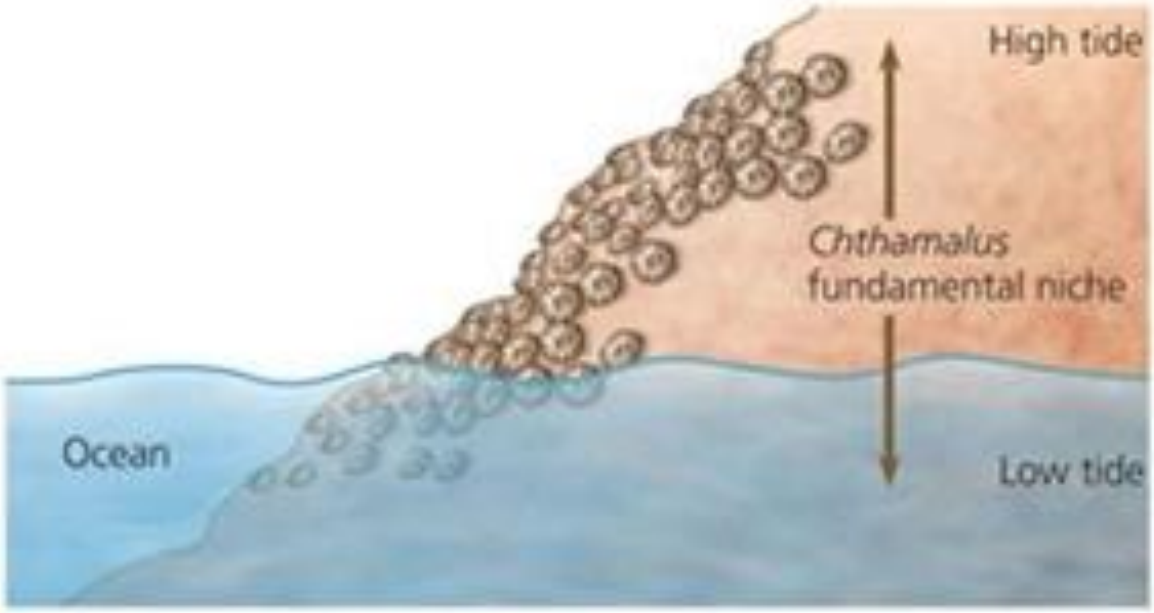
What could be driving patterns of species distribution in the rocky intertidal?

What determines where a species can exist?

Niche: the set of abiotic and biotic conditions under which an organism can survive and reproduce.

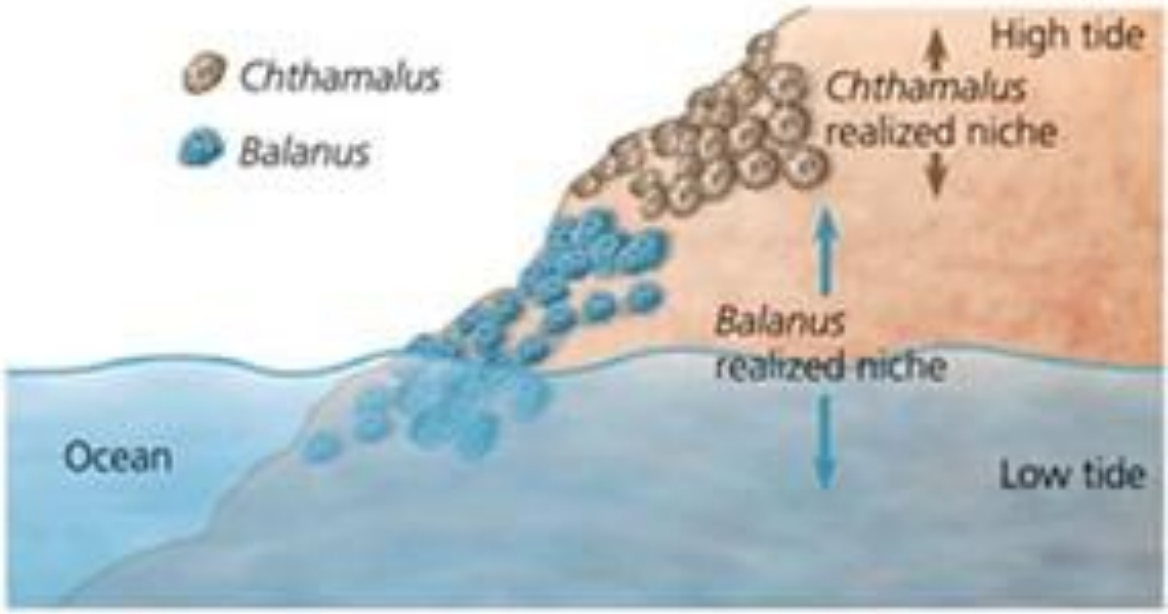
Fundamental niche: the physical conditions under which an organism can live, in the absence of biotic interactions.

Realized niche: the actual niche of a species who see distribution is restricted by biotic interactions, such as predation, competition, disease, and parasitism.



