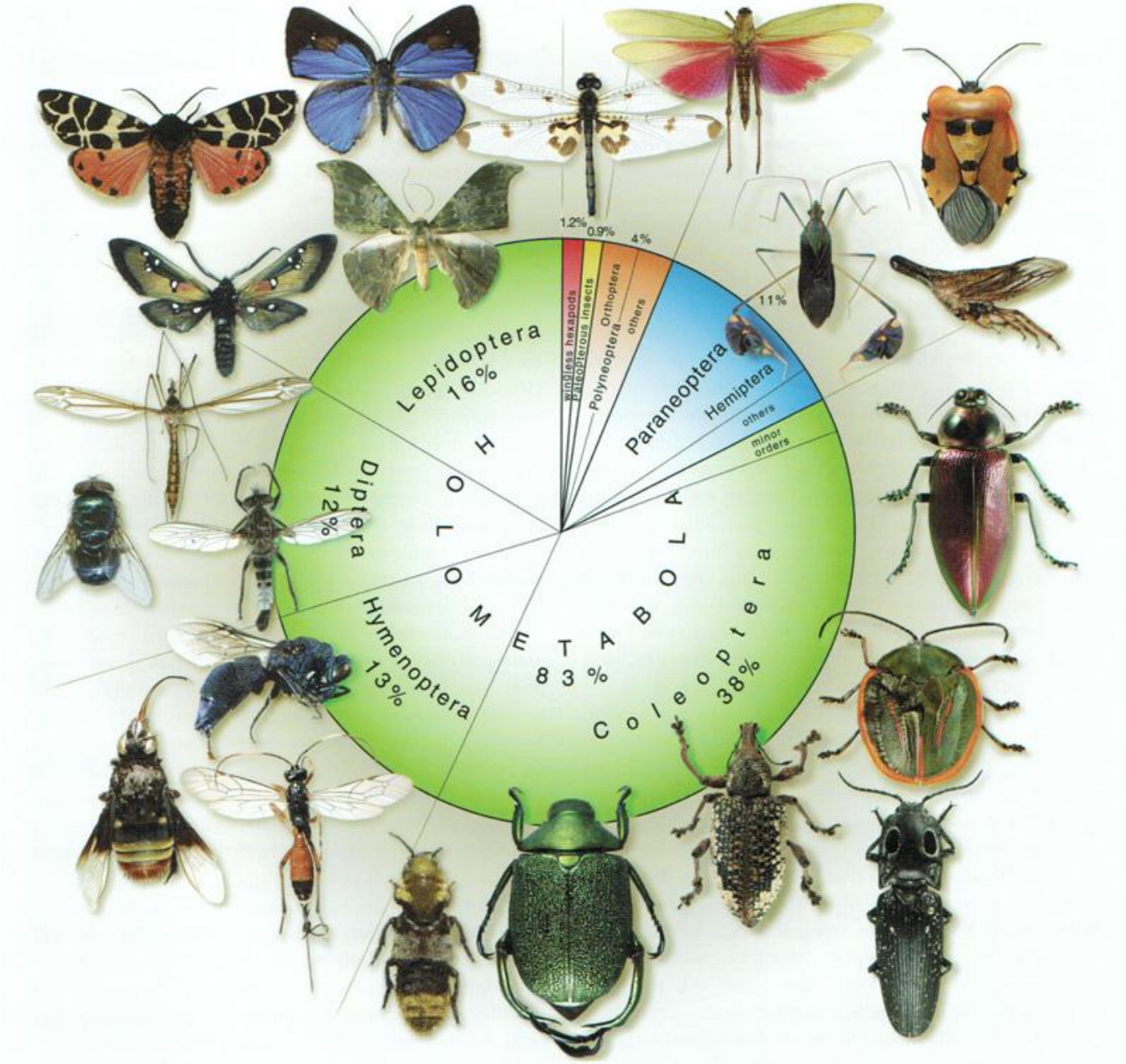
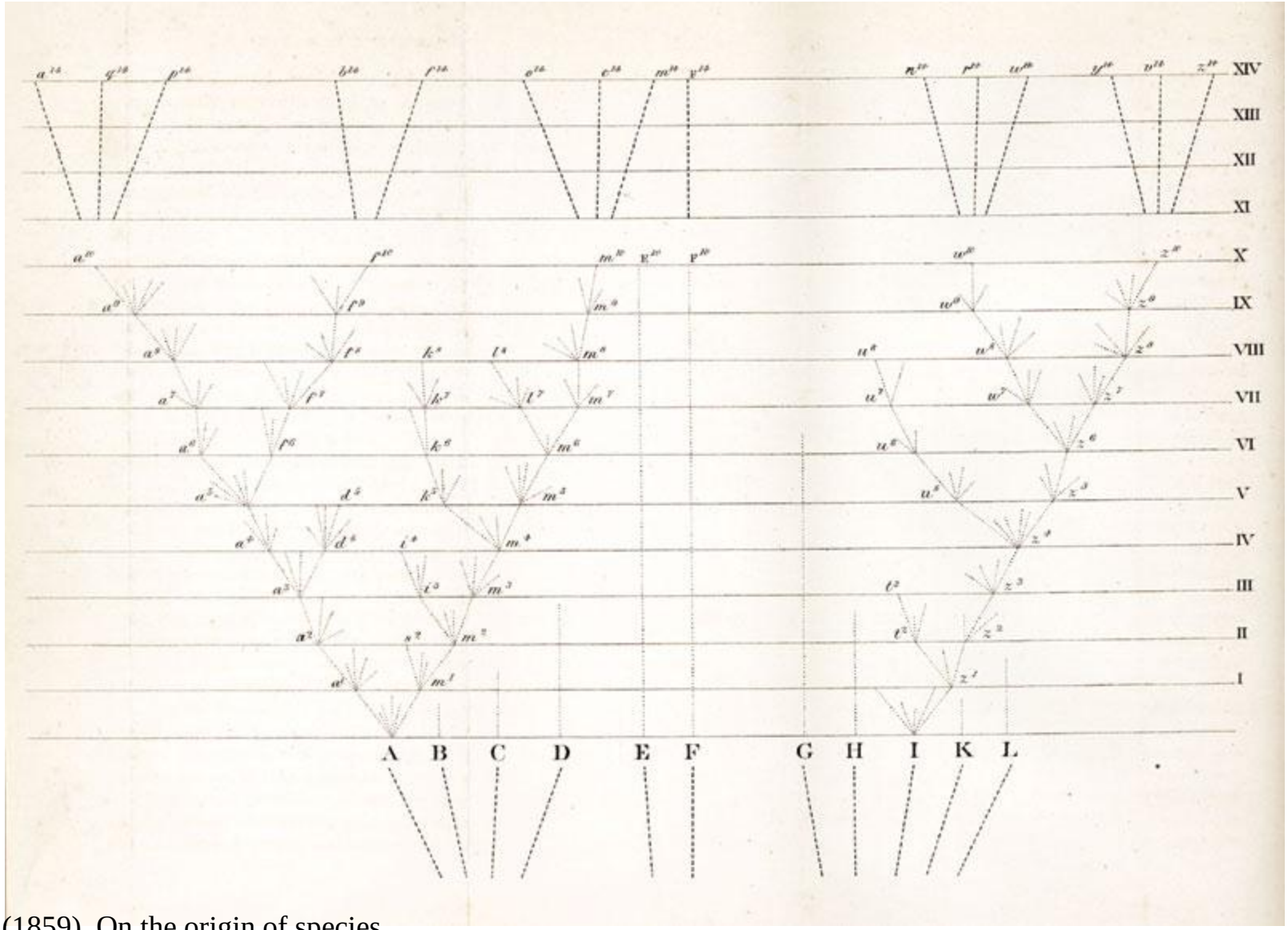
Insect Diversity & Biogeography

Grimaldi & Engel (2005). Evolution of the Insects



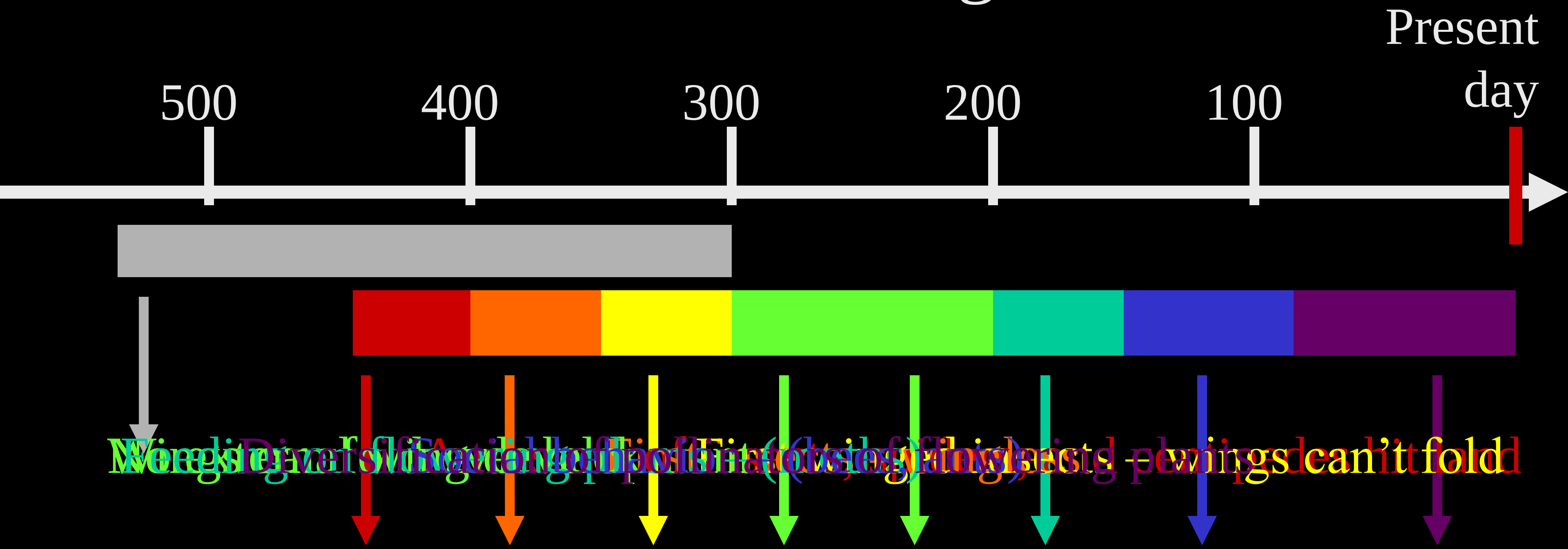
Grimaldi & Engel (2005). Evolution of the Insects

