

# What is science?

Finding out about the world using the Scientific Method

*The scientific method*

## The scientific method includes:

- Hypotheses
- Predictions
- Data
- Test

*The scientific method*

- Put forward a **hypothesis** with a **prediction** different from that of alternative hypotheses
- Collect **data**
- Check results against the prediction: **refute** either hypothesis or alternatives

*The scientific method*

## Why this method?

- Incredibly successful!
- Excludes bias
- Otherwise: it is VERY easy to make up an explanation after the fact

*Scientific language*

Science	Not science
Hypothesis	<del>Guess</del>
Theory	<del>Truth</del>

**Inference:** sometimes an underlying law or process can be inferred but not directly observed; this is often how a theory is developed.

*Scientific language*

Science	Not science
Hypothesis	<del>Guess</del>
Theory	<del>Truth</del>
Evidence	<del>Proof</del>

only in mathematics!

*Scientific language*

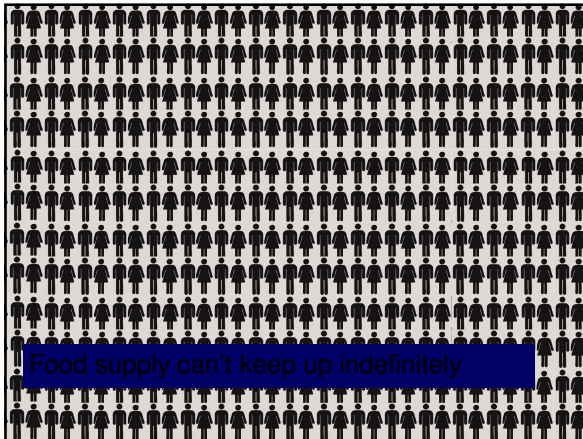
Science	Not science
Hypothesis	<del>Guess</del>
Theory	<del>Truth</del>
Evidence	<del>Proof</del>
support/contradict	<del>prove/disprove</del>

## What is evolution?

The process of genetic change in populations of organisms over time

- ### 4 straightforward observations
1. Fossil records show that life used to be different
  2. Organisms are good at what they do
  3. Organisms multiply in number
  4. Children tend to resemble their parents

**Organisms are good at what they do: "adapted"**

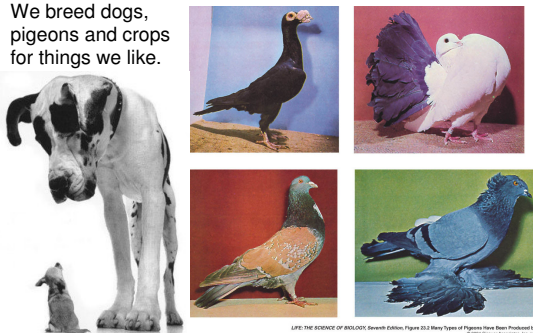



Food supply can't keep up indefinitely

- ### Natural selection
- They can't all survive
  - **Variation** between individuals: some are more likely to survive than others.
  - Some variation is **heritable**, since children tend to resemble their parents
  - Next generation resembles those who did best in previous generation
  - Given time, lots of small changes add up to make large changes

## Artificial selection

We breed dogs, pigeons and crops for things we like.

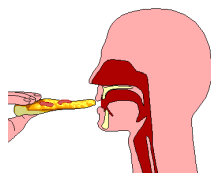


## Key components of evolution

- **Variation** within populations
- **Selection** on this variation (limited resources)
- **Inheritance** of this variation

## Theory of evolution explains other stuff too

- Evolution can't design from scratch: it can only modify what went before
- Sometimes this leads to "bad design"
- When we swallow, we risk choking because our breathing hole is in the way, and needs to be closed off.
- We inherited this bad design from an ancestral lungfish.



## Another example of bad design

- Human nerve cells and retina are the other way around
- This leads to a blind spot, detached retinas, and light distortion by nerves before it hits the retina



Nesse and Williams, Sci. Am. 1998

## Some types of evidence for evolution

1. Fossil record
2. Can find a consistent history or "family tree" of how organisms are related to one another, using both appearance and DNA
3. Biogeography: these trees correspond with what we know about how continents move
4. Some evolution is fast enough to be directly observed eg antibiotic resistance

The theory of evolution makes sense of a huge variety of observations (including geological) that would otherwise seem random, and leads to more experiments.

## Summary: what evolution is

- Variation, selection and inheritance
- Change in a **population** over time
- An explanation for the appearance of design in living things (adaptation)
- An explanation for examples of "bad" design
- The intellectual framework for all of biology

Joanna Masel: What evolution is and what it isn't