Fundamental

Realized

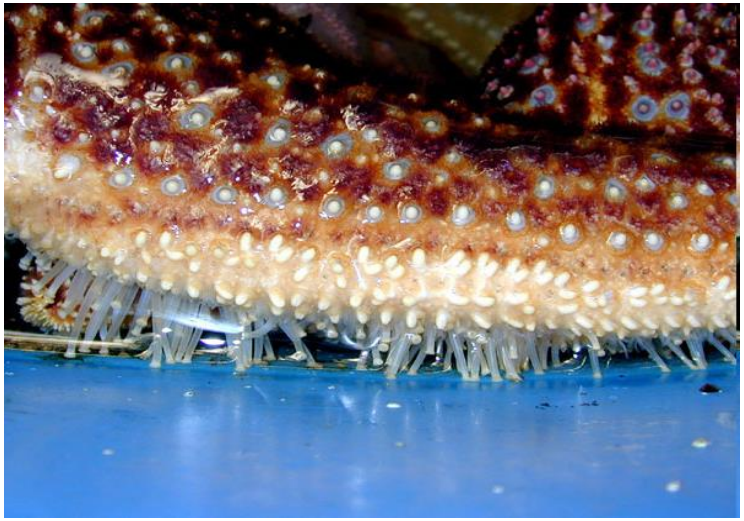


https://socratic.org/questions/what-is-a-fundamental-niche

Challenges of life in the rocky intertidal

Rocky intertidal adaptations

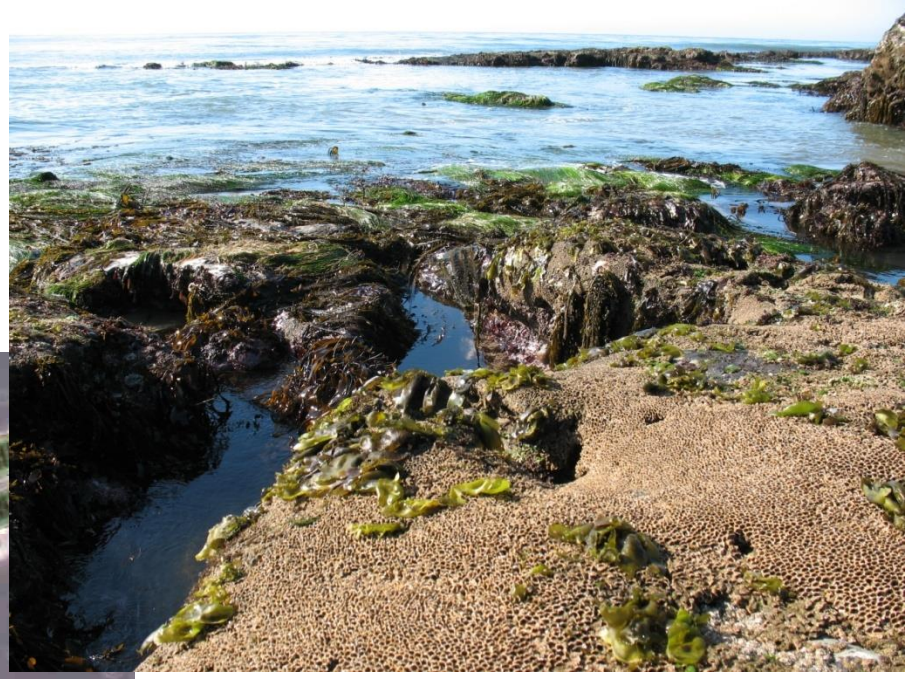
1. Wave shock



http://eebweb.arizona.edu/courses/ecol183/field%20trip%20handouts/Intertidal%20Zones.pdf

