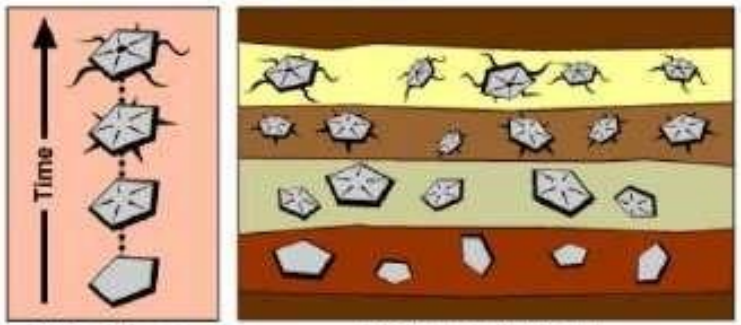


Evidence for Evolution

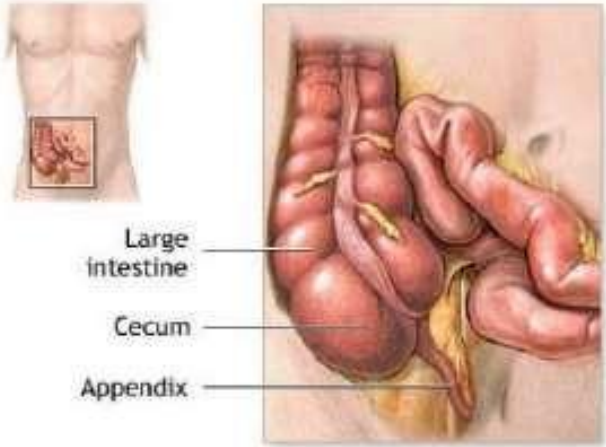
Fossil record



Gradual lineage evolution

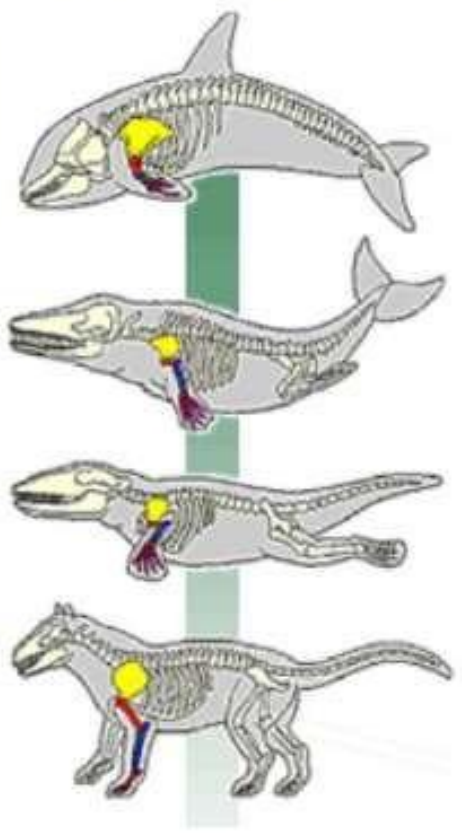
Rock strata with fossils

Vestigial structures



<http://www.nlm.nih.gov/MEDLINEPLUS/ency/imagepages/1128.htm>

Homologous structures

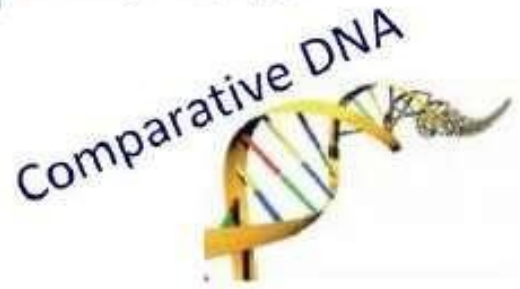


<http://evolution.berkeley.edu/evosite/evo101/VIIAPaceevolution.shtml>

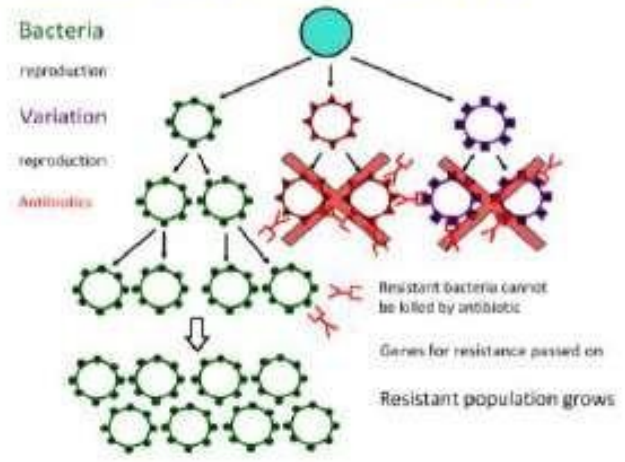
Selective breeding



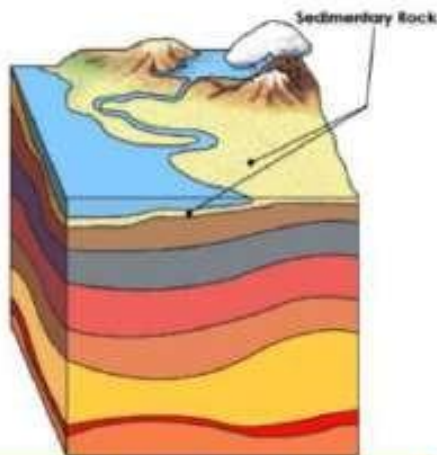
http://www.bbc.co.uk/schools/ks3bitesize/science/images/bio_dogs.gif



Observable changes



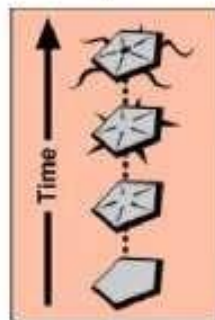
The Fossil Record



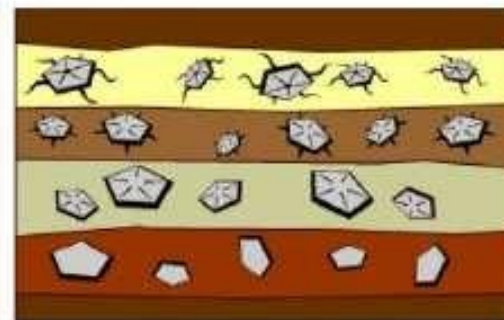
As layers of sedimentary rock are put down, the inorganic components of plants, animals and prokaryotes are preserved. Simply put, the deeper they are, the older they are.

