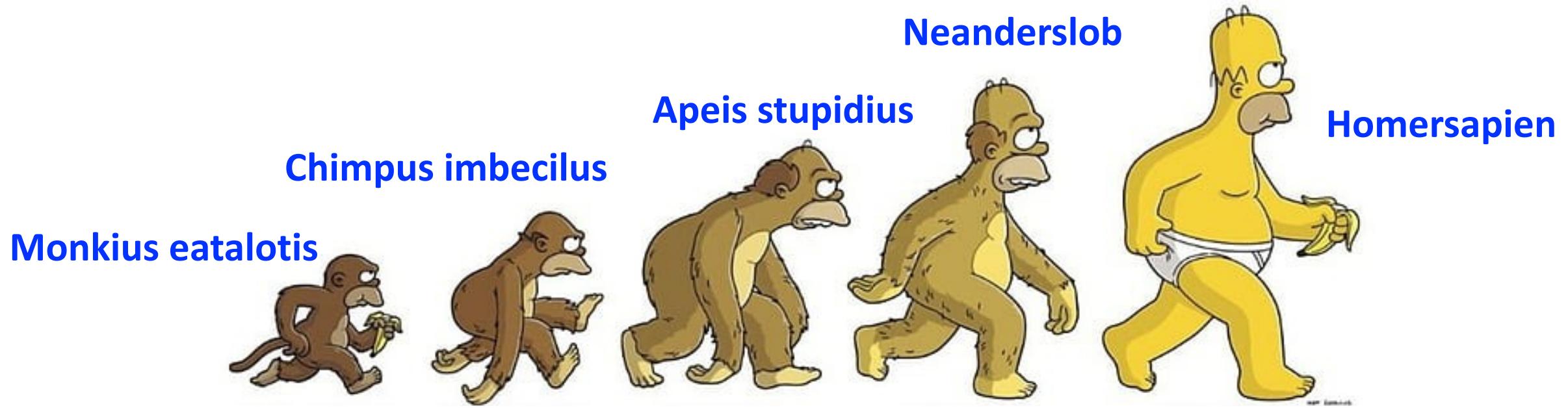
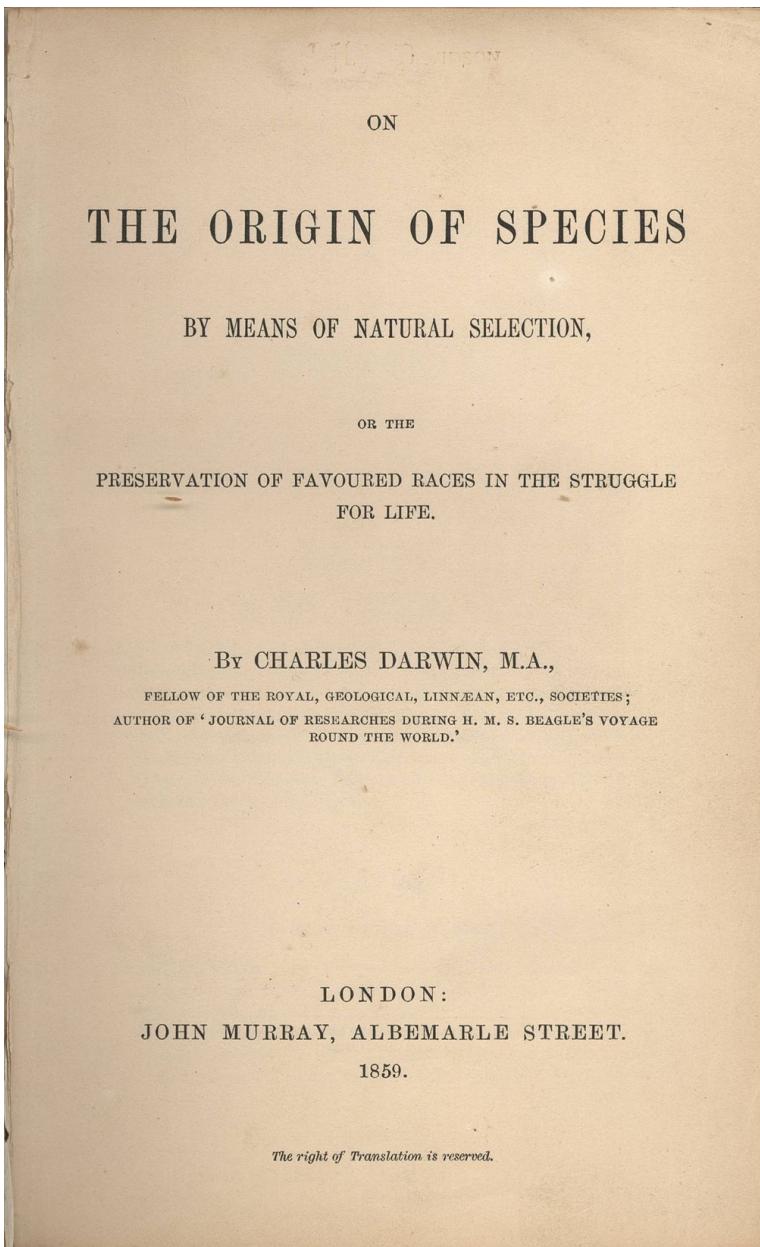


# Evolution of Homer Simpson



Do characters in Anime / Manga evolve?  
How about Kizuna Ai?

# The book that changed Biology forever



On  
**THE ORIGIN OF SPECIES**  
**BY MEANS OF NATURAL SELECTION**  
**OR THE**  
**PRESERVATION OF FAVORED RACES IN THE STRUGGLE**  
**FOR LIFE**  
**By Charles Darwin**  
**1859**

# Creationism

Religious belief that God created animals, plants, etc.

# Natural Selection

Natural selection is the evolutionary mechanism by which extant species have descended from ancestral species

Extant **species** = what are living as of now (e.g., us the humans)

Extinct **species** = what were living but are not found any longer (e.g., dinosaurs)

Note that the emphasis is on **species**, not **individuals**!

# Natural Selection

Natural selection is the evolutionary mechanism by which extant species have descended from **ancestral** species



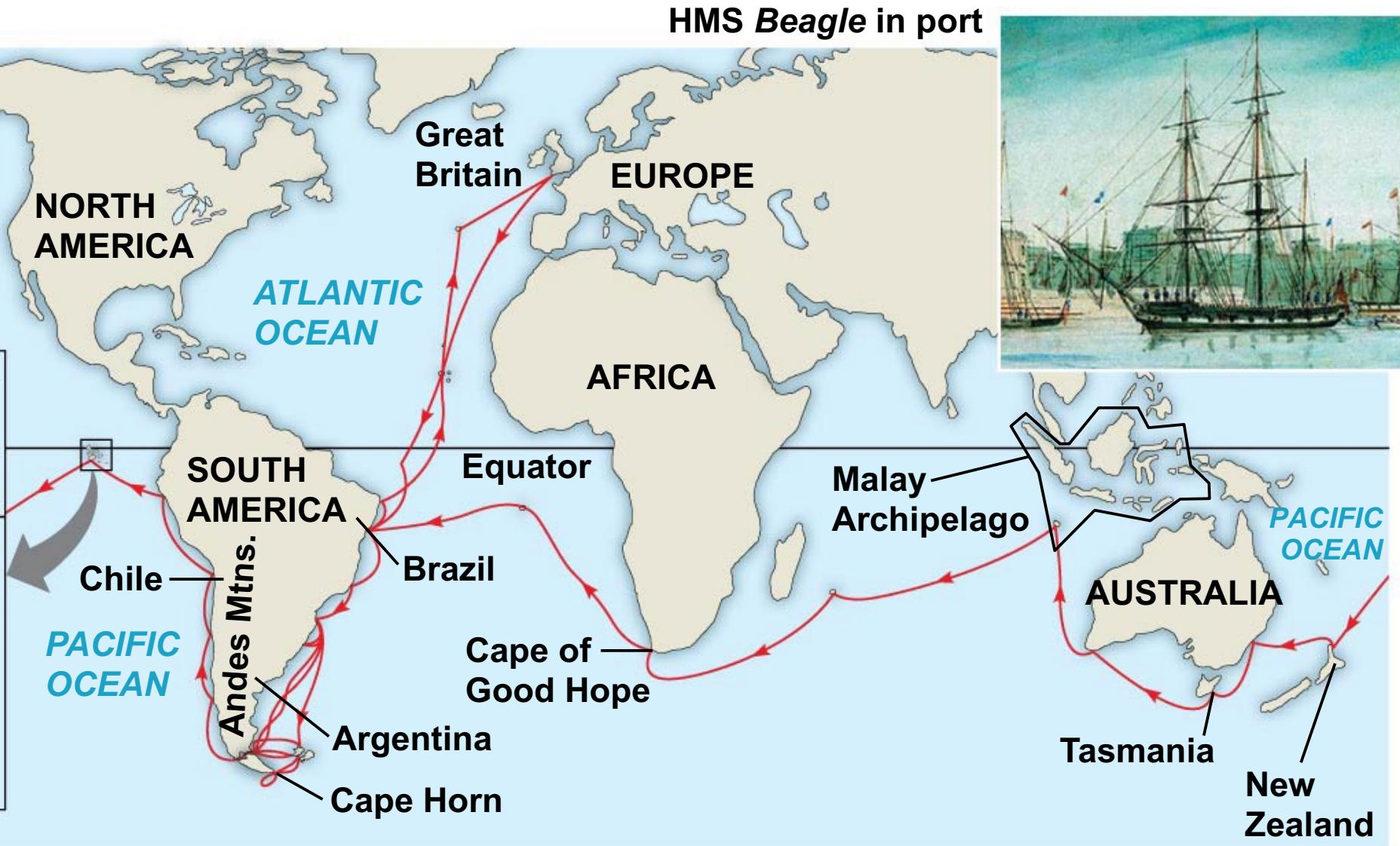
Natural selection is the evolutionary mechanism by which extant species have descended from **extinct** species



# The voyage of HMS Beagle (December 1831–October 1836)

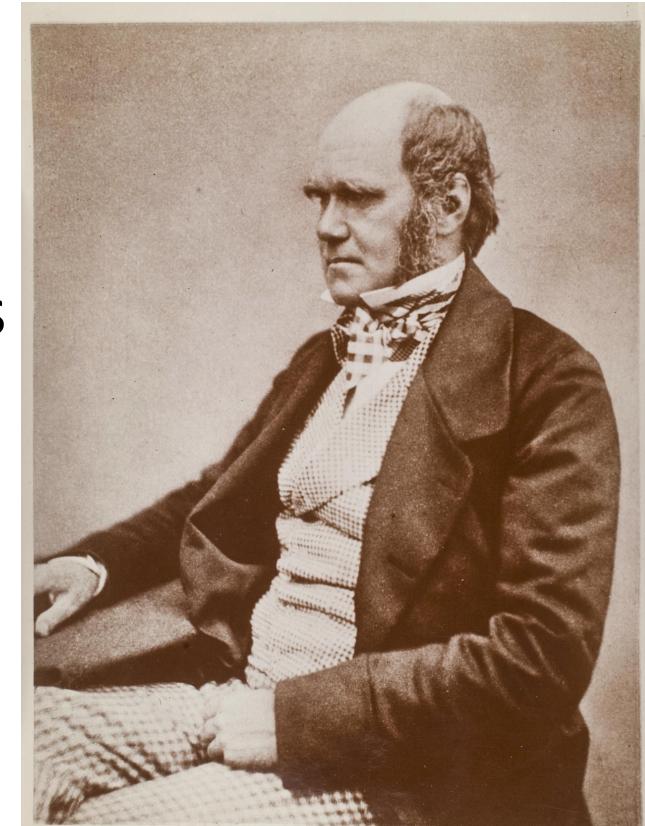
5

Darwin in 1840,  
after his return  
from the  
voyage



# Charles Darwin (1809-1882)

- Darwin collected birds, insects, spiders, plants, and fossils
- These specimens came from all over the world
- Especially from islands i.e., isolated populations



