

- Class 10
- Reminder: Presentations next week!
- Recommendation: Have me check your journals

- 1:30-2:15 Slides: Evolution
- 2:15-3:20 Activity: Biodiversity of California



Biodiversity & Evolution

What is Biodiversity?

- Represents the variety of life on Earth
- The number of different types of organisms
 - Species Diversity
- And other types of diversity ...



Which has more Biodiversity?

How many species are there?

- **About 2 million known species**
(UN Millennium Ecosystem Assessment)
 - *Some estimates claim over 8 million species on Earth!*
- **15,000 new species discovered every year!**
 - *Deep Ocean, Tropical Rainforest, Caves, Soil*
- **New frog species discovered in New York City 2008**



"Five New Species Found Hiding Right Under Our Noses", bbc.com, 24 Nov, 2014

"How Many Species Are There on Earth and in the Ocean?", Camilo Mora, et al, *PLOS Biology*, Aug 2011

Other types of Biodiversity?



ECOSYSTEM DIVERSITY in a Landscape



FUNCTIONAL DIVERSITY in an Ecosystem
(grazers, detritivores)

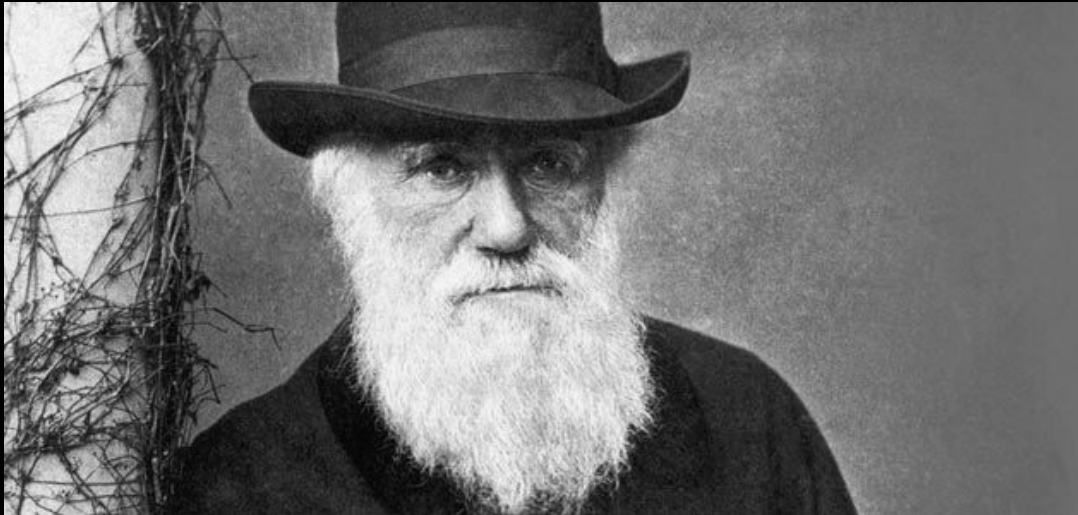


GENETIC DIVERSITY in a species population

Why and How Did Biodiversity Arise?

The one word answer is:

EVOLUTION



Characteristics of Evolution

- Populations evolve over time, not individuals
- Occurs independently in different geographical areas
 - *Similar coping strategies for similar environmental niches*
 - *E.g., Desert biomes have succulent stems and thorny leaves*



- Extinction is a natural outcome of evolution
 - *Most of the species that ever lived are extinct: They evolve into new species*
 - *But, extinction rate today is much higher than normal*

What is Evolution?

Process of change, over time, *in populations*

- Variations in populations
 - Genetic diversity
- Selected by
 - Environment (**Natural Selection**)
 - Who gets to live long enough to reproduce
 - Mates (**Sexual Selection**)
 - Who gets to reproduce
- Gives rise to Biodiversity



Mechanism of selection

- **Genes get expressed as traits in organisms**
 - Genetic diversity => Diversity in traits *in populations*
 - E.g., Variation in size and shape of beak within a population of Anna's hummingbird
- **Some traits help organisms survive in the surrounding Environment**
 - Natural Selection (e.g., camouflage)
- **Some traits give the organism a reproductive edge**
 - Mate Selection (e.g., bright feathers could be attractive)