Sedimentary Rock

These fossils show a transition over time that echoes the development of species through the theory of evolution.



Gradual lineage evolution



Rock strata with fossils



NOVA

FOSSIL EVIDENCE



FISH TO AMPHIBIANS

Eusthenopteron looked and behaved a lot like modern fish, but hidden within its fins were the precursors of the arm and leg bones of four-limbed land animals. The later *Tetralape* took a further step toward terrestrial life with early wrist and finger bones that allowed the animal to prop itself up and poke its head from the water of the shallow swamps it favored. *Tetralape*'s skeleton indicates that it probably breathed both through gills, like *Eusthenopteron*, and through a lung-like structure, like the later *Ichthyostega* and modern amphibians. *Ichthyostega*'s even stronger limbs probably developed so that it could maneuver around thick vegetation in its marshy habitat and even haul itself along muddy banks when necessary.

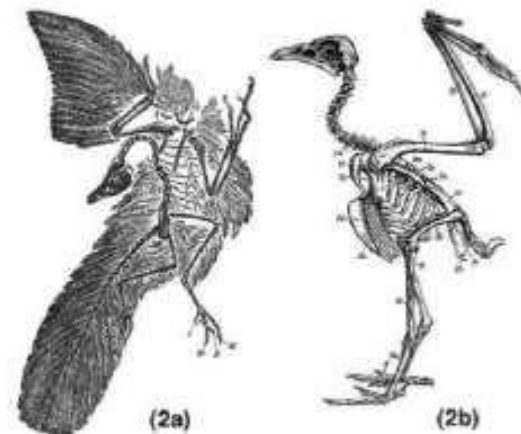
Images not to scale

Dates, in millions of years ago, give the estimated age of known fossils.

PAGE | 1 of 2 | NEXT

<http://www.pbs.org/wgbh/nova/id/transitional.html>

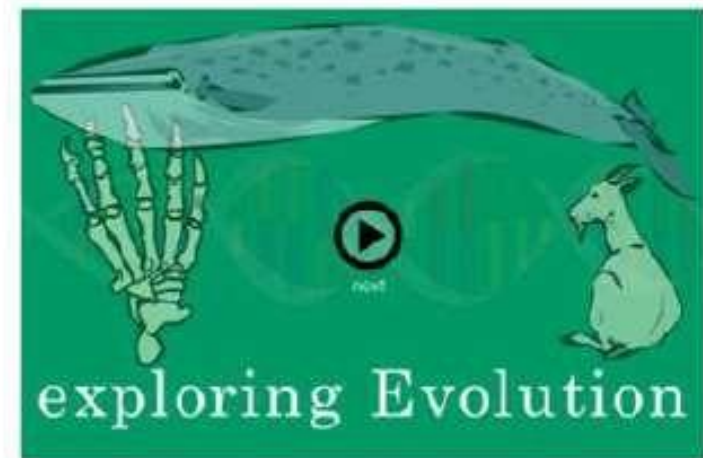
Some fossils, such as the famous *Archaeopteryx lithographica*, represent transition species:



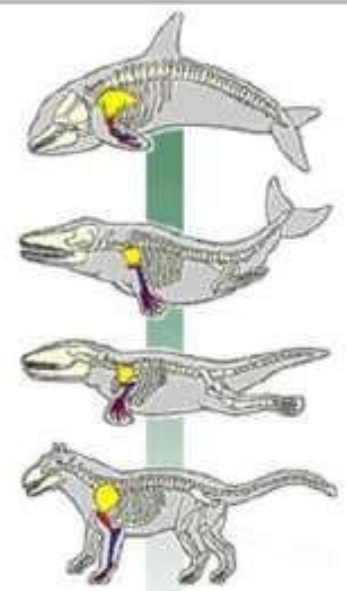
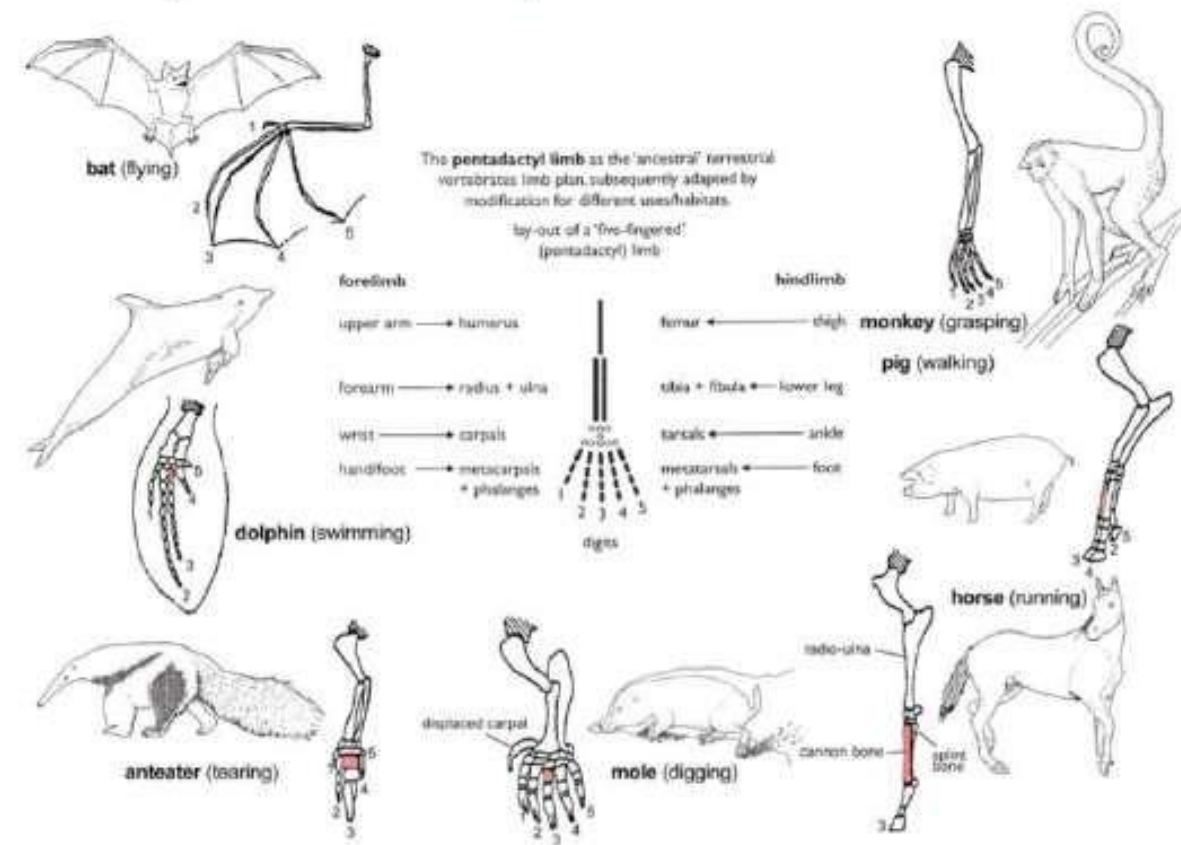
Archaeopteryx lithographica