Charles Darwin



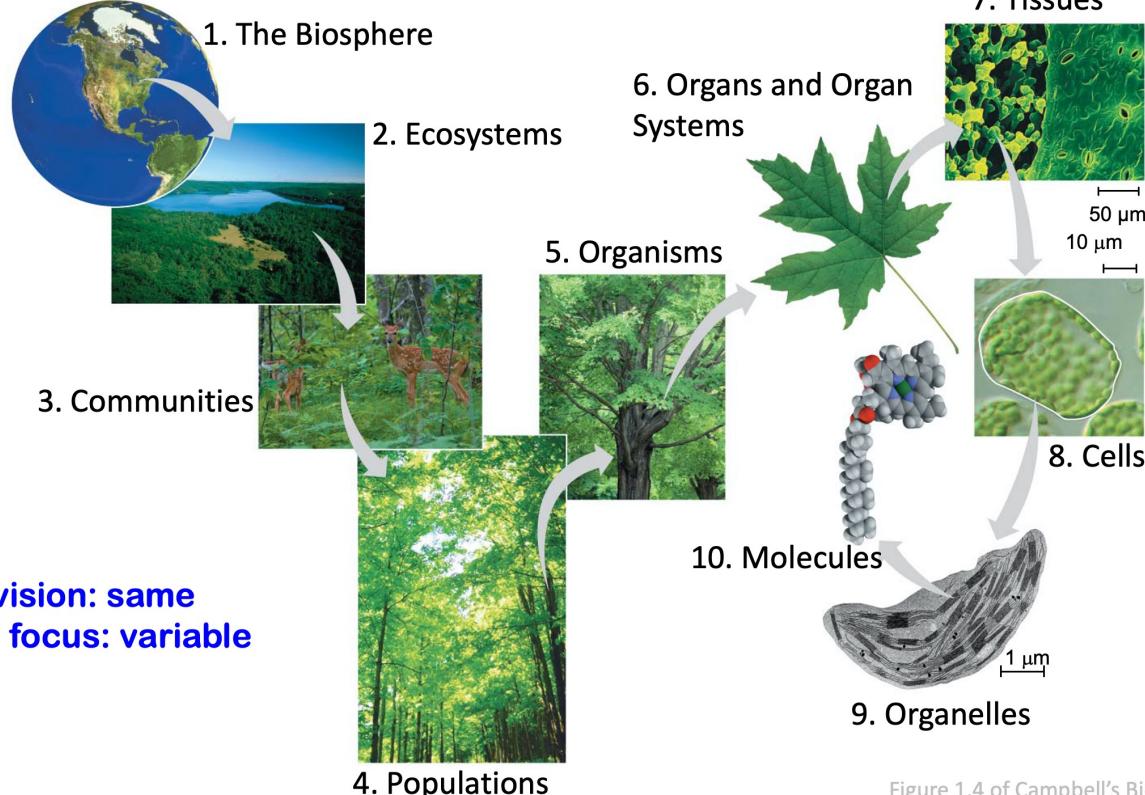
Figure 4 of Stürzenbaum et al., (2009) Earthworm genomes, genes and proteins: the (re)discovery of Darwin's worms. Proc. R. Soc. B., 276, 789-797

**AVOID anthropocentric  
views, interpretations, ...**

# Slide from Lecture 1

## Study of biology

31



Ecosystem: all living things in an area + non-living components (soil, light, water, gases, ...)

Community: The set of organisms inhabiting an ecosystem

Population: all individuals of a species in a community

Organism: an individual in a population

# Today's topics

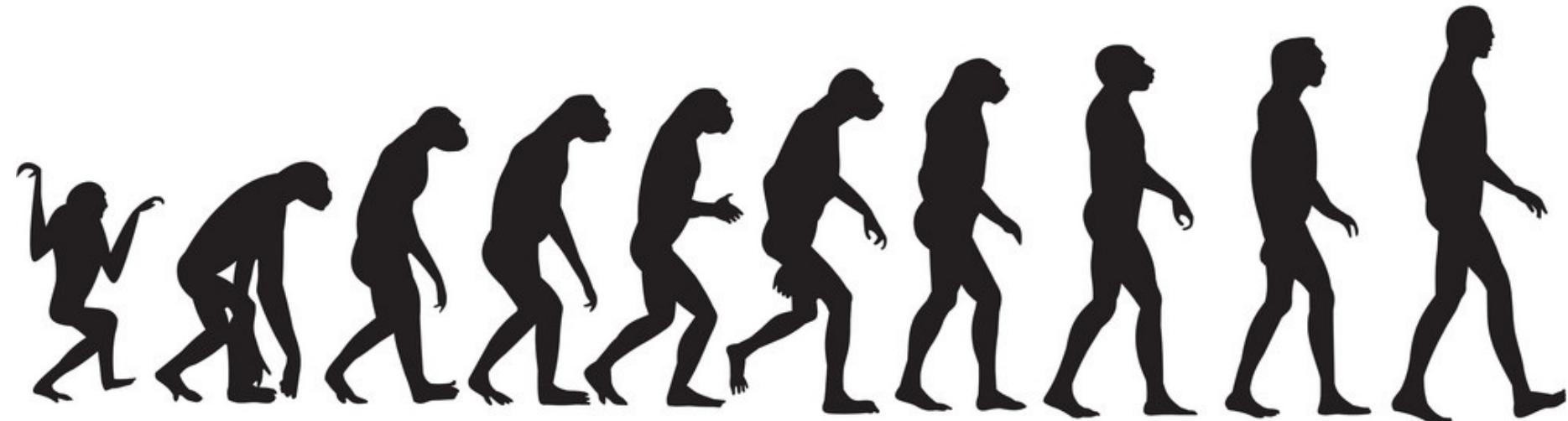
- Evolution: what, how, and why?
- Observations in support of evolution
- Religion and Science: skepticism of Evolutionary theory
- Evolution in a laboratory

# Does this depict evolution?



Can this be the same individual in different stages?

# Does this depict evolution?

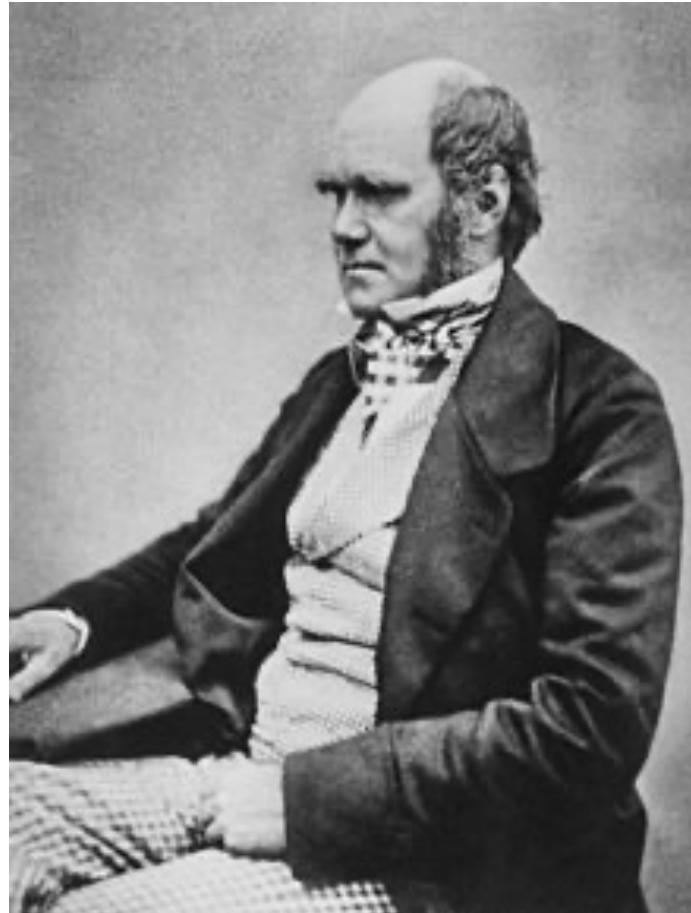


Can this be the same individual in different stages?

# What is evolution?

- One of the definitions
  - Change in the properties of a population over time (spanning generations)
- Another definition
  - **Descent with modification** (Darwin's proposal)
    - Species are descendants of ancestral species
    - Ancestral species were different from the present day species
- Yet another definition
  - **Change in the genetic composition of a population from one generation to another**

# Adaptation



Charles Darwin  
(1809-1882)

*Adaptation*

Inherited characteristics of organisms  
that enhance their  
survival and reproduction  
in specific environments

# Finches in the Galapagos islands: 1 of 3



Cactus eater

*Geospiza scandens*

Species: Cactus ground finch

Beak: Long and sharp

Adaptation for: tearing and eating cactus flowers and pulp

# Finches in the Galapagos islands: 2 of 3



Insect eater

*Certhidea olivacea*

Species: Green warbler finch

Beak: Narrow and pointed

Adaptation for: grasping insects

# Finches in the Galapagos islands: 3 of 3



Seed eater

*Geospiza magnirostris*

Species: Large ground finch

Beak: Large but short

Adaptation for: cracking open seeds  
that fall onto the ground from trees

# Variation of inherited traits

In this case: a trait that provides better camouflage

Observation #1

Members of a population often vary in their inherited traits

Beetles that camouflage well have lesser chances of being predated

They out-survive those which do not camouflage well



Asian ladybird beetles

# Darwin's inferences. 1 of 2

Individuals whose inherited traits give them a higher probability of surviving and reproducing in a given environment tend to leave more offspring than other individuals



Asian ladybird beetles

# Offspring: few or many?

Observation #2

All species produce more offspring than their environment can support

Many (or most) of these offspring fail to survive and reproduce

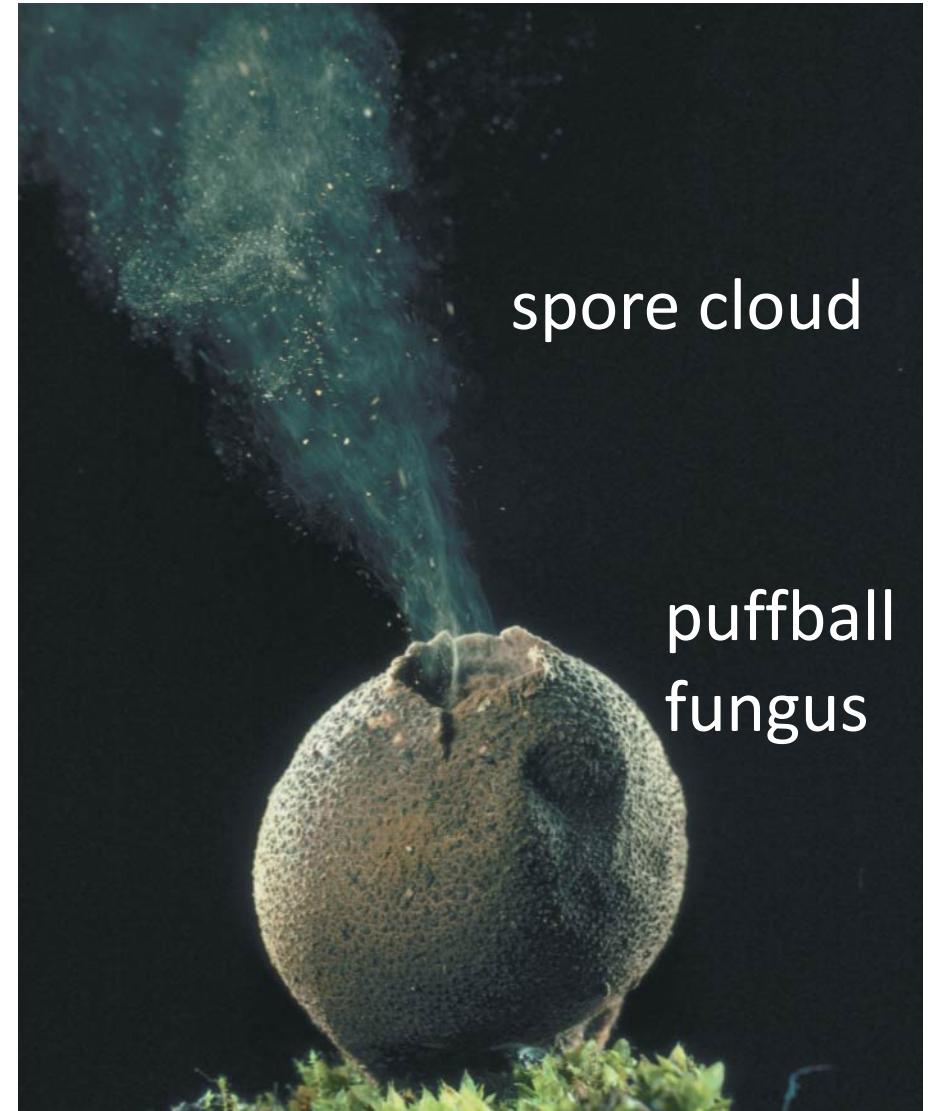


Figure 22.11 in Campbell Biology by Reece et al., (10<sup>th</sup> edition)

