

Evolutionary Biology



A story of thinkers, adventurers,
and the history of life on earth

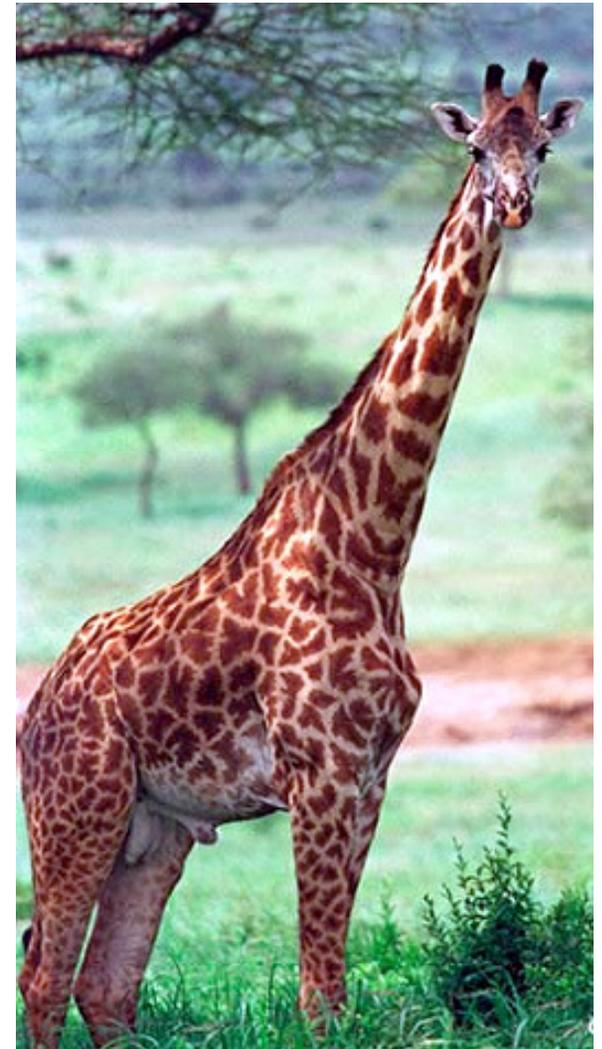
Lamarck - “Acquired traits”

1809 - French biologist proposed that species had changed over time, and were related by common ancestry

Thought that traits which an organism **acquired** during its lifetime (by “trying”) were passed on to its offspring

- for instance: giraffes stretched their necks to reach high tree branches, so their offspring would **inherit longer necks**

If you get a tattoo, will your kids be born with the same tattoo?.....

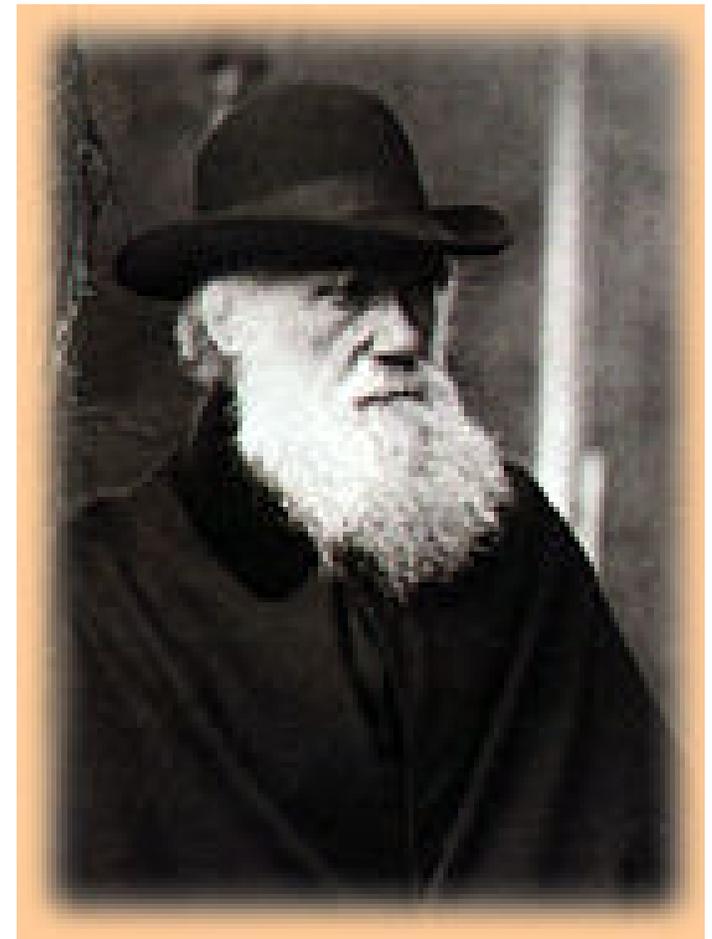


The Birth of Evolutionary Theory

In the early 1800's, some enterprising young men began exploring the world's biodiversity with an eye for **pattern** and **process** in the natural world.

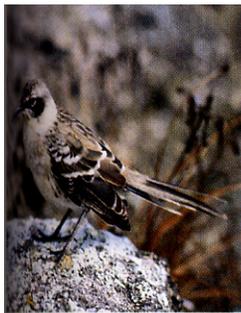
One was **Charles Darwin**

- educated, from a wealthy family
- set off to explore the world after college (1832-1836)
- collected and observed animal life from islands on a boat called the Beagle



Evolution and Islands

Darwin observed that neighboring islands in the Galapagos had similar, but different, species of mockingbirds



Nesomimus parvulus ■



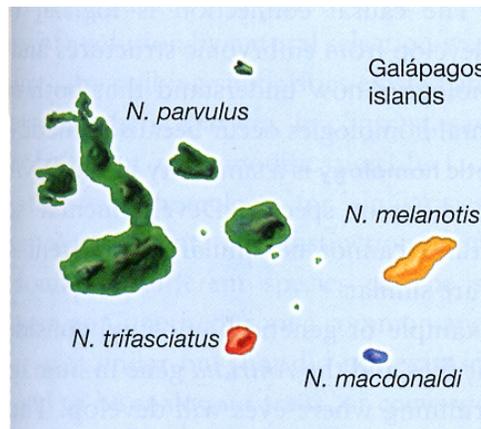
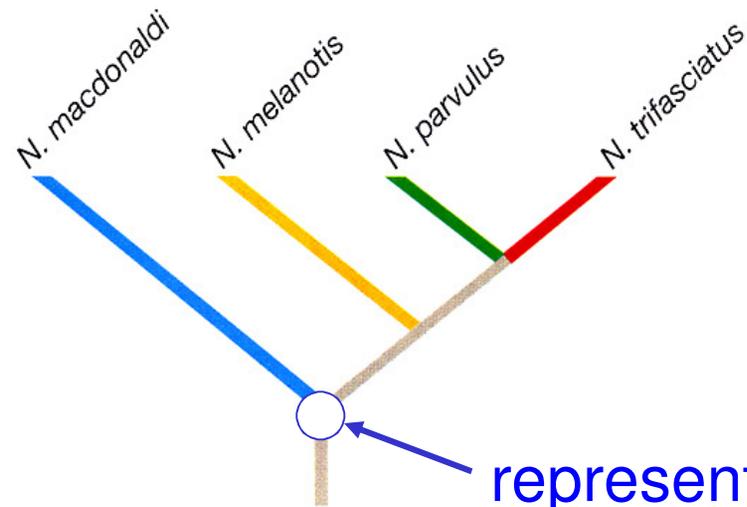
Nesomimus melanotis ■