Homologous Structures

Darwin noticed many similarities in the structures of different species: parts of the body (such as the pentadactyl limb) which had been adapted for different functions. This is evidence of common ancestry and shows **adaptive radiation**.



<http://www2.edc.org/weblabs/ExploringEvolution/evolution.swf>



evolution of the whale

<http://evolution.berkeley.edu/evosite/evo101/VIIAPaceevolution.shtml>

http://en.wikipedia.org/wiki/Image:Evolution_pl.png

Evolution:

The **cumulative change** in the **heritable characteristics** of a **population**.

cumulative change: small changes upon small changes over many generations

heritable characteristics: gene-controlled factors

population: not an individual

Peppered Moth Melanism: evolution in action

Peppered moth (*Biston betularia*)

Selection pressure: predation by birds

Variation:



White phenotype (*typica*)
common before industrial revolution
camouflaged against white lichen
on trees



Black phenotype (*carbonaria*)
common after industrial revolution
camouflaged against black soot



<http://www.techapps.net/interactives/pepperMoths.swf>

Environmental change: sooty pollution from factories

Result: *typica* stands out against soot-covered trees
carbonaria is camouflaged by black soot

typica population declines due to predation
carbonaria population increases

This has reversed again with clean air policies.

Play another one here:
Virtual Peppered Moths



<http://www6.district125.k12.il.us/~nfischer/Moth/>



".....can we doubt (remembering that *many more individuals are born than can possibly survive*) that *individuals having any advantage*, however slight, over others, would have the best chance of surviving and procreating their kind? On the other hand, we may feel sure that any variation in the least injurious would be rigidly destroyed. This preservation of favourable variations and the rejection of injurious variations, I call Natural Selection'

Darwin C. (1859) *The Origin of Species*

http://www.biology.ed.ac.uk/public/images/c_darwin.jpg

There is **variation** between members of a species.



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There is **variation** between members of a species.

A result of

Random Mutation



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Random Mutation

Sexual Reproduction

DNA replication

viral infection

meiosis

crossing over
(recombination)
prophase I

random assortment
of chromosomes
metaphase I



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A result of

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Sexual Reproduction

DNA replication

viral infection

meiosis

random fertilisation

crossing over
(recombination)
prophase I

random assortment
of chromosomes
metaphase I





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Mutations that give an **advantage** are selected for.

The individual which can best compete in the struggle for survival will survive long enough to reproduce - and pass on the trait.

Mutations that give a **disadvantage** are selected against.

A mutation or trait that means an individual is less well suited to the environment will make it more difficult for the individual to survive.
The individual is less likely to pass on the trait.



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Populations tend to produce more offspring than the environment can support.

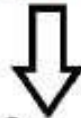


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Struggle for Survival
(*Nature red in tooth and claw**)

*who wrote that?

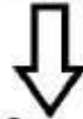


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Competition for Food ← Struggle for Survival

- finding
- reaching
- catching
- opening
- digesting

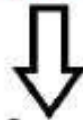


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Struggle for Survival

Competition for Food

- finding
- reaching
- catching
- opening
- digesting

Predation

- catching
- fighting
- avoiding
- escaping

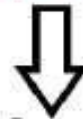


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Struggle for Survival



Competition for Food

- finding
- reaching
- catching
- opening
- digesting

Predation

- catching
- fighting
- avoiding
- escaping

Parasitism

- invading
- avoiding
- removing
- tolerating

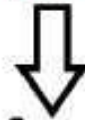


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- reaching
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Predation

- catching
- fighting
- avoiding
- escaping

Parasitism

- invading
- avoiding
- removing
- tolerating

Disease

- invading ●
- avoiding ●
- removing ●
- tolerating ●

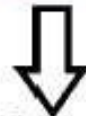


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Parasitism

- invading
- avoiding
- removing
- tolerating

Disease

- invading ●
- avoiding ●
- removing ●
- tolerating ●

Competition for Mates

- attracting ●
- fighting ●
- selecting ●
- fertilising ●
- providing for ●

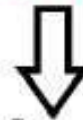


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Populations tend to produce more offspring than the environment can support.



