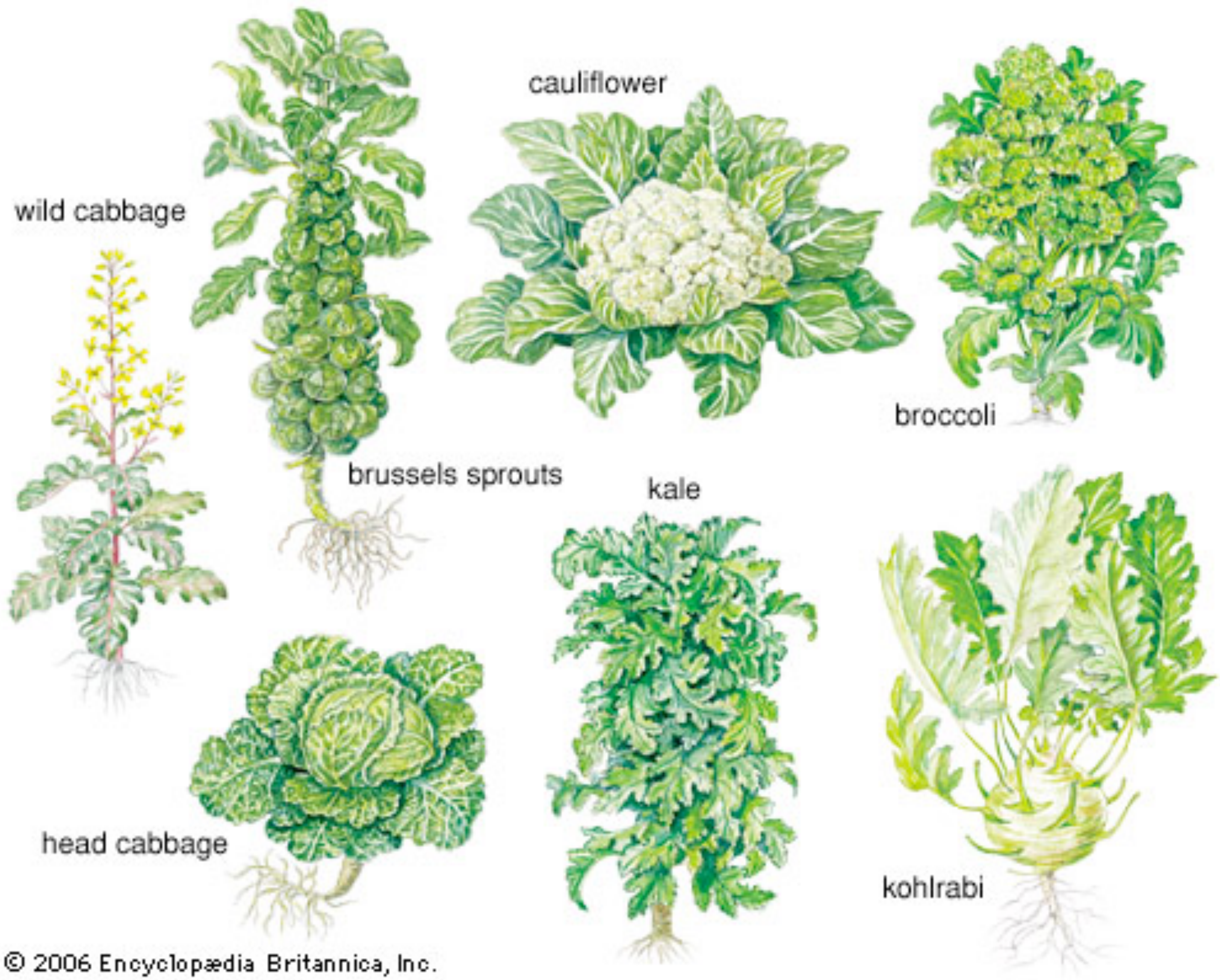
EVOLUTION & ADAPTATION *(EEB214S)* 2012

Lecture 6: Evidence for Evolution

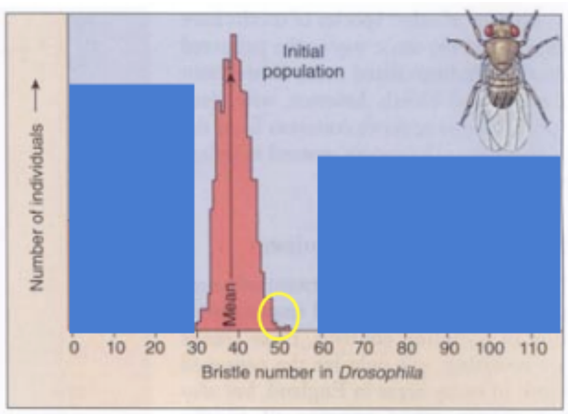
Artificial and natural selection


cauliflower
wild cabbage
broccoli
brussels sprouts
kale
head cabbage
kohlrabi

Artificial selection

Bristle number

1



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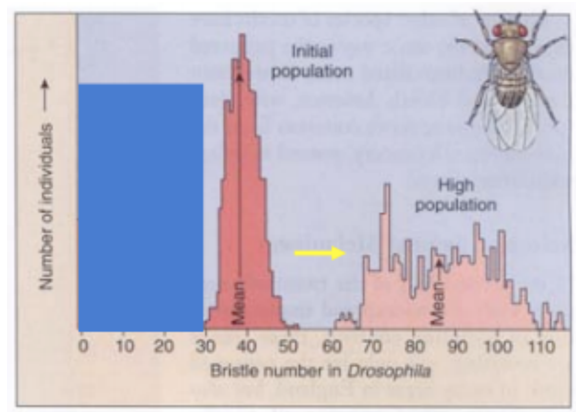

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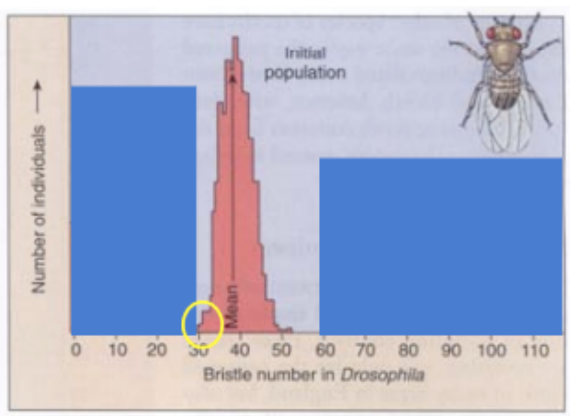

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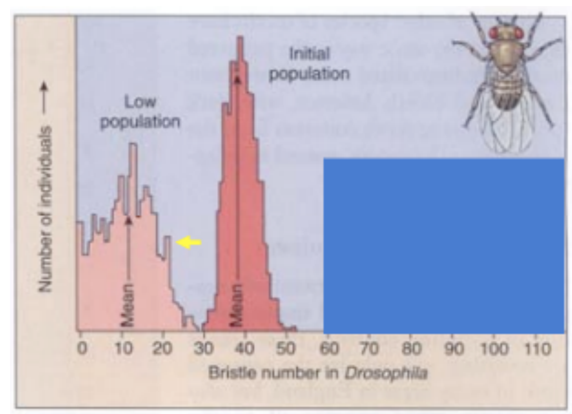


Canis lupus familiaris

Eurasian grey wolf domesticated about 10,000 years ago

The diversity that we see in dogs is astounding e.g. domestic dogs vary in weight from 2 pound Chihuahua to 180-pounds English Mastiff, wild dogs vary only between 2 and 60 pounds.

All these breeds have been selected for in less than 10,000 years.

What is the difference between artificial selection and natural selection?

Under artificial selection humans are determining who reproduces, while under natural selection, the environment is.

what is the evidence that natural selection operates in nature?

