Evolution

- Define the term *variation*.
- Discuss the fact that variation occurs within as well as between species.
- Describe the differences between continuous and discontinuous variation, using examples of a range of characteristics found in plants, animals and microorganisms.
- Explain both genetic and environmental causes of variation.
- Outline the behavioural, physiological and anatomical (structural) adaptations of organisms to their environments.
- Explain the consequences of the four observations made by Darwin in proposing his theory of natural selection.
- Define the term *speciation*.
- Discuss the evidence supporting the theory of evolution with reference to fossil, DNA and molecular evidence.
- Outline how variation, adaptation and selection are major components of evolution.
- Discuss why the evolution of pesticide resistance in insects and drug resistance in microorganisms has implications for humans.

What is Variation?

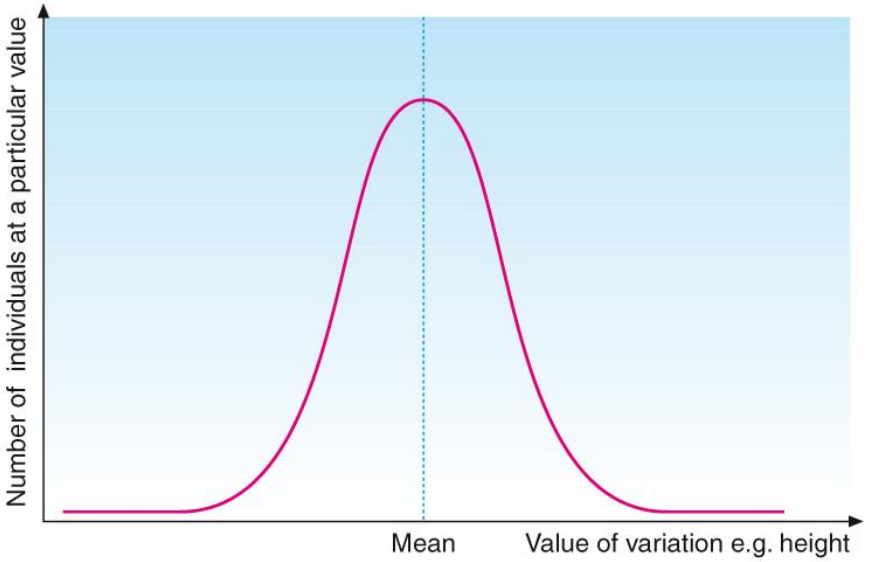
- The differences between individuals.
  - Interspecific variation
    - Variation between different species.
      - Usually obvious.
  - Intraspecific variation
    - Variation between individuals of the same species.
      - Often less obvious.

Two types of variation:

- Continuous
  - Data can take any value.
    - Most individuals have values close to the mean value.
    - Fewer individuals have values at the extremes.
    - Data show a normal distribution.

- Discontinuous
  - Data fall into discrete categories.
    - Individuals may be evenly distributed between the categories or there may be more or one type than another.

Continuous Variation



Discontinuous Variation

Causes of Variation

- Genetic
  - Sheer number of genes.
    - 25000 genes, many having more than one allele.
      - Chances of two individuals with same genome is remote.
  - Meiosis
    - Produces 4 non identical gametes from each cell (Random Assortment).
    - Chiasmata increase variation.
  - DNA Mutations
    - Affect proteins produced and so affect characteristics.
      - Cause new alleles to arise.
  - Random Fertilisation
    - Randomly combining two gametes.

- Environmental
  - External conditions affect growth & development.
    - Eg food availability, living conditions.

Adaptation

- Any variation that helps an organism to survive in its environment.

- Adaptations become selected for over the generations:
  - An individual that is better adapted to its environment is more likely to survive until it passes on its genes to its offspring.

Different types of adaptation

- Behavioural
- Physiological
- Anatomical

Behavioural Adaptations

- Behaviour patterns that increase survival.

- Eg. Woodlice increasing their movement in light & dry conditions but decreasing movement in dark & damp conditions.

Physiological Adaptations

- Variations in biochemistry that help survival.

- Eg. Tanning of skin in conditions of prolonged sunlight to protect against UV radiation.