# Darwin's inferences. 2 of 2

Unequal ability of individuals  
to survive and reproduce in a given environment  
leads to accumulation of favorable traits  
in the population over generations

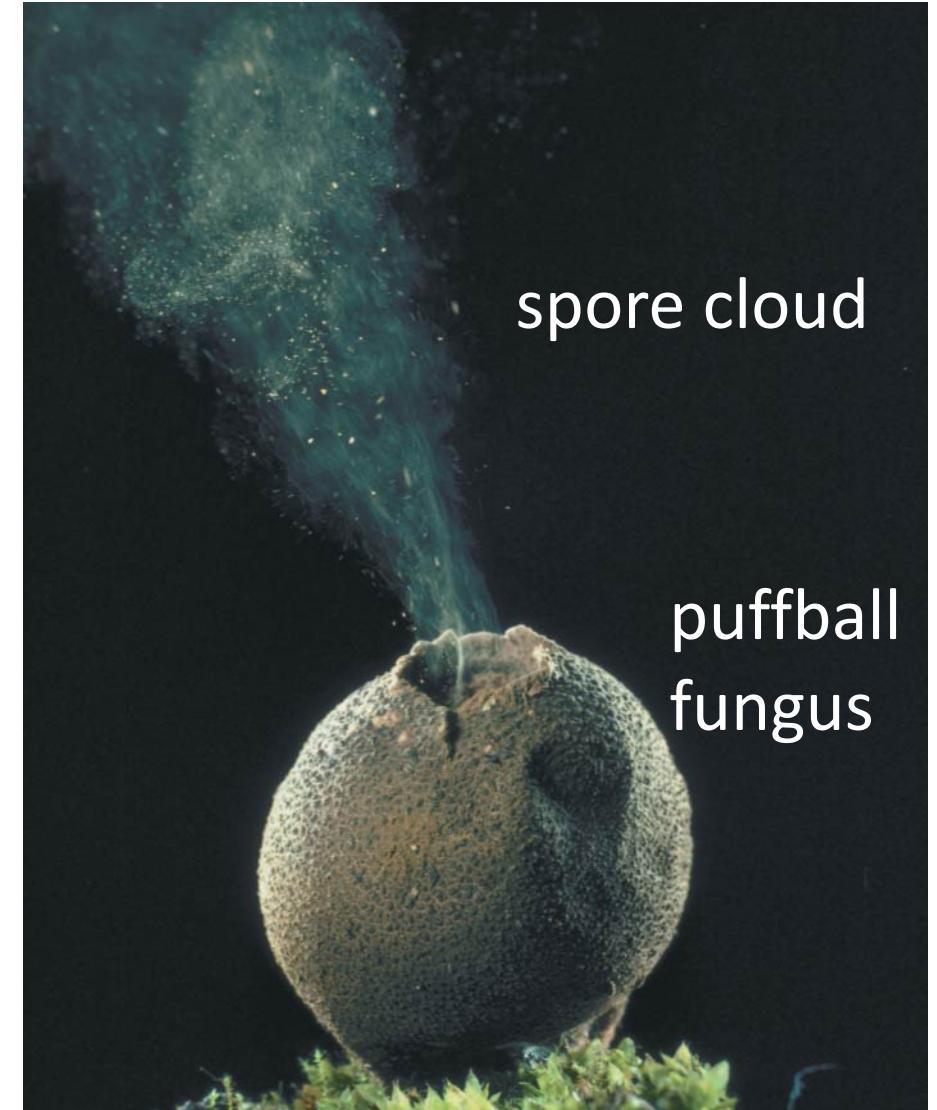
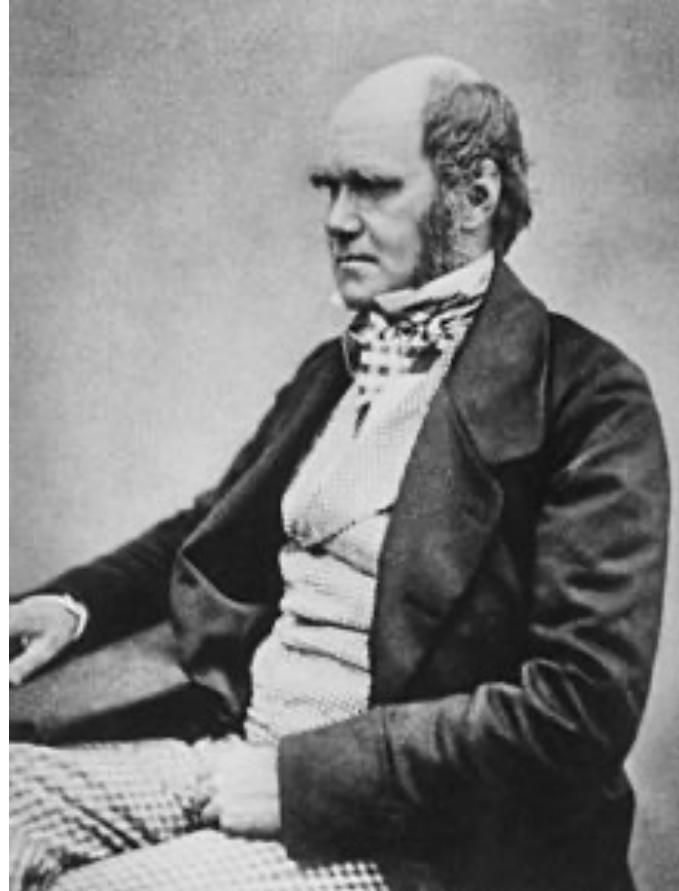


Figure 22.11 in Campbell Biology by Reece et al., (10<sup>th</sup> edition)

# Natural selection

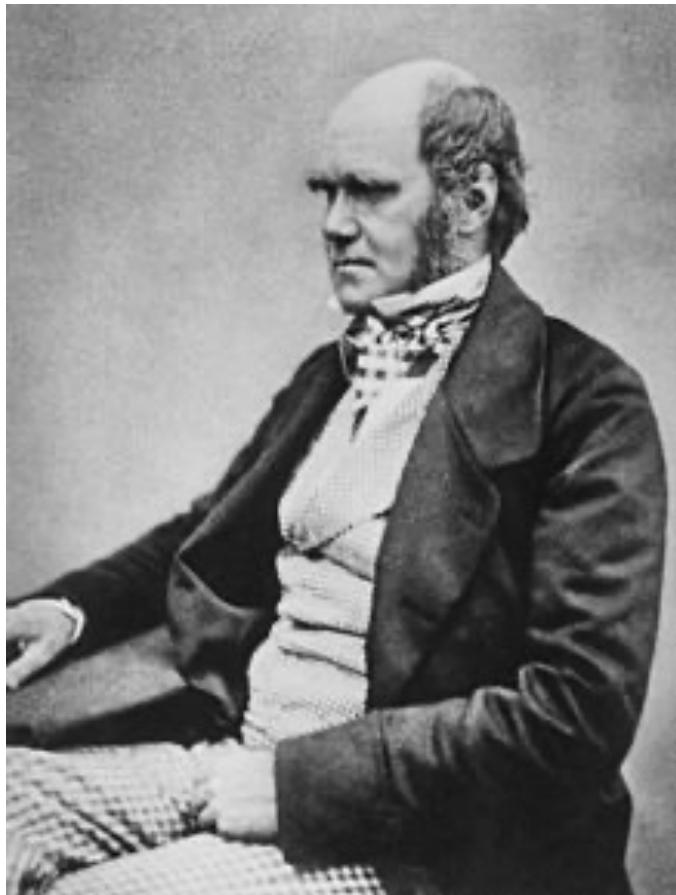


Charles Darwin  
(1809-1882)

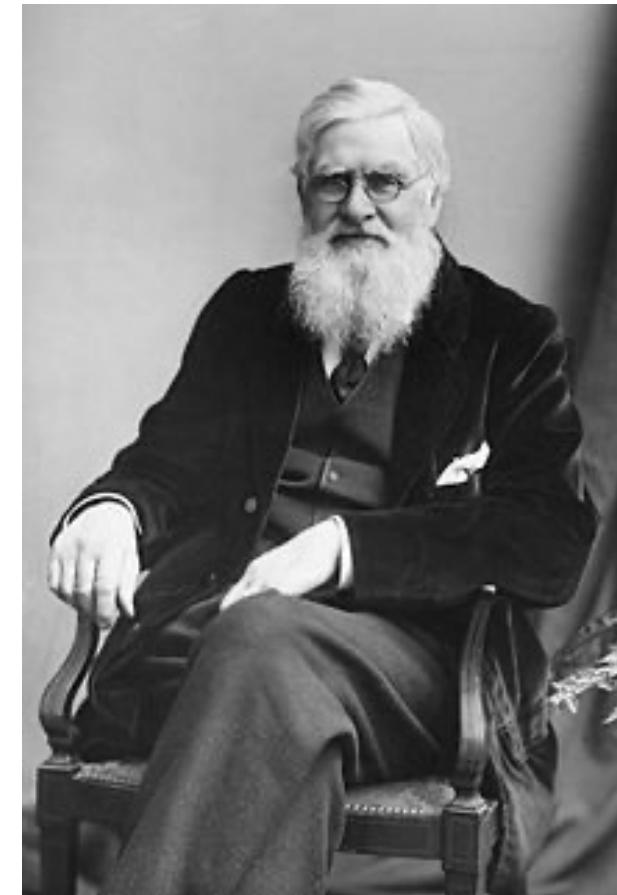
*Natural selection*

Individuals with certain traits  
tend to survive and reproduce  
at higher rates  
because of such traits

# Natural selection



Charles Darwin  
(1809-1882)



Alfred Wallace  
(1823-1913)

*Descent with modification by natural selection* can explain three broad observations:

1. Unity of life – organisms share many characteristics  
Organisms have descended from a common ancestor
2. Diversity of life  
Organisms accumulate modifications – adaptations – to fit to varied habitats
3. Match between (traits of) organisms and their environments

**Duality of unity and diversity**

# Today's topics

- Evolution: what, how, and why?
- Observations in support of evolution
- Religion and Science: skepticism of Evolutionary theory
- Evolution in a laboratory