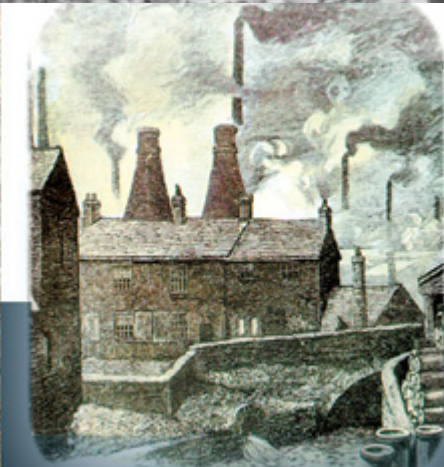
Example of Natural Selection

Organisms better adapted to their environment tend to survive and produce more offspring

- The environment (nature) *selects* which individuals live and reproduce
- E.g., Urban population of Peppered Moth



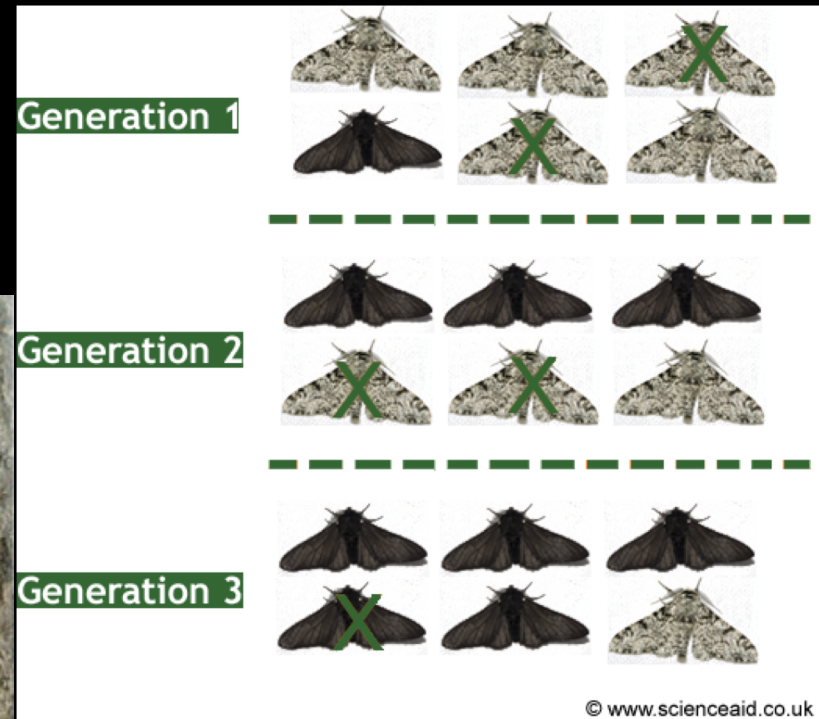
Before



Industrial Revolution



After



Notes on Pepper Moth Natural Selection

Variation in population:

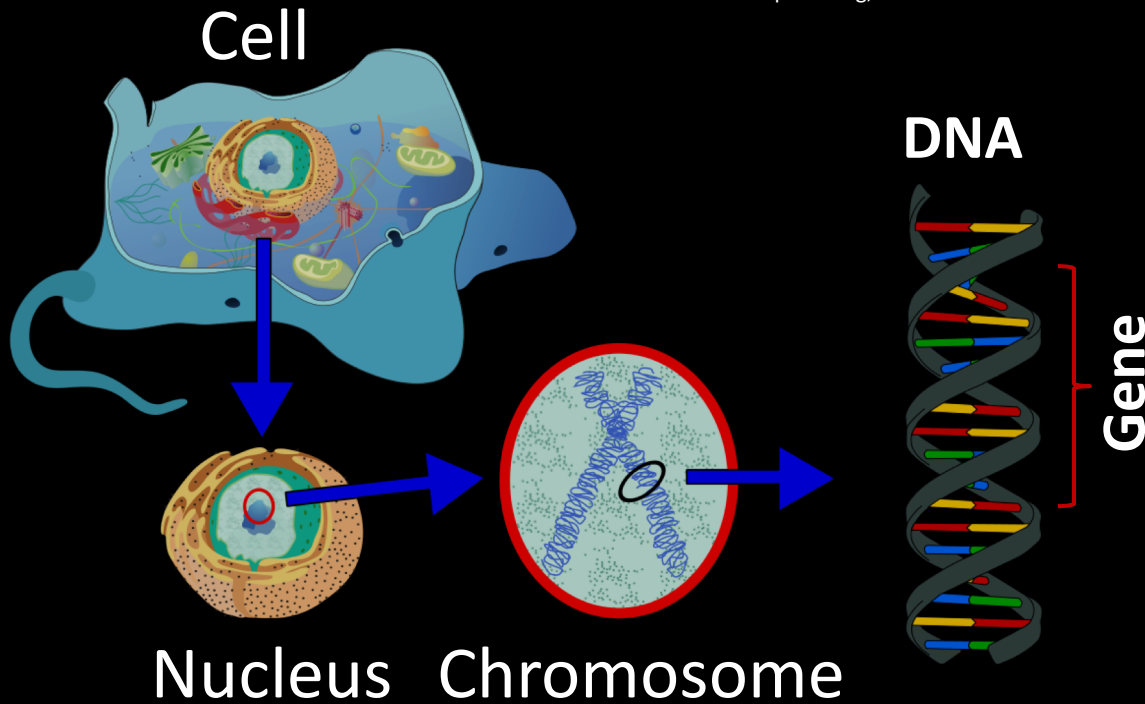
- Pepper moth population in urban areas of Britain have a natural variation in wing coloration. This occurs due to *random variation* in the genes.

Change in Environment *selects on the existing population*

- Coal was extensively used during the Industrial Revolution. This led to emission of black soot in urban areas (where the industries were located), which got deposited on surfaces on the walls of buildings.
- The black walls exposed the light colored moths and hid the dark colored moths from predatory birds.
- More light colored moths got eaten, likely before they were able to reproduce.
- More dark colored moths survived, likely until they could reproduce.
- Over generations, the population contained more dark colored moths
- The darker moths were *better adapted* to the new environment the industrialization brought about.

What are Genes?

Wikipedia.org, Creative Commons License

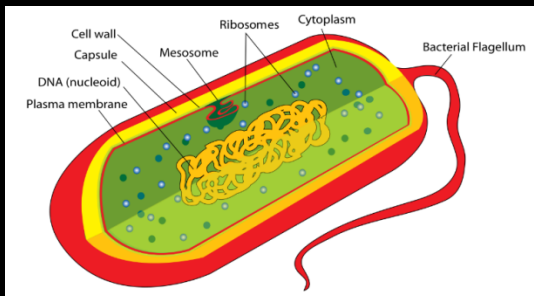


Genes are regions of chromosomes that code for a trait

I.e., Genes are part of the DNA sequence that code for a trait

DNA:

Deoxyribo**N**ucleic**A**cid



Genes are also part of organisms without a nucleus like bacteria and viruses

How does genetic change occur?

Populations of species acquire genetic variation through 3 processes

- **Recombination**

- Meiosis (process of formation of eggs and sperms) is where Recombination happens
- See the following video on Meiosis on Youtube:
<http://www.bozemanscience.com/meiosis>

- **Mutation**

- Chemical Changes in DNA at random locations in germ cells
- Can occur due to environmental causes or due to errors while copying DNA to form germ cells
- E.g., exposure to radiation, chemicals in the environment

- **Horizontal Gene flow**

- Incorporation of genes from a different species into a germ cell
- E.g., incorporating bacterial genes into cotton seeds to make pesticide resistant cotton plants
- Occurs naturally as well as through bio-engineering by humans

Only those changes that are either beneficial or neutral to the survival of the organism will show up in the population

Genetic Variation Example

- **What is genetic variation?**
 - **Random changes in the genes of an organism**
 - *E.g., each frog in the species *O. buckleyi* is different due to random variation in some genes*
 - **Those that are beneficial or neutral survive**
 - **Constitute the Gene Pool of the species**

Osteocephalus_buckleyi



How does selection lead to Speciation?