Nesomimus trifasciatus ■



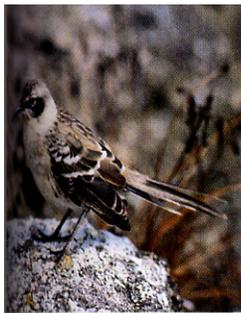
Nesomimus macdonaldi ■



represents an **extinct** ancestral bird, that first colonized islands

Evolution and Islands

Darwin observed that neighboring islands in the Galapagos had similar, but different, species of mockingbirds



Nesomimus parvulus ■



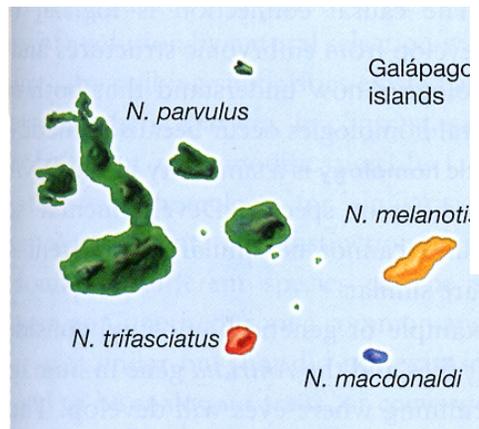
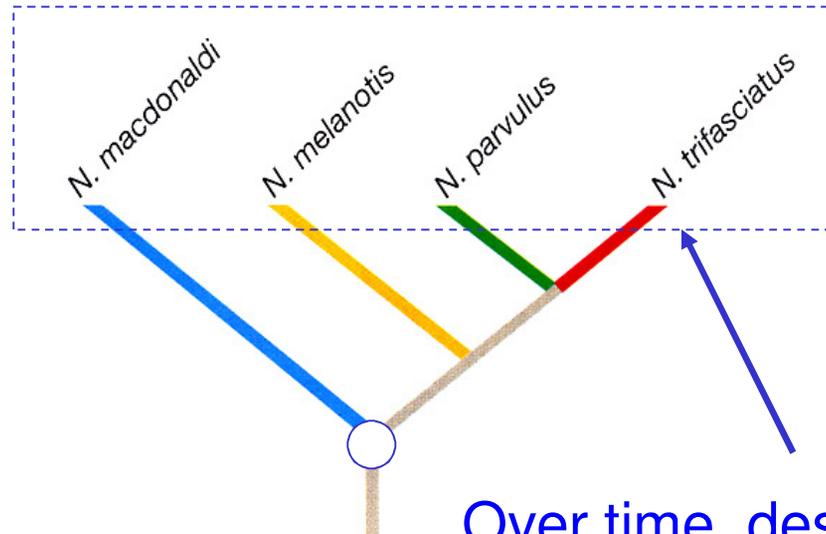
Nesomimus melanotis ■



Nesomimus trifasciatus ■



Nesomimus macdonaldi ■



Over time, descendents of that first island bird evolved into the **different species** now found on each island

Origin of Species

Darwin set off on Beagle with no clear idea of evolution

- returned with basic ideas of his theory, and data to support it

However, he knew that proposing how species “came into existence” would create controversy in Victorian England

- sat on his theory for **20 years**, writing *Origin of Species*

Alfred Russell Wallace

Wallace's family lost their fortune, so he worked, educated himself, and took off to explore the world as a young man

While Darwin sat home writing his book, Wallace traveled the world, financing his trips by collecting and selling animals

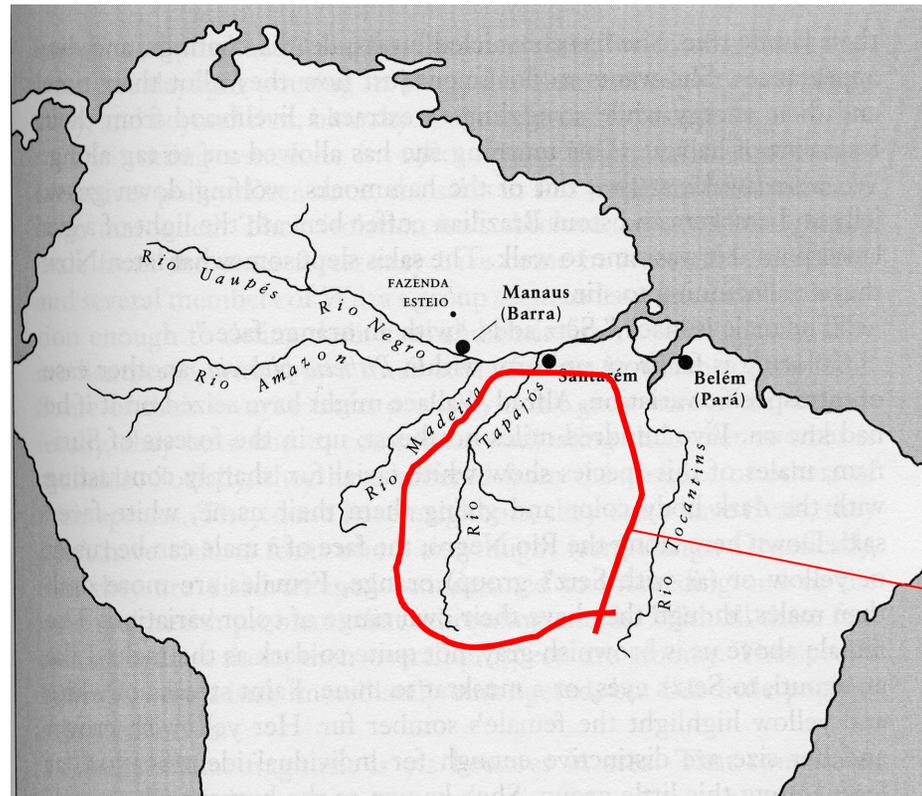
Wallace's collections gave him insight into:

