Biogeography - the study of the geographic distribution of organisms.

The current distribution of organisms can be explained by historical events and current climatic patterns.
Darwin was the first to draw attention to the distribution of organisms and their implications for understanding evolution.

- Neither the similarity or dissimilarity of the inhabitants of various regions can be wholly accounted for by climatal or other physical conditions.

- Barriers of any kind, or obstacles to free migration, are related in a close and important manner to the differences between the productions of various regions.

- Inhabitants of the same continent or the same sea are related, although the species themselves differ from place to place.
Darwin argued that the evidence against special creation was apparent in biogeography.

- Organisms found on oceanic islands are the kinds of organisms that have the capacity for long-distance dispersal.
- Organisms without dispersal abilities often do well on islands when they are transported there by humans.
- Most of the species on islands are clearly related to species on the nearest mainland.
- The proportion of endemic species on an island is particularly high when the opportunity for dispersal to the island is low.
- Island species often bear marks of their continental ancestry.
Biogeographic Patterns

The distribution of higher taxa allow the designation of several “biogeographic realms.” The biogeographic realms are defined by groups of organisms that are unique to or highly diverse within those regions.
Each biogeographic realm has some species or higher taxa that are endemic - found nowhere else.

The pattern of endemism is repeated in many groups within a biogeographic realm.

Armadillos, anteaters, antshrikes, and armored catfishes are South American endemics.
Biogeographic realms are largely the product of geologic history - the movement of continental landmasses.

A single interconnected landmass - “Pangaea” was present in the Triassic. The climate was warm and many organisms were widely distributed.
During the Jurassic the northern continents were largely separated, but a single large southern continent “Gondwana” remained.
At the end of the Mesozoic, the southern continents had separated. Shallow oceans covered the interior North America and Eurasia. Some landmasses were in very different positions than today. India was a large island off the east coast of Africa and Australia was very close to Antarctica.
By the middle of the Tertiary the continents were positioned as we know them today. India collided with Asia and the Himalayas were built. Australia was isolated in the southern Indo-Pacific. North and South America were still separated by a seaway through what is now Central America.
The biogeographic realms reflect the history of connections and separations of land masses. For example, even though Australia is close to southeast Asia today, Australian flora and fauna are very different from that found in Asia. Wallace noted the abrupt transition of plants and animals across the islands of Indonesia.
Within a biogeographic realm, the flora or fauna may be divided into provinces based on restricted distributions of species or groups of species.
The borders between adjoining realms and provinces are not absolute because some are relatively recent and thus some taxa are shared between them due to having a once widespread ancestor. For example, some closely related species of animals and plants are shared between Europe and North America. Each is likely to have a common ancestor that existed on both continents before their separation.

North American

Sycamore

European

dace

Plane tree
In addition, the borders can be relatively porous and species from one realm have recently invaded adjoining realms. The formation of the Isthmus of Panama in the Tertiary allowed an exchange of Nearctic and Neotropical species. North America has been invaded recently by South American groups: Armadillos, Opossums, Cichlid fishes, and Bromeliads.

More recently, the connection between Asia and North America allowed the exchange of Nearctic and Palearctic species - including humans.
Some higher taxa have **disjunct distributions**. They have unique species found in nonadjoining regions. Examples include the lungfishes, with a single species in South America, a single species in Australia, and three species in Africa.

The few remaining lungfish species are evolutionary “relicts” of a time when lungfish were broadly distributed.
The distribution of organisms or higher taxa today can be influenced by ecological requirements of the species, geological barriers that haven’t been crossed (e.g. mountains, deserts), or by historical factors - Extinction, Dispersal, and Vicariance.

Extinction removes a taxon from a region where it was formerly present. (e.g. horses and relatives in North America, elephant relatives throughout North America, and Northern Europe).

Dispersal by individuals of a species expand the range of a taxon. Range expansion is the movement of a species across a favorable habitat. Jump dispersal is movement across a barrier.

In both starlings and cattle egrets an initial jump was followed by a continuing range expansion.
Vicariance is the separation of populations by new barriers. Barriers arise by geologic or climatic change.

Vicariance can result in allopatric speciation.