Speciation = Creation of a new species

- **Adaptive Radiation (same location)**
 - Populations separated into different Niches
- **Reproductive Isolation (different locations)**
 - Populations separated into different regions
 - Due to changes in landforms
 - Earthquakes, Floods, Climate Change, Human Activities
 - Due to migration
 - Each population subject to different environments

Ecological Niche (recap)

- The **specific way** a species uses the habitat
 - Enabled by special **adaptations**
 - Gives rise to **roles** in ecosystem
 - Lets a species avoid competition with other species
 - e.g., hunter, pollinator, grazer, detritivore



Adaptive Radiation and Niches

Darwin's Finches in Galapagos Islands



The ancestral population of finches migrated to the Galapagos from the mainland. On the mainland,

- All individuals shared the same habitat, ate similar type of food
- Had the same type of beak (some variation due to genetic diversity)



Large ground finch (seeds)



Cactus finch
(cactus fruits and flowers)



Vegetarian finch (buds)



Woodpecker finch (insects)

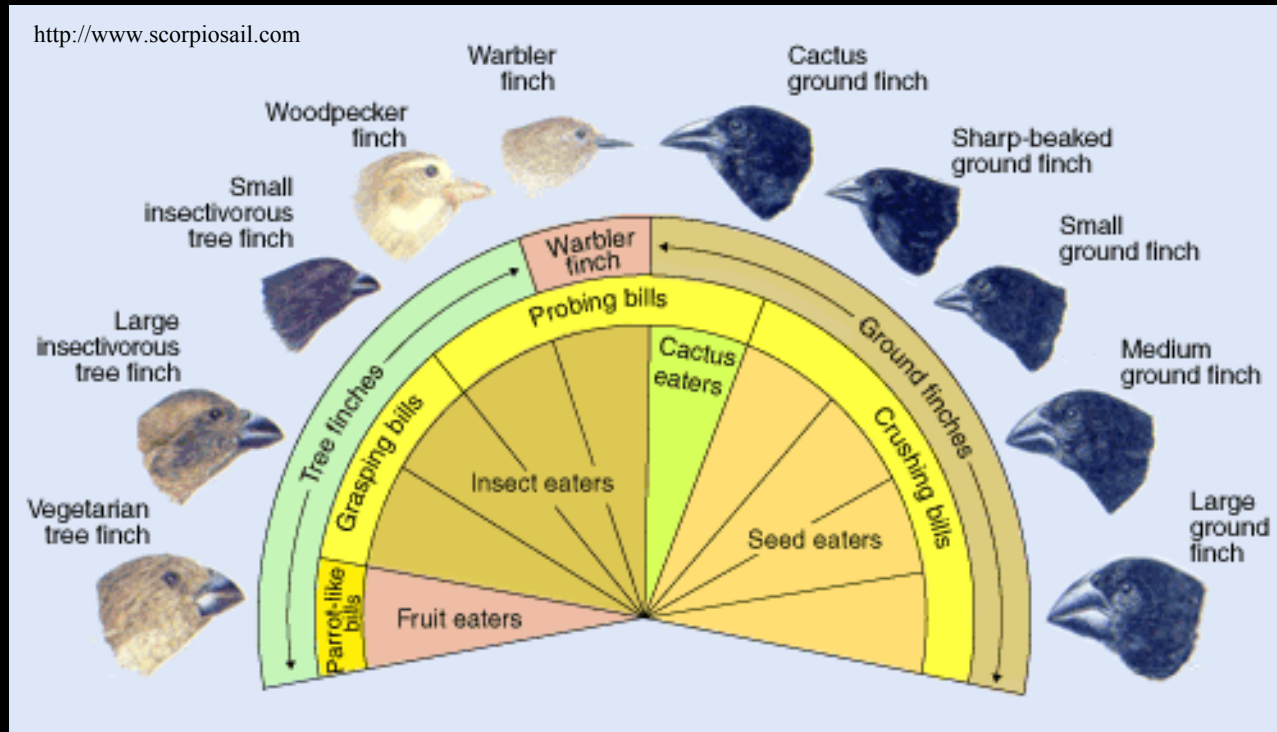
- Food Resources on island were different from mainland
- The island was much smaller than the mainland

Consequently,

- Population separated into different niches to avoid competition
- This was possible because of the variation already present in the population