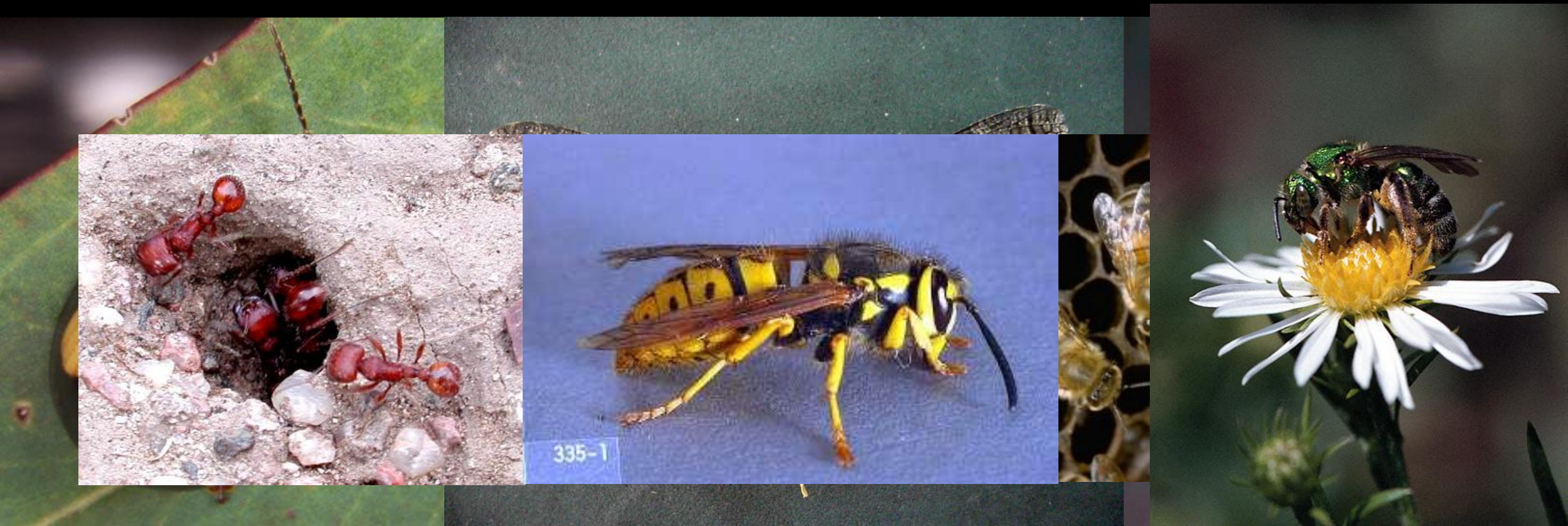
“Tree thinking”