- **variation** within a species
(all individuals are not the same)
- **geographical distribution** of species
(not random)



Alfred Russell Wallace

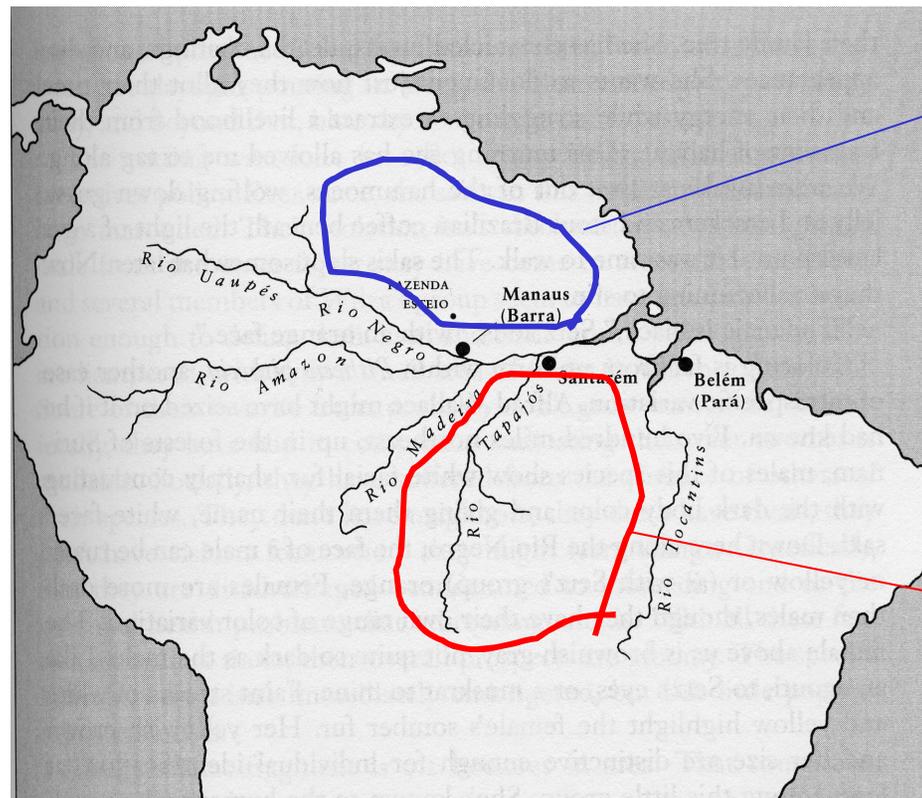
His observations suggested that **geographical boundaries** could explain species distributions



one species
of spider
monkey
P. irrorata

Alfred Russell Wallace

His observations suggested that **geographical boundaries** could explain species distributions



Different
species
of spider
monkey

P. monachus

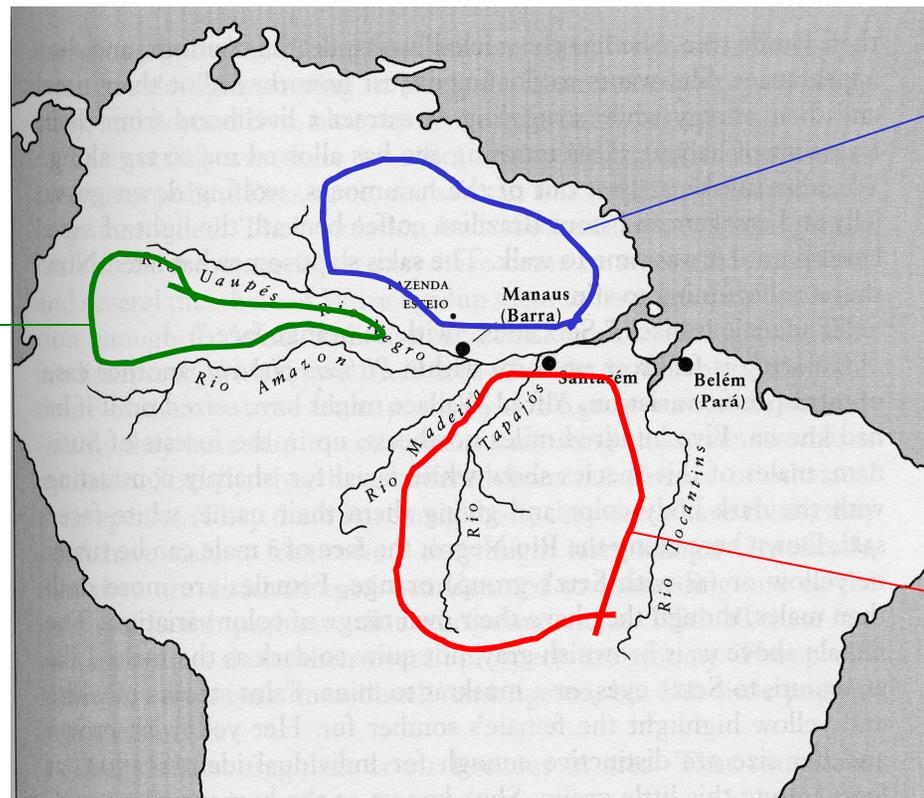
one species
of spider
monkey

P. irrorata

Alfred Russell Wallace

His observations suggested that **geographical boundaries** could explain species distributions

3rd species,
predicted by
Wallace,
P. pithecia



Different
species
of spider
monkey

P. monachus

one species
of spider
monkey

P. irrorata

Rivers set the boundaries between related species

Darwin & Wallace

Wallace had the idea that species evolved over time, but took a while to figure out how (natural selection)

He and Darwin corresponded by letter during his adventures

In 1858, Darwin received a manuscript from Wallace outlining the basics of evolution via natural selection

- his friends urged him to quickly write up a summary of his 20 years' worth of thoughts + data
- both papers were read aloud together and then published

Darwin's history-changing book

The following year (1859), Darwin published his book
*On the Origin of Species by Means of Natural Selection, or
the Preservation of Favoured Races in the Struggle for Life*

Major idea - new species arise by **descent with modification**
from ancestral species

descent: modern species are descended from extinct species

modification: species gradually **adapted** to their environment
(became different from what their ancestors looked like)

History forgot about Wallace, but his independent discovery of
natural selection helped convince other scientists of this
revolutionary new principle