Peromyscus polionotus

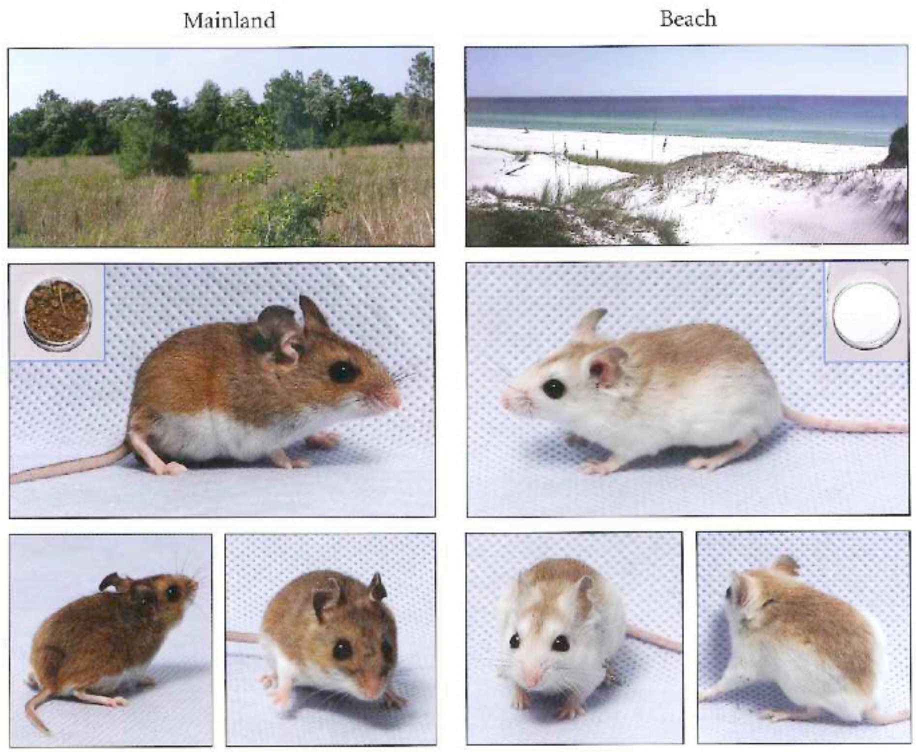
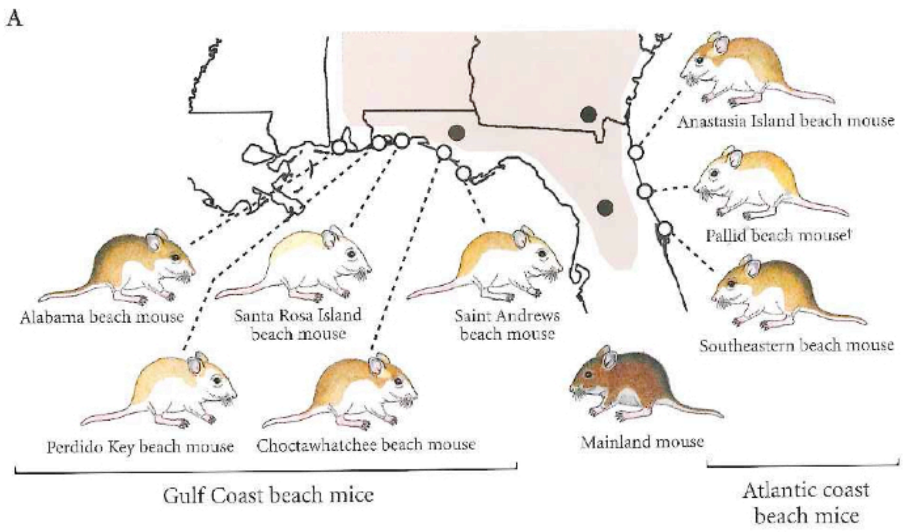


FIGURE 2 *Camouflaging color patterns of mice from different habitats.* Oldfield mice (*Peromyscus polionotus*) can be found in two distinct habitats in Florida—oldfields which are vegetated and have dark loamy soil, and coastal sand dunes which have little vegetation and brilliant white sand. Mice that occupy these different habitats have distinct coat-color phenotypes: mainland mice have a typical dark brown coat, whereas beach mice largely lack pigmentation on their face, flanks and tail. Typical habitat, soil samples and mice are shown. [Sacha Vignieri (habitat), Clint Cook (mice)]



The "oldfield" mice vary in colour but are generally darker than those "beach mice" that invaded the barrier islands off the Gulf Coast of Alabama and northern Florida and the coastal habitat on the Atlantic seaboard.

How do we know that their coat colour has changed in response to natural selection?