Anatomical Adaptations

- Structural differences that increase survival.

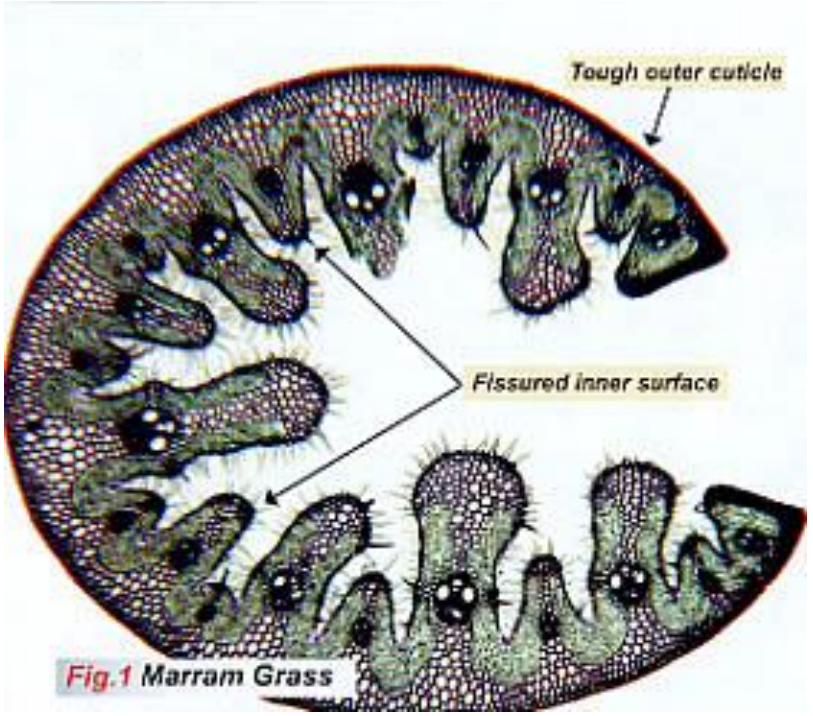
- Eg. Different shaped beaks of birds to help them eat certain types of food.

Adaptations of Xerophytic Plants

- Plants adapted to low water availability.
- Cacti, Marram grass.

Adaptations of Xerophytic Plants

- Behavioural
  - Closing stomata when water is limited.
    - Reduces transpiration.
  - Opening stomata only at night.
    - When air is cool & more humid.
  - Folding/rolling leaves when water is low.
    - Trap moist air in folds to reduce water vapour gradient.



Adaptations of Xerophytic Plants

- Physiological
  - Cells able to store water.
    - Water may be able to be stored for a long time.

Adaptations of Xerophytic Plants

- Anatomical
  - Long but shallow root system.
    - Absorb a lot of water during brief rainfall.
  - Fleshy stems.
    - Water storage.
  - Small leaves.
    - Reduced transpiration.
  - Waxy leaves.
    - Water lost only through stomata.
  - Curled, folded or hairy leaves.
    - Trap moist air in folds to reduce transpiration.

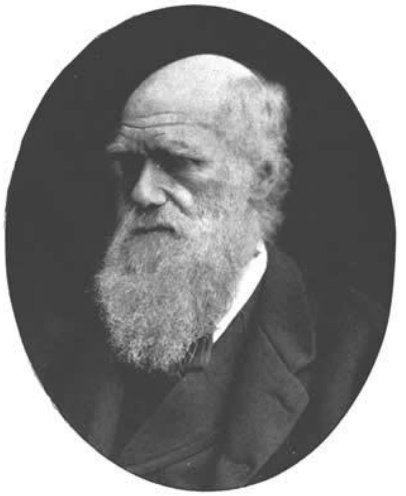
Natural Selection

- When an environmental factor determines which individuals survive and which die.
  - Individuals are selected from the population or undergo selection pressure.

Examples of Natural Selection

- Availability of food
  - Individuals adapted to eat the available food is at an advantage.
- Predators
  - Individuals that avoid being seen or can escape have an advantage.
- Diseases
  - Individuals resistant to diseases have an advantage.
- Physical/Chemical factors
  - Individual able to tolerate extreme environments have an advantage.