Rocky intertidal adaptations

2. Desiccation



Rocky intertidal adaptations

3. Immersion

Rocky intertidal adaptations

4. UV exposure

5. Drastic temperature changes

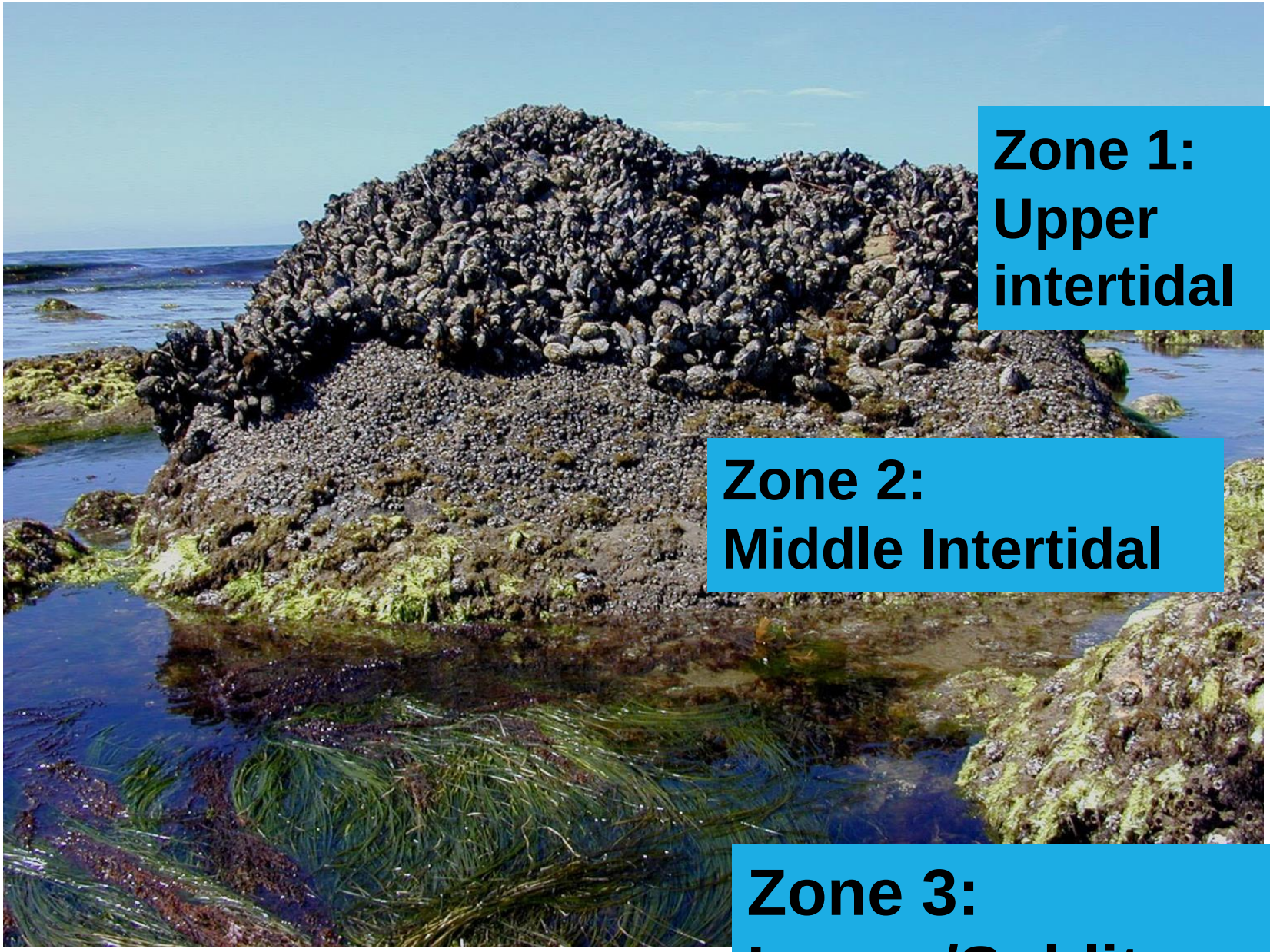
Rocky intertidal adaptations

6. Salinity variation & extremes

7. Feeding

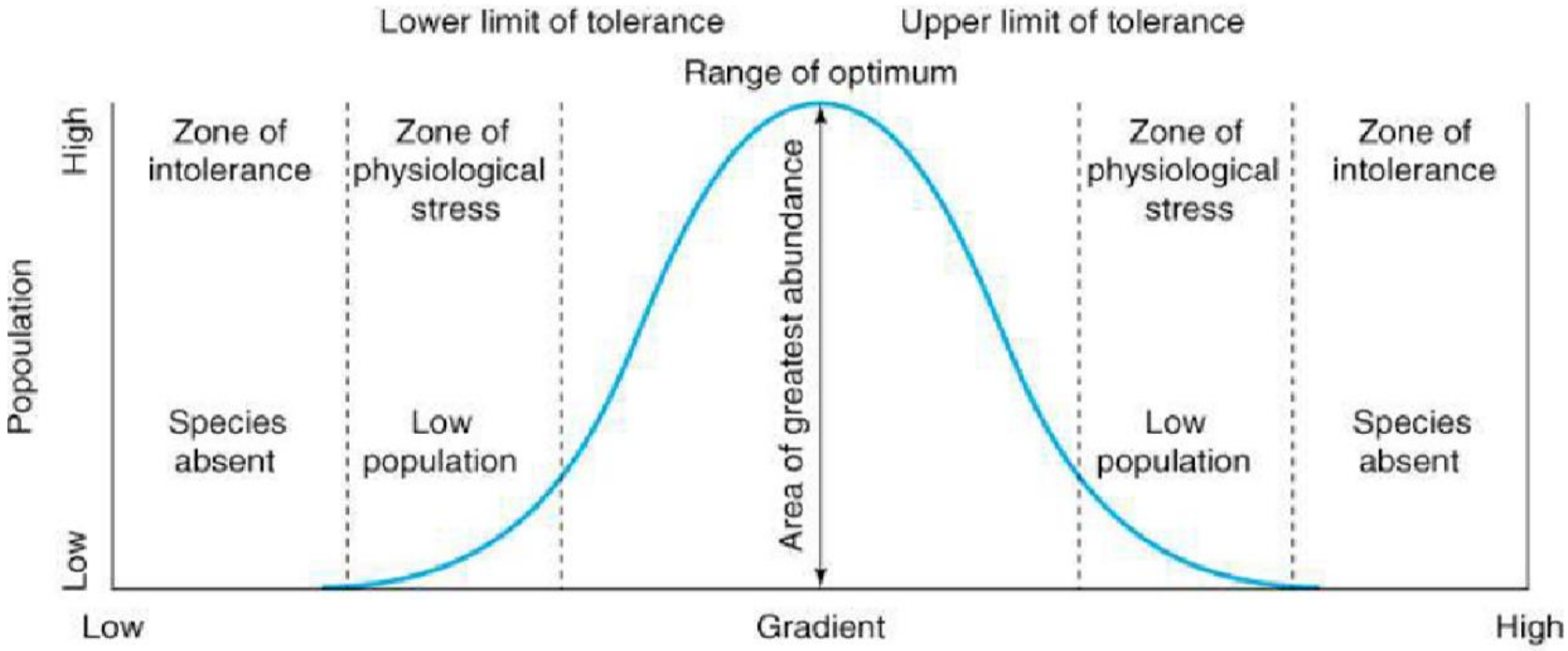
Rocky intertidal adaptations

8. limited space (hard substrate)