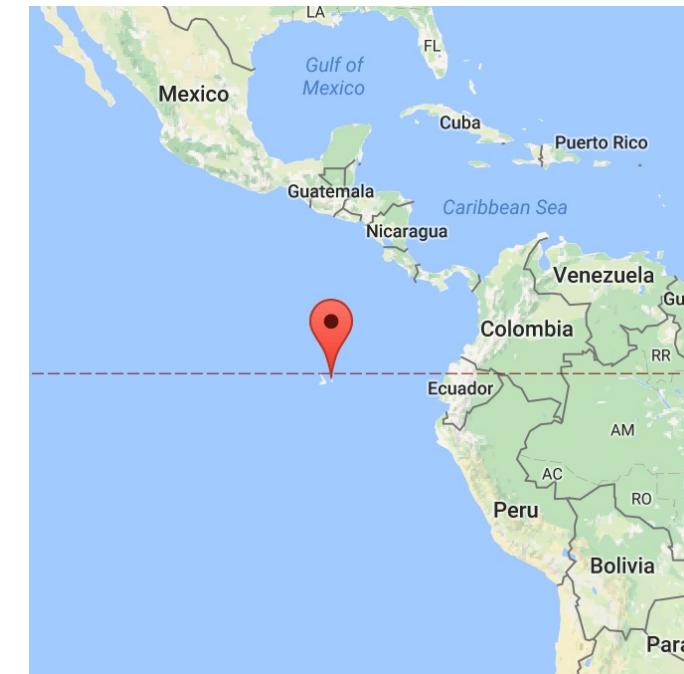
# Observation #1

# Evolution of medium ground finch

## Medium ground finch



Location: Daphne Major Island  
part of the Galapagos islands



# Consequence of drought...

Medium ground finch



Before a long drought in 1977  
~1200 birds

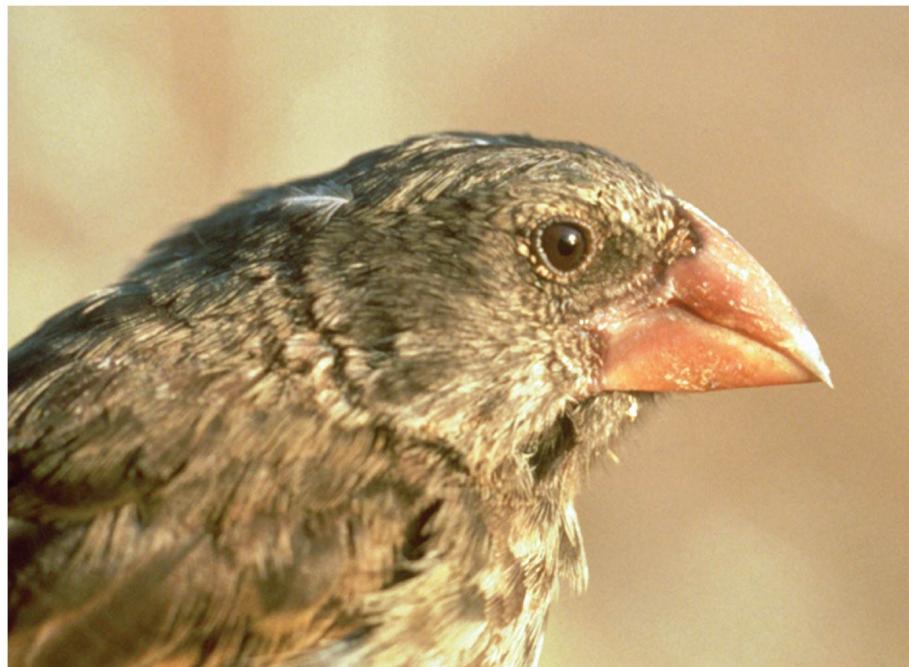
After the drought  
~180 birds survived

During drought  
Small, soft seeds in short supply

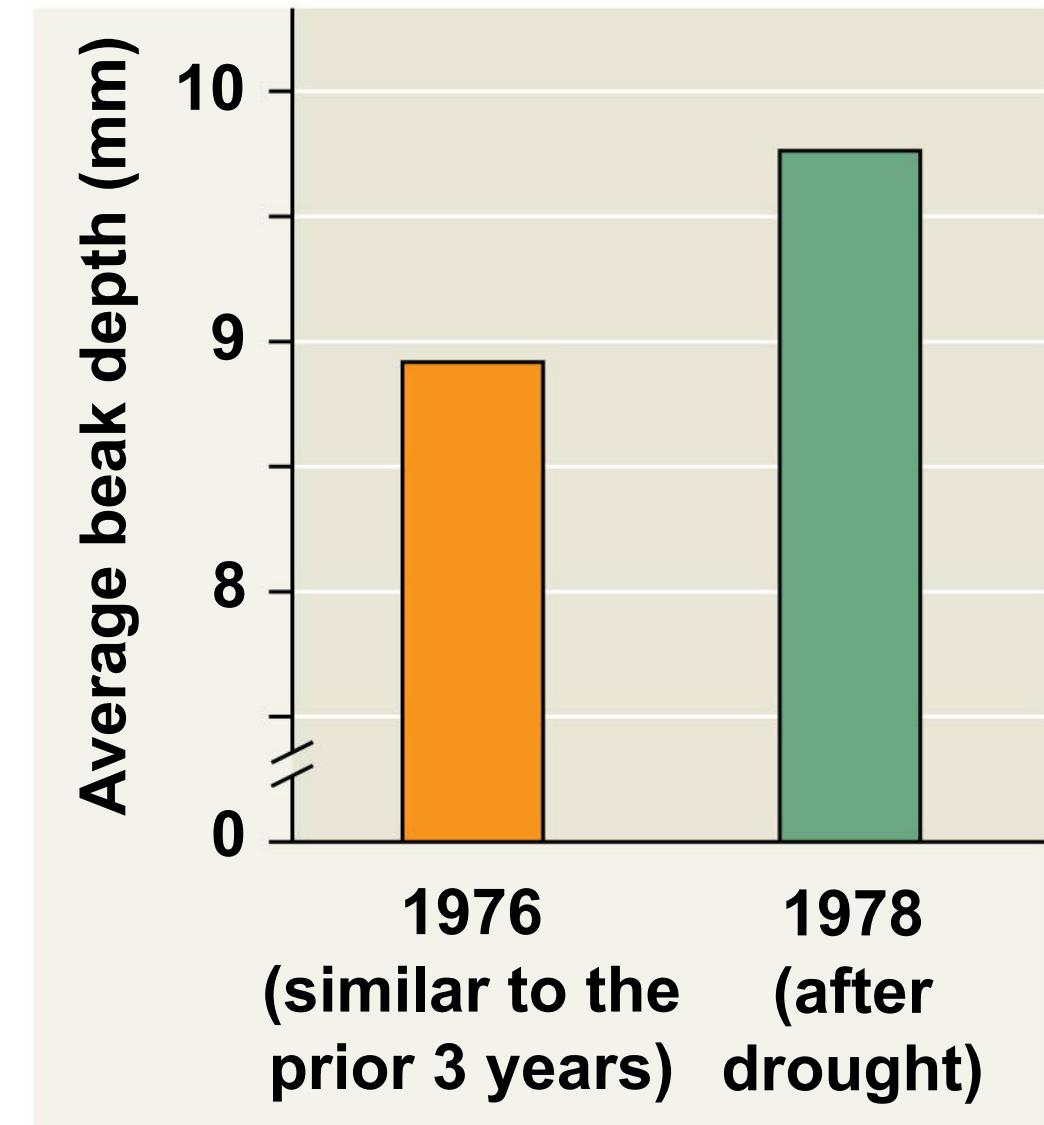
Large, hard seeds were plentiful

# Change in beak size...

Medium ground finch



Finch population evolved  
by natural selection





<https://www.princeton.edu/news/2017/11/27/study-darwins-finches-reveals-new-species-can-develop-little-two-generations>



# Study of Darwin's finches reveals that new species can develop in as little as two generations

**Staff, Office of Communications**

Nov. 27, 2017, 3:54 p.m.



The arrival 36 years ago of a strange bird to a remote island in the Galápagos archipelago has provided direct genetic evidence of a novel way in which new species arise.

On Nov. 23 in the journal *Science*, researchers from Princeton University and Uppsala University in Sweden [report](#) that the newcomer belonging to one species mated with a member of another species resident on the island, giving rise to a new species that today consists of roughly 30 individuals.

The study comes from work conducted on Darwin's finches, which live on the Galápagos Islands in the Pacific Ocean. The remote

# Change in beak size of a finch or a population of finches? 31

Medium ground finch



Finch population evolved  
by natural selection

Individual finches did NOT evolve!

Each bird had a beak of a particular size, which did NOT grow larger during the drought.

Rather, the proportion of birds with large beaks in the population increased from generation to generation

i.e., the population evolved, not its individual members.

# Observation #2

# Variation in coat coloration

Two populations of mice that belong to the same species *Peromyscus polionotus*

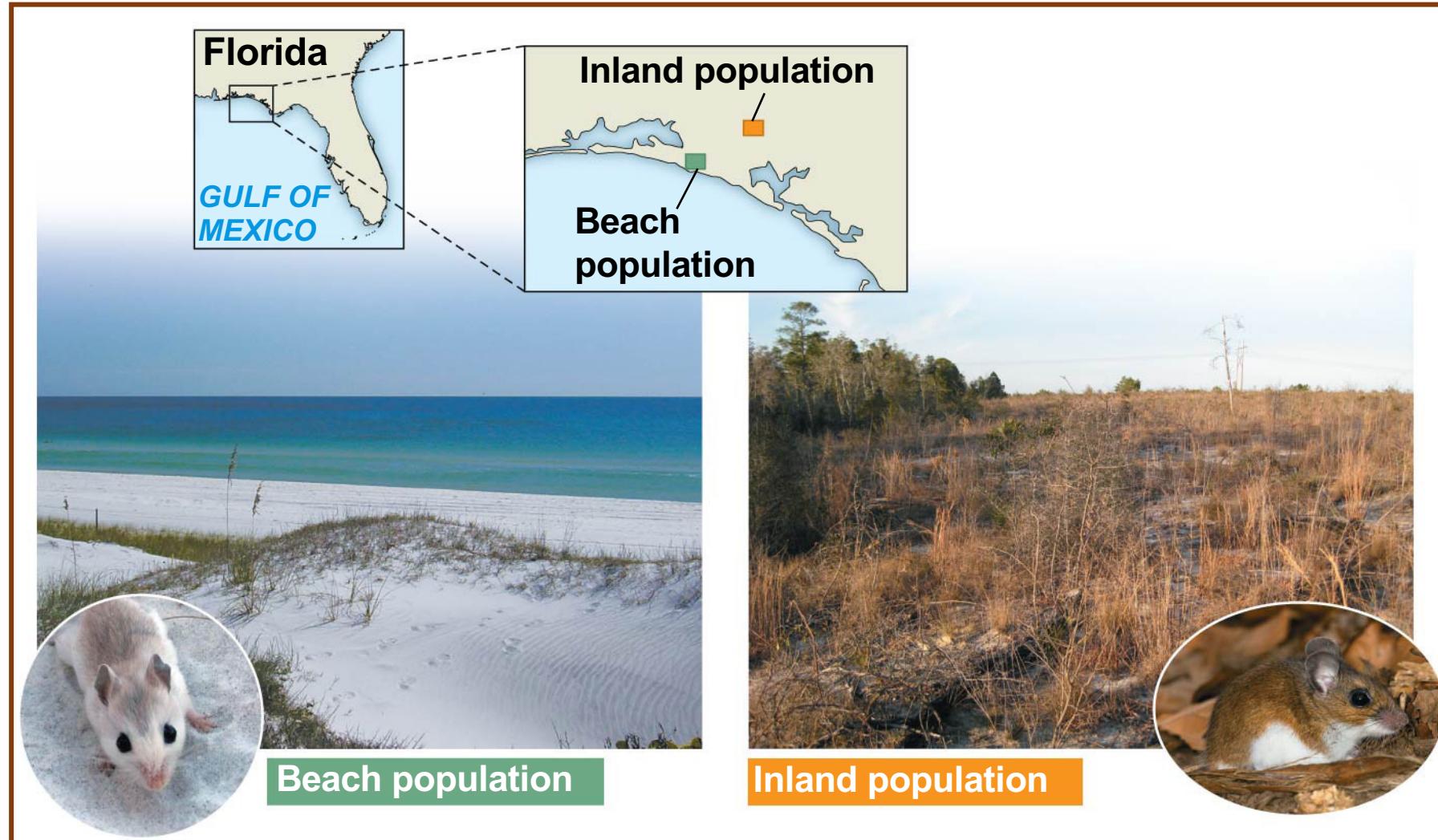


Figure 1.24 in Campbell Biology by Reece et al., (10<sup>th</sup> edition)