Charles Darwin

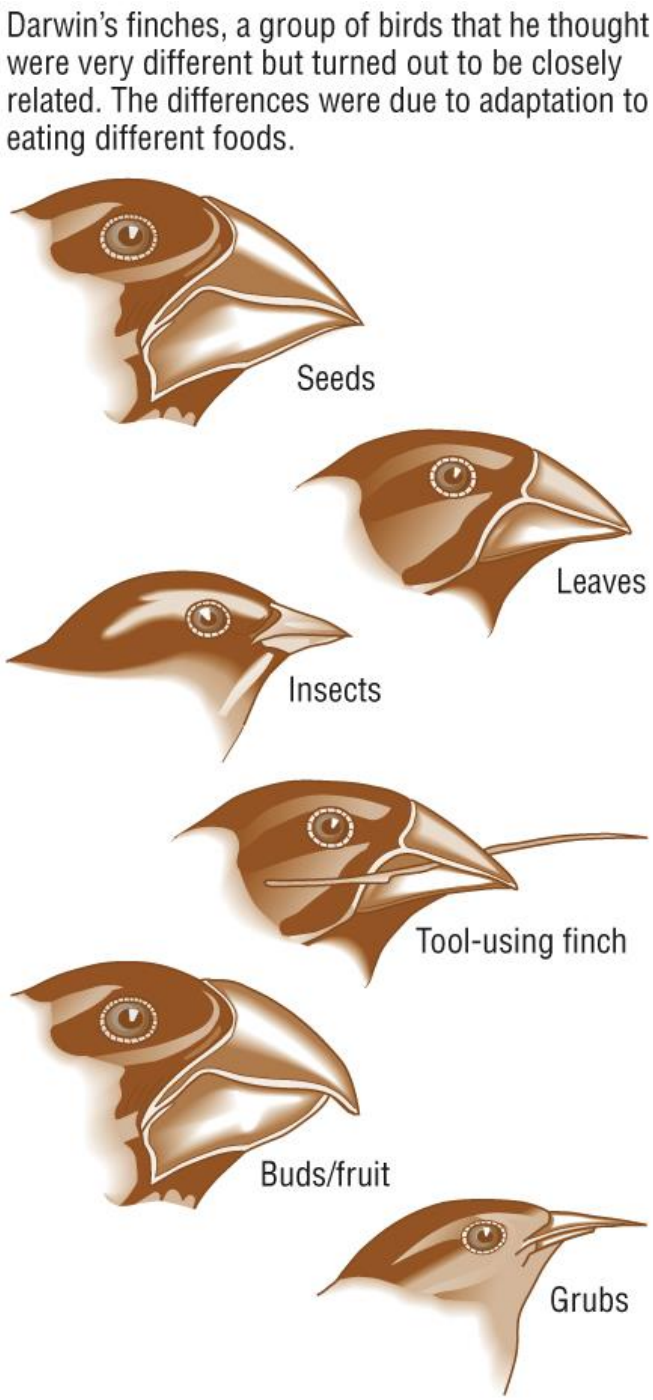


- A naturalist.
- Proposed natural selection as a mechanism for evolution.
  - Evolution was not a new idea – people just didn't know how it happened.

- Darwin's observations led him to some key ideas:

Galapagos Finches

- Darwin observed variation in beak shape between the same species of finches living on the different islands.



Darwin's thoughts

Organisms generally produce a large number of offspring

Yet population sizes remain fairly stable

There is competition between individuals for food & resources

All individuals are different and those that are better adapted to their environment survive & reproduce.

Survival of the fittest.

Only these individuals pass on their characteristics to the next generation

Over time, the population becomes better adapted.

Speciation

- The formation of a new species from an existing one.
  - Via a long, slow accumulation of changes over several generations.
  - A reproductive barrier stops the diverging species from mating with each other.
  - The changes become so great over time that the two species can no longer interbreed.