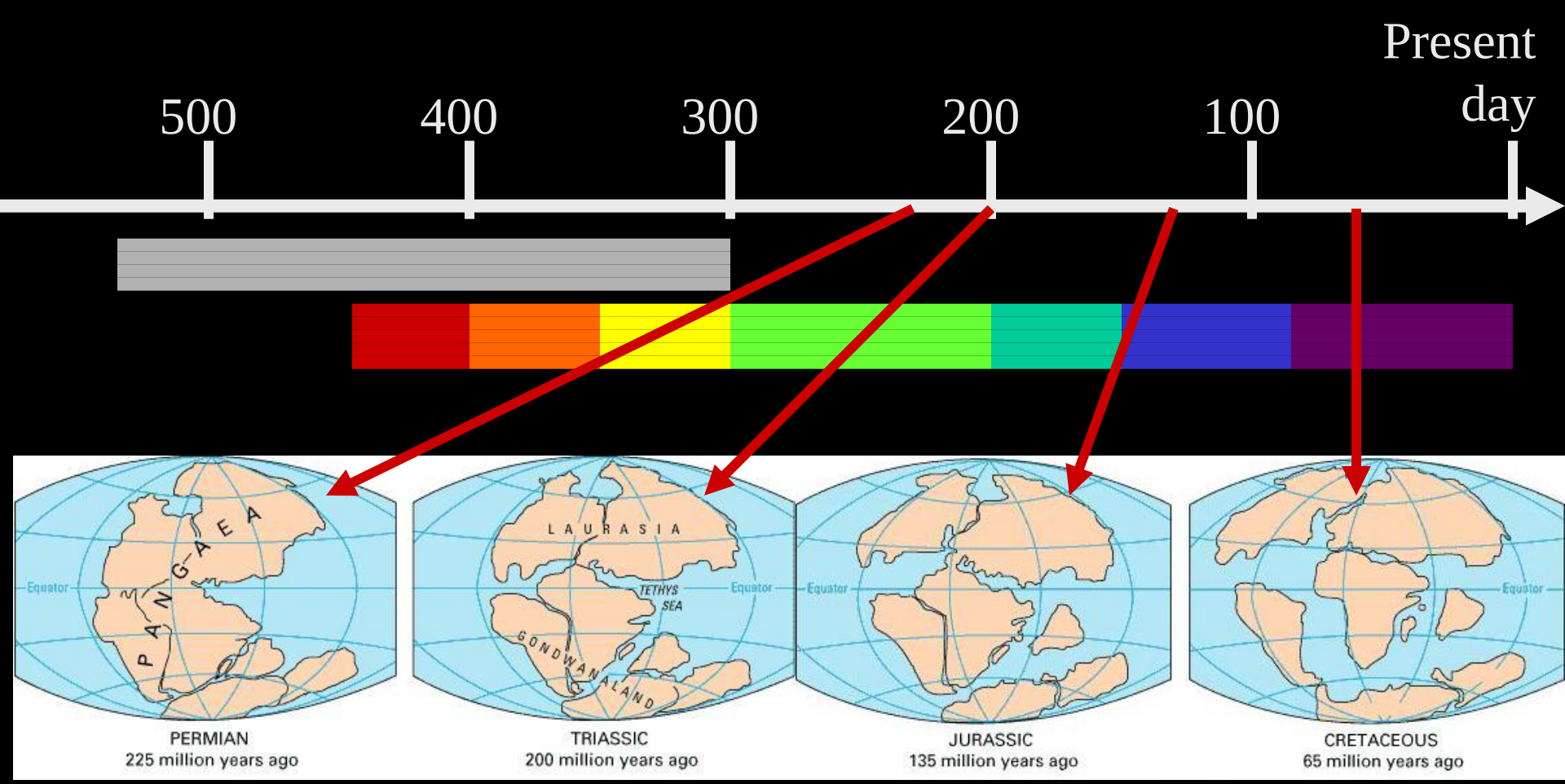


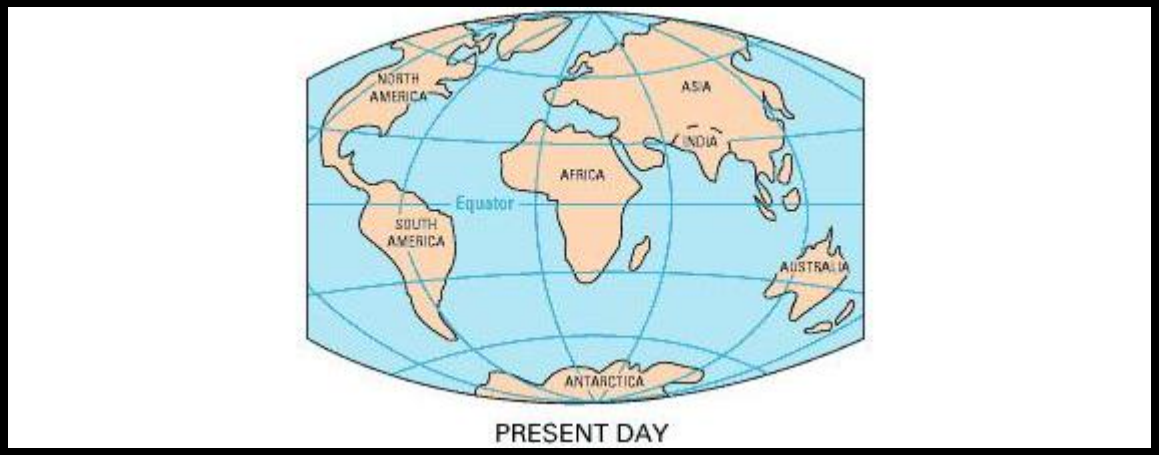
Darwin (1859). On the origin of species

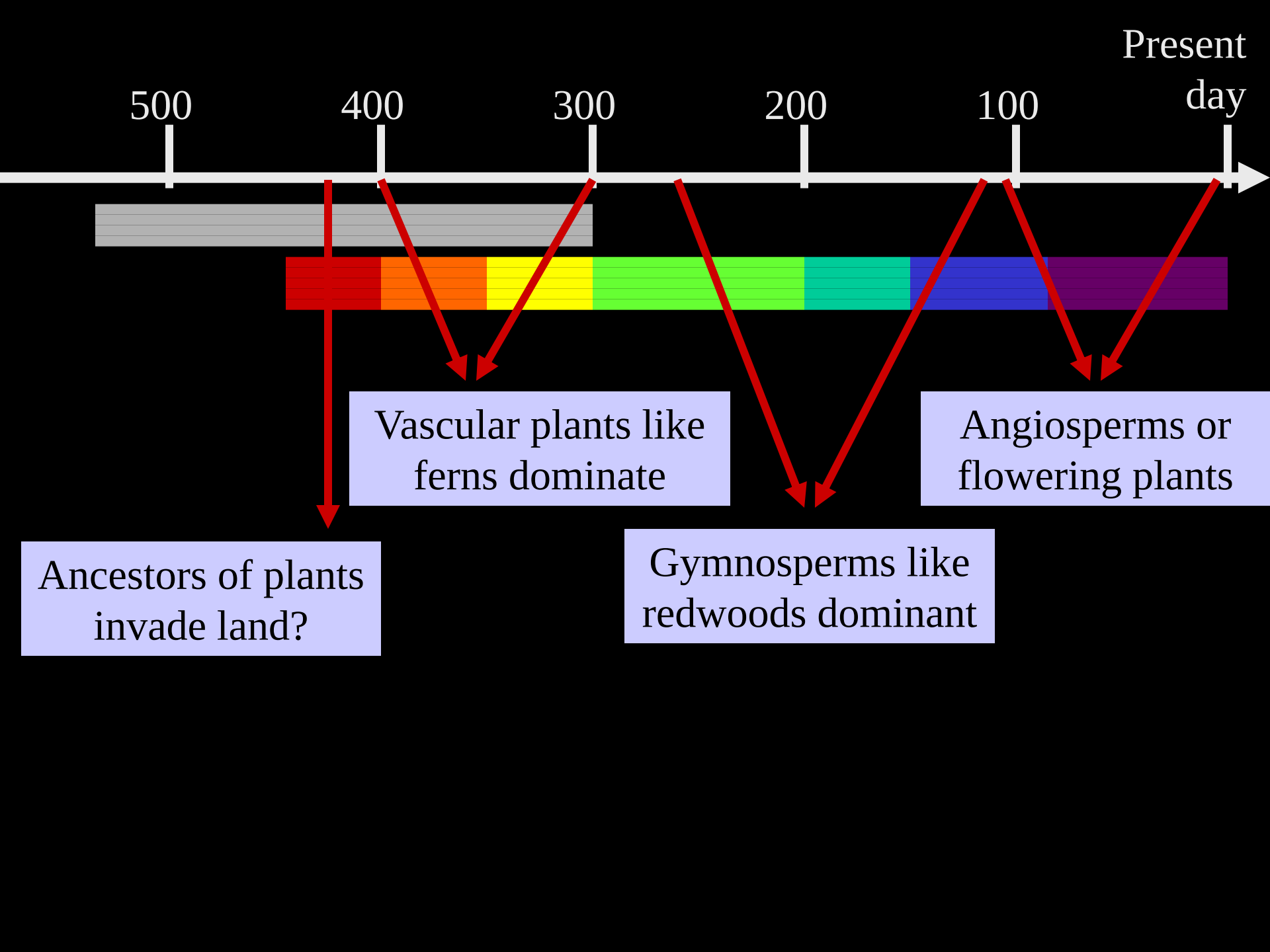
Millions of Years Ago

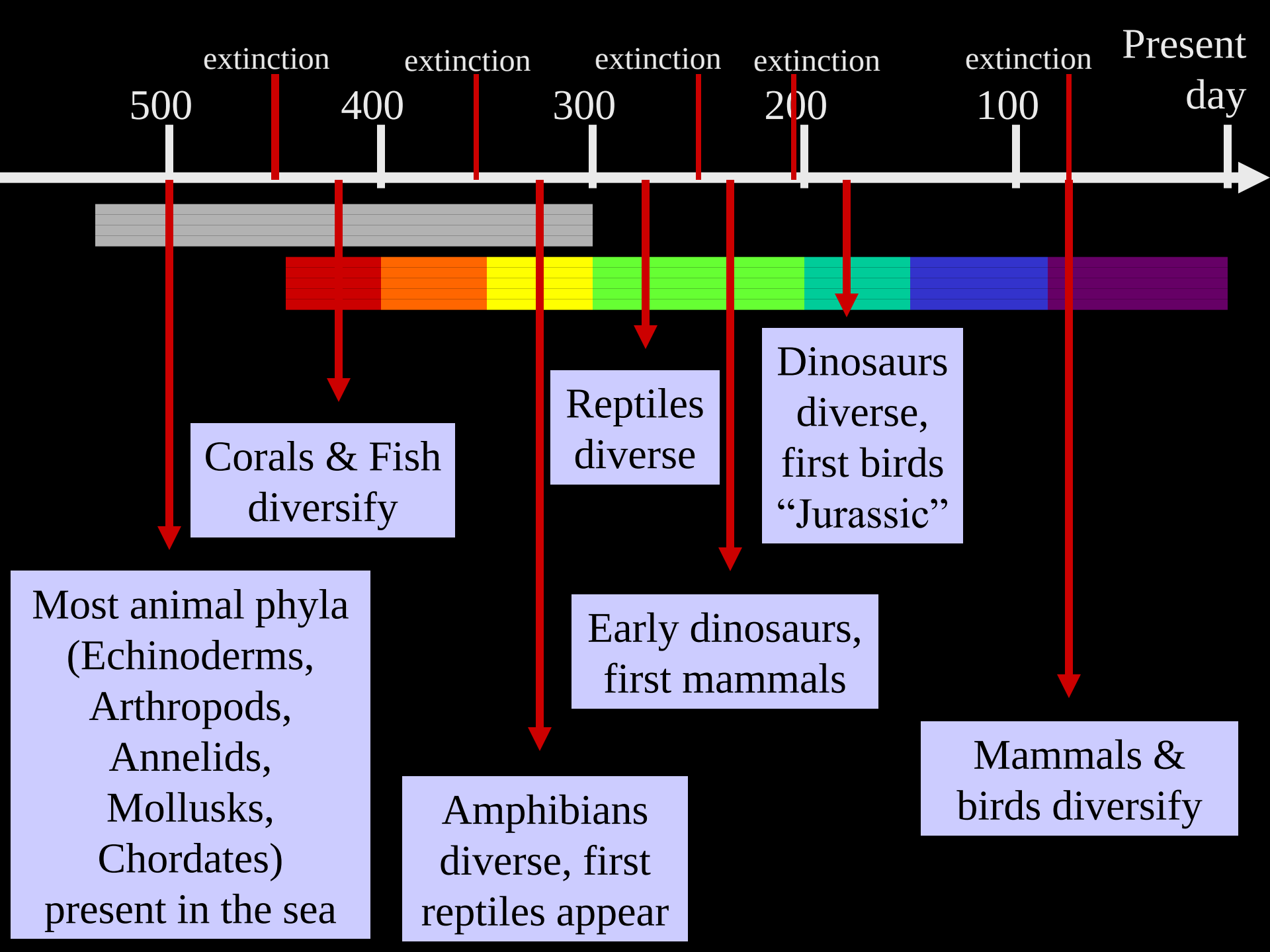


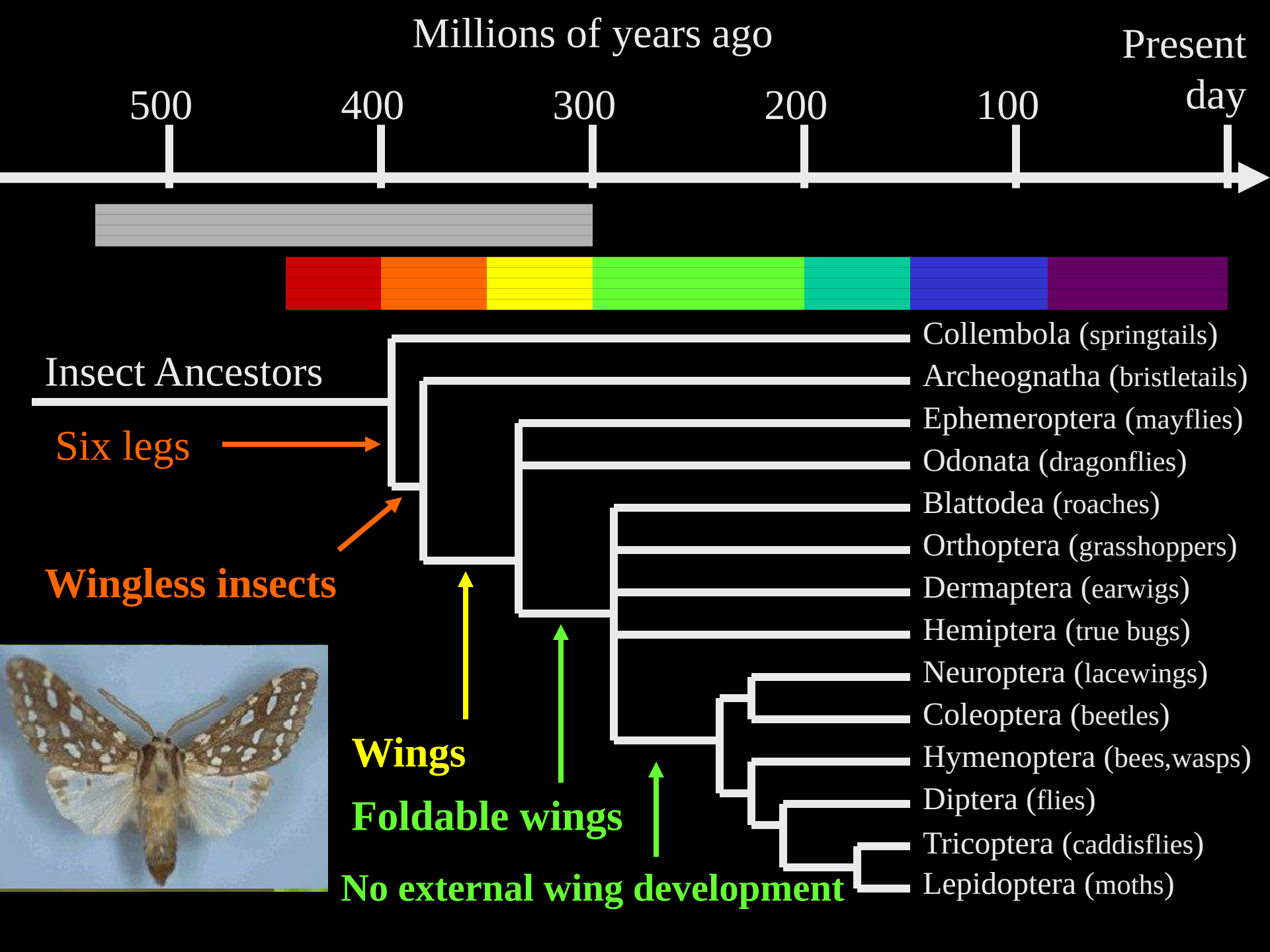



Present day
500
400
300
200
100
Equator
PANGAEA
PERMIAN
225 million years ago
LAURASIA
TETHYS SEA
GONDWANALAND
TRIASSIC
200 million years ago
JURASSIC
135 million years ago
CRETACEOUS
65 million years ago


NORTH AMERICA
ASIA
INDIA
AFRICA
Equator
SOUTH AMERICA
AUSTRALIA
ANTARCTICA
PRESENT DAY


Present day
500
400
300
200
100
Vascular plants like ferns dominate
Angiosperms or flowering plants
Ancestors of plants invade land?
Gymnosperms like redwoods dominant

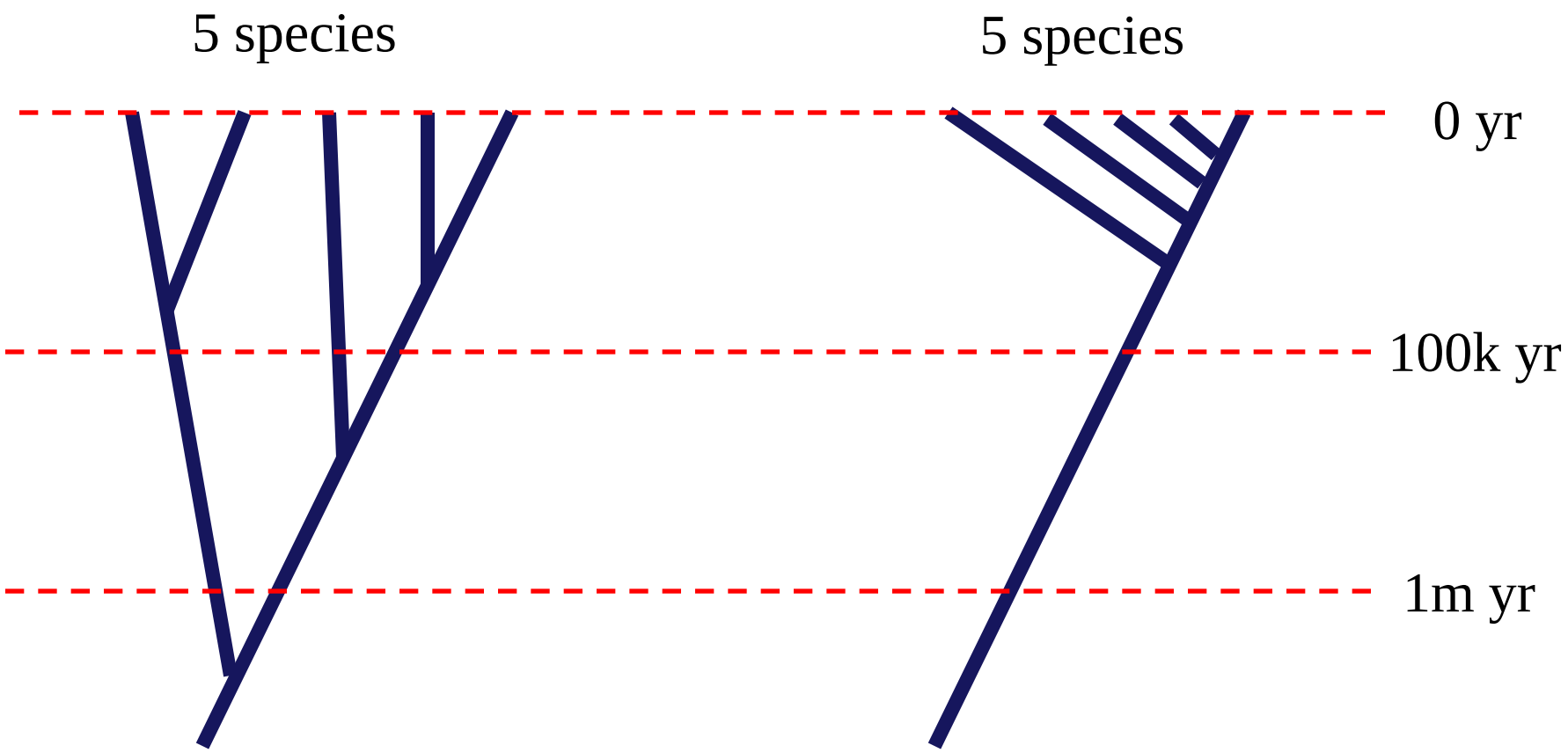

extinction
extinction
extinction
extinction
extinction
Present day
500
400
300
200
100
Most animal phyla (Echinoderms, Arthropods, Annelids, Mollusks, Chordates) present in the sea
Corals & Fish diversify
Amphibians diverse, first reptiles appear
Reptiles diverse
Early dinosaurs, first mammals
Dinosaurs diverse, first birds “Jurassic”