Evolution by Natural Selection

Darwin's theory had 4 basic proposals:

- (1) Individuals within a species are **variable**
- (2) Some of this variation is passed to offspring
(in other words, traits are **heritable**)
- (3) In every generation, more offspring are produced than can survive (due to limited resources: space, food, etc)
- (4) Survival and reproduction are **not random**:
 - individuals with the most **favorable variations** survive and produce the most young
 - this is the mechanism of evolution, called ***natural selection***

Evolution by Natural Selection

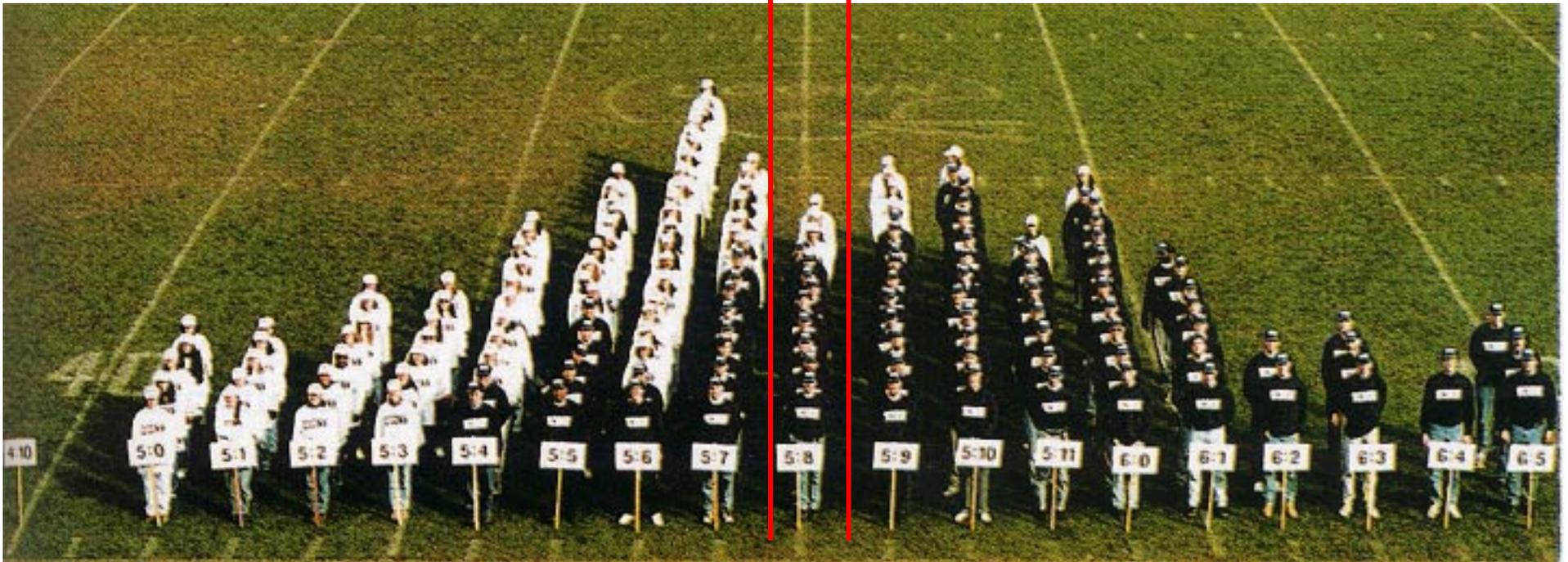
Darwin's 1st proposal:

(1) Individuals within a species are **variable**

some are
very short..

average height

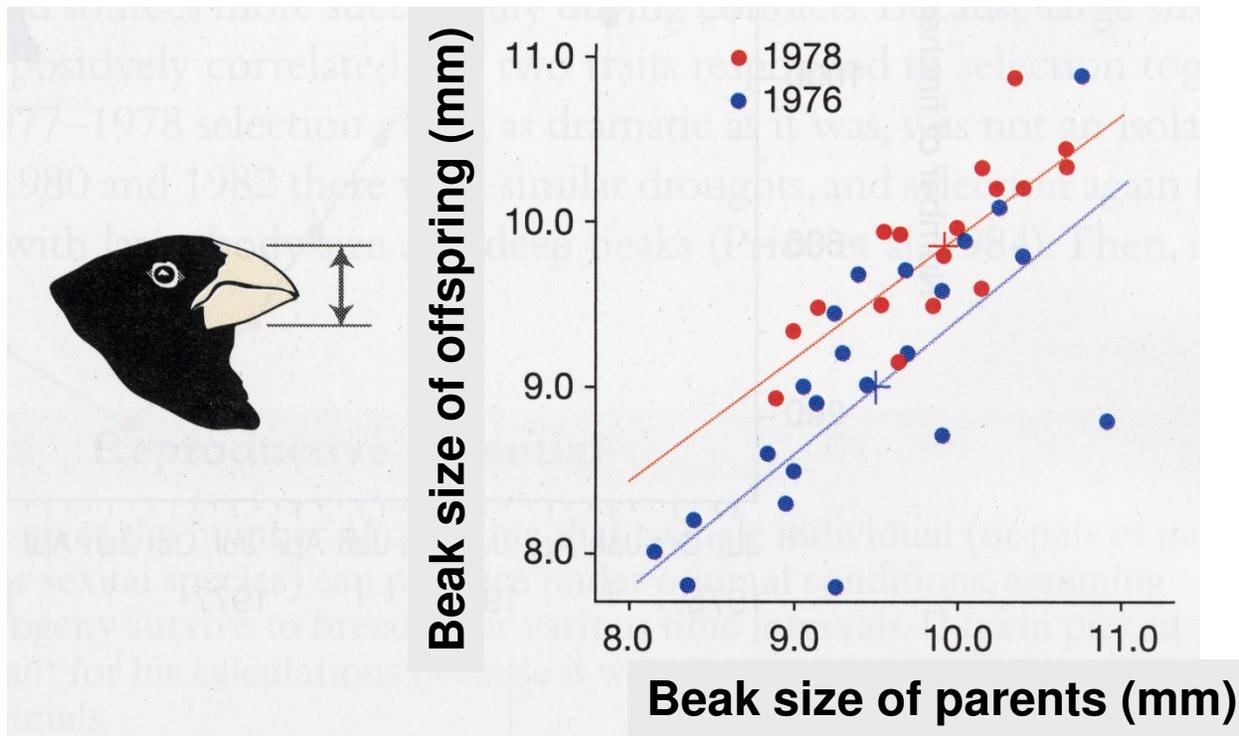
..some are
very tall



Evolution by Natural Selection

Darwin's 2nd proposal:

- (2) Some of this variation is passed to offspring
(in other words, traits are *heritable*)



offspring tend to resemble their parents

Evolution by Natural Selection

Darwin's 3rd proposal:

- (3) Every generation, **more offspring** are produced than can possibly survive

Organism

Reproductive potential

aphid

524 billion in one year

bacteria

layer of cells 7 feet deep would cover the earth in only 2 days!

starfish

10^{79} offspring in 16 years

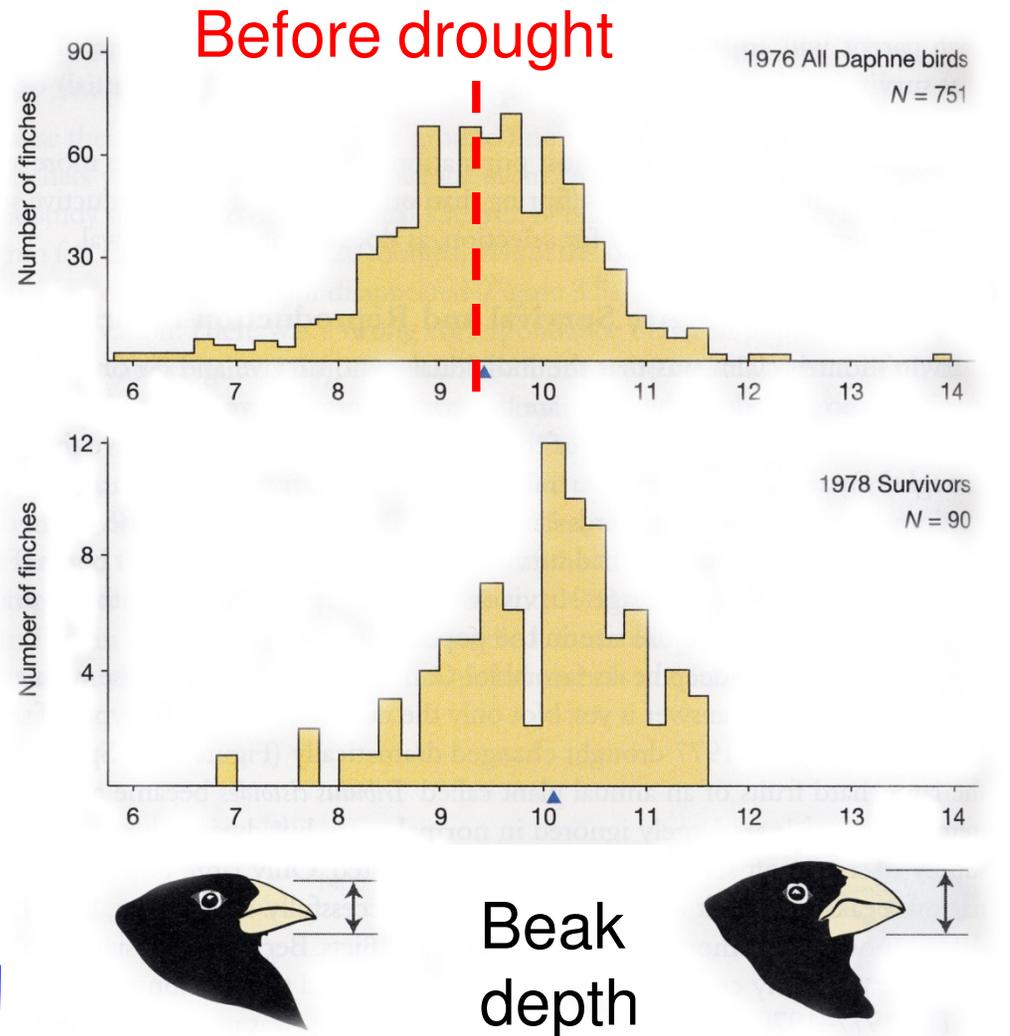
Evolution by Natural Selection

Darwin's 4th proposal:

natural selection

the offspring that end up surviving to adulthood are the ones best suited (***adapted***) to the conditions they experienced growing up