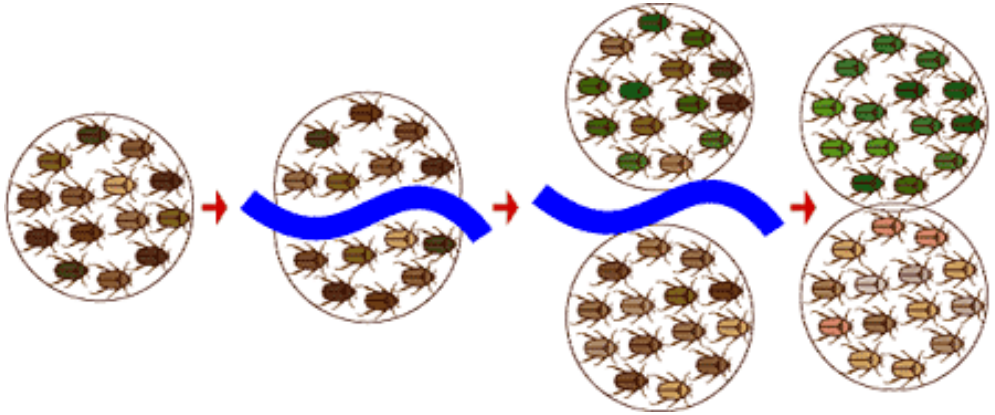
Reproductive Barriers

Geographical Isolation **ALLOPATRIC SPECIATION**

Behavioural, Chemical or Physical Isolation **SYMPATRIC SPECIATION**

Allopatric Speciation

- **Geographical isolation** leads to the splitting of the original population and the creation of two or more distinct gene pools due to the action of natural selection. Interbreeding will not then occur.
  - Eg. Darwin's Finches



Sympatric Speciation

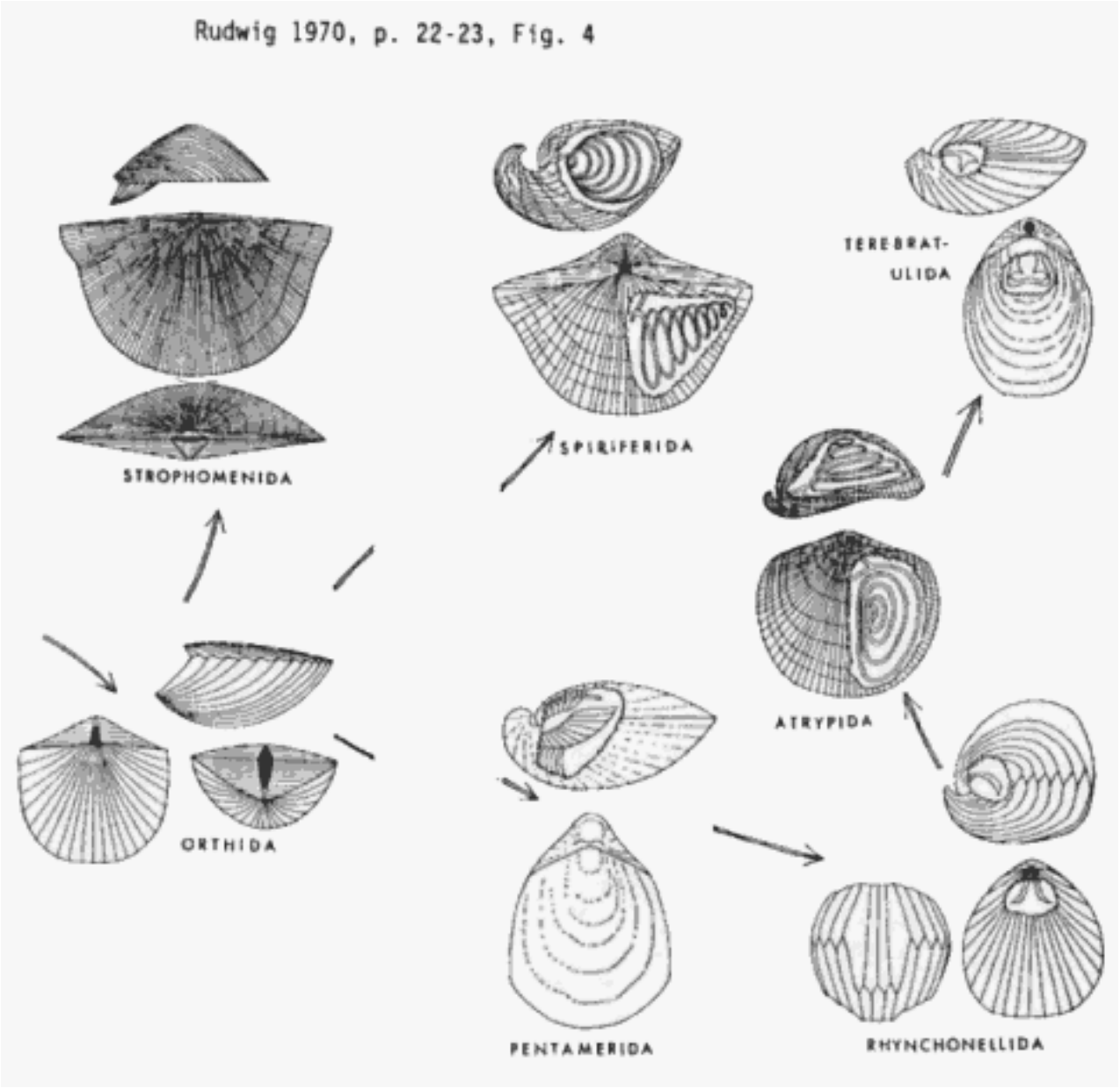
- Different courtship behaviour.
- Living in different habitats of the same area and so do not meet at breeding times.
- Different breeding times.
- Structural differences in sex organs.
- Sperm may fail reach egg or sperm may not fuse with egg.
- Hybrid less viable or fertile than parents.