Mammals & birds diversify


Millions of years ago
Present day
500
400
300
200
100
Insect Ancestors
Six legs
Wingless insects
Wings
Foldable wings
No external wing development
Collembola (springtails)
Archeognatha (bristletails)
Ephemeroptera (mayflies)
Odonata (dragonflies)
Blattodea (roaches)
Orthoptera (grasshoppers)
Dermaptera (earwigs)
Hemiptera (true bugs)
Neuroptera (lacewings)
Coleoptera (beetles)
Hymenoptera (bees,wasps)
Diptera (flies)
Tricoptera (caddisflies)
Lepidoptera (moths)

Adaptations for success: Why are insects so successful?

- What is success?
  - Numeric Success (sheer abundance)
  - Diversity
    - Numbers of species
    - Phylogenetic diversity
  - Persistence (ancient lineages)

Phylogenetic Diversity



Adaptations for success

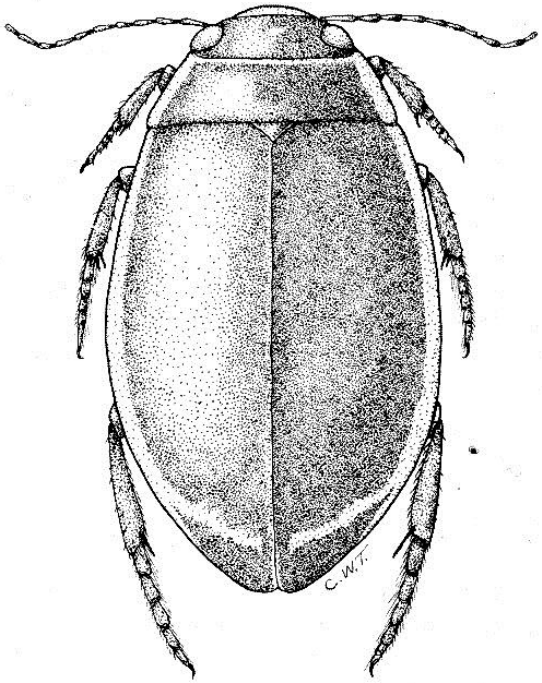
- Morphological adaptations
  - Wings, Folded Wings, Holometabolous lifecycle
  - Exoskeleton, Mouthparts, Legs, etc.
  - Small size in a heterogeneous habitat
- Ecological & behavioral specialization
  - Associations with flowering plants
  - Host-parasite, parasitoid, predator relationships
  - Habitat specialists
  - Social behavior