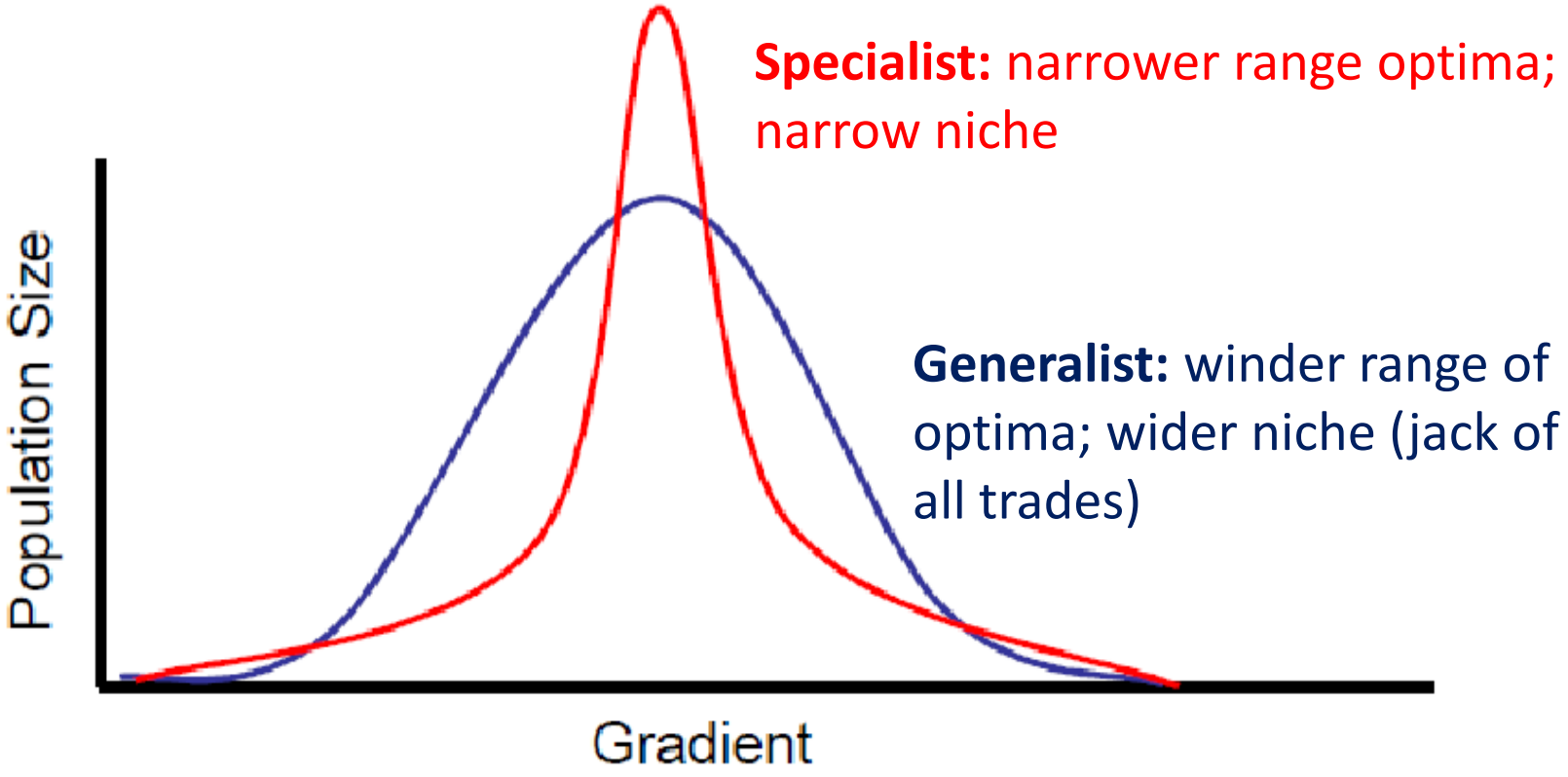

Zone 1:
Upper
intertidal
Zone 2:
Middle Intertidal
Zone 3:
Lower/Sublitorral

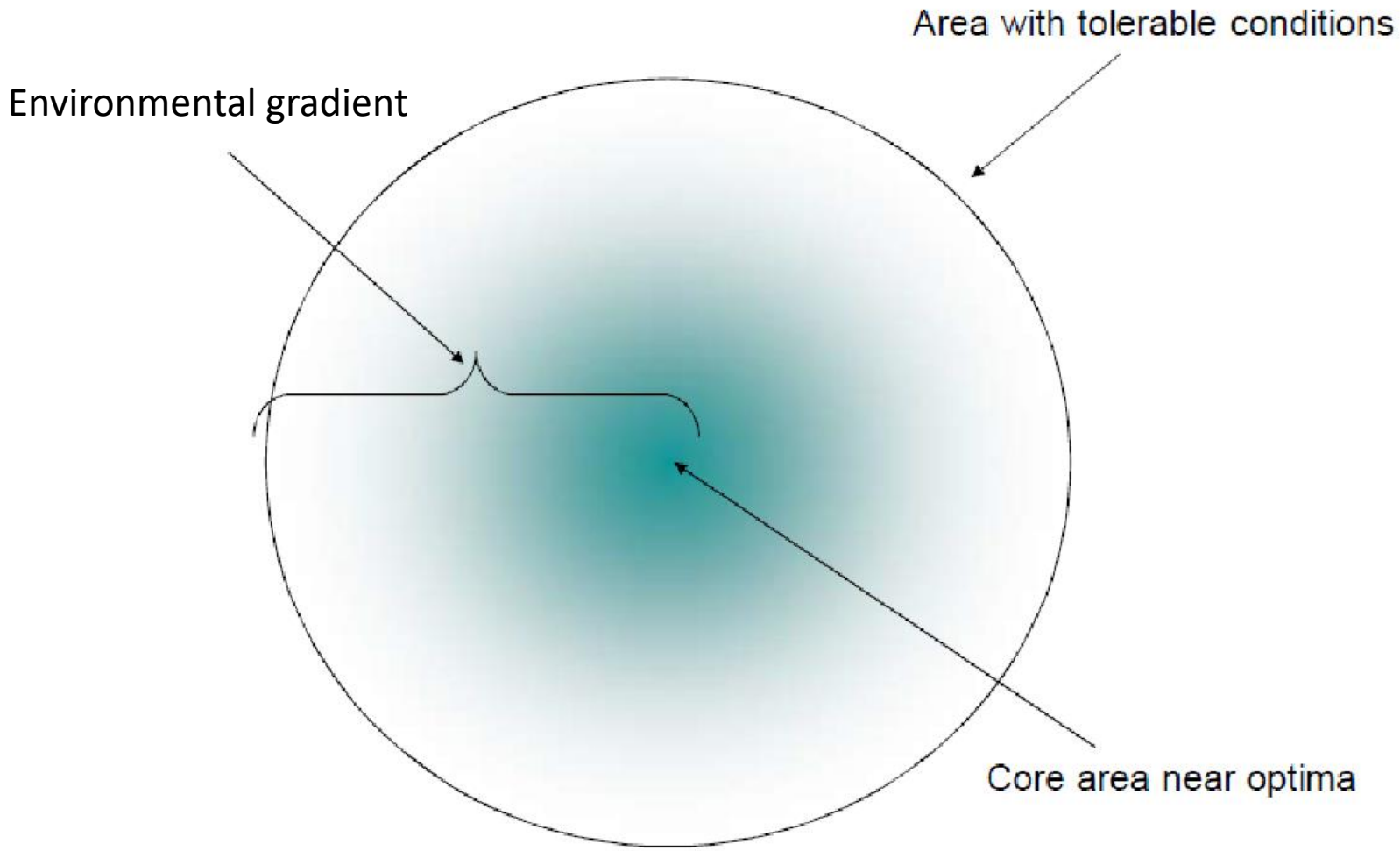
Fitness and ecological gradients