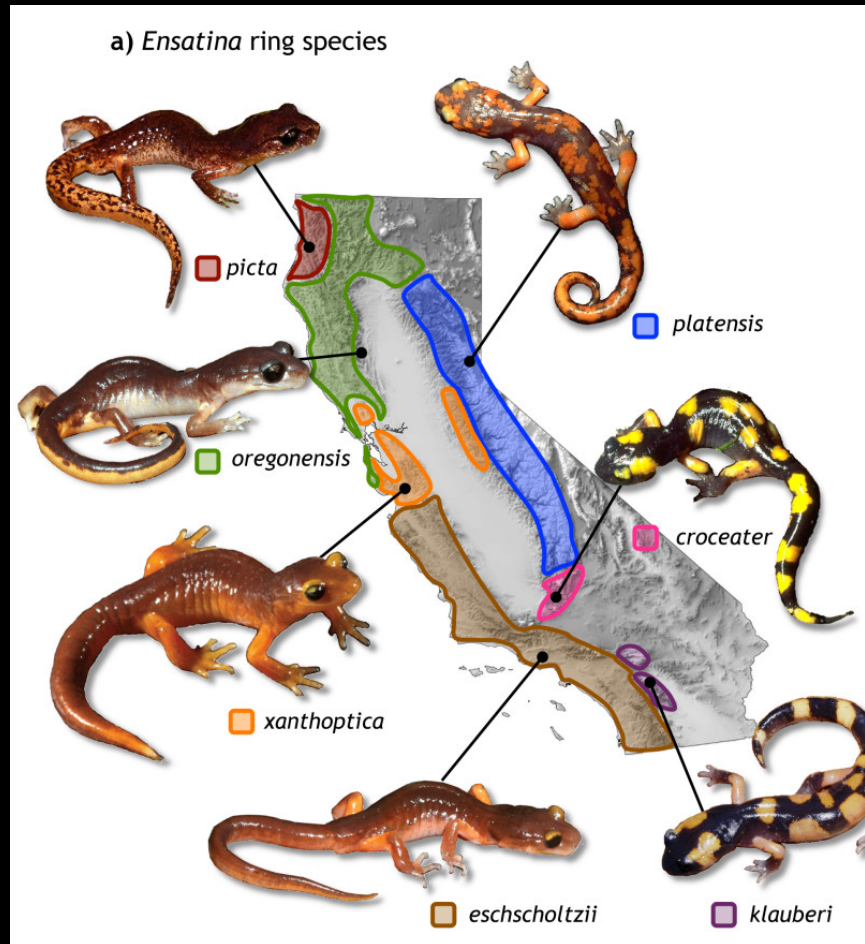
Adaptive Radiation and Niches

Darwin's Finches in Galapagos Islands



- Variation in food preference kept populations separated
 - Over many generations changes accumulate
 - The changes are large enough that they cannot interbreed
 - New species!

Reproductive Isolation - Migration



- A single population exists in a location
- Either due to migration or changes in landscape (earthquakes, floods, volcanic activity, human activity), the population splits
- The separated populations cannot interbreed
- They evolve differently, due to different environments
- Become different species over many generations.

Notes on Ensatina Evolution

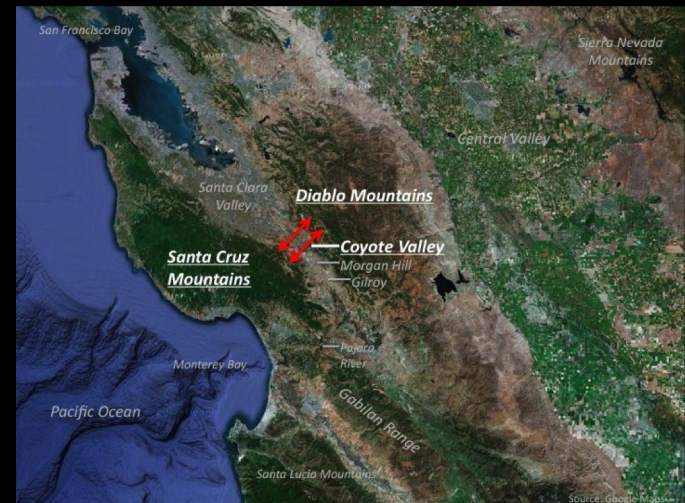
- Ancestral population of Ensatinas in California originated in N. California
- Way in the past, populations of this ancestral species started migrating from their original range. Over generations they move further and further occupying new available habitats (suited to their lifestyle)
- On their southward migration, they could only inhabit the cooler mountainous areas to the east and west of Central Valley, but not Central Valley itself.
- Now there are three populations:
 - The original ancestral one to the north
 - Second population to the south and west of Central Valley
 - Third population to the south and east of Central Valley
- The three populations are subject to different environmental conditions
- Natural selection happens and the populations diverge genetically
- Two new species are formed to the south for a total of 3 species including the ancestral species
- This process repeats itself upon further southward migration
- In the region where Central Valley ends and the two mountain ranges are connected again, it gets occupied by two completely different species of Ensatina.
- California's diversity in topography has given rise to increased biodiversity!!