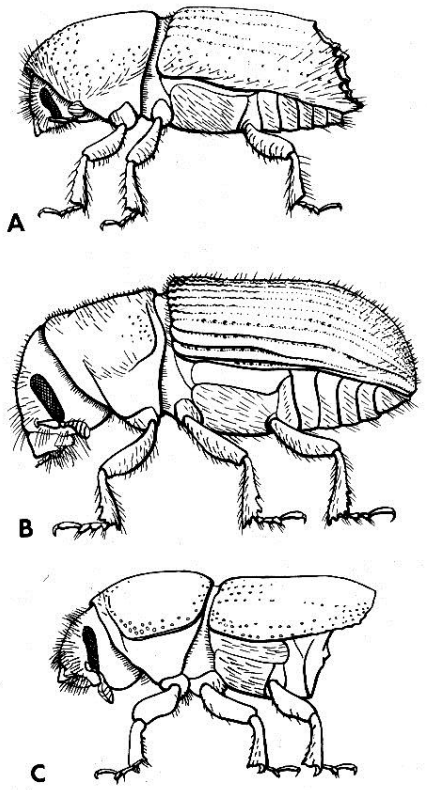
Exoskeleton

Coleoptera (beetles)

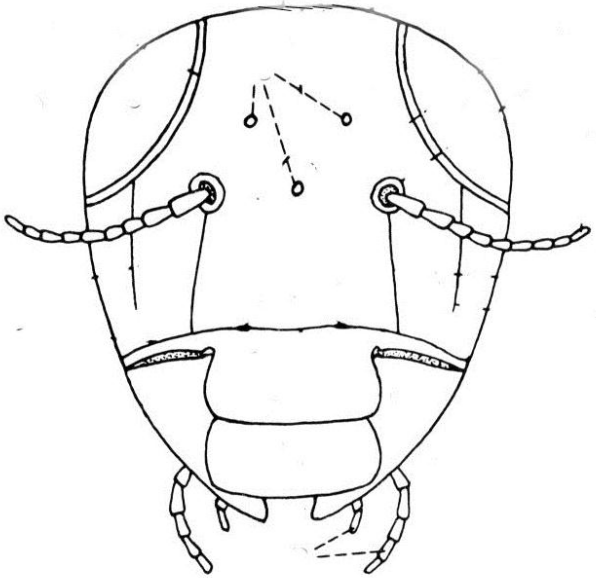
Greek “koleos”= sheath, “ptero”= wing

- Hard outer protection
- Waterproof
- Size limit

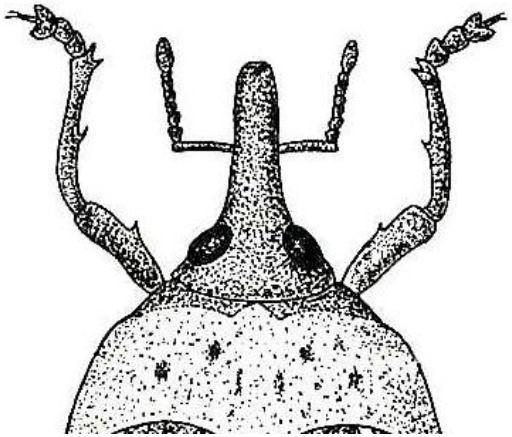


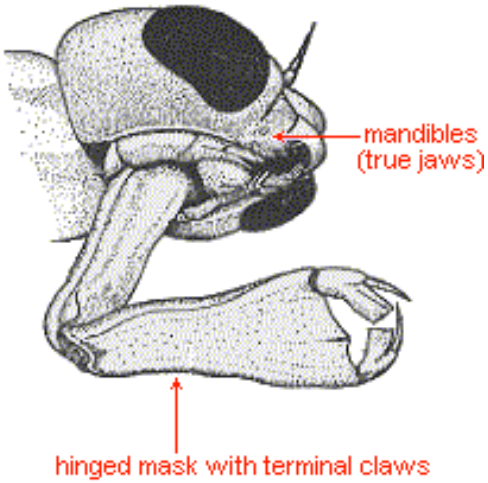


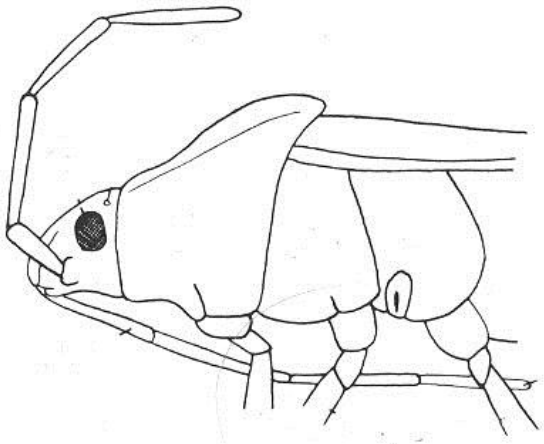
Mouthparts



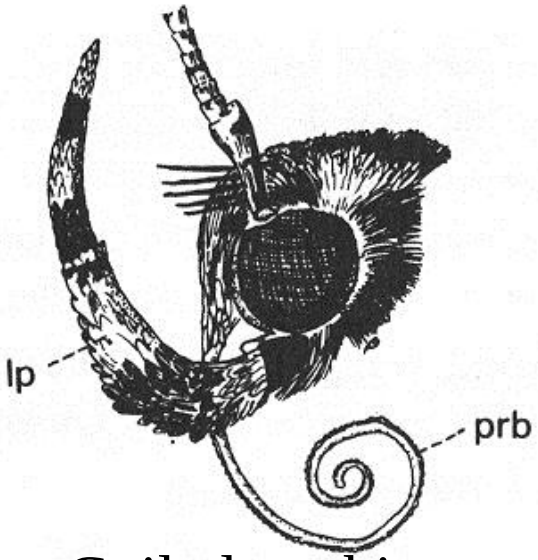
Chewing



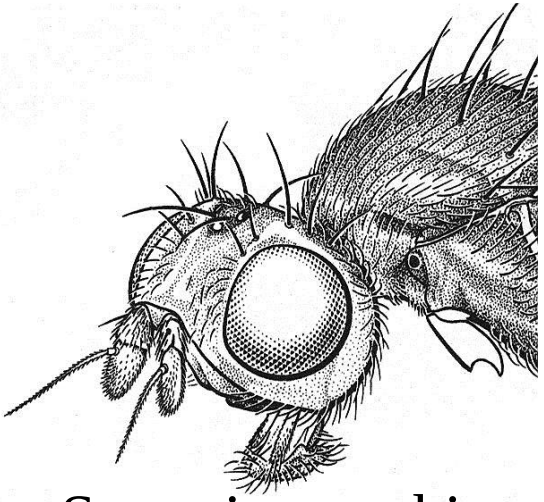




Piercing-sucking



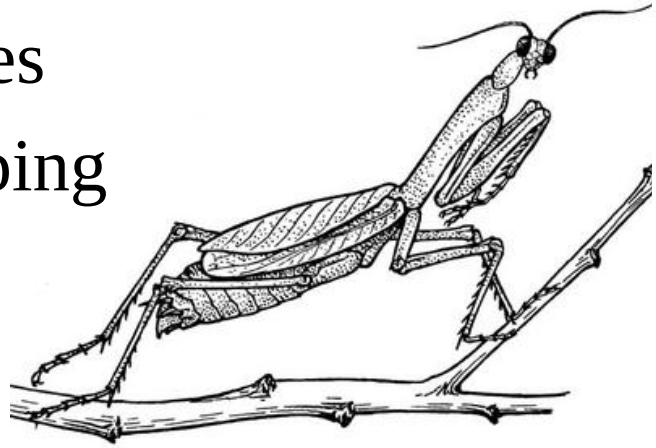
Coiled-sucking

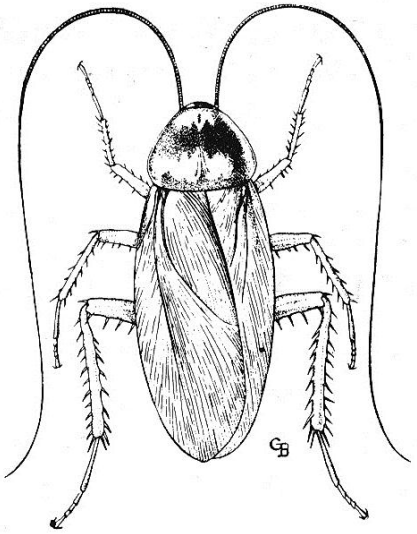


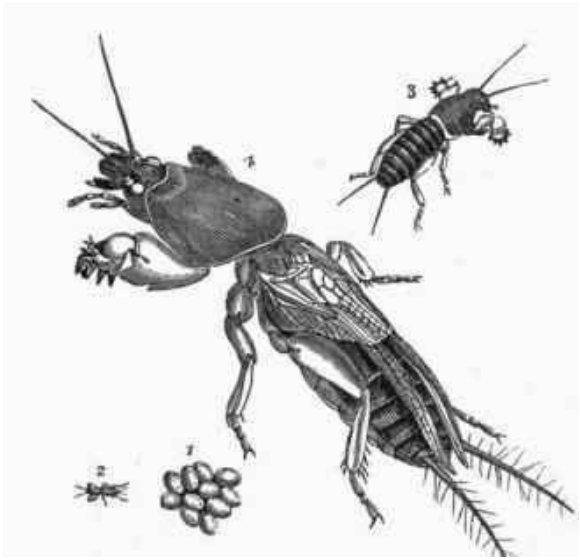
Sponging-sucking

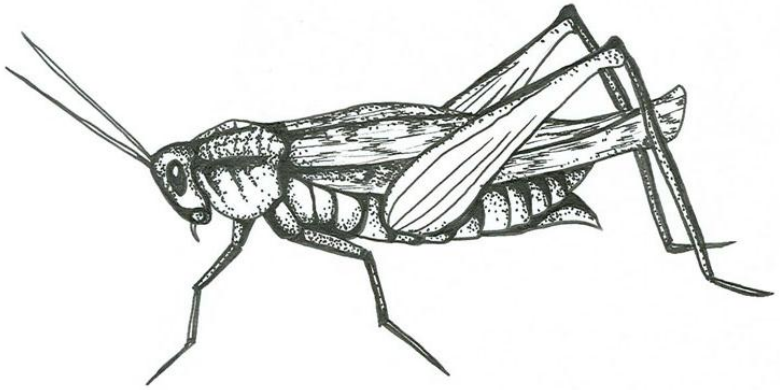
Legs

- Spiny – uneven surfaces
- Enlarged femur – jumping
- Paddles – swimming
- Shovel-like – digging
- Raptorial – prey capture