The Evidence for Evolution

- The fossil record.
- Biological molecules.

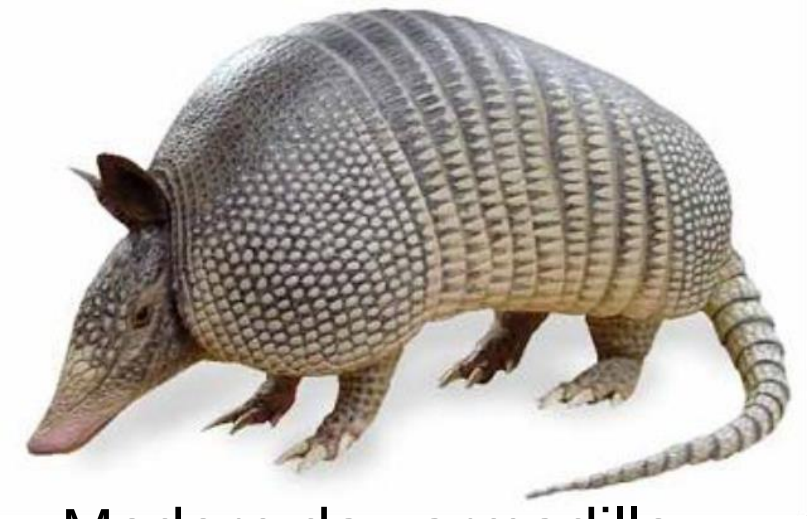
Fossils

- Fossilised brachiopods show small changes over time.
  - Structures becoming more complex