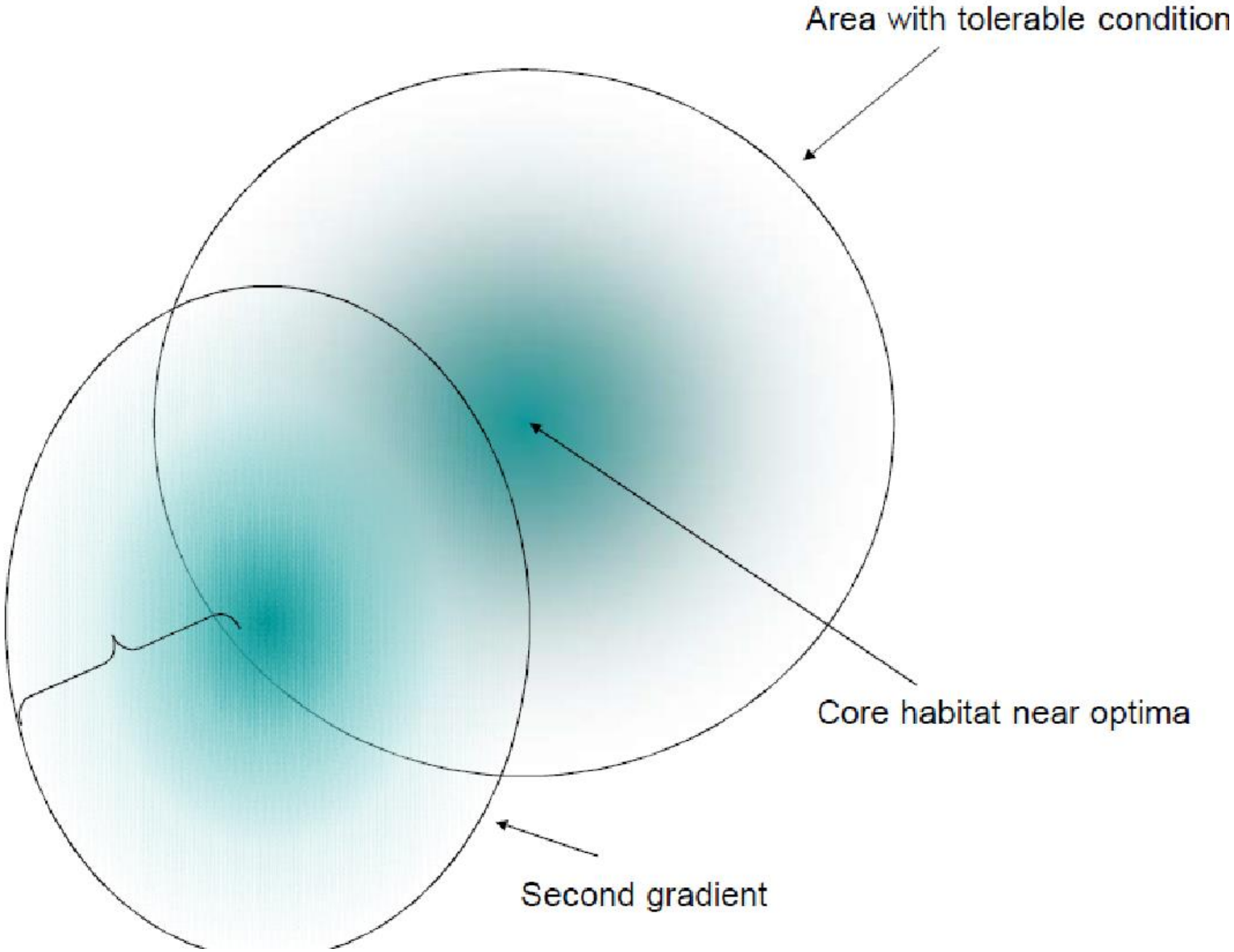
- Species are distributed across multiple gradients, demonstrate maximum fitness near optima.
- For a population, population size is maximized at this optima

