
Topic 1

Genes and Evolution

Overview

- The genetic basis
- Evolution by natural selection
- Genes and behavior

Question:

What is more important?

Nature or Nurture?

The genetic basis

- Is it correct to claim that “a violent person has violent genes”?

- **in the 70's**

environment

→ (violent) behavior

- **in the 90's**

genes

→ (violent) behavior

- **today**

genes ↔ environment ↔ (violent) behavior

Source of Similarities and Differences

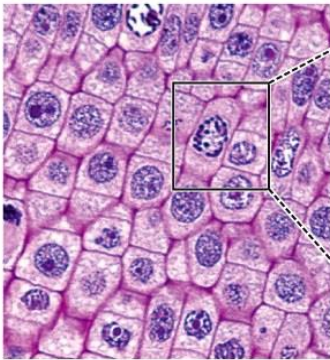
- Similarities such as showing similar emotions, following similar patterns in life
- Differences such as ability to learn math, response to a stressful situation
- Sources of variability in mental processes and behaviors

Nature (genes, biology, heredity....)

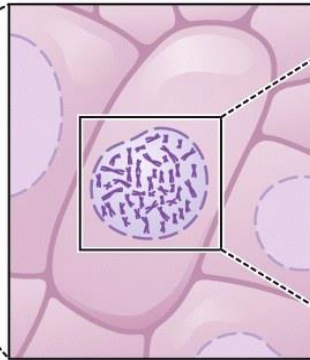
vs

Nurture (experience & learning)

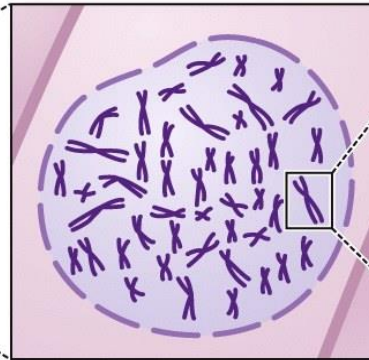
The genetic basis



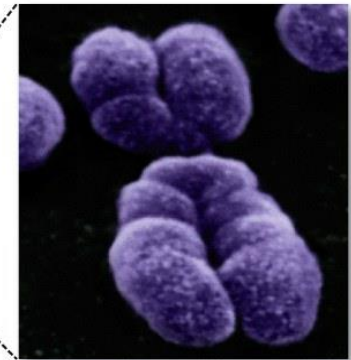
Human skin, shown here at about 200 times its actual size, is made of cells.



Each cell contains a nucleus.

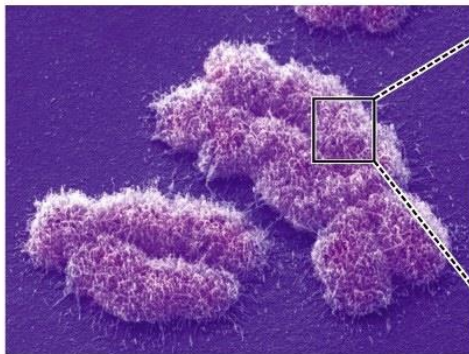


Each human nucleus contains 46 chromosomes.

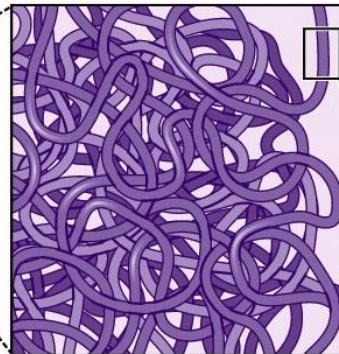


Chromosomes carry instructions for how to build and operate a body.

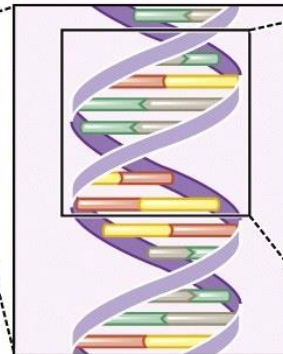
Psychology, 8/e Figure 2.2
© 2011 W. W. Norton & Company, Inc.