this is observed in natural populations all the time



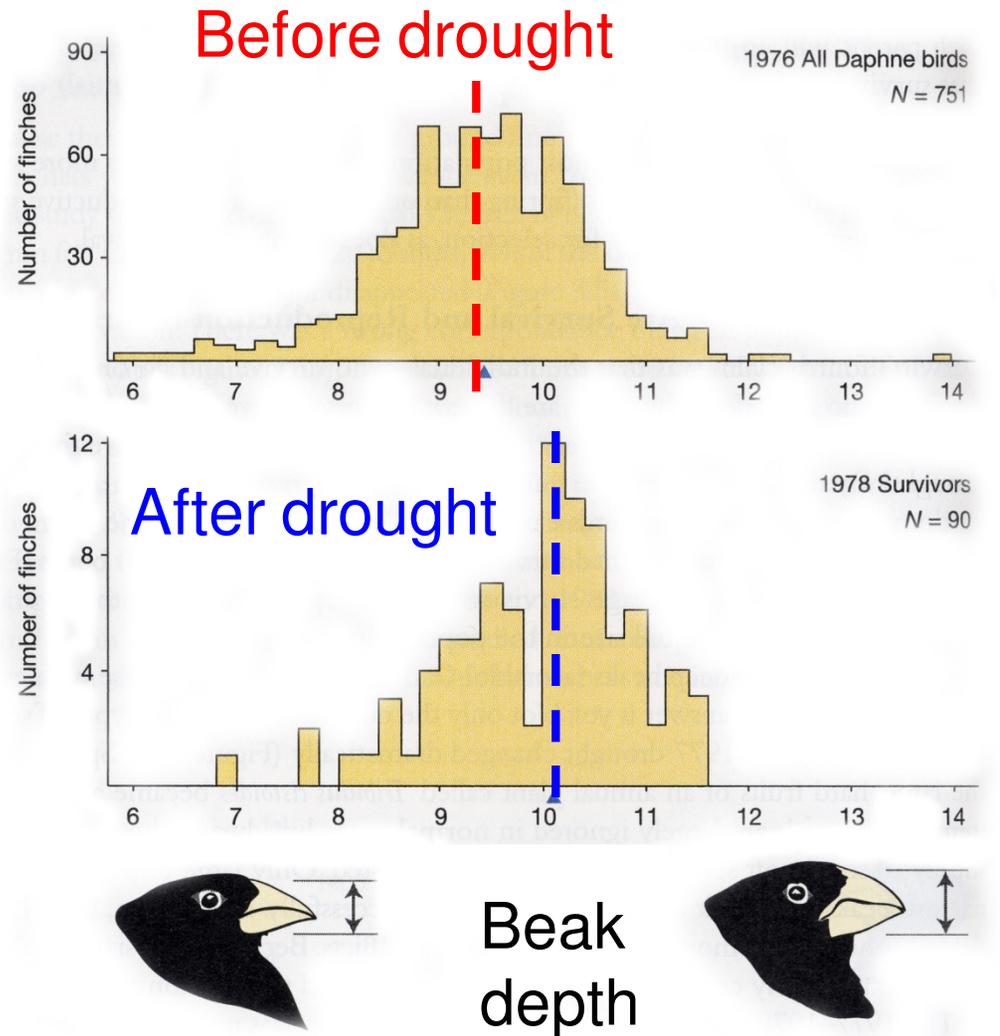
Evolution by Natural Selection

Darwin's 4th proposal:

natural selection

- drought favored bigger beaks that could crack the tough seeds that were available

A change in the genetic makeup of a population is termed **evolution**



Evolution by Natural Selection

Any change in the genetic makeup of a population is termed **evolution**

- this can happen by chance, by natural selection, in response to human action, etc.

Natural selection results in **adaptation to the environment**, producing organisms that are better suited to their particular niche

Adaptation increases **fitness**, or how much an individual contributes to next generation (how many offspring)

- if you live forever but have no kids, your fitness = 0

Sexual selection and female choice



Males have traits important in mating displays (color, tail, claws) whereas females lack such ornamentation

- male energy goes into looking sexy, attracting mates
- females invest energy in making large, healthy offspring

Sexual Selection

Darwin's sequel, *The Descent of Man and Selection in Relation to Sex*, was dedicated to this phenomenon

How could traits involved in male display or competition persist in the face of natural selection?

- shouldn't natural selection weed out brightly colored individuals (by predation), or those wasting energy on big tails?

Sex helps organisms cope with changing environments, but it also introduces opportunities for **sexual selection**

Sexual Selection

Sexual selection can occur when:

- males must appeal to **female preferences** to attract mates

Females may choose mates based on traits that indicate health, or superior genes..

... or just based on arbitrary preferences of that species
(what color their eyes see most clearly, for instance)



Sexual Selection

Sexual selection can occur when:

- males must appeal to **female preferences** to attract mates
- **males compete** with each other for access to females



Sexual Selection

Sexual selection can occur when:

- males must appeal to **female preferences** to attract mates
- **males compete** with each other for access to females

Whereas natural selection makes a population more **adapted** to its environment, sexual selection does **not** -- it makes one sex (usually males) more attractive to the other

- increases **fitness** by increasing reproductive success
- does **not** increase adaptation or survival

A note about mutation

Mutation is a change to your DNA

We tend to think of mutation as a bad thing - it screws you up

Most of the time, this is true; a random change to your DNA is much more likely to mess something up than it is to make you suddenly work better, by chance

However, sometimes mutations cause changes that are actually a *good* thing, under some environmental conditions

Ultimately, it is mutation that creates new variation, the stuff which natural selection works on to produce adaptation

A critical phrase: **variation precedes adaptation**

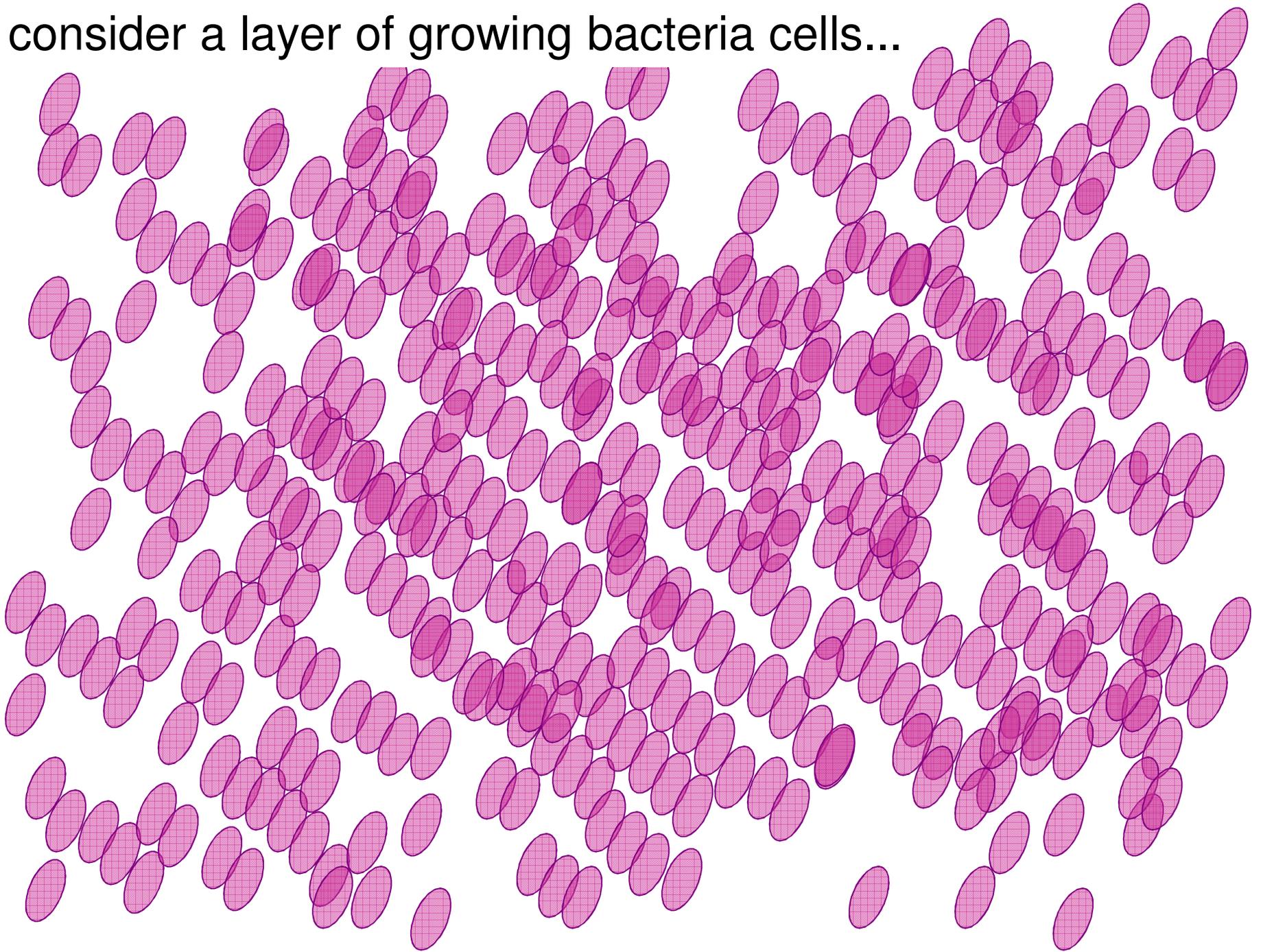
- selection only works on **genetic variation** that is **already present** in a population
- acquired traits are not passed to offspring, so those traits do not evolve in response to selection (sorry, Lamarck)