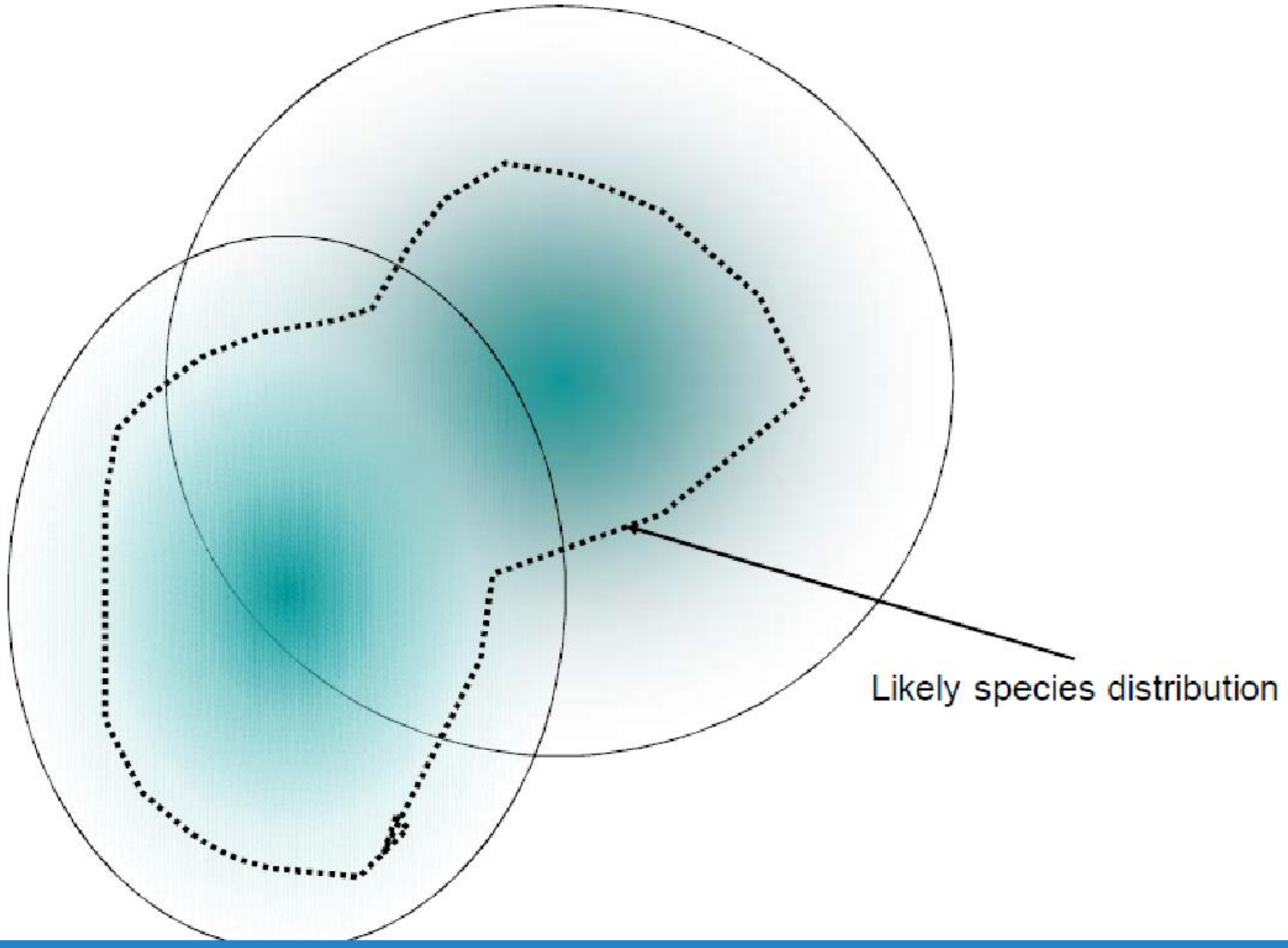


Niche width: range of gradient(s) over which a species occurs and is abundant

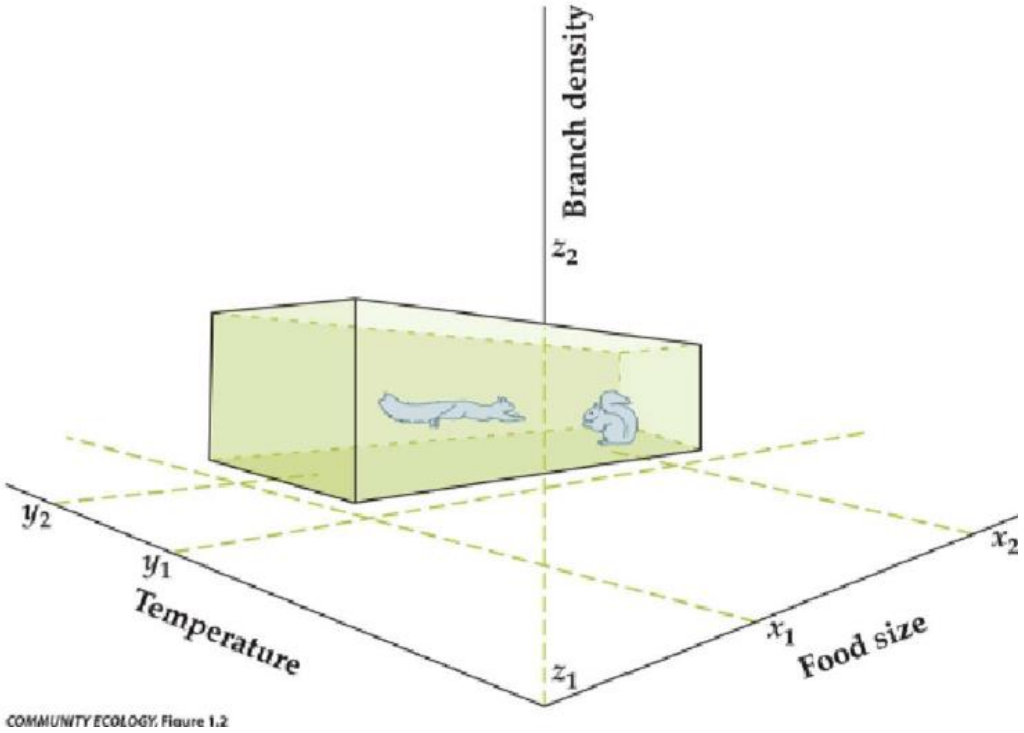



Area with tolerable conditions
Environmental gradient
Core area near optima


Area with tolerable condition
Core habitat near optima
Second gradient


Likely species distribution

Niche is made up of multiple optima along many gradients! N-dimensional hypervolume (each dimension is an abiotic or biotic resource)