# Why does coat color vary with habitat?

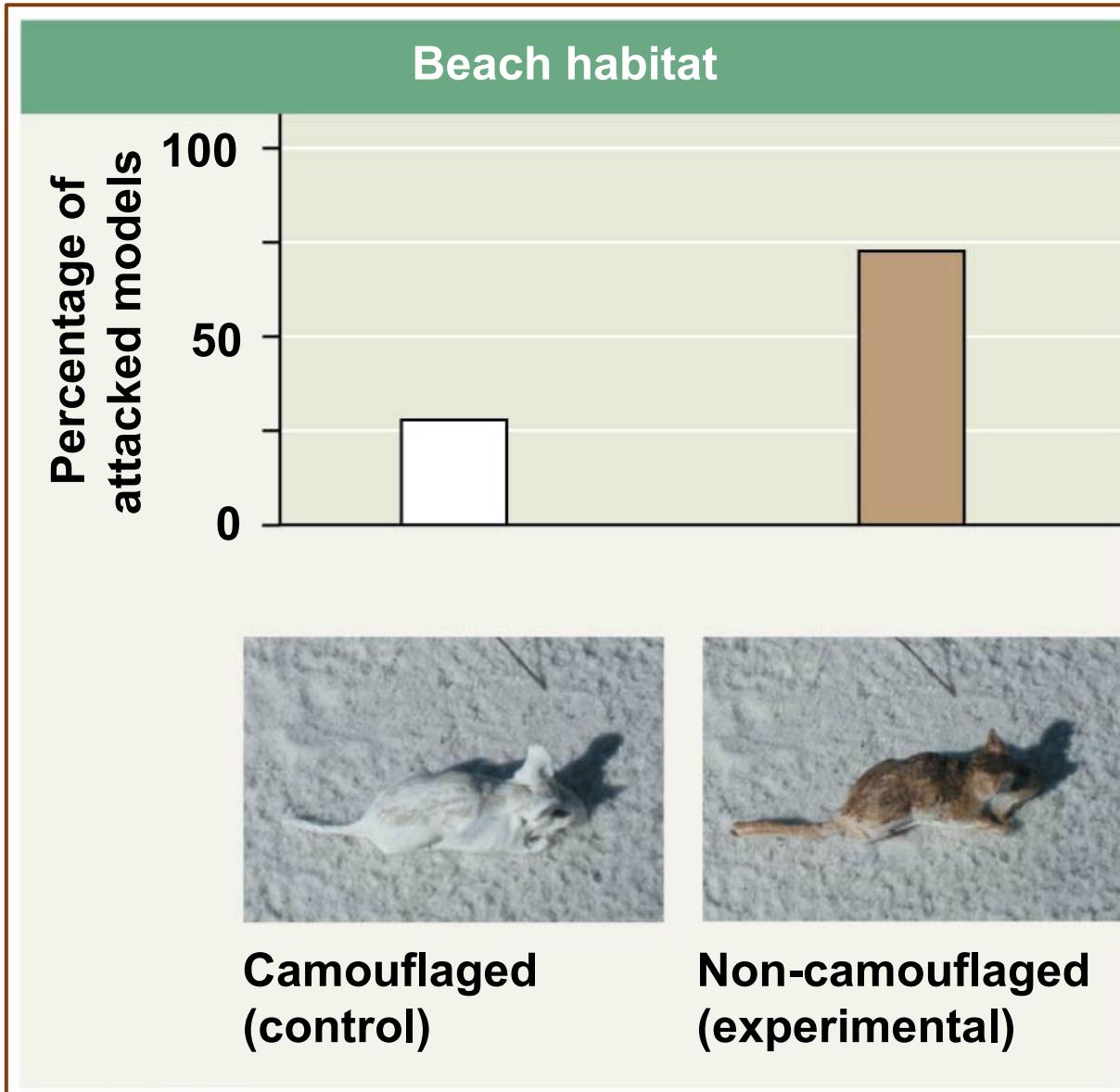
- **Hypothesis**

Coloration provides camouflage and hence protection from predation

- **Experimental design**

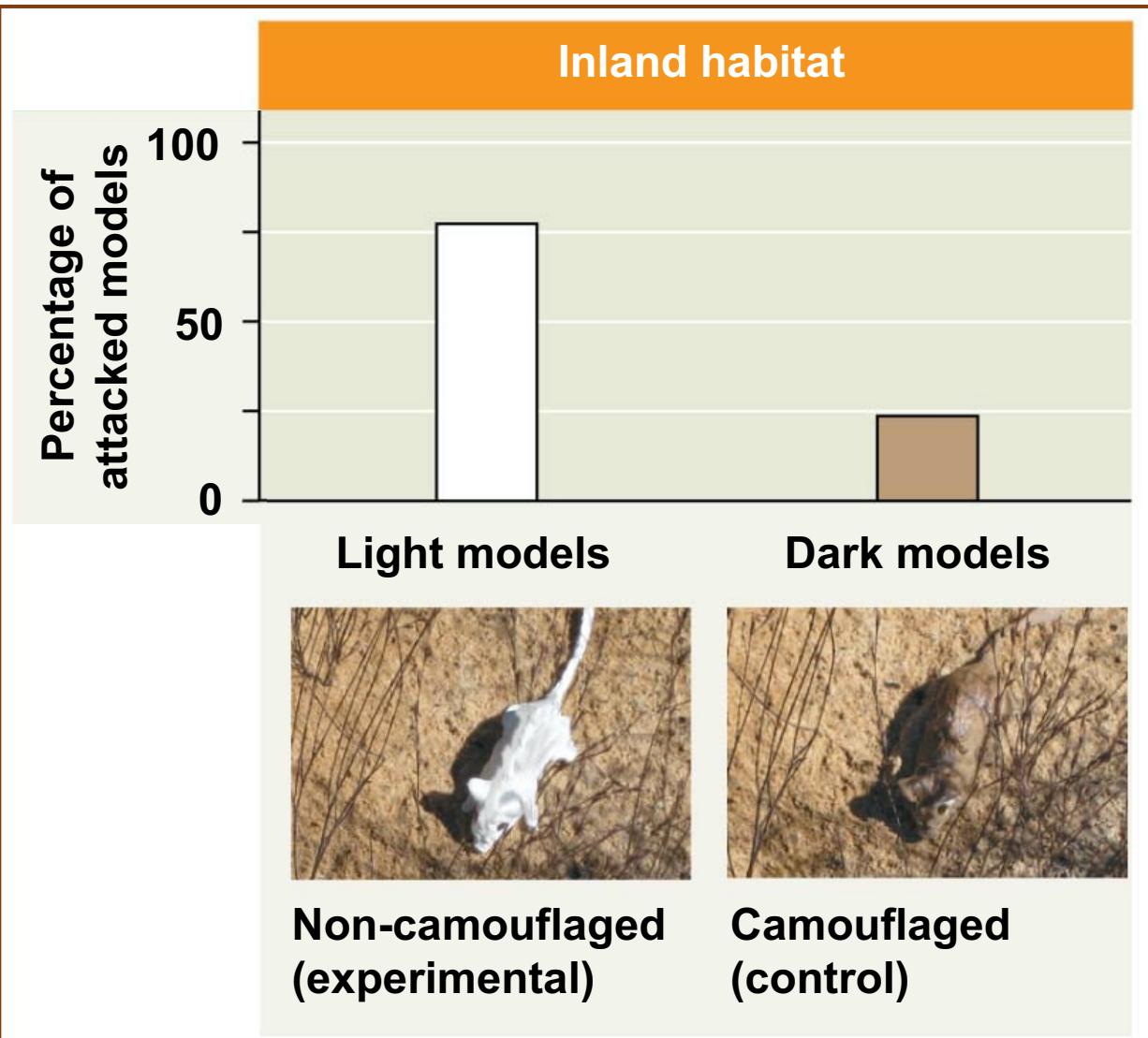
1. Spray-paint mouse models to match colour patterns of mice population
2. Place equal number of both models randomly in each of the two habitats
3. Count damaged or missing models the next morning

# Camouflage and rate of predation



- Mouse models resembling the native mice in the **beach habitat** are the **control group**
- Mouse models resembling the native mice in the **inland habitat** are the **experimental group**
- Observations: **Brown coated mice models had more predation than white coated mice**
  - Bites and gouge marks + disappearance

# Camouflage and rate of predation



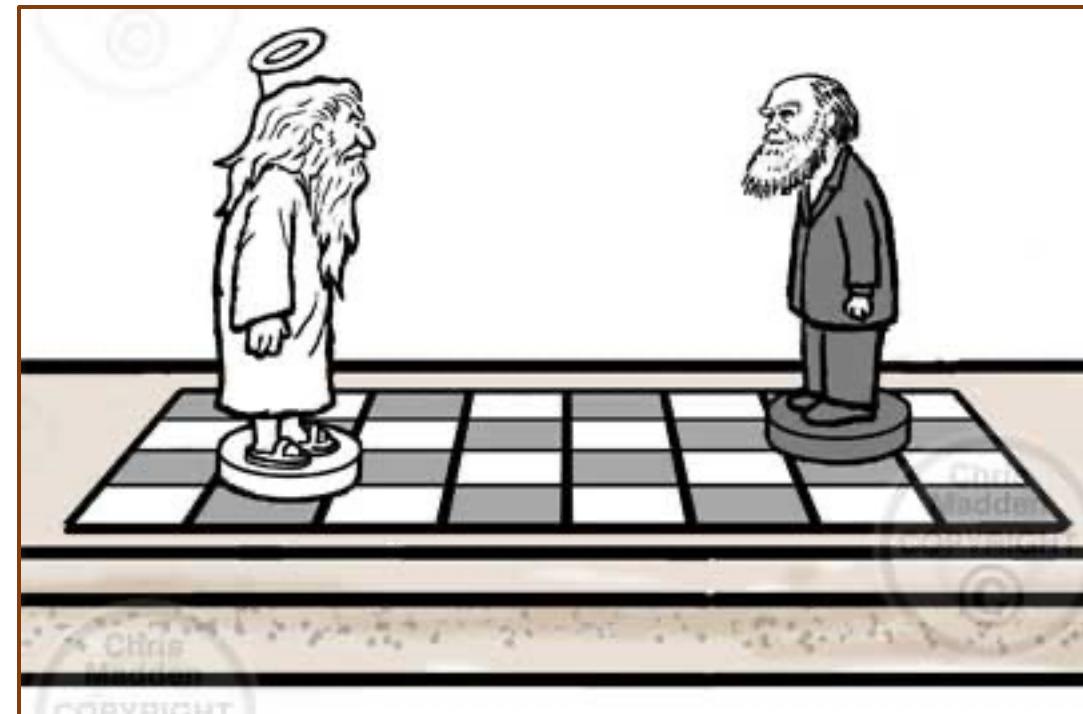
- Mouse models resembling the native mice in the **inland habitat** are the **control group**
- Mouse models resembling the native mice in the **beach habitat** are the **experimental group**
- Observations: **White coated mice models had more predation than white coated mice**
  - Bites and gouge marks + disappearance

- **Hypothesis**
  - Coloration provides camouflage and hence protection from predation
- **Experimental design**
  - Predation of spray-painted mouse models that match colour patterns of mice population
- **Inference**
  - “Fitness” (= ability to leave offspring) depends upon how well coat colour matched the environment
  - Natural selection

## Points to note

1. Natural selection occurs through interactions between individuals and their environment but  
***individuals do NOT evolve; populations evolve over time***
2. Natural selection can amplify or diminish only those heritable traits that differ among the individuals in a population
3. Environmental factors vary from place to place, and over time  
Traits favorable in one place / time, may be useless or detrimental at some other place / time

- Evolution: what, how, and why?
- Observations in support of evolution
- Religion and Science: skepticism of Evolutionary theory
- Evolution in a laboratory



Thursday

india world sports cities opinion ipl 2018 karnataka elections entertainment lifestyle education photos videos board results 2018

HOME > INDIA

## Darwin's theory wrong, nobody saw ape turning into man: Minister Satyapal Singh

Union minister Satyapal Singh said Darwin's theory needs to change in school and college curriculum.

INDIA Updated: Jan 21, 2018 06:05 IST

Press Trust of India, Aurangabad



Union minister Satyapal Singh said our ancestors have nowhere mentioned that they saw an ape turning into a man.(AP File Photo)

<https://www.hindustantimes.com/india-news/darwin-s-theory-scientifically-wrong-nobody-saw-ape-turning-into-man-union-minister-satyapal-singh/story-hZ6R2BihRNfd93sDGWwbuN.html>

Home > India > Darwin theory row: Union Minister Prakash Javadekar asks Satyapal Singh to refrain from 'such comments'

## Darwin theory row: Union Minister Prakash Javadekar asks Satyapal Singh to refrain from 'such comments'

Javadekar, the Union Human Resource Development Minister, maintained that science should not be diluted, insisting that the government has no plans to hold a national seminar to prove Darwin's evolution theory wrong.

How do we know that organisms have evolved?