Kaufman's (gruesome) Experiment

- Created large enclosures with light and dark soil.
- Into them he released light and dark mice.
- And finally he added an owl, a hungry one.

- The mice with the more conspicuous coats were picked off most readily, the more camouflaged mice survive better.

How do we know that the predators were being selective based on coat colour?

100s of models were set out 10, apart each afternoon

Returned the next day to find clues to what had eaten them

Camouflaged mice have a 50% higher probability of survival compared to matching mice - the advantage was symmetrical

THE ADAPTIVE SIGNIFICANCE OF COLOR VARIATION

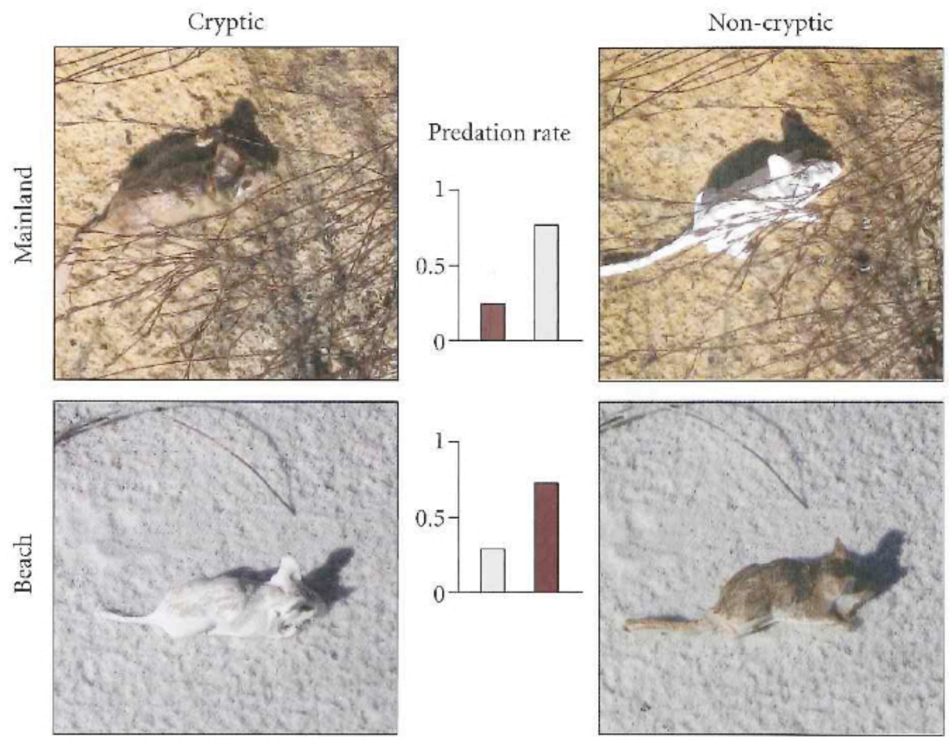


FIGURE 3 *Linking environment to phenotype: cryptic coloration matters for survival in the wild.* Typical clay models of mice, painted to resemble beach and mainland forms, laid out in both mainland (Lafayette Creek Wildlife Area) and beach habitat (Topsail Hill State Park) in Florida. Relative predation rates of dark and light models in mainland (top) and beach (bottom) habitats are shown. Crypsis reduces predation rate by approximately one-half in both the mainland and beach habitat. (Sacha Vignieri)

So it seems that coat colour is being selected upon by predators.

Natural selection, acting on coat colour, has simply changed the genetic composition of a population, increasing the proportion of genetic variants (the light-colour genes) that enhance survival and reproduction.

what do we need for natural selection to act?

Three things are required for NS to work (create an adaptation):

1. Variation
2. Heritability
3. Selection must act to affect an individual's probability to leave offspring.

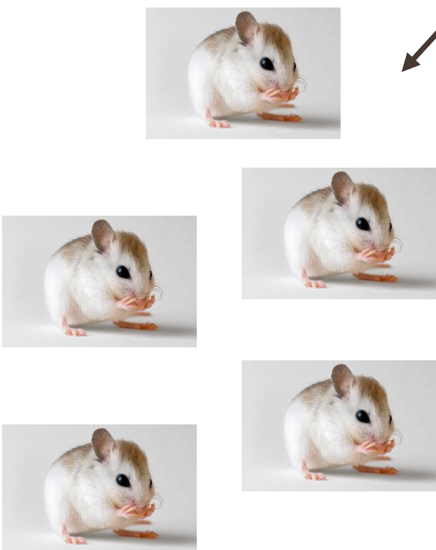
We know that the oldfield mice **vary** in coat colour

Where does this variation come from?