COMMUNITY ECOLOGY, Figure 1.2

PISASTER
.03—.41
.05—.05
.27—.37
X—.02
.63—.12
.01—.03
NUMBERS—CALORIES
X=<.01
THAIS
1 SP.
.05—.10
.95—.90
CHITONS
2 SPP.
LIMPETS
2 SPP.
BIVALVES
1 SP.
ACORN BARNACLES
3 SPP.
MITELLA

Paine 1966

Gause's Principle of Competitive Exclusion:

No two species with the same niche can co-exist; eventually one must out-compete the other

Big Ideas

- The combination of biological (biotic) and physical(abiotic) factors structure marine systems
- Abiotic factors control upper limits, biotic factors control lower limits of many species
- The combination of these factors can influence the biodiversity and ecosystem functioning of marine systems

Rocky intertidal zonation patterns

Upper limit of zones set by physical factors:

1. Substrate availability
2. Tidal range (exposure time)
3. Wave impact

Rocky intertidal zonation patterns

Lower limit of zones set by biological factors:

1. Adaptations of organisms to conditions
2. Competition for space
3. Predation

Abiotic factors determine upper limit
Biotic factors determine lower limit

How would you test this prediction?

5-minute break out exercise!

Devise and describe a manipulative experiment (or experiments) to test these predictions, making note of your control and experimental treatments, and how different outcomes would support or refute each prediction.

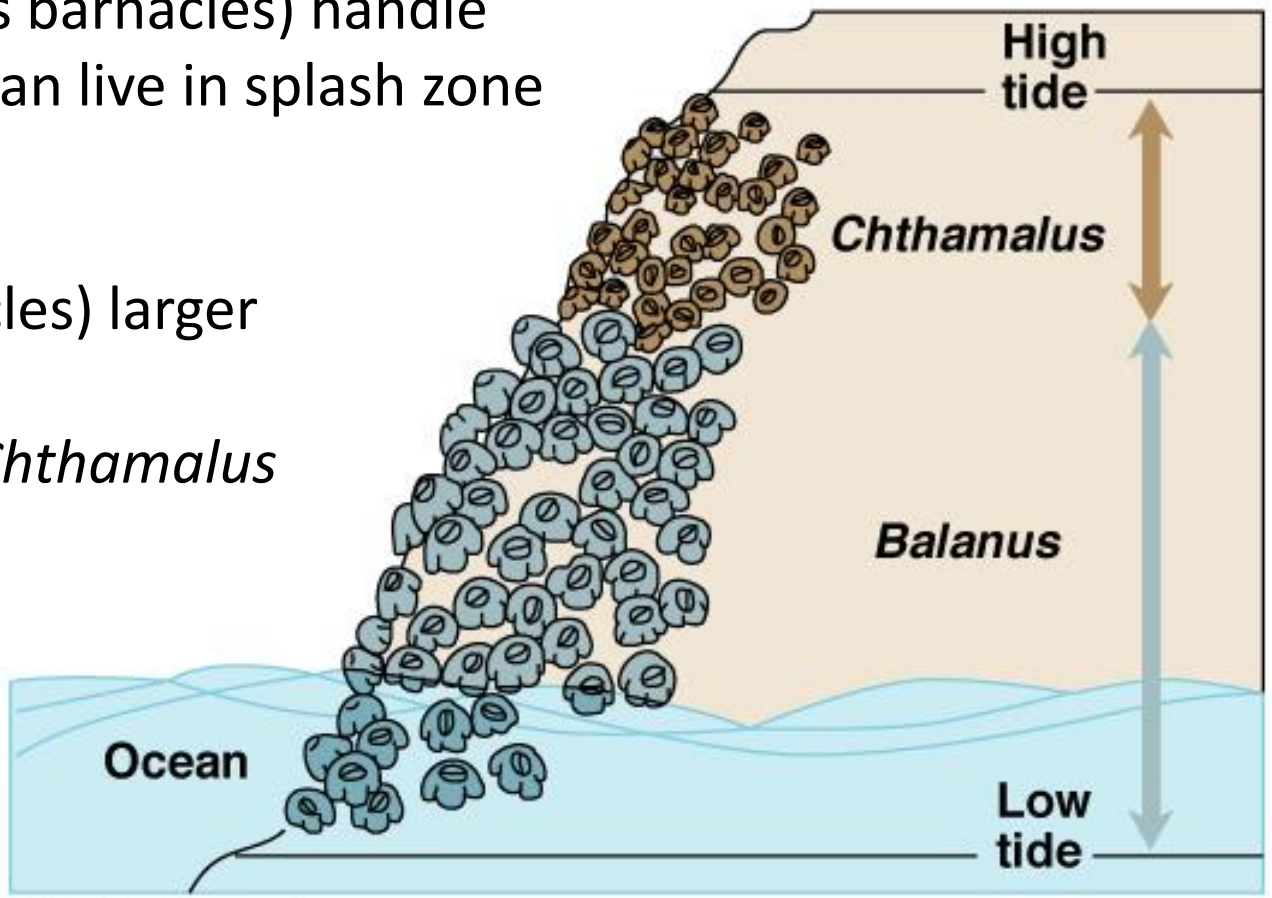
Ecologic Interactions: Competitive Exclusion

Limited space

Chthamalus (buckshots barnacles) handle desiccation better, so can live in splash zone where no competition

Balanus (acorn barnacles) larger

Outcompete smaller *Chthamalus* (buckshot barnacles)



Why are there so many similar species?