<http://indianexpress.com/article/india/darwin-theory-row-prakash-javadekar-satyapal-singh-monkey-apes-human-evolution-scientifically-wrong-5036269/>

# MICHAEL BEHE

A (R)evolutionary Biologist

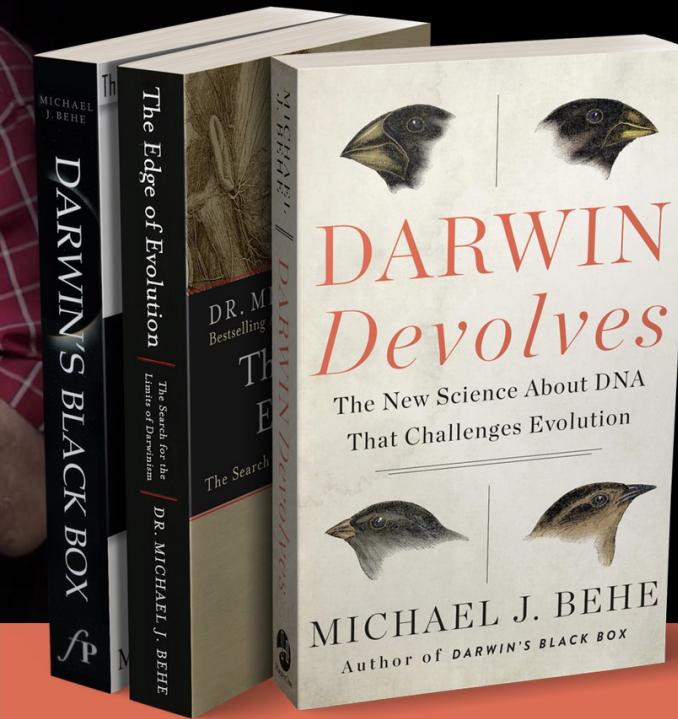
## Secrets of the Cell



with Michael Behe



**Michael J. Behe** is Professor of Biological Sciences at Lehigh University in Pennsylvania and a Senior Fellow at Discovery Institute's Center for Science and Culture. He received his Ph.D. in Biochemistry from the University of California in 1978. Behe's current research involves



DARWIN DEVOLVES

<https://michaelbehe.com/>

# MICHAEL BEHE

*A (R)evolutionary Biologist*

## Secrets of the Cell

with Michael

If we are to get a satisfactory answer to  
how the most complex, stunning life-forms arose,  
it is time to acknowledge the conclusion that  
only an intelligent mind could have designed life



ichael J. Behe is Professor of Biological Sciences at Lehigh University in Pennsylvania and a Senior Fellow at Discovery Institute's Center for Science and Culture. He received his Ph.D. in Biochemistry from the University of California, San Diego in 1978. Behe's current research involves



DARWIN DEVOLVES

<https://michaelbehe.com/>

# News

► Home      ► Undergraduate      ► Graduate      ► Personnel      ► Facilities      ► Calendar      ► Positions Available      ► News      Contact Us



photos courtesy of Amber Rice, Ph.D.

## Department position on evolution and "intelligent design"

The faculty in the Department of Biological Sciences is committed to the highest standards of scientific integrity and academic function. This commitment carries with it unwavering support for academic freedom and the free exchange of ideas. It also demands the utmost respect for the scientific method, integrity in the conduct of research, and recognition that the validity of any scientific model comes only as a result of rational hypothesis testing, sound experimentation, and findings that can be replicated by others.

The department faculty, then, are unequivocal in their support of evolutionary theory, which has its roots in the seminal work of Charles Darwin and has been supported by findings accumulated over 140 years. The sole dissenter from this position, Prof. Michael Behe, is a well-known proponent of "intelligent design." While we respect Prof. Behe's right to express his views, they are his alone and are in no way endorsed by the department. It is our collective position that intelligent design has no basis in science, has not been tested experimentally, and should not be regarded as scientific.



*Biological Sciences*

## News

While we respect Prof. Behe's right to express his views,  
they are his alone and are in no way endorsed by the department.  
  
It is our collective position that  
  
intelligent design has no basis in science,  
  
has not been tested experimentally, and  
  
should not be regarded as scientific.

The department faculty, then, are unequivocal in their support of evolutionary theory, which has its roots in the seminal work of Charles Darwin and has been supported by findings accumulated over 140 years. The sole dissenter from this position, Prof. Michael Behe, is a well-known proponent of "intelligent design." While we respect Prof. Behe's right to express his views, they are his alone and are in no way endorsed by the department. It is our collective position that intelligent design has no basis in science, has not been tested experimentally, and should not be regarded as scientific.

- Acquire knowledge about us and our surroundings...
  - observe,
  - propose testable hypothesis,
  - design experiments to verify, ...
- Scientific inquiry – evidence based explanations
- Theory explains a natural phenomenon
  - is supported by a large body of experimental / mathematical evidence

Deliver to P  
Mumbai 400076

Books ▾

of pandas and people



EN ▾

All Fresh Amazon miniTV Sell Amazon Pay Gift Cards Buy Again Gift Ideas Health, Household & Personal Care Coupons

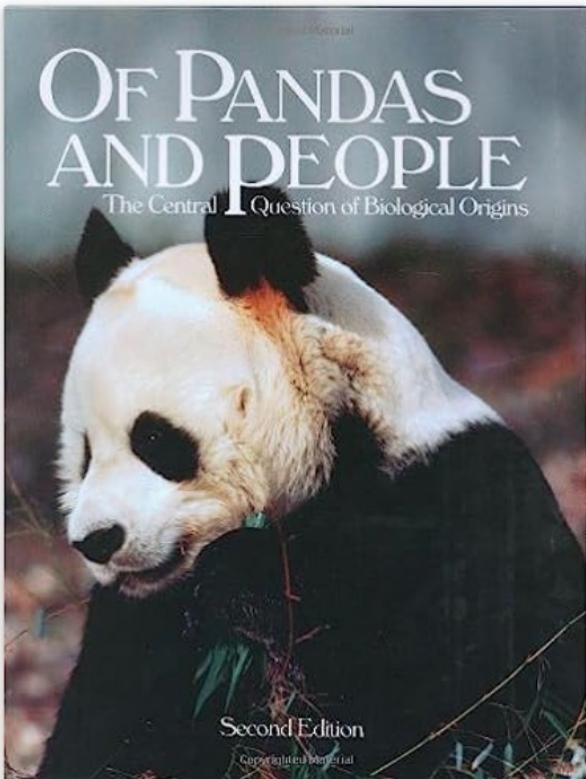
JUBIL

Books Advanced Search New Releases & Pre-orders Best Sellers ▾ Browse Genres ▾ Children's & Young Adult ▾ Textbooks ▾ Exam Central ▾ All Indian Languages ▾

Lifetime free credit card  
Apply now & get rewards worth ₹1,700\*  
with Amazon Pay ICICI Bank Credit card

Apply now

T&amp;C Apply

Back to results

## Of Pandas and People: The Central Question of Biological Origins Textbook Binding – Import, 1 August 1989



- This book promotes the theory of intelligent design
- Life began abruptly through an intelligent creator
- The book is silent on who this creator is, or could be



# Dover is a village in the USA



18 October 2004

School Board of Dover made a change in the curriculum of 9<sup>th</sup> standard Biology

Students will be made aware of gaps/problems in  
Darwin's Theory and of other theories of evolution  
including, but not limited to, intelligent design

Note: Origins of life will not be taught



# Kitzmiller v. Dover Area School District (M.D. Pa.) (2005)



By John R. Vile

## Related cases in Creationism / Intelligent Design and Separation of Church and State, Establishment Clause

One of the most famous American trials of the 20th century was the Scopes Monkey Trial (1925), involving a Tennessee law designed to limit the teaching of evolution in public schools.

In Epperson v. Arkansas (1968), the U.S. Supreme Court struck down a similar prohibition, after which states adopted laws for “balanced treatment” of the subject by including a requirement to teach “creation science.” In

Edw

this

the E

PA

Des

Amendment challenge

Looking for ways to evade this decision, some opponents of teaching evolution shifted to an emphasis on



## SEE ALSO

- Creationism
- Edwards v. Aguillard (1987)
- Endorsement Test
- Epperson v. Arkansas (1968)
- Establishment Clause (Separation of Church and State)
- Evolution
- Intelligent Design
- Lemon Test

## Decision was successfully challenged in a court of law by parents

“intelligent design” at the start of the course. Megan’s mother, along with seven other Dover families, sued the school district, alleging that the policy violates the constitutional separation of church and state. A federal judge eventually agreed (AP Photo/Carolyn Kaster used

• Beckwith, Francis J. Law, Darwinism and Public Education: The Establishment Clause and the Challenge of Intelligent Design. Lanham, MD: Rowman and

https://www.amazon.in/Design-Life-Discovering-Intelligence-Biological/dp/0980021308

amazon.in Deliver to P Mumbai 400076 Books Search Amazon.in EN Hello, Bhuvanesh... Account & Lists Returns & Orders Cart

All Fresh Amazon miniTV Sell Amazon Pay Gift Cards Buy Again Gift Ideas Health, Household & Personal Care Coupons JUBILEE Join Prime now \*Redirects to primevideo.com

Books Advanced Search New Releases & Pre-orders Best Sellers Browse Genres Children's & Young Adult Textbooks Exam Central All Indian Languages

Lifetime free credit card Apply now & get rewards worth ₹1,700\* with Amazon Pay ICICI Bank Credit card Apply now T&C Apply

Books > Higher Education Textbooks > Science & Mathematics

**The Design of Life: Discovering Signs of Intelligence in Biological Systems: 1 Hardcover – Import, 28 February 2009**

by William A. Dembski (Author), Jonathan Wells (Author)

★★★★★ 27 ratings See all formats and editions

**Hardcover** ₹5,021.89

3 Used from ₹3,196.27 6 New from ₹4,762.00

EMI starts at ₹240. No Cost EMI available.

Save Extra with 4% Cashback

No Cost EMI: Avail No Cost EMI on this product.

From [https://en.wikipedia.org/wiki/Of\\_Pandas\\_and\\_People](https://en.wikipedia.org/wiki/Of_Pandas_and_People)

**Cashback (3):** ₹150 cashback & ₹1,550 welcome rewards on [Amazon Pay ICICI Credit Card](#). 3% cashback every time on shopping. Apply now! T&C. Not applicable on Amazon Business Transactions | [See All](#)

▼ See 2 more

Free Delivery 10 days Replacement Secure transaction

Buy new: ₹5,021.89 Inclusive of all taxes FREE delivery April 27 - May 1. Details

Deliver to P - Mumbai 400076

Sold and fulfilled by [WesternShop](#).

Add to Cart Buy Now Secure transaction

Add to Wish List

Toyshine Fun Interactive Play Basketball Game... Deal of the Day ₹1,139.00 ₹1,999.00 prime

Sponsored Have one to sell? Sell on Amazon

'The illusion of purpose is so powerful' writes Richard Dawkins 'that biologists themselves use the assumption of good

Deliver to P  
Mumbai 400076

Books ▾

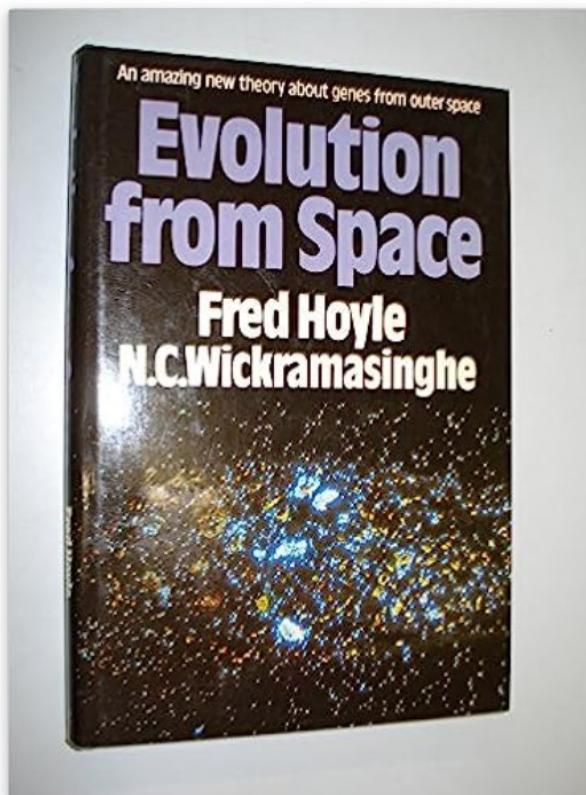
Search Amazon.in

[All](#) [Fresh](#) [Amazon miniTV](#) [Sell](#) [Amazon Pay](#) [Gift Cards](#) [Buy Again](#) [Gift Ideas](#) [Health, Household & Personal Care](#) [Coupons](#)[Books](#)[Advanced Search](#)[New Releases & Pre-orders](#)[Best Sellers ▾](#)[Browse Genres ▾](#)[Children's & Young Adult ▾](#)[Textbooks ▾](#)[Exam Central ▾](#)[All Indian Languages ▾](#)

Lifetime free credit card

Apply now & get rewards worth ₹1,700\*  
with Amazon Pay ICICI Bank Credit card[Apply now](#)

\*T&amp;C Apply

[Books](#) › [Sciences, Technology & Medicine](#) › [Engineering & Technology](#)

## Evolution from Space Hardcover – 13 August 1981

by [Sir Fred Hoyle](#) (Author), [Chandra Wickramasinghe](#) (Author)

19 ratings

[See all formats and editions](#)

If life on earth was seeded from outer space,  
how did life on outer space evolve?