In other words, once selection kicks in, it's too late to "try" to get different in order to survive -- you must **already** have a trait that enables you to survive

- survivors are the "lucky winners" of a genetic lottery

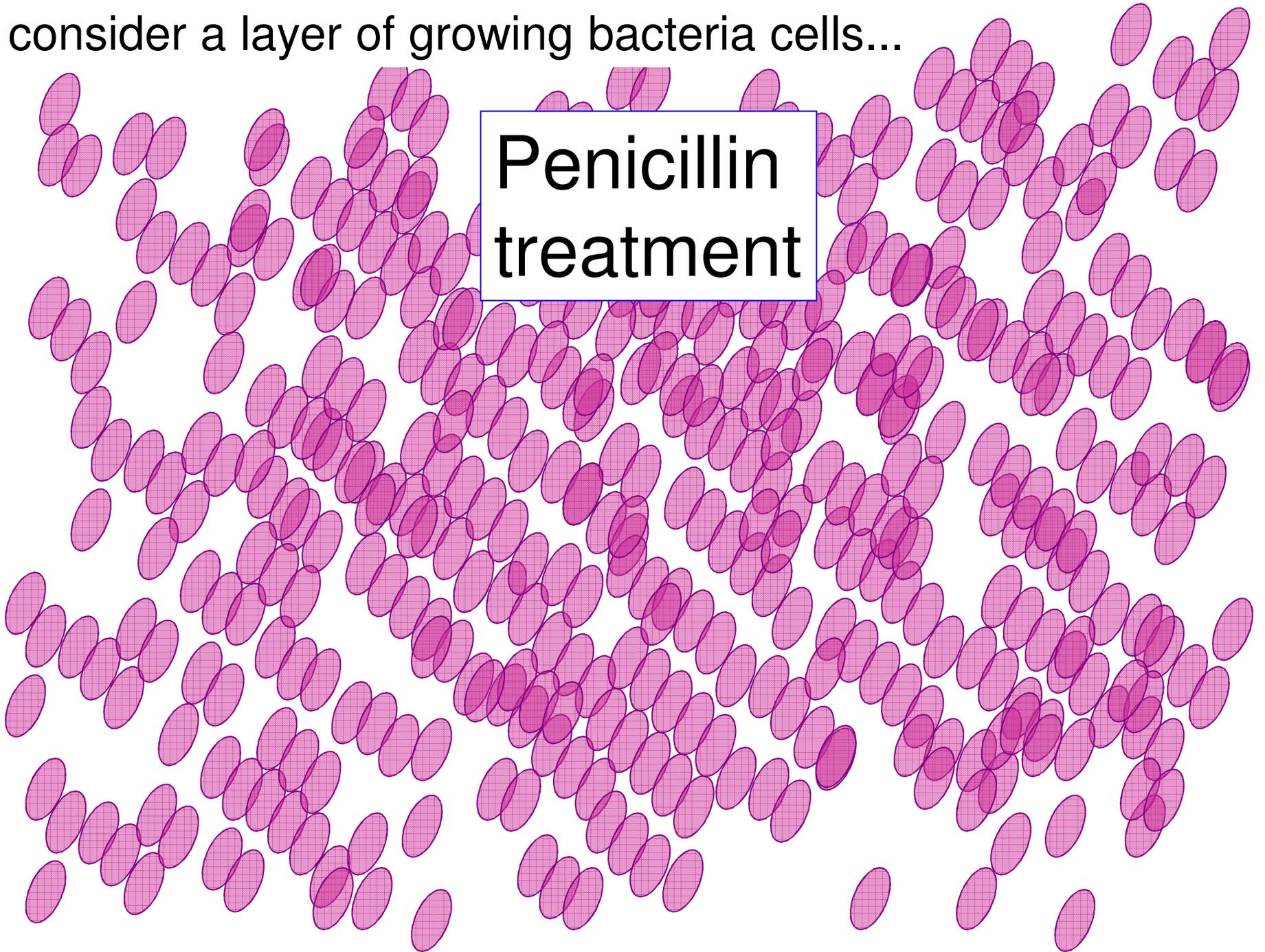
Make sure you can explain this difference between what Darwin and Lamarck proposed for how species adapt over time to their environment

consider a layer of growing bacteria cells...