"Nothing in biology makes sense except in the light of evolution"
- T. Dobzhansky

Population biology

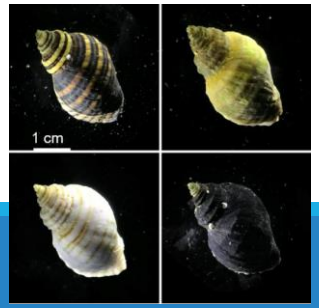
1. Populations will grow exponentially if left 'unchecked'.
2. Populations do not grow exponentially
3. Populations are limited by one ore more resources

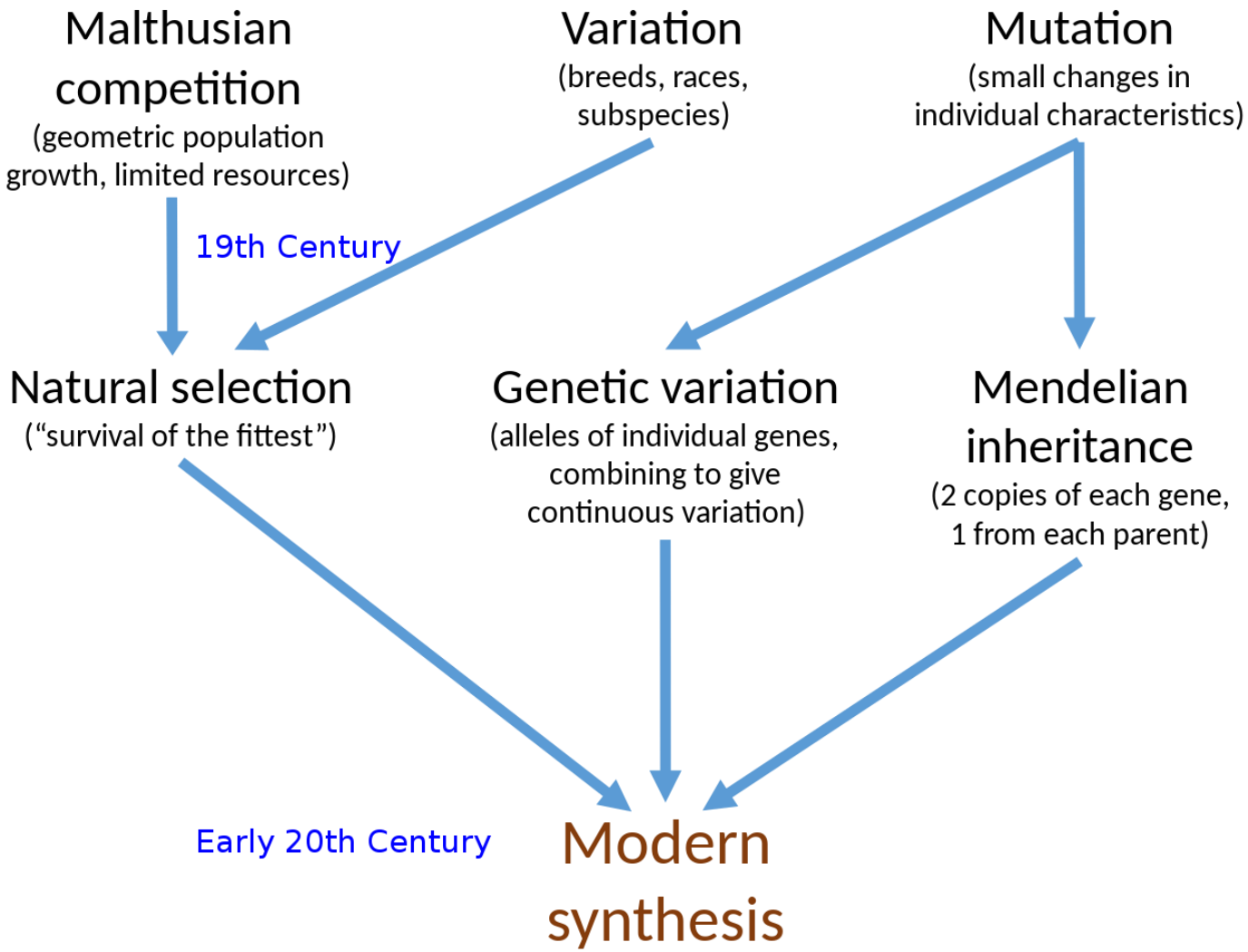
Genetics

4. Populations are variable
5. Variability is heritable
6. Ability to acquire resources is related to heritable traits

Evolution via natural selection

7. Variability in resource acquisition results in unequal survivorship and reproduction
8. Unequal survivorship and reproduction results in changes in gene frequency over time




Malthusian competition
(geometric population growth, limited resources)
Variation
(breeds, races, subspecies)
Mutation
(small changes in individual characteristics)
19th Century
Natural selection
("survival of the fittest")
Genetic variation
(alleles of individual genes, combining to give continuous variation)
Mendelian inheritance
(2 copies of each gene, 1 from each parent)
Early 20th Century
Modern synthesis

Within a population, variability is maintained through:

Plasticity – one genotype capable of producing multiple phenotypes

- Response to environmental cues

Polymorphisms – multiple alleles maintained (preserved) in a population

- Selection forces change over a gradient
- Heterozygote advantage
- Selection against most common alleles (eg color morphs)
- Habitat mosaic results in different selection forces

Stream spawning

Beach spawning