Climatic change can result in disjunct populations of a species because of the extinction of populations in regions that have become unfavorable. Example: *Saxifraga cernua*
Historical Biogeography

Strict vicariance produces completely consistent patterns of phylogenetic divergence and geographic separation.
Dispersal can be inferred when geologic events precede cladogenic events.

Dispersal can be concluded only when the pattern can’t be explained by vicariance.
Extinction complicates interpretations of vicariance and dispersal.
The Hawaiian Islands have formed from a series of volcanic eruptions on the submerged Pacific plate as it moved over a “hot spot.” Islands are progressively younger to south and east. Islands were colonized by species from nearby islands as they formed.

A phylogenetic analysis of crickets suggests that the oldest species are found on the oldest islands.
Several groups of organisms are distributed from Africa to Madagascar, and to India. The distribution of those organisms today may be explained by strict vicariance - due to widespread distribution among the southern continents before separation.
Some groups have distributions consistent with an ancestral Gondwanan distribution with diversification after continental separation—a vicariant pattern.
The prosimians in Madagascar and Africa appear to have diverged long after the breakup of Gondwana. A pattern that can only be accounted for by dispersal.
The pattern of distribution among species of chameleons is not consistent with the breakup of the southern continents. It is best explained by origination in Madagascar (M) and dispersal to Africa (A), the Seychelles Islands (SE) and to India (I).
Phylogeography is the description and analysis of the processes that govern the distribution of genetic lineages. Genetic analysis is used to construct a genetic phylogeny and then the phylogeny is mapped onto geography.

Classically there have been two hypotheses for the evolution of humans, the multiregional hypothesis - modern *Homo sapiens* evolved simultaneously throughout the old world from archaic *Homo sapiens* with exchange of genetic information by gene flow - and the out-of-Africa hypothesis - modern humans evolved in Africa and moved out replacing previously widely dispersed archaic humans.
Mitochondrial DNA analysis of modern humans suggests that Asian, European, Australian and Indonesian populations all share a common ancestor that dispersed from Africa about 50,000 years ago. Multiple dispersals out of central Asia appear to account for European populations.
Diverse From the Start

The diversity of genetic markers is greatest in Africa (multicolored dots in map), indicating it was the earliest home of modern humans. Only a handful of people, carrying a few of the markers, walked out of Africa (center) and, over tens of thousands of years, seeded other lands (right). “The genetic makeup of the rest of the world is a subset of what’s in Africa,” says Yale geneticist Kenneth Kidd.
Ecological Biogeography

The current distribution of a species over broad geographic areas may be the product of past dispersal or vicariance, but the local distribution of a species may be better explained by its tolerance of physical variables (soil pH, salinity), its requirements for sustaining a population (oxygen concentration, soil nutrients), its competitors for resources, or factors that reduce its ability to live in an area (predators, parasites, disease).

Ecologists ask what factors limit the distribution of a species: Why does a species live in one area but not another?
Ecologists and evolutionary biologists are both interested in explanations for broad patterns of species diversity.

Commonly, within any group of organisms there are more species in the tropics than at higher latitudes.
There are several possible explanations for this pattern:

• Time hypothesis: tropical regions have remained largely undisturbed since the K/T boundary while temperate zones have undergone repeated glaciations recently. The tropics have had more time for the evolution of more species.

• Niche partitioning hypothesis: species in the tropics have more specialized life-styles. Thus, more species can exist with a given range of resources.
• Resource hypothesis: the greater productivity in the tropics allows a greater range of resources for species to exploit. Thus allowing more species to coexist.

• Predation hypothesis: greater rates of predation, parasitism, and disease in the tropics results in less competition for resources and thus more overlap in resource use.

Each hypothesis has some evidence to support it.
How many species can an area support? On islands, there is a general relationship between species diversity and total area.

This suggests there many be a maximum number of species that an area can support - an equilibrium number.
MacArthur and Wilson have proposed that the species diversity of an area is determined by a balance between rates of species immigration from other areas and rates of extinction.

Small islands are less likely to receive random immigrants from a mainland source population. Populations on small islands are also more likely to go extinct due to chance events.

Thus large islands close to the mainland should have the most species and small islands far from the mainland should have the fewest species. This idea has been broadly supported and is known as the Island Biogeographic Theory.