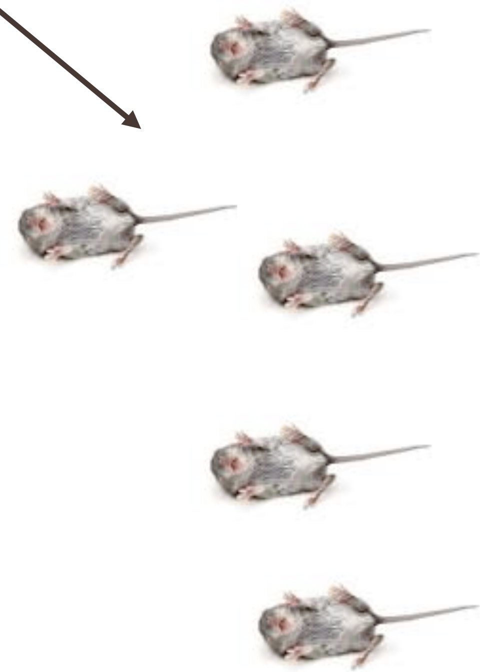
Mutations - accidental changes in the sequences of DNA that usually occur as errors when the DNA is copied during cell division.

The mutations occur at random.

If you take pregnant females out of the wild and let them reproduce under lab conditions



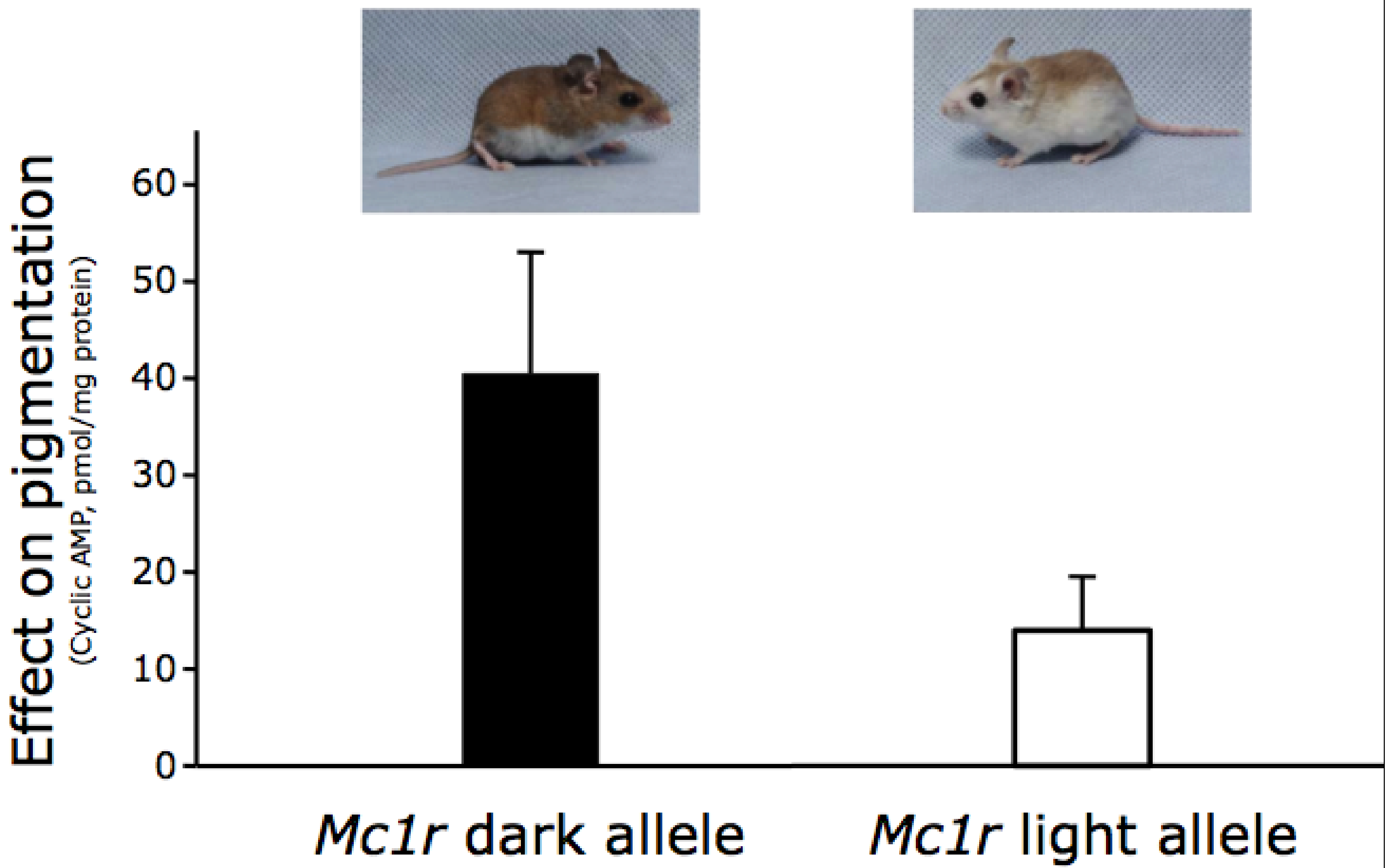
You see that coat colour is **heritable**