Struggle for Survival → Competition for Space

- living space/shelter ●
- nesting space ●
- reproductive space ●

Competition for Mates

- attracting ●
- fighting ●
- selecting ●
- fertilising ●
- providing for ●

Disease

- invading ●
- avoiding ●
- removing ●
- tolerating ●

Parasitism

- invading ●
- avoiding ●
- removing ●
- tolerating ●

Predation

- catching ●
- fighting ●
- avoiding ●
- escaping ●

Competition for Food

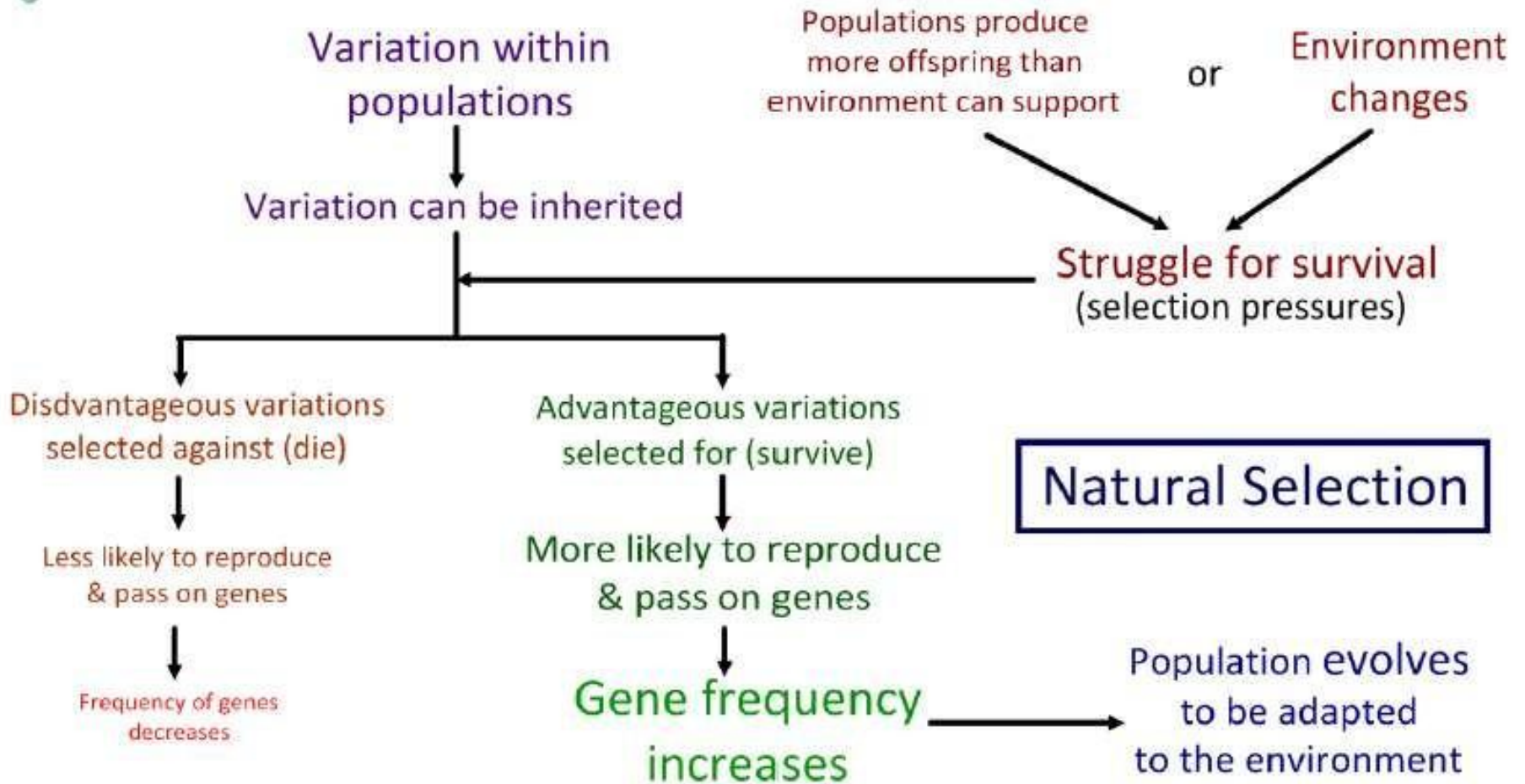
- finding ●
- reaching ●
- catching ●
- opening ●
- digesting ●



