How historical events have affected the biology on the planet?

Changing climate and physical conditions

Rearrangements of the continents and ocean basins
Catastrophic collisions with asteroids

An exclusive focus on local environmental conditions will yield an incomplete understanding of diversity.

Diversity has generally increased over the past several hundred million years.
There are several fundamental processes in biogeography.

The early “dispersalists”

Wallace
Darwin

Gray

The “extremists”

Lyell

Hooker
“Other authors have thus hypothetically bridged over every ocean and united almost every island with some mainland. If indeed the arguments used by Forbes are to be trusted, it must be admitted that scarcely a single island exists which has not recently been united to some continent.

This view cuts the Gordian knot of the dispersal of the same species to the most distant points, and removes many a difficulty; but to the best of my judgement we are not authorized in admitting such enormous geographical changes within the period of existing species.”

Darwin, 1859
No evidence was ever discovered for the lost corridors proposed by the extensionists.

However, Continental drift theory made a lot of sense.

As a result, the debate between dispersalists and extensionists has been replaced by a debate between dispersalists and vicariance biogeographers.

What is dispersal?

Simply, the movement of organisms away from their birthplace.
The role of dispersal in biogeography
Dispersal and Range Expansion

Jump dispersal

**Definition:**
Movement of individual organisms across large distances of inhospitable, followed by the successful establishment of a population of the original disperser's descendants at the destination.

This usually takes place over a time period less than the life span of the individual and often over inhospitable terrain.

The sheepshead minnow (*Cyprinodon variegatus*)

It has been able to colonize these habitats by dispersing many hundreds of miles across ocean water. It's ability to tolerate wide ranges of salinity makes this possible.
We can see the same thing over longer distances and greater time periods for many other archipelagoes.

The Galapagos lie 800 km west of Ecuador in the Pacific Ocean.

The Hawaiian Islands lie 4000 km west of Mexico.

An example can be seen in the rapid recolonisation of Krakatau after all life was wiped out by the volcanic explosion of 1883.

**Diffusion**

**Definition:**
Diffusion is the gradual movement of populations across hospitable terrain for a period of many generations. Species that steadily expand their ranges can be said to be diffusing.

Gradual spread of individuals outward from the margins of a species’ range. It is a slower form of range expansion involving not just individuals, but populations.
Range expansion

Vellela (by-the-wind sailors)

- The photo shows a lefty (backslash) →
- LEFT backslash: \ 
- RIGHT slash: /

Lefty

Range expansion

California

No otter zone

Point Sur

Point Sur

Point Pinos

Point Mugu

Point Dume

Point Mugu

Point Dume

Point Sur

Point Sur

Point Sur
Range expansion

Secular migration

Definition:
Secular migration is diffusion taking place so slowly that the diffusing species undergoes appreciable evolutionary change during the process. The range of the species expands or shifts over long time intervals (thousands or millions of years). The environments themselves may change and natural selection acts on the descendant populations.

Evolutionary divergence through range expansion. Evolutionary time scale.

Secular migration - camels

Measey et al. (2017) African Biodiversity and Conservation
Range shift

Shift happens: trailing edge contraction associated with recent warming trends threatens a distinct genetic lineage in the marine macroalga *Fucus vesiculosus*.

Vicariance

Species A \(\rightarrow\) Species A' \(\rightarrow\) Species A'' \(\rightarrow\) Species B \(\rightarrow\) Species C

Ancestral population \(\rightarrow\) Geographic isolation \(\rightarrow\) Speciation

Vicariance

Species A \(\rightarrow\) Species A' \(\rightarrow\) Species A'' \(\rightarrow\) Species B \\(\rightarrow\) Species C

Ancestral population \(\rightarrow\) Geographic Isolation \(\rightarrow\) Speciation
The nature of long-distance dispersal means that organisms often have to survive for periods of time in environments that are hostile to them. These environments constitute physical and biological barriers to dispersal. The effectiveness of such barriers in preventing dispersal depends not only on the nature of the barrier, but also on the organism dispersing.

**BARRIERS**

**Vicariance**

Split ~150 “geminate” (twin) species

Allopatric speciation in snapping shrimp

*Alpheus* – sibling species
Flying shells: historical dispersal of marine snails across Central America

Osamu Miura1,2,*, Mark E. Torchin1, Eldredge Berlimingham1, David K. Jacobs3 and Ryan F. Hechinger1

Cerithideopsis
Charles Darwin first postulated that invertebrates, including marine snails, could be dispersed long distances by birds. However, in contrast to terrestrial and fresh water invertebrates, there is little evidence for this for marine animals.

Our genetic evidence coupled with evidence from field studies provide a conservative estimate that marine snails crossed Central America on two separate occasions, established their alleles, which subsequently spread along both coasts.

This suggests that not only is such passive dispersal possible for marine organisms, but that it can occur across seemingly insurmountable barriers.

BIOTIC EXCHANGE AND DISPERSAL ROUTES

Biogeographers often distinguish three kinds of dispersal routes based on how they effect biotic interchange.

1. **Corridors**. Allow dispersal by permitting movement.

2. **Filters**. Conditions fall outside range of physiological tolerance. Restrictive dispersal pathway. Conditions restrictive to some species, not others. Can be biotic or abiotic.

3. **Sweepstakes routes**. Hazardous or accidental dispersal mechanisms by which animals move from place to place. The standard examples are island hopping and natural rafts.
Dispersal corridor

- Wide variety of corridor habitats
- Dispersal from A to B easy

Allow dispersal by permitting movement

Dispersal filter

- Limited array of corridor habitats
- Dispersal from A to B difficult, only certain species

Conditions fall outside range of physiological tolerance.
Restrictive dispersal pathway.
Conditions restrictive to some species, not others.
Can be biotic or abiotic.

Sweepstakes dispersal

- No corridor habitats
- Very occasional migrants

Hazardous or accidental dispersal mechanisms by which animals move from place to place.
The standard examples are *island hopping* and *natural rafts*.
Dispersal: unintended/rarer movements
**Dispersal vs Migration**

Dispersal: *unintended/rarer* movements

Migration: *periodic* movements

**Migration**

- Feeding Migration
- Spawning Migration
- Recruitment/Juvenile Migration
- Seasonal Migration

**Migration**

Many types of fish migrate on a regular basis, on time scale ranging from daily to annually or longer.

Travel over distances ranging from a few meters to thousands of km.
They occur in order to take advantage of favourable conditions, wherever the feeding areas are. Migratory marine fish travel long distances within the sea to spawn and return to the feeding areas. There are no barriers within the sea and fish have learned to travel long distances with in sea to spawn & return to the feeding areas. Truly migratory marine fish.
Phylogeography or historical biogeography

Avise coined the term in 1987.

“Study of the principles and processes governing the geographic distributions of genealogical lineages, including those at the intraspecific level, on the basis of molecular data.”
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HISTORICAL BIOGEOGRAPHY
DISPERSAL
VICARIANCE
BARRIERS