[Returns Policy](#)[Secure](#)

transaction

[Report incorrect product information.](#)[Print length](#)[Language](#)[Publisher](#)[Publication date](#)[ISBN-10](#)

# Today's topics

- Evolution: what, how, and why?
- Observations in support of evolution
- Religion and Science: skepticism of Evolutionary theory
- Evolution in a laboratory

# Experiment #1

# Evolution in a flask



Richard E. Lenski

Started evolution experiments in 1988 and still continuing...

# Design of the experiment

A single *E. coli*



12 populations



Grow each in a  
limiting growth  
medium



Save samples at  
periodic intervals

Initially, every 100 generations  
Later on, every 500 generations



# Design of the experiment

A single *E. coli*



12 populations



Grow each in a  
limiting growth  
medium

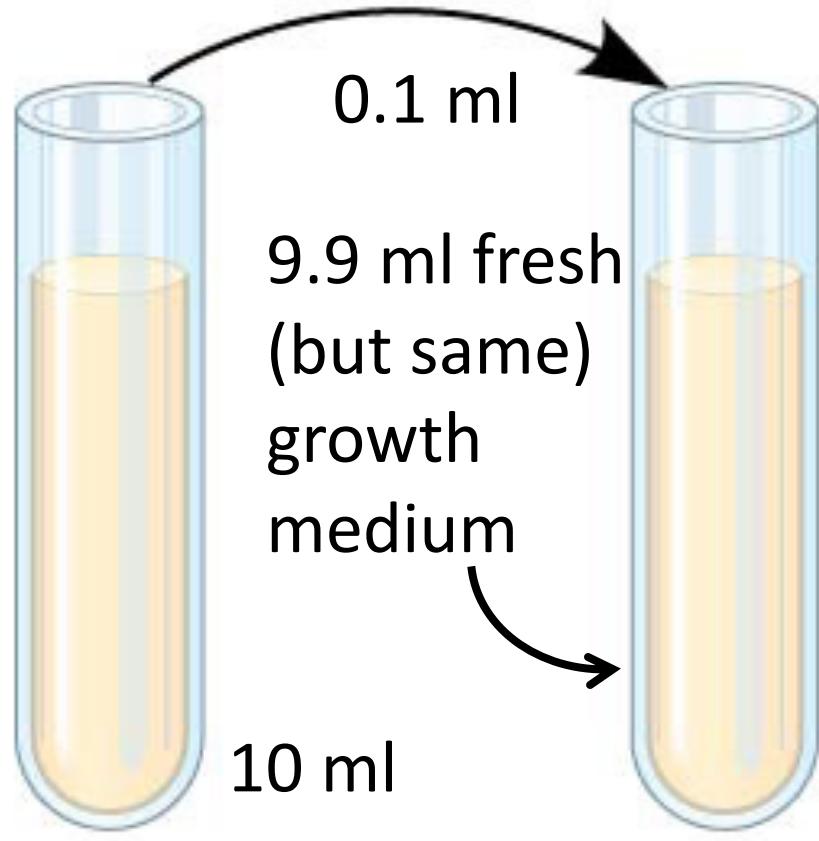


Save samples at  
periodic intervals

Initially, every 100 generations  
Later on, every 500 generations

- Monitor each population for 20,000 generations (3,000 days)
- Humans 20,000 generations = 400,000 years (20 years / generation)

# Design of the experiment



Growth medium provided was challenging

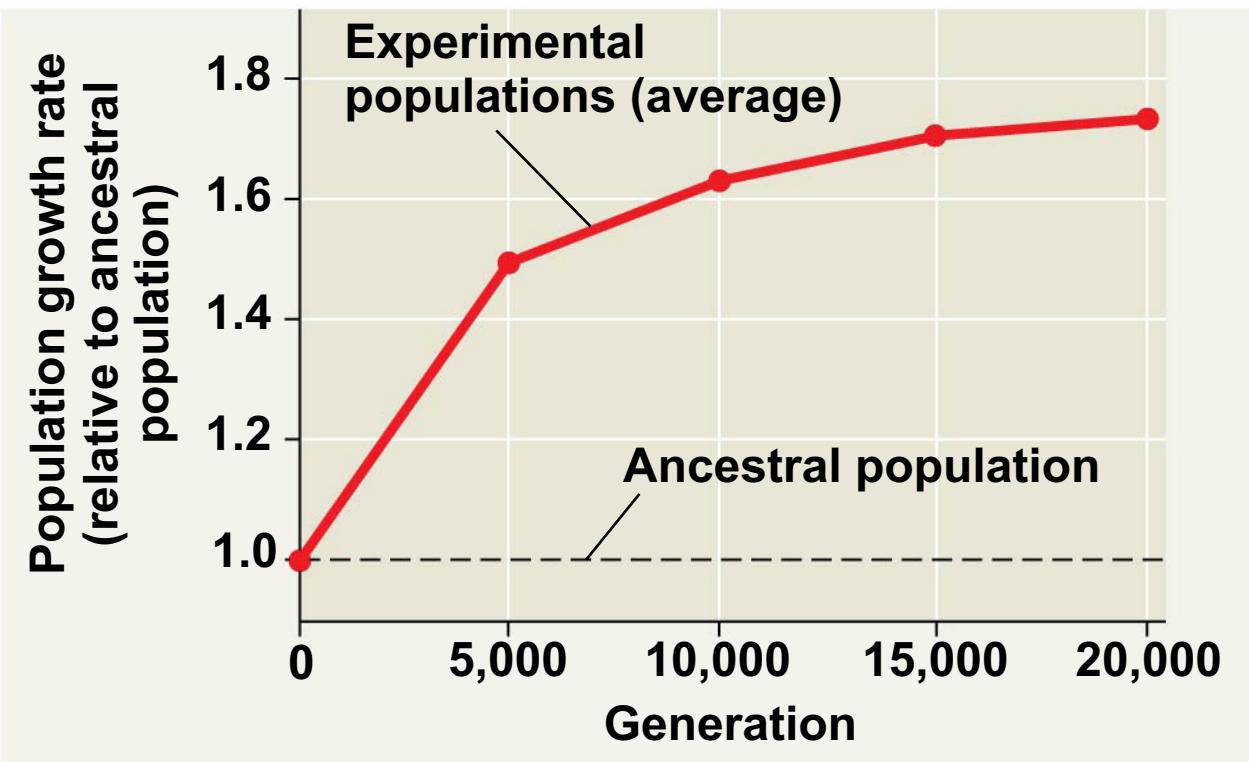
Only low levels of nutrients (glucose + other resources) required for growth

Undergo 6-7 binary fissions – limiting resource gets exhausted – wait until they are transferred to fresh medium next day

Schematic shows test tubes but experiments were carried out in conical flasks

# Outcome of the experiment

Growth tested in experimental (low glucose) environment



- Fitness of the experimental populations measured as the rate at which each population grew
- Increased rapidly for the first 5,000 generations and more slowly for the next 15,000 generations

# Conclusions and ...

- Populations of *E. coli* accumulate beneficial mutations for 20,000 generations
  - Allowed evolution of higher growth rates in the new environment
- Laboratory experiments allow comparing organisms across generations
  - Compare the abilities of evolved bacteria against their ancestors
- Confirmation of adaptation by natural selection

# Conclusions and ...

- Lenski's evolution-in-a-flask experiment
  - Source of carbon: glucose and citrate
  - Parent (or ancestral) *E. coli* uses glucose but not citrate
- Appearance of citrate utilizers..
  - *E. coli* have been growing every day in a citrate-containing medium
  - After 15+ years of evolving in a flask, “suddenly”, a population that could use citrate appeared
  - Genetics of this switch is being studied (at the time of video interview!)

# Experiment #2

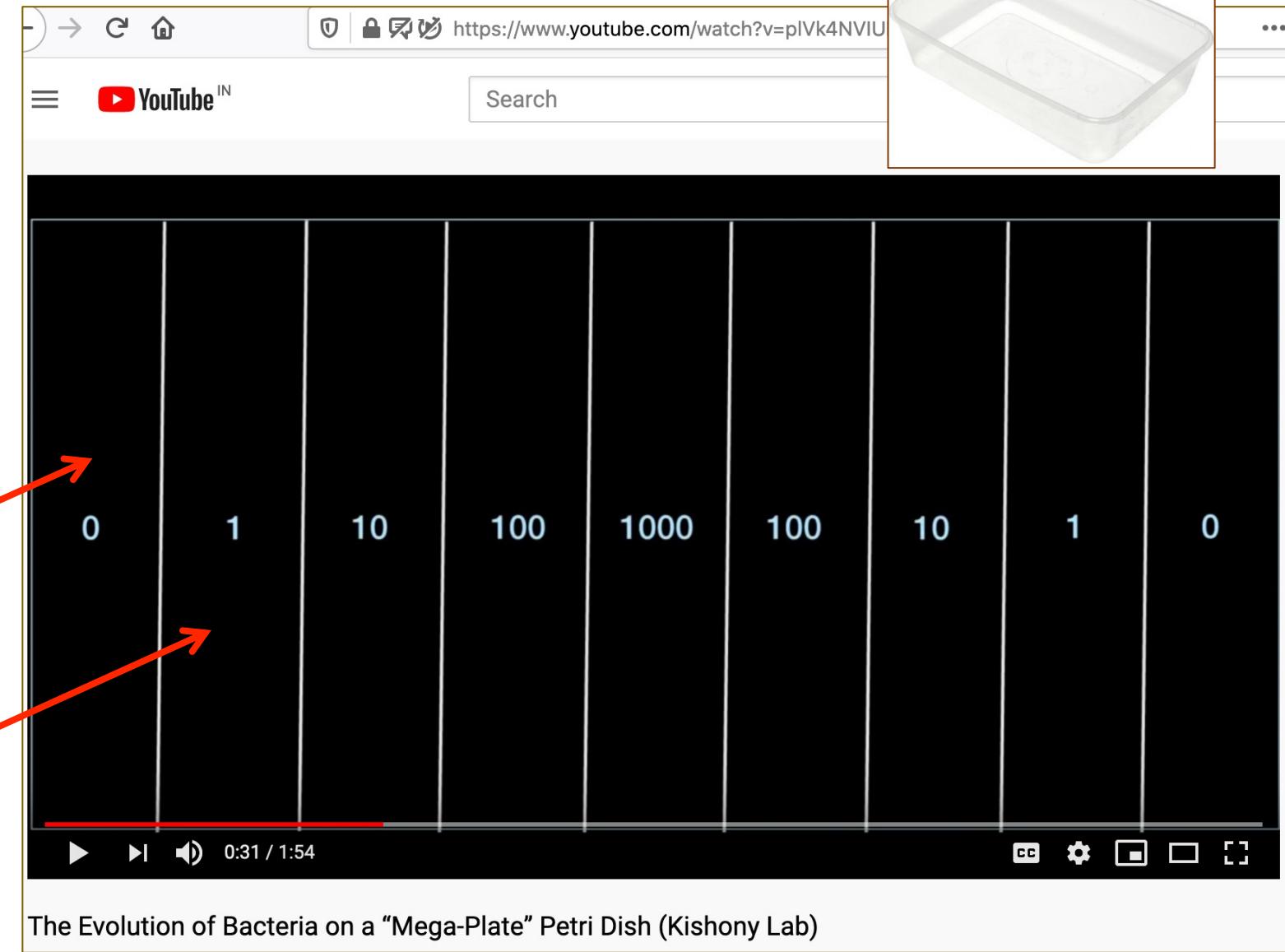


# Understanding mutation, selection, and evolution

Experimental set up: a gradient of antibiotic from the edges to the center of the Petri dish