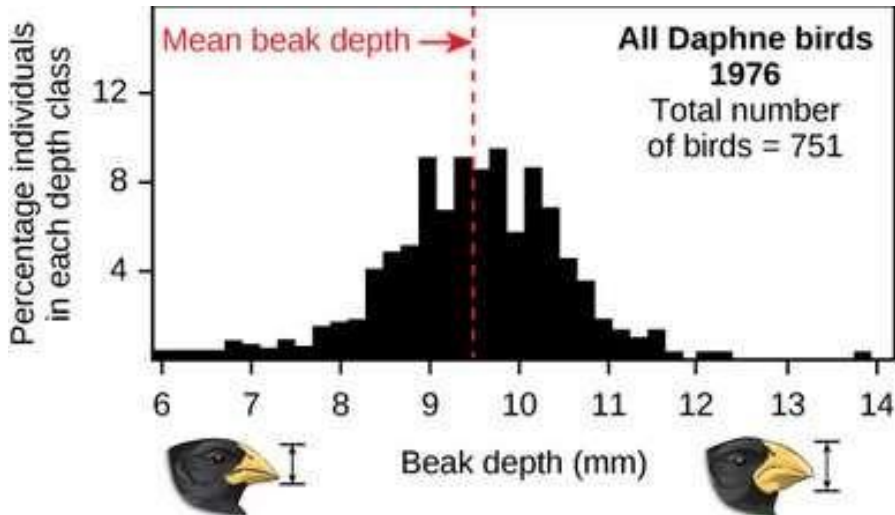
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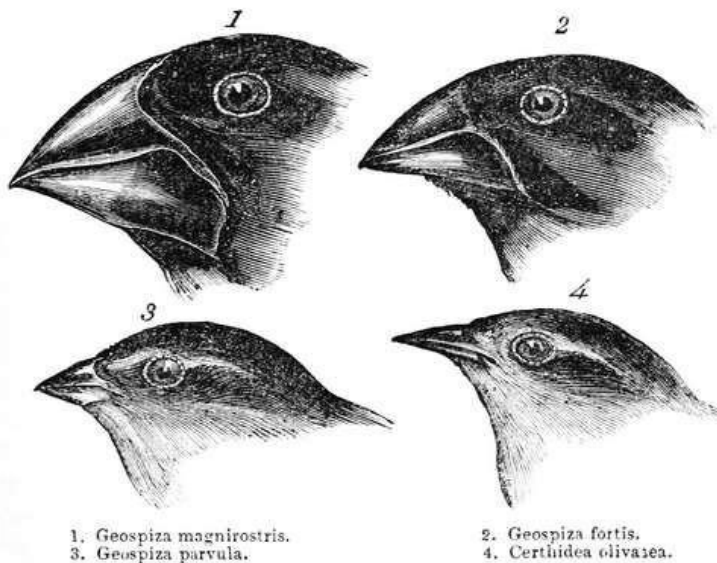
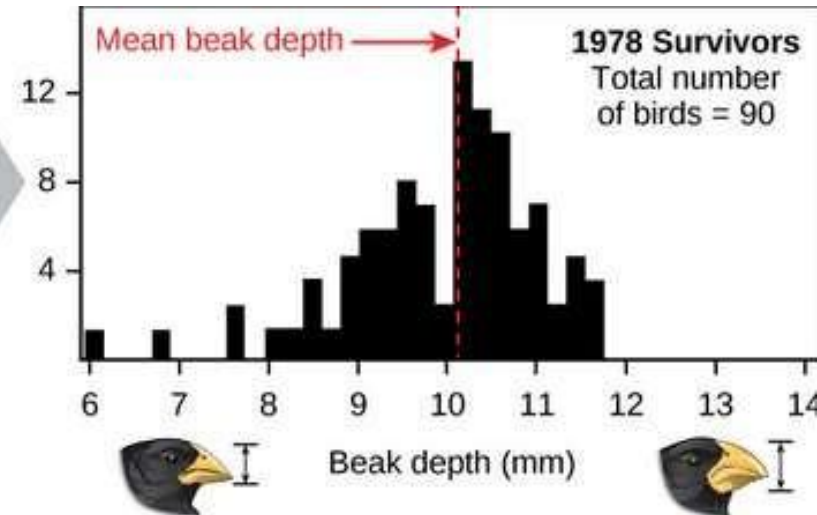
http://www.biology.ed.ac.uk/public/images/c_darwin.jpg



The Finches of Daphne Major



Drought in 1977



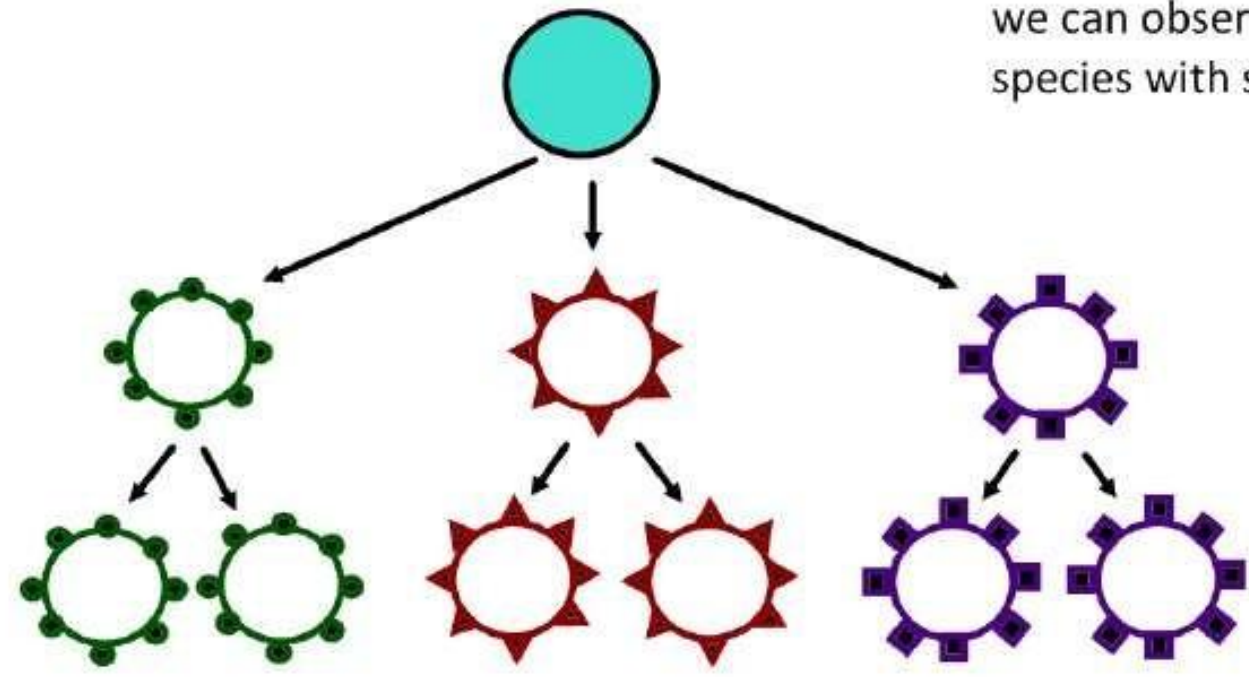
we can observe evolution in species with short life-cycles