Ecological & Behavioral Specialization

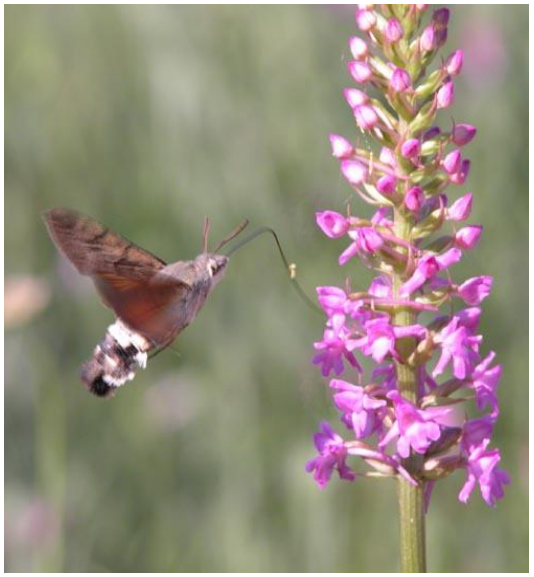





Associations with flowering plants

- Pollination (insects rewarded for pollen transfer)
- Herbivory (leaf/stem chewing, sucking, mining)
- Wood/root-boring (eg. bark beetles)
- Flower/seed-boring (eg. dried grain pests)
- Gall-forming (leaf, stem, and root galls)
- Decomposition (deciduous leaves – dead trees)