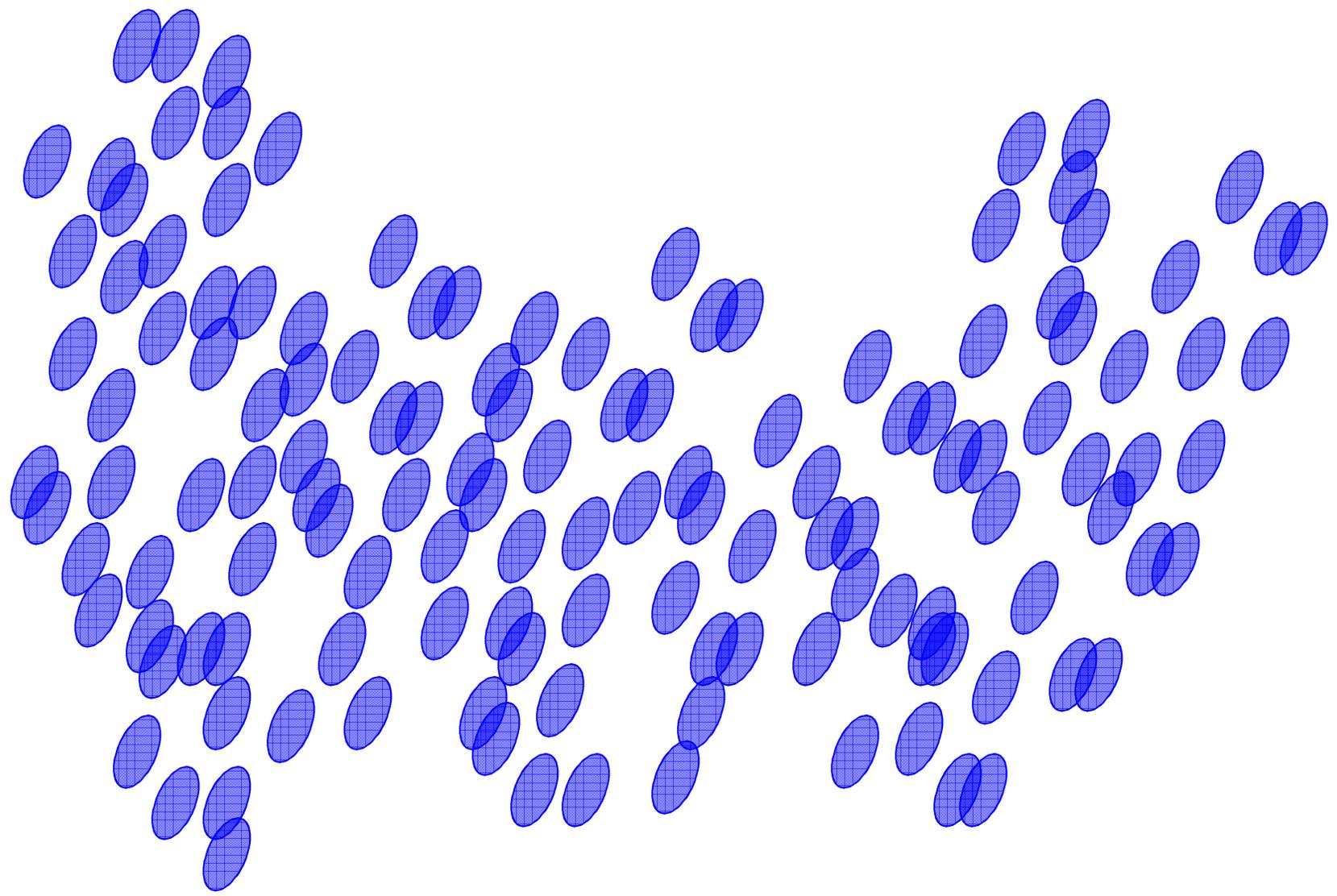
consider a layer of growing bacteria cells...

**Penicillin
treatment**

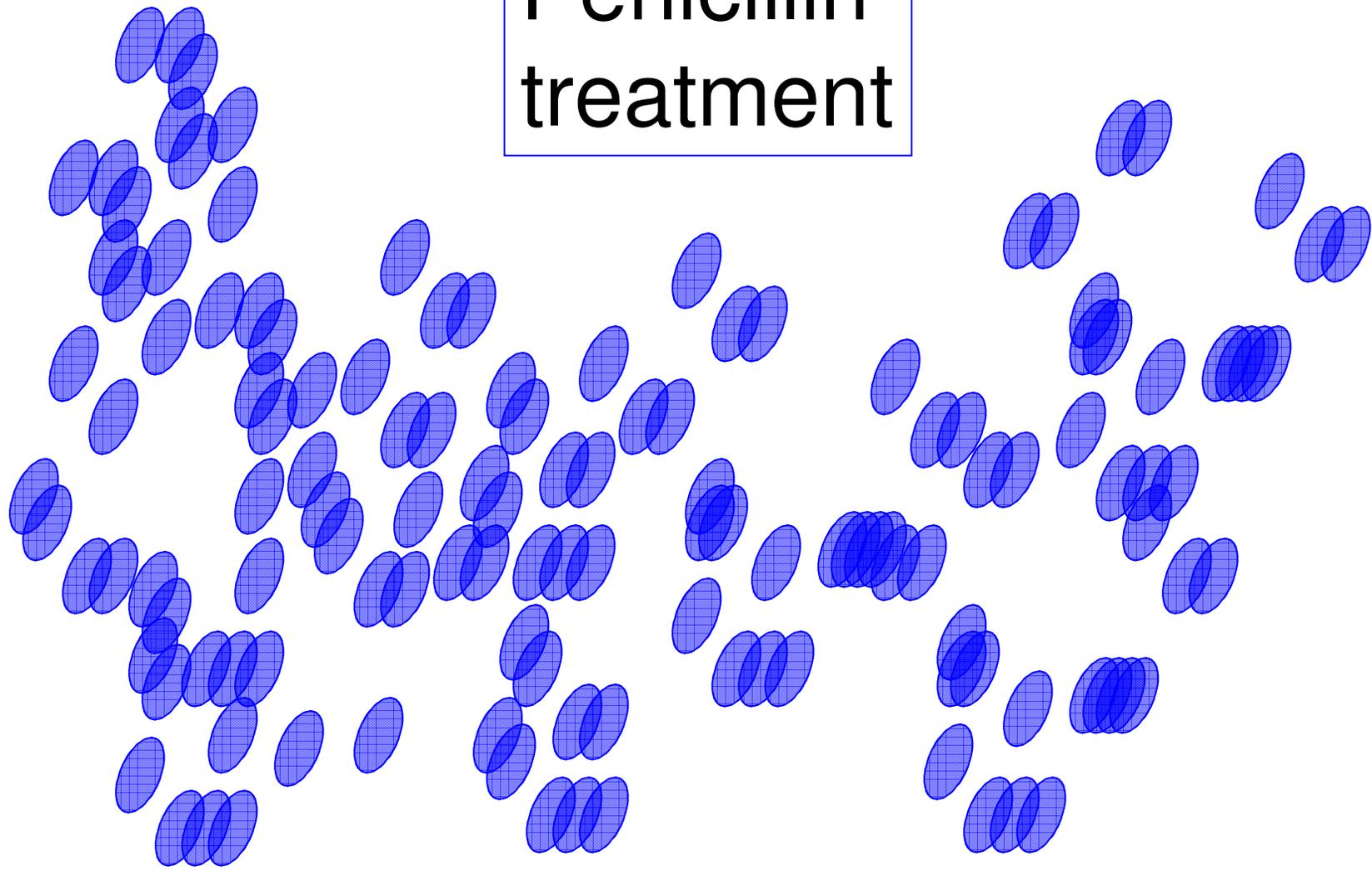


Penicillin treatment





Penicillin treatment



Which statement is correct?

- A) All the bacteria tried to mutate to survive the penicillin, but only one succeeded in mutating; that cell was the fittest
- B) By chance, one cell carried a mutation that made it immune to penicillin treatment, so only it survived; its offspring inherited resistance to the drug