Bacteria

reproduction

Variation

reproduction



Bacteria

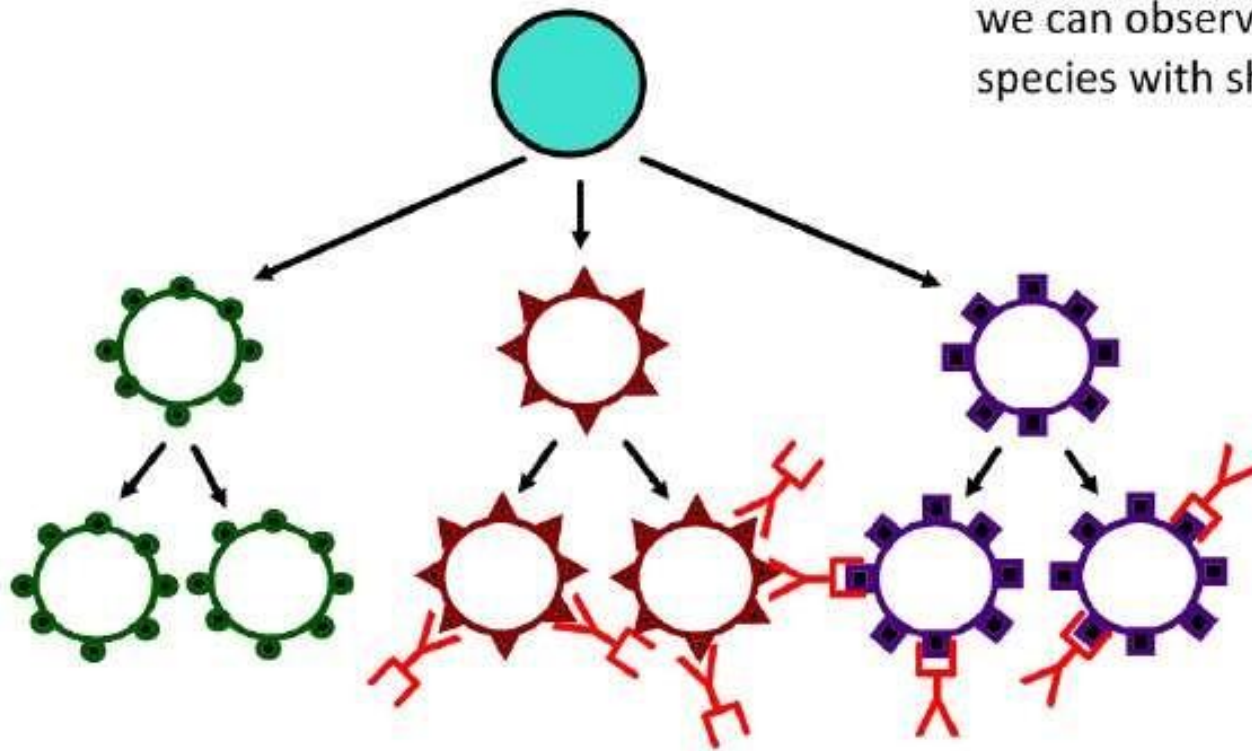
reproduction

Variation

reproduction

Antibiotics

we can observe evolution in species with short life-cycles



we can observe evolution in species with short life-cycles