Reproductive Isolation - Human Barriers

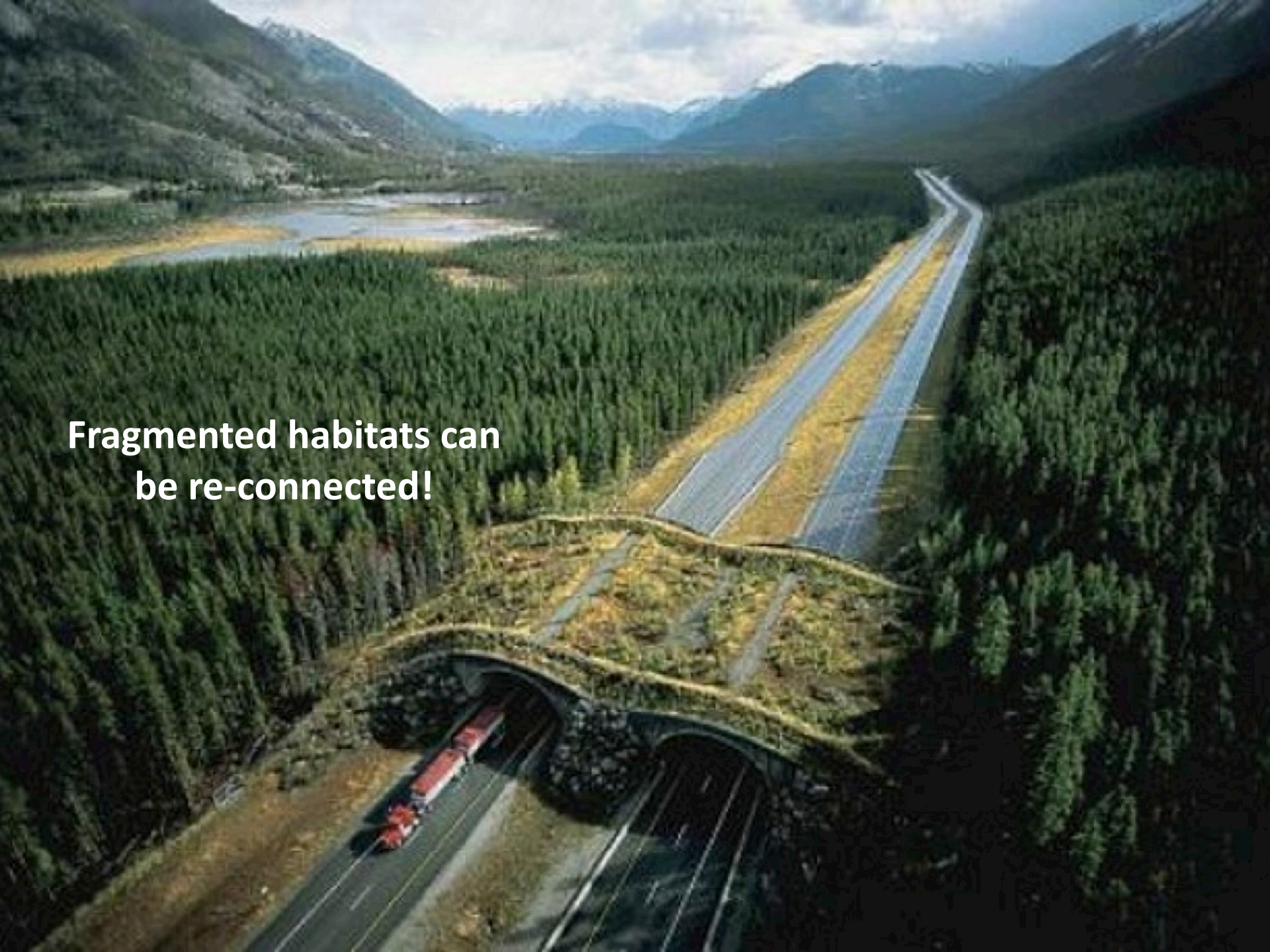


Habitat fragmentation
and habitat loss

- Roads
- Urban areas



**Fragmented habitats can
be re-connected!**

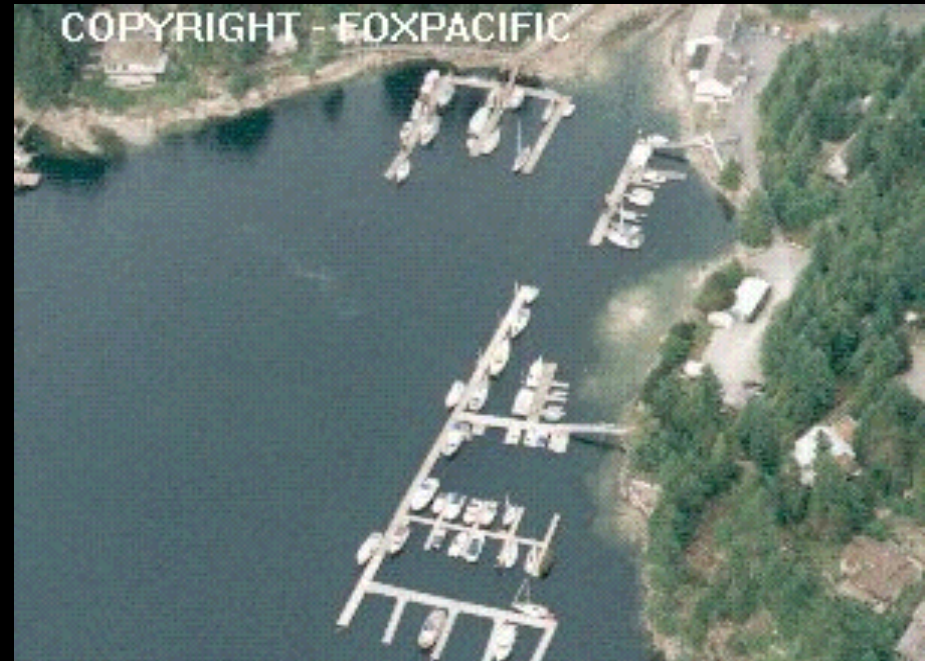


Reduced genetic diversity



What is the Human impact – HIPPO – on Biodiversity?

Reduced species diversity



Reduced ecosystem diversity

Why should we care about biodiversity? Is there value?

Without biodiversity we would not be able to survive for very long.

- **Source of fresh air, fresh water, food, raw materials, medicines, recreation**
- **\$41 trillion a year in ecosystem services!!**
- **All biodiversity contributes to those ecosystem services.**

Does Biodiversity have only *instrumental value* or



Rosy Periwinkle: Anticancer compounds

Class 10 In-class Research Activity: Biodiversity of California and Ecological Niche

**Answer the following using the Atlas of Biodiversity of California,
Which is available for checkout at the SRC**

1. Why is California such a “special place” for Biodiversity? (pg. 2-3)
2. Define rarity, richness and endemic species.
3. Which states in the continental US have rarity and richness?
4. How many endemic vascular plants, amphibians, reptiles, birds, mammals and freshwater fishes are in California?
5. Where is the highest richness of plant, amphibian, reptile, bird, mammal and freshwater fishes in California (name the general areas) and why? Refer to the relief map of California.
6. Look closely at the richness maps and how they relate to where you live.
7. Name 5 types of habitats that are unique to California and list 2 species that are found in each habitat type.
8. Now pick one species that is mentioned in the atlas. Write down what habitat and ecosystem it is found in. Research its ecological niche, and some adaptations that help it to live in that habitat to fill that niche.