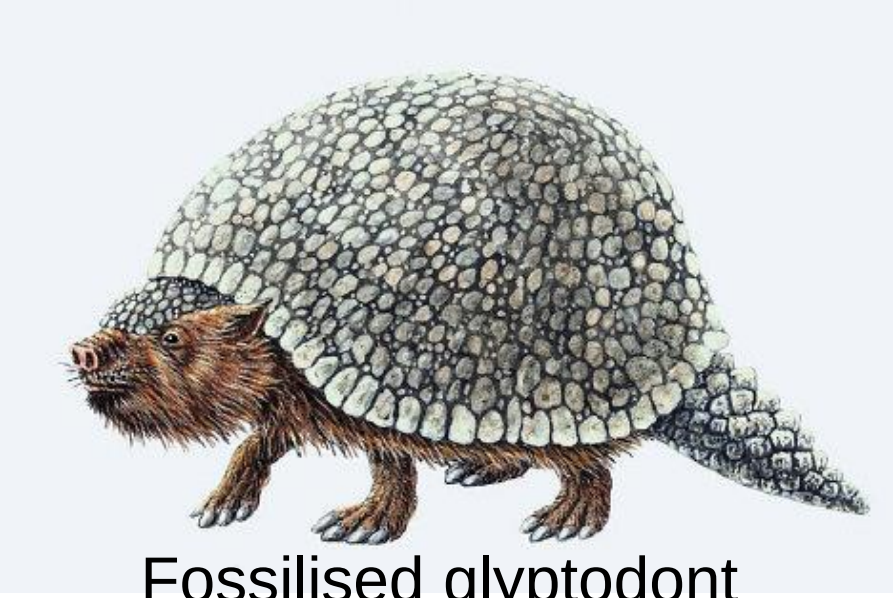


Fossils

- Show many similarities to living species.



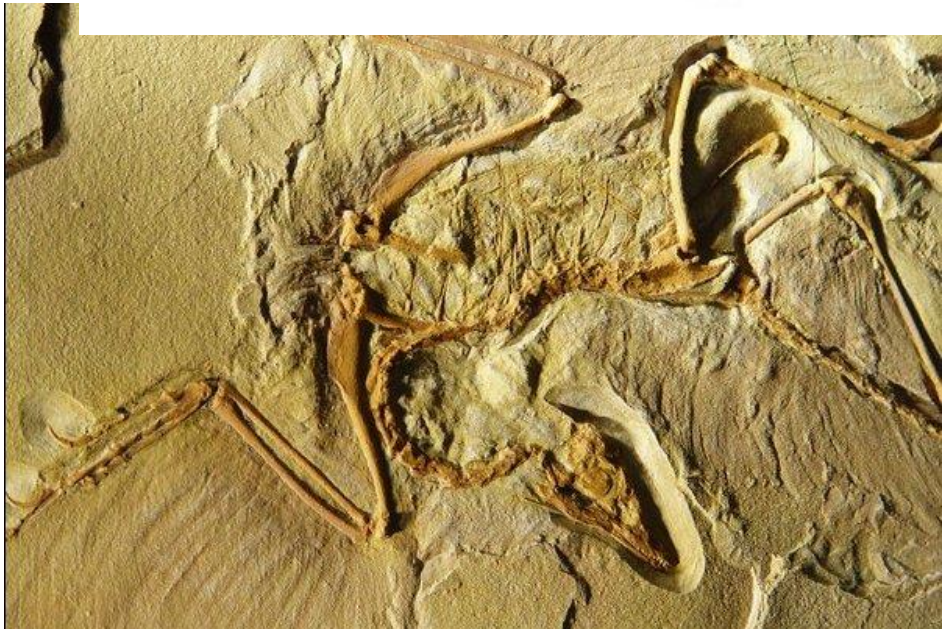
Modern day armadillo



Fossilised glyptodont

Fossils

- Show links between major groups.
  - Archaeopteryx appears to be one of the earliest birds, yet it shows many reptilian features.



Problems with fossils

- Only the hard parts of an organism survive long enough to become fossilised.
  - Many organisms have no hard parts so leave no fossils.
- Fossils only form under certain conditions.
  - Many potential fossils never get the chance to form.
- Many fossils become destroyed by rock movements.

- So the fossil records are not complete – there are many gaps.

Biological Molecules

- Certain molecules are common to all organisms:
  - This is evidence that present-day species evolved from earlier ones.
  - Closely related species separated more recently.
  - Variations in the structure of DNA, Cytochrome c & many Proteins show these patterns.

DNA & Protein Sequencing

- Show that the more closely related two species are, the more similar these molecules are between the two species.
  - Eg.
    - Only 1.2% of Human coding DNA differs from that of the chimp.
    - 1.6% is different from that of the gorilla.
    - ~15% is different from the mouse.

Evolution Today

- If a new selection pressure arises, populations within a species will evolve.
  - Insects have evolved to be resistant to insecticides e.g. *Anopheles* (malarial mosquito)
  - Bacteria have evolved to be resistant to antibiotics e.g. MRSA