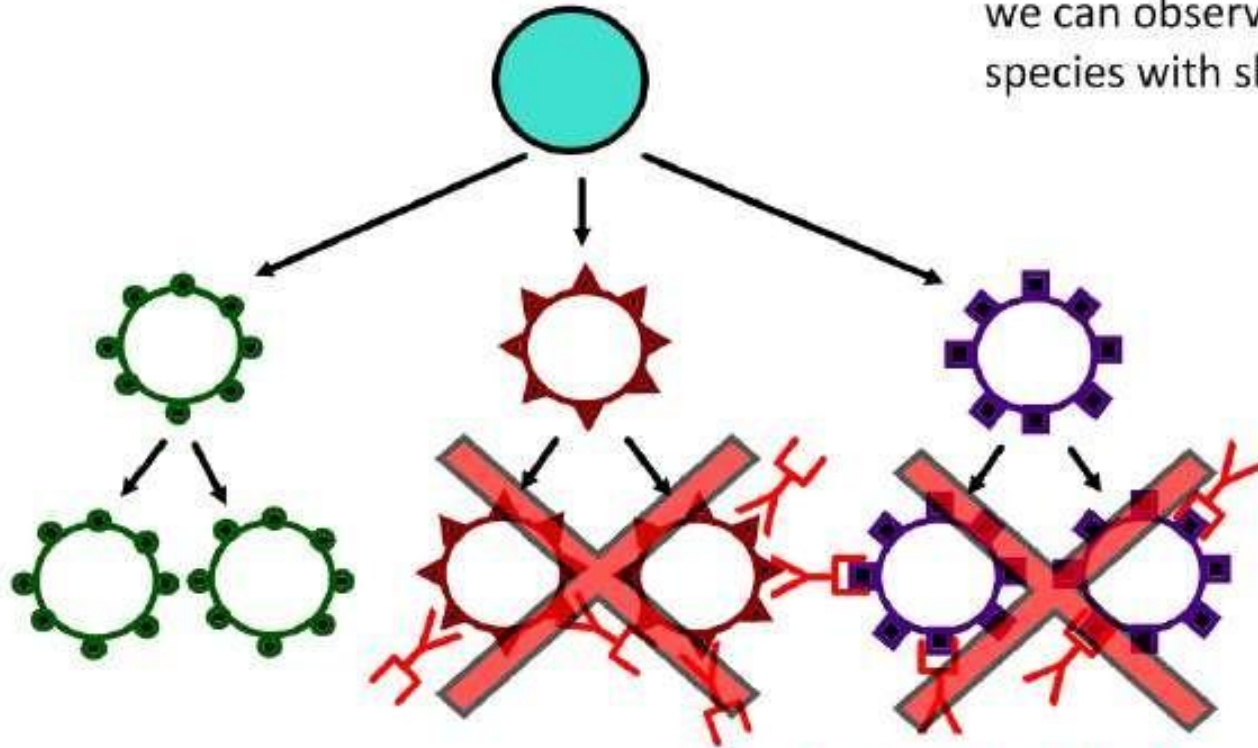
Bacteria

reproduction

Variation

reproduction

Antibiotics



resistant strain survives

non-resistant strains killed

Bacteria

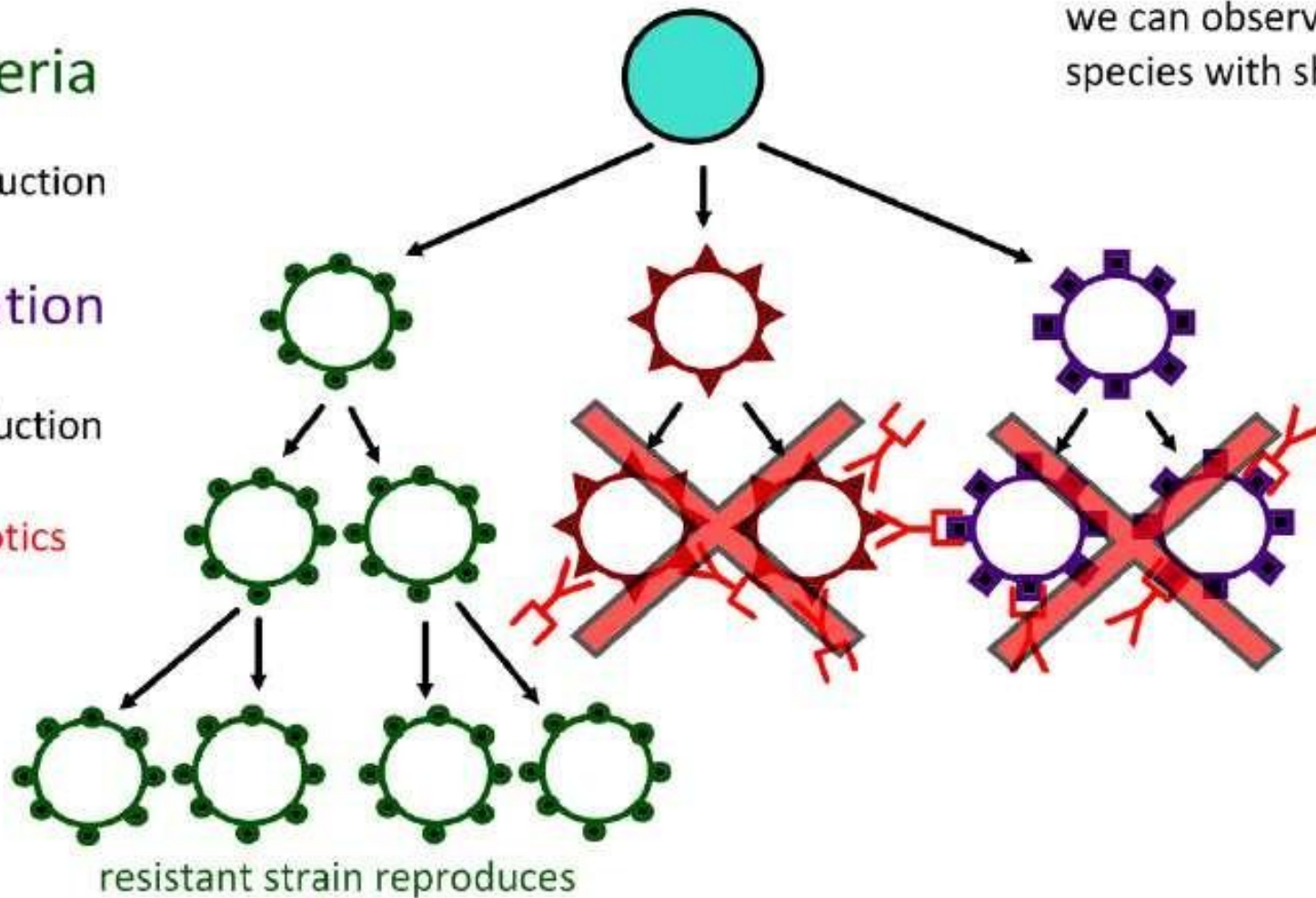
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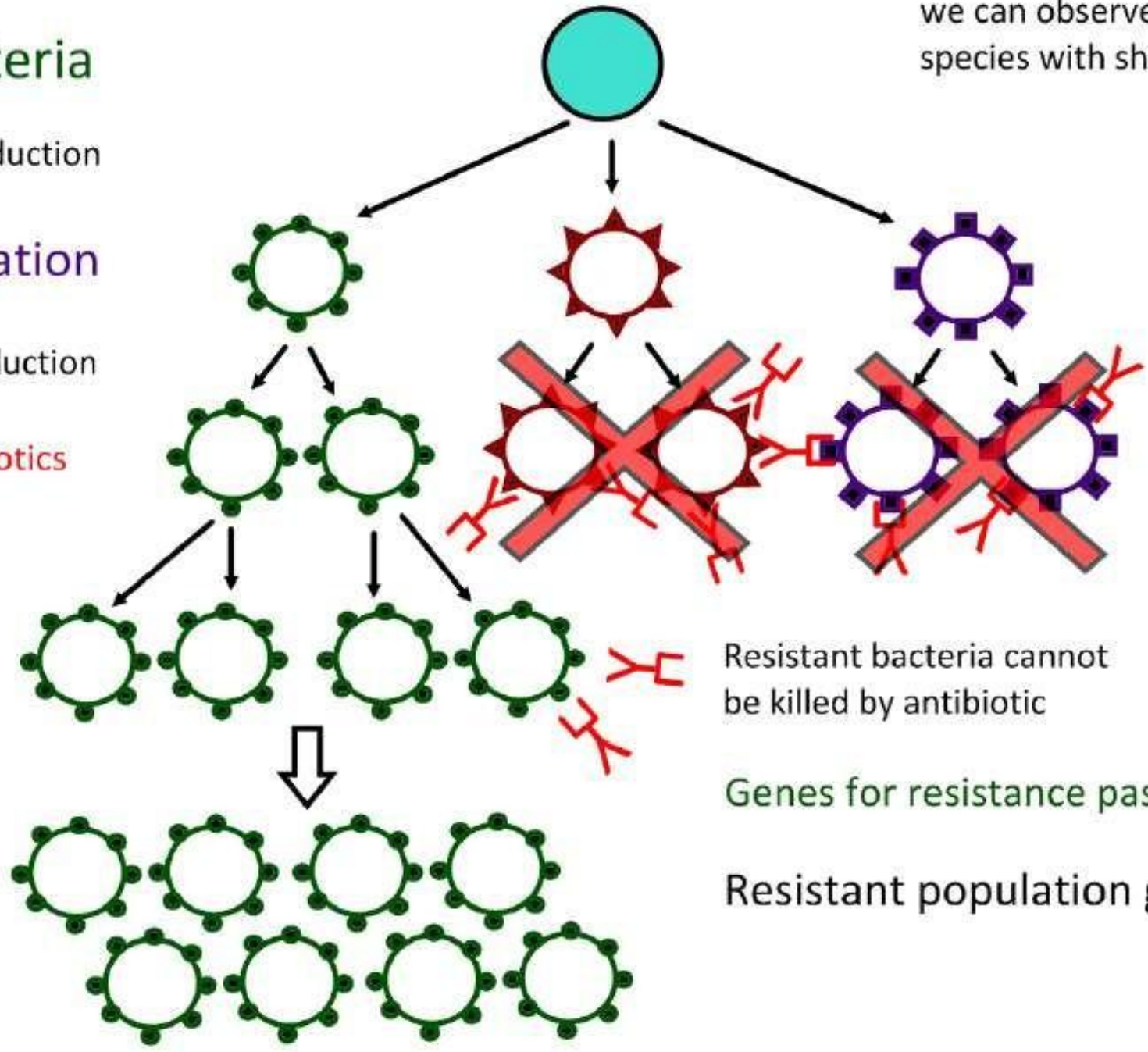
Bacteria