Pollination



Chewing, sucking, and mining

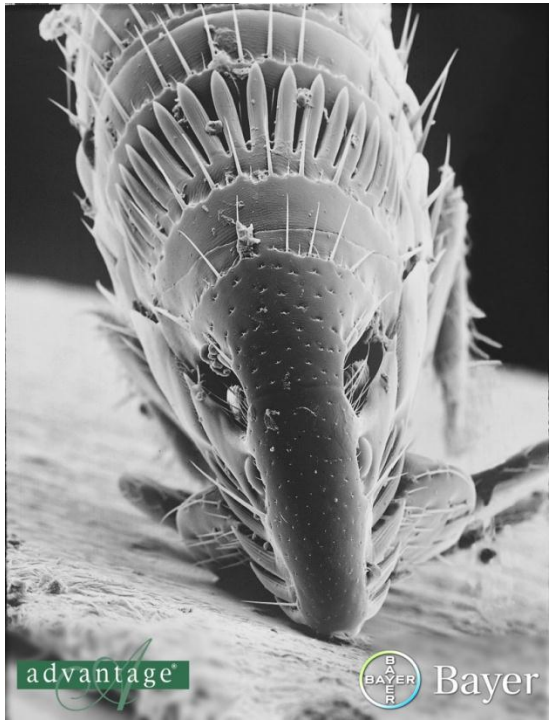
Wood/root borers

Seed/fruit/flower-borers

Gall-forming

Decomposition

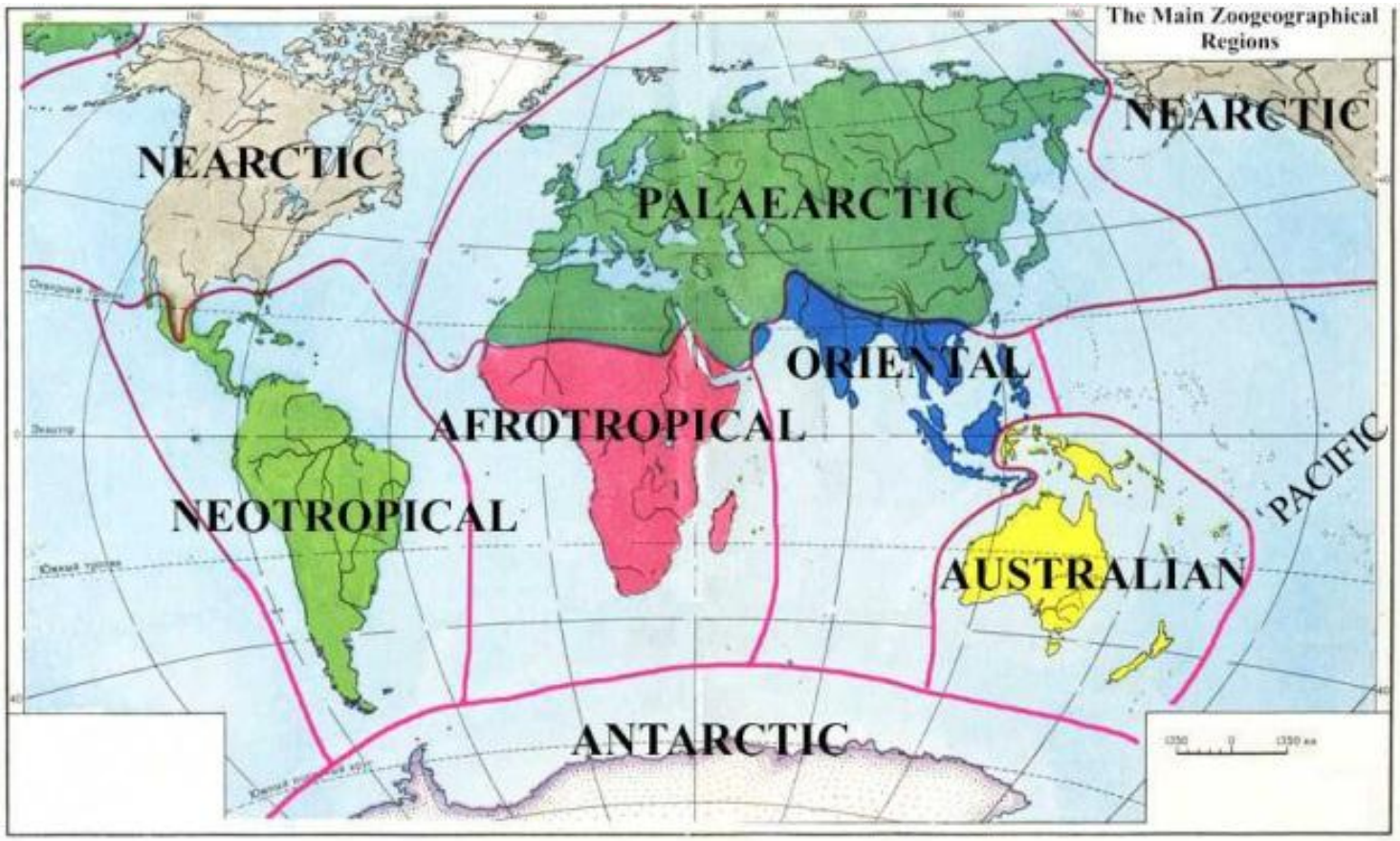
Host-parasites, parasitoids, predators



Habitat specialization

Social behavior

Biogeography



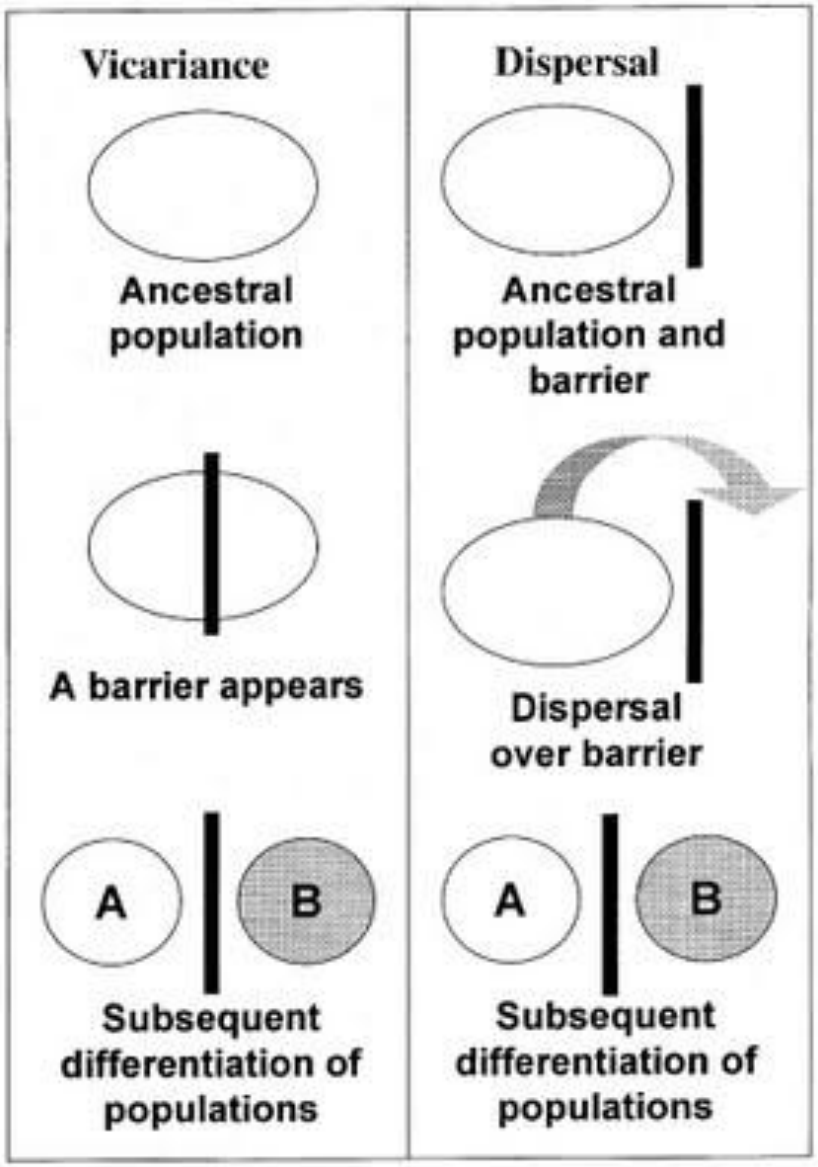
Distribution of Argentine Ant in California

Effected counties include:

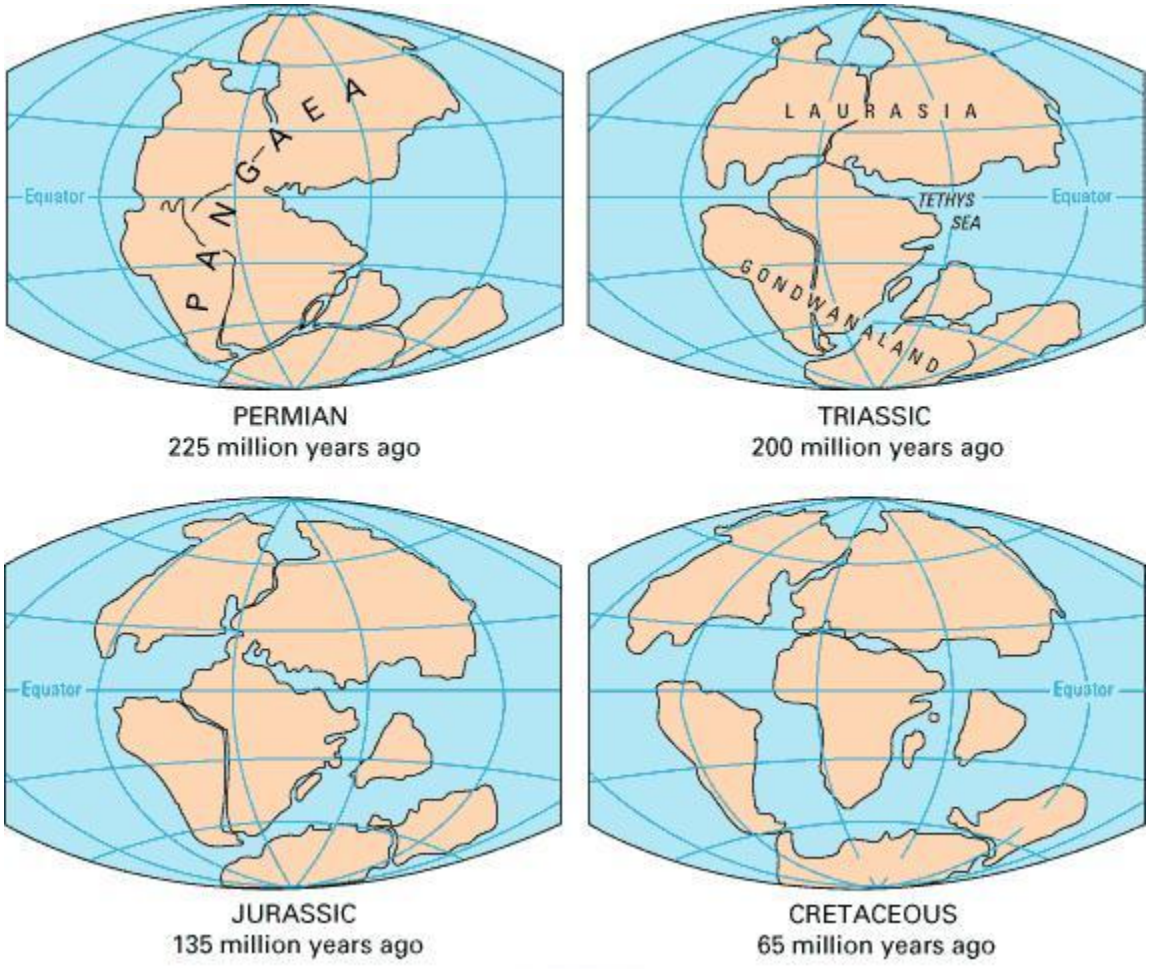
Trinity, Shasta, Sonoma, Napa, Marin, Solano, San Francisco, Contra Costa, San Joaquin, San Mateo, Alameda, Santa Cruz, Santa Clara, Stanisiaus, Monterey, San Luis Obispo, Santa Barbara, Ventura, Los Angeles, Orange, Riverside, San Diego and Catalina Island