genetic variation must affect an individual's probability of leaving offspring

- Think about the Kaufman experiments.
- **Evolution by selection is then a combination of randomness and lawfulness. The occurrence of mutations that generate an array of genetic variants, both good and bad; and then the lawful process of natural selection that orders this variation, keeping the good and winnowing the bad.**
- Richard Dawkins definition of natural selection is **"the non-random survival of random variants".**

Mutation in the pale Gulf mice



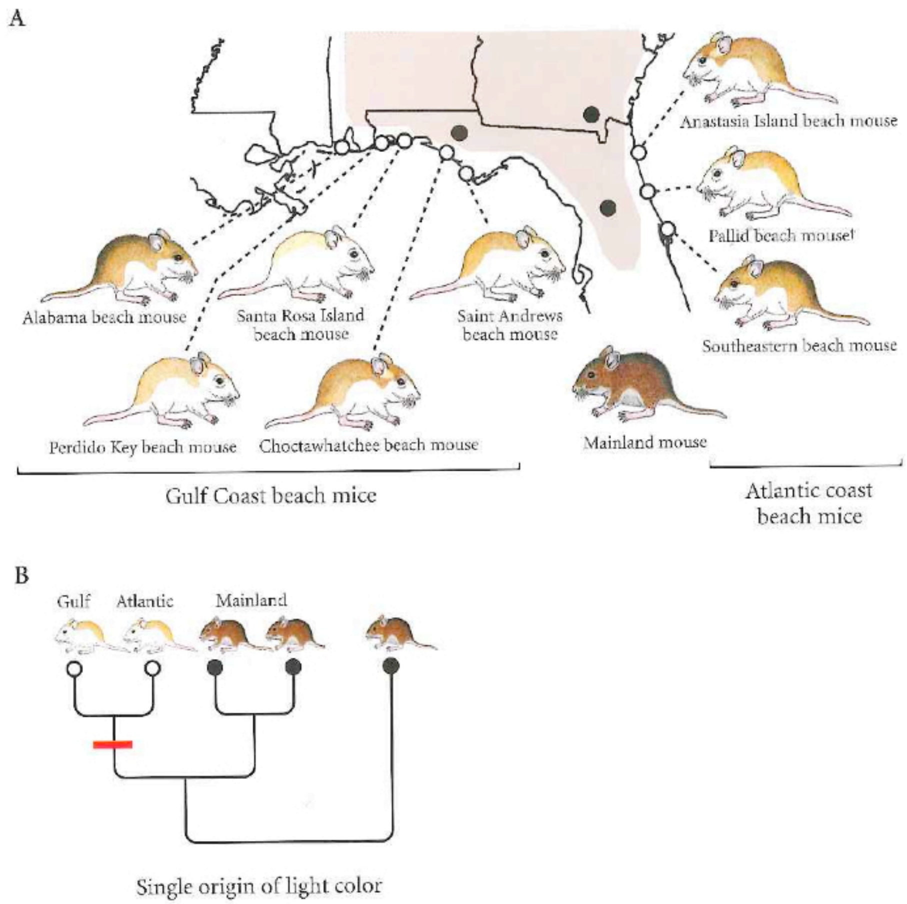
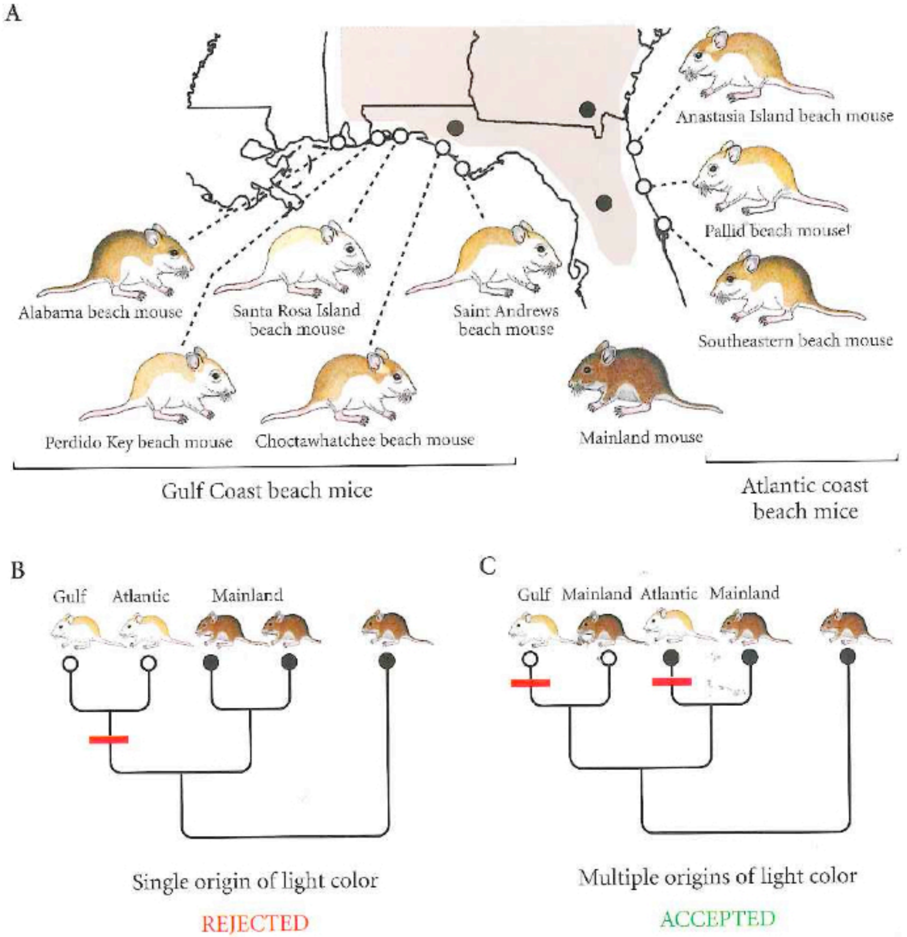


FIGURE 6 *Pale beach mouse subspecies occur along both the Gulf Coast and the Atlantic coast of Florida.* (a) Cartoons represent the typical color pattern of each of the eight beach mouse subspecies. Circles represent the location of each subspecies, whereas the range of mainland mice is shown in tan, with black dots representing collecting sites in the panhandle and central Florida as well as Georgia. (b) Possible relationship among subspecies if light pigmentation has evolved a single time. (c) Actual relationship of populations based on DNA data showing that light coloration in beach mice likely evolved twice independently—once in the Gulf Coast and a second time in Atlantic populations. Red bars indicate the evolution of light pigmentation.