No antibiotic

Barely more than what an *E. coli* can survive



Sulfation is a key modification found throughout nature. Sulfate esters have been identified in carbohydrates but can also decorate lipids, proteins, and steroids, drastically altering the biophysical properties of these molecules. Sulfated glycans are essential for multiple aspects of eukaryotic cell biology. Sulfated glycans of the glycosaminoglycan class, which include heparan sulfate and chondroitin sulfate, ubiquitously coat the cells of all mammals where they regulate extracellular cell signalling, growth and homeostasis. Additionally, the mucus layer coating the colon surface is composed of secreted mucins, highly *O*-glycosylated and

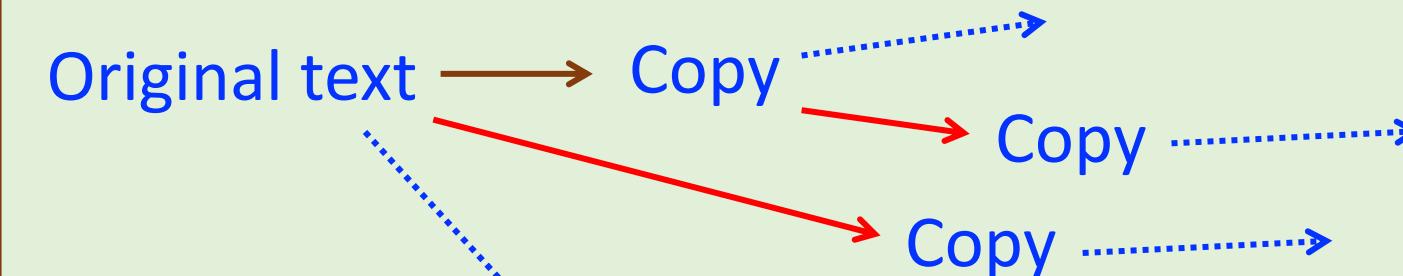
## **Randomly chosen text formed using letters of the English alphabet**

between the gut microbes and the intestinal epithelium, preventing close contact and thus inflammation. Sulfated glycans also play critical roles in marine environments. For example, the cell walls of algae, which provide 50% of all primary carbon fixation on Earth, contain an abundance of sulfated glycans that include the carrageenans, ulvans, porphyrans, fucoidans and sulfated exopolysaccharides, which are essential for cell wall functionality and structure but also have utility as a renewable industrial resource. These sulfated marine glycans also serve as critical bacterial nutrient sources, underpinning food webs and carbon recycling.

# Copying a text

- Copy a text several times
  - Average error rate (e.g., number of mistakes / 1000 characters typed)
  - Range of number of mistakes (lowest and highest number of mistakes found)
- Every time a text is copied, we can expect some mistakes in the copy
  - Either no mistakes whatsoever (i.e., zero mistakes) or any number within the range
- Mistake can happen anywhere in the text

Sulfation is a key modification found throughout nature. Sulfate esters have been identified in carbohydrates but can also decorate lipids, proteins, and steroids, drastically altering the biophysical properties of these molecules. Sulfated glycans are essential for multiple aspects of eukaryotic cell biology. Sulfated glycans of the glycosaminoglycan class, which include heparan sulfate and dermatan sulfate, are found in many tissues, particularly in mammals where they regulate extracellular matrix assembly. These molecules form a layer coating the basement membrane, the interface between the extracellular matrix and the underlying epithelial cells. In the lungs, the mucus layer is heavily sulfated glycosaminoglycans, which are important for maintaining the integrity of the airway. In the gut, sulfated glycans are involved in the regulation of gut microbiome interactions and inflammation. Sulfated glycans are also found in the extracellular matrix of connective tissue, where they provide structural support and regulate cell adhesion.



the cell walls of algae, which provide 50% of all primary carbon fixation on Earth, contain an abundance of sulfated glycans that include the carrageenans, ulvans, porphyrans, fucoidans and sulfated exopolysaccharides, which are essential for cell wall functionality and structure but also have utility as a renewable industrial resource. These sulfated marine glycans also serve as critical bacterial nutrient sources, underpinning food webs and carbon recycling.

# Copying a text

- When I use a copy as the original for the next round of copying, the new copy will have mistakes made in the first copy as well as the second copy
  - There is a non-zero probability that the mistake in the first copy gets corrected
- There is a non-zero probability that the meaning changes
  - Mistake may be such that the sentence does not make sense

# Hitting the antibiotic wall...

1. Growth by binary division
2. Mutations take place by design
  - a) DNA polymerase is error-prone
  - b) Makes mistakes during replication
  - c) These mistakes are what we call as mutations



# Hitting the antibiotic wall...

### 3. Mutations are cumulative

- Back mutations are possible

### 4. Out of the millions of progeny, a handful become capable of withstanding higher concentration of antibiotic

- This is a truly chance event



The Evolution of Bacteria on a “Mega-Plate” Petri Dish (Kishony Lab)

# Hitting the antibiotic wall...

5. Progeny of resistant mutants survive
  - Others get eliminated
  - Selection
6. Progeny of resistant mutants thrive
  - No competition for resources
  - Growth is vigorous



# Hitting the antibiotic wall...

7. Mutations continue to accumulate
  - Back mutations (= revertants) are possible
8. Out of the millions of progeny, a handful become capable of withstanding higher concentrations of antibiotic
  - Another chance event



- Probability of a spontaneous mutation in a gene:  $1 \times 10^{-7}$  / cell division
- Number of *E. coli* cells that arise newly in a person's intestine:  $2 \times 10^{10}$  per day
- Number of mutations in a gene in the population:  $2 \times 10^3$  / day
- Inference:

mutation rates are very low but  
are sufficient to quickly generate genetic diversity  
in species with short generation times and large populations

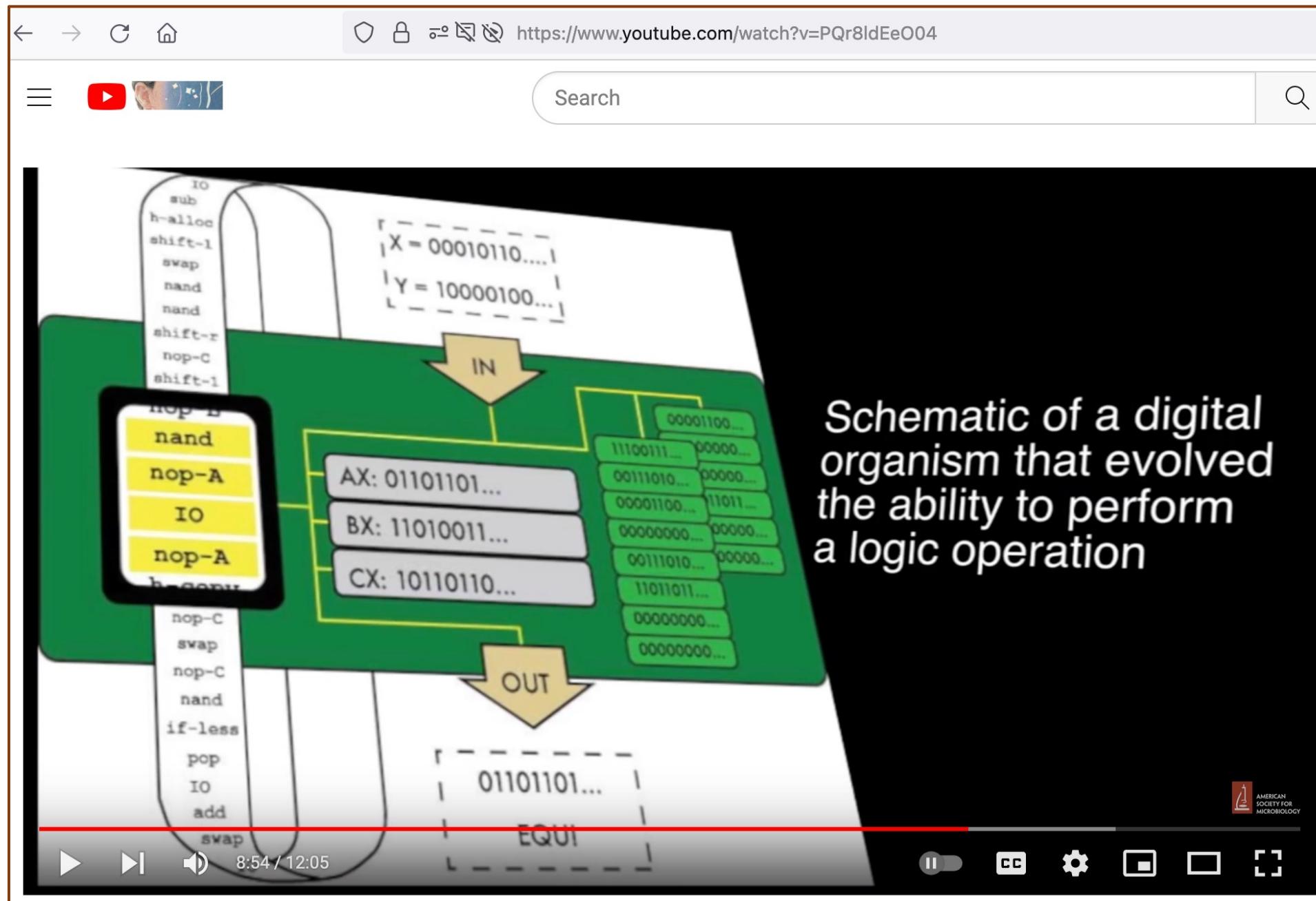
# Population evolves, individuals don't...

- Evolution of antibiotic resistance: mega Plate experiment
  - Mutation, selection, and evolution
  - Population evolves, individuals don't... Why?
    - The genome of an individual remains the same throughout – no question of ‘evolution’
    - A population is heterogeneous in terms of genetic makeup. A population is dominated by progeny of organisms which have a growth advantage

# “Evolution in a laboratory”-type experiments

**Beneficial or Risky**

- Lenski's collaboration with physicists, philosophers, and computer scientists
- Idea is to have software that evolve
  - Take principles of biology of mutation and selection
  - Create self-replicating computer programs... in other words, computer viruses!
  - Instead, make programs that evolve to solve difficult mathematical problems
  - Evolve robots...





NEWS

CAREERS

COMMENTARY

JOURNALS ▾

COVID-19

Science

HOME &gt; NEWS &gt; SCIENCEINSIDER &gt; SCIENTISTS BRACE FOR MEDIA STORM AROUND CONTROVERSIAL FLU STUDIES

SCIENCEINSIDER | HEALTH

# Scientists Brace for Media Storm Around Controversial Flu Studies

23 NOV 2011 · BY MARTIN ENSERINK

Dated 23 Nov 2011

SHARE:



**ROTTERDAM, THE NETHERLANDS**—Locked up in the bowels of the medical faculty building here and accessible to only a handful of scientists lies a man-made flu virus that could change world history if it were ever set free.

The virus is an H5N1 avian influenza strain that has been genetically altered and is now easily transmissible between ferrets, the animals that most closely mimic the human response to flu. Scientists believe it's likely that the pathogen, if it emerged in nature or were released, would trigger an influenza pandemic, quite possibly with many millions of deaths.

In a 17th floor office in the same building, virologist Ro

Center calmly explains why his team created what he sa <https://www.science.org/content/article/scientists-brace-media-storm-around-controversial-flu-studies>

... a man-made flu virus that could change world history if it were ever set free

- Evolutionary experiment on the breeding of corn has been going on for 110 years
  - Fewer generations than that in Lenski's experiment
- Evolution-in-a-laboratory type experiments @ IIT Bombay
  - Prof. Anirban Banerjee (BSBE)
  - Prof. Kiran Kondabagil (BSBE)
  - Prof. Supreet Saini (Chemical Engineering)