Updated January 2011

Vicariance and Dispersal



Vicariance – Gondwana distribution



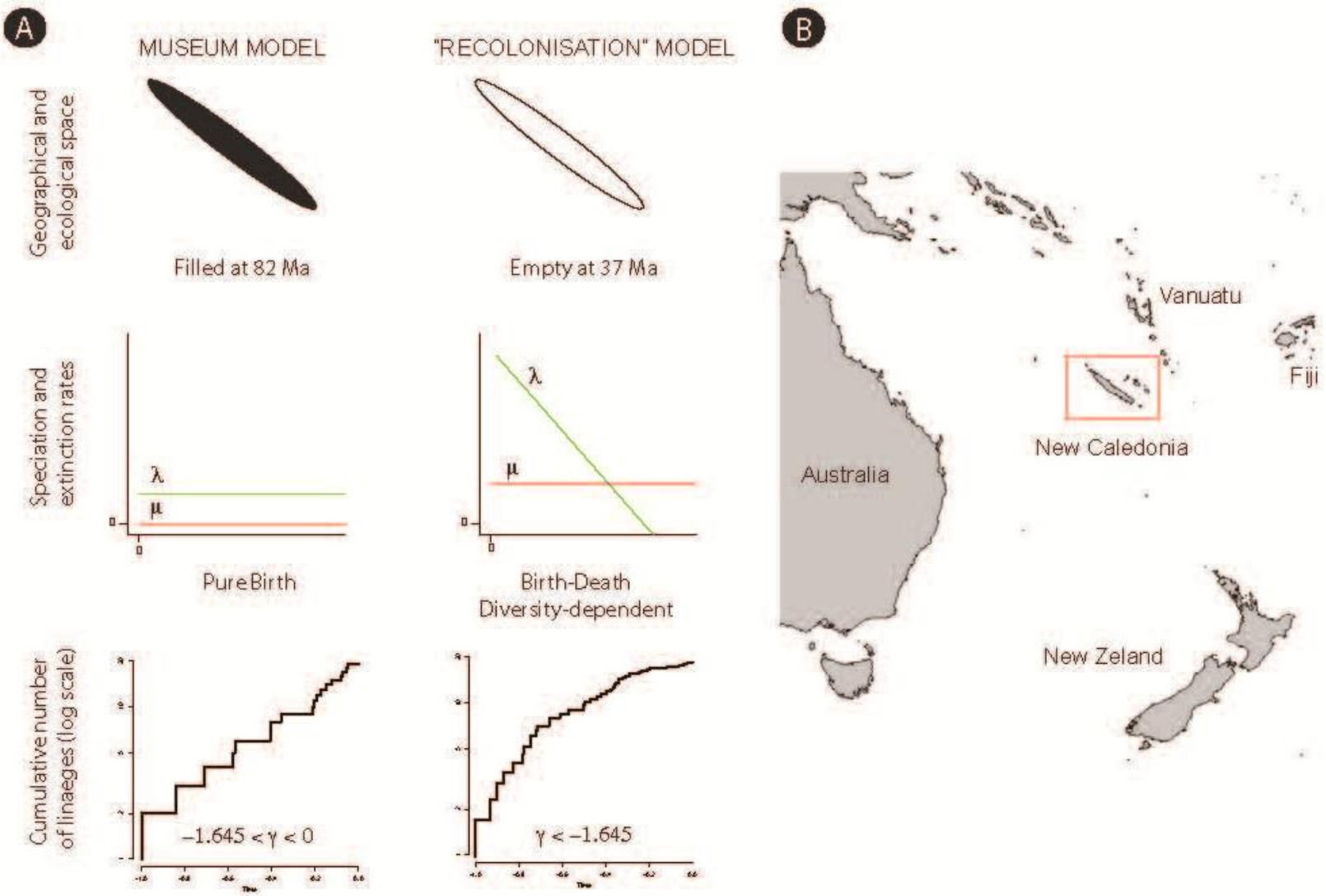
Gondwana Distribution

Nothofagus (southern beech) forest

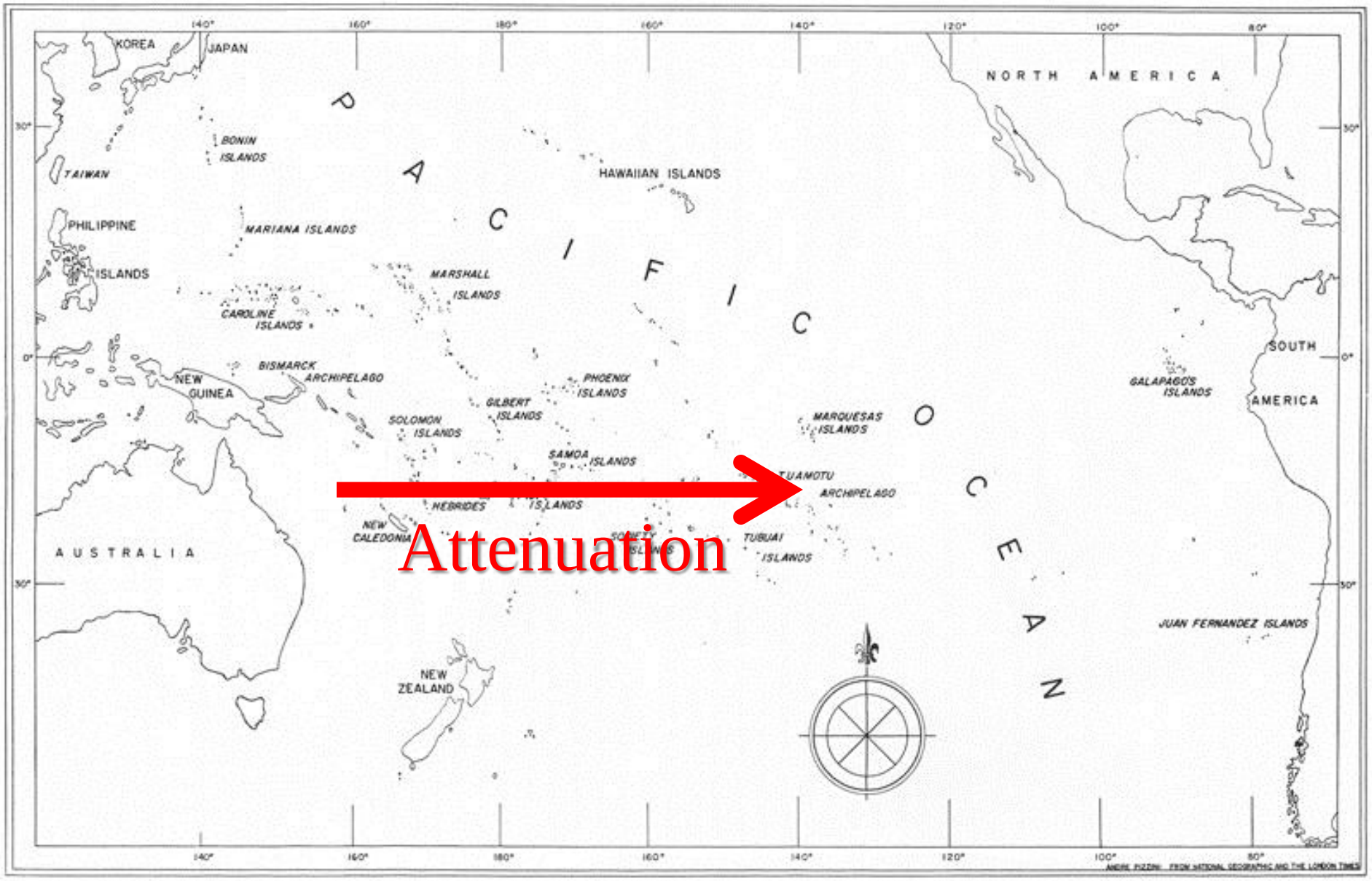
Puriri moth

New Zealand, Australia, New Caledonia, Papua New Guinea

New Caledonia - Submerged 40 mya?



Dispersal


KOREA
JAPAN
NORTH AMERICA
BONIN ISLANDS
TAIWAN
HAWAIIAN ISLANDS
PHILIPPINE ISLANDS
MARIANA ISLANDS
MARSHALL ISLANDS
CAROLINE ISLANDS
BISMARCK ARCHIPELAGO
NEW GUINEA
PHOENIX ISLANDS
GILBERT ISLANDS
SOLOMON ISLANDS
MARQUESAS ISLANDS
SAMOA ISLANDS
TUAMOTU ARCHIPELAGO
HEBRIDES ISLANDS
NEW CALEDONIA
TUBUAI ISLANDS
SOUTH AMERICA
GALAPAGOS ISLANDS
JUAN FERNANDEZ ISLANDS
AUSTRALIA
NEW ZEALAND
Attenuation

Biogeography of *Cydia* in the Pacific

6

2

3

21+

56

1

1

220+ species worldwide

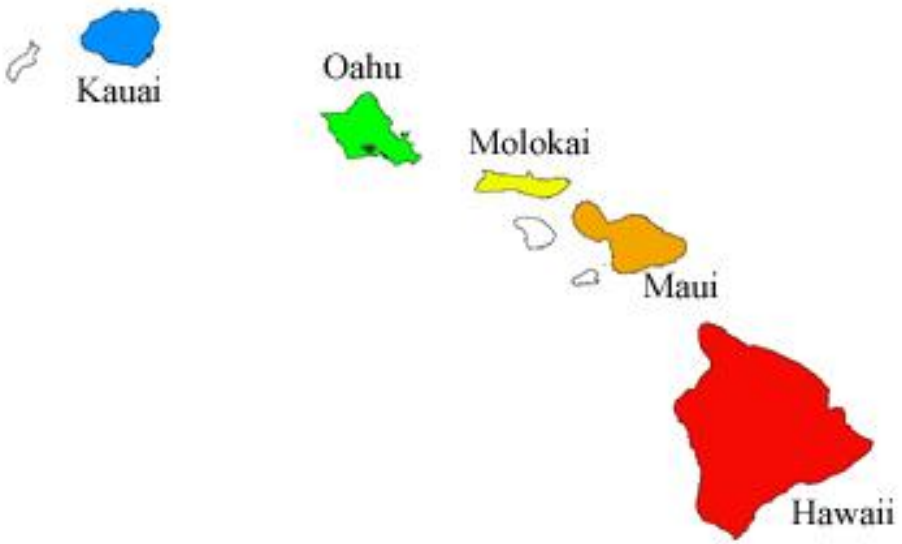
Fabaceae host plants of Hawaiian *Cydia*

Sophora chrysophylla

Acacia koa

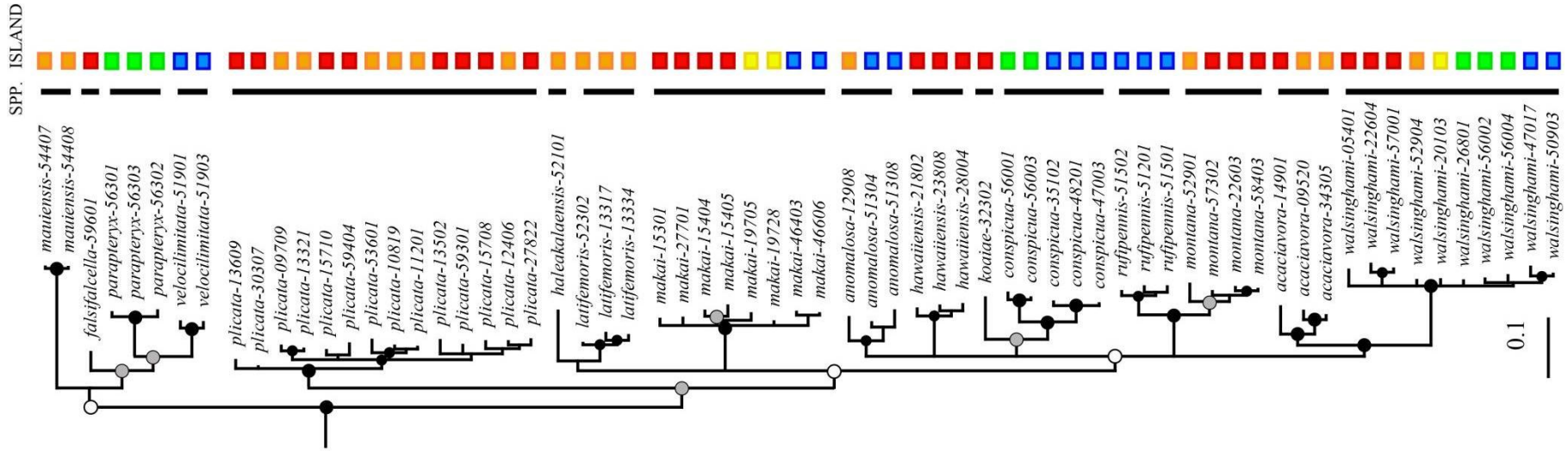
Canavalia spp.

Biogeography of Hawaiian *Cydia*



Progression Rule (Hawaii)

Speciation progresses from older to younger islands



Hawaiian *Cydia* phylogeny

Maui origin (1.2-2.2 My)

Host-shifts early in diversification

Colonization of similar niche across islands accompanied by speciation