reproduction

Variation

reproduction

Antibiotics



Resistant bacteria cannot be killed by antibiotic

Genes for resistance passed on

Resistant population grows

Antibiotic Resistance: evolution in action

Staphylococcus aureus - bacteria

Variation: **Methicillin-resistant (MRSA)**
Methicillin-susceptible (MSSA)

Environmental change: application of methicillin

Result: **MSSA is killed**
MRSA survives
MRSA reproduces

Resistant gene proliferates

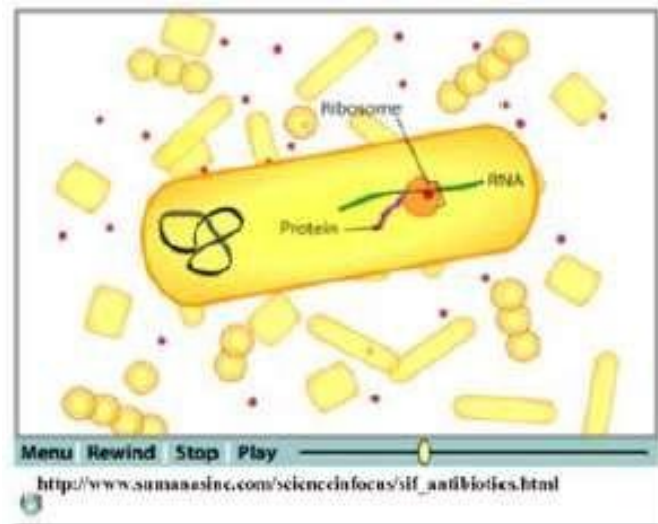


<http://www.nicolewolfart.com/portfolio/Animation/MRSA.html>

MRSA population increases

MRSA is dominant strain

Methicillin is no longer effective against infection



Menu Rewind Stop Play

http://www.summahealth.com/scienceinfocus/sif_antibiotics.html

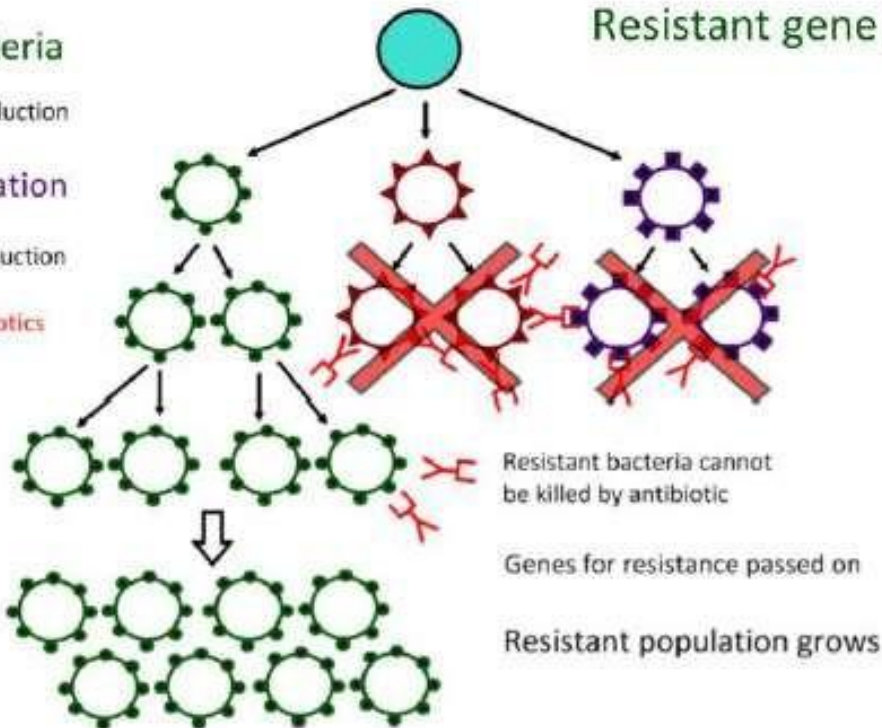
Bacteria

reproduction

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Antibiotics



Bibliography / Acknowledgments

BioNinja

Your one-stop biology resource



[Jason de Nys](#)



[Chris Paine](#)