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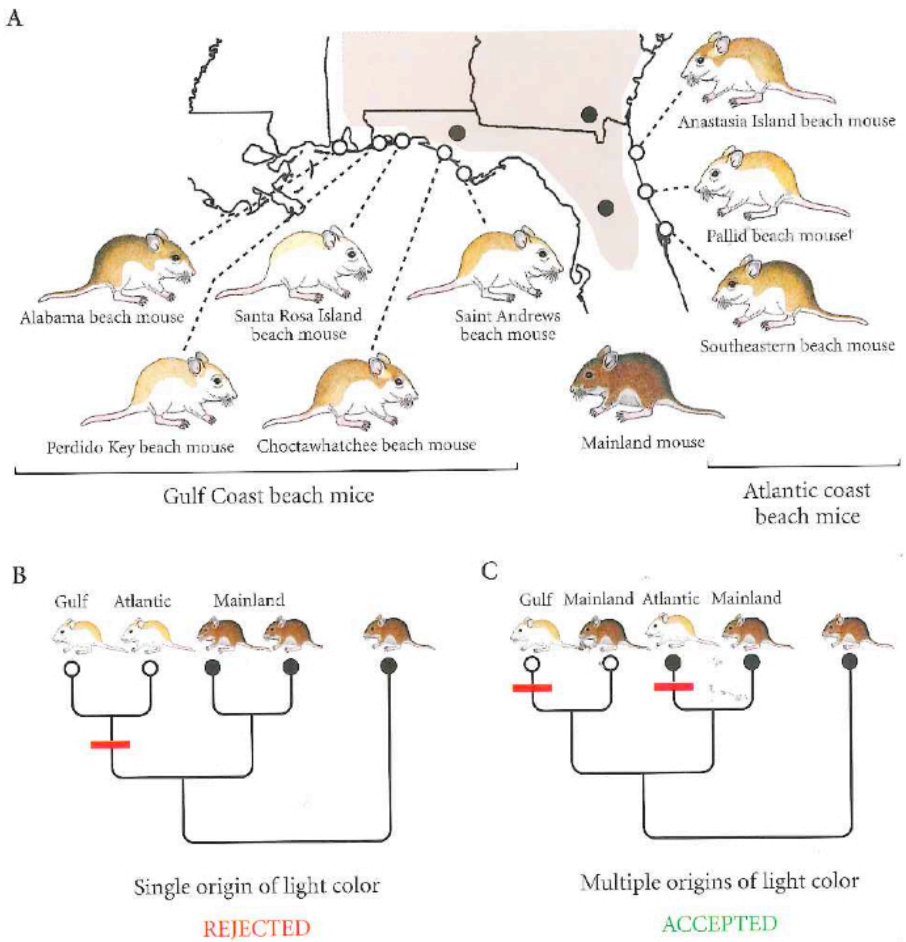

These data suggest that light colouration has evolved independently on the Gulf and Atlantic coasts

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In fact the mutation in the Mc1r that causes the paleness of the Gulf mice does not occur in the Atlantic pale mice.

Darwin thought that natural selection acted extremely slowly over many generations, altering populations over thousands and millions of years.

He was wrong.

We can see natural selection acting not only in our lifetime, but within a single experiment.

Tales of evolution from the common gut bacteria

(from microbiologist Richard Lenski, MSU)

- 12 "tribes" of E. coli bacteria, each tribe was housed in a flask that contained a specific amount of glucose, the primary E. coli food source
- Allowed to reproduce until it has exhausted its food source
- 1/10th of the fluid in each flask was taken and transferred to a new flask that had the exact contents as the one before it.
- Since 1988…(44,000 or so bacterial generations).
- **Selection has made the bacteria better adapted to a feast-famine regime: The bacteria now grow 70% quicker than when he started his experiment.**
- Lenski *et al* have identified 9 mutations that allow the bacteria to grow quicker.

Tales of evolution from the common gut bacteria

(from microbiologist Barry Hall, U of Rochester)

Bacteria with no gene to break-down lactose

Grown only with lactose

Initially the bacteria didn't grow but then it suddenly started to.

A mutation had occurred that allowed the bacteria to break it down (if only poorly)

Three things are required for NS to work (create an adaptation):

1. Variation
2. Heritability
3. Selection must act to affect an individual's probability to leave offspring.

- Eventually another mutation occurred that allowed the bacteria to produce more of the enzyme that had newly acquired the ability to break down lactose
- And then other that allowed the bacteria to pump more lactose into them cell, so it could eat faster.
- Evolution of complexity?