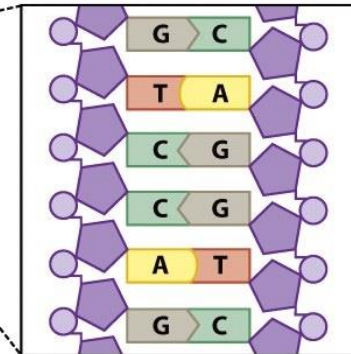
Chromosome



Chromosomes are made up of coiled strands of DNA.



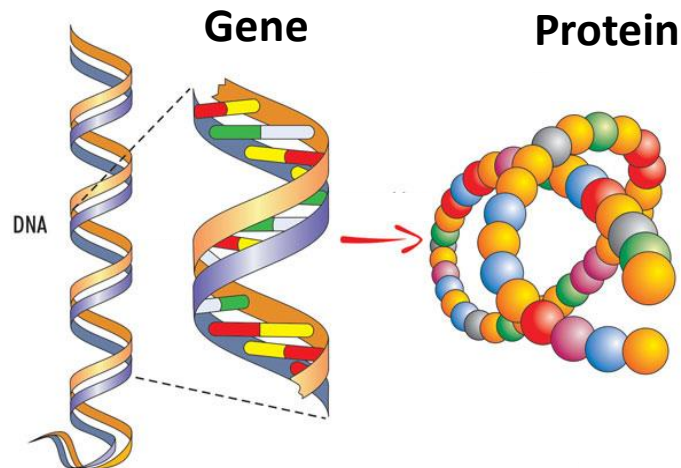
The DNA molecule has a double helix shape.



The rungs of the double helix are made up of complementary chains of adenine (A), thymine (T), guanine (G), and cytosine (C).

Genes: Our Codes for Life

- **Chromosomes** containing **DNA** (*deoxyribonucleic acid*) are situated in the nucleus of a cell.
- **Genes**
 - functional biochemical units of heredity which that make up the chromosomes
 - meaningful sections of the DNA molecule
 - govern the cell's functioning by providing instructions for making proteins

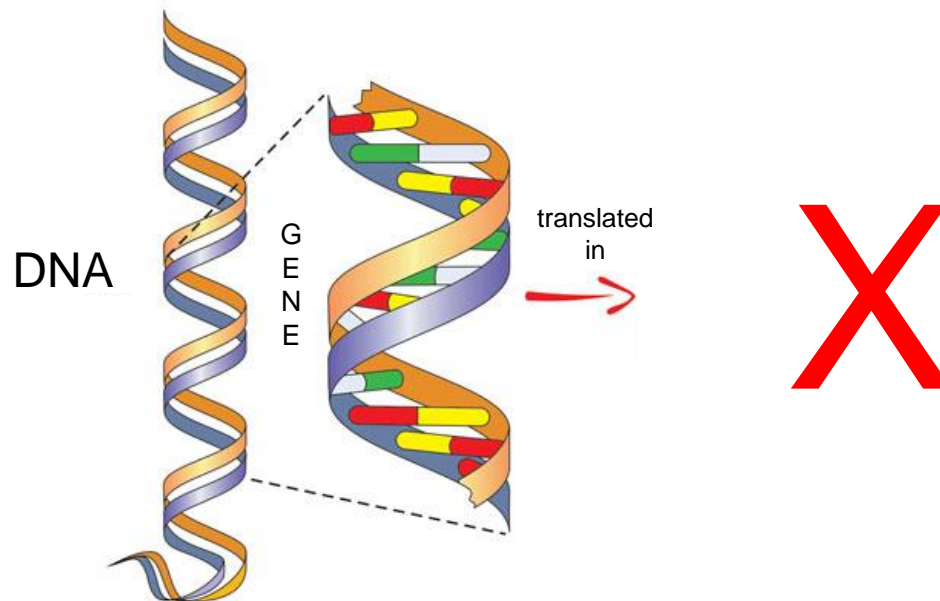


Think:

Our genes predispose our biology; does this mean they determine our behaviors?

The genetic basis

- **Gene expression**
 - whether a gene is turned “on” or “off”
 - the extent to which a gene is transcribed into a sequence of amino acids (protein)



The genetic basis

- **Gene expression (...continued)**
 - In each cell, some genes are expressed at any point in time and others are not.
 - This is controlled by the biochemical environment inside the cell.
 - The biochemical environment inside the cell is influenced by
 - the environment outside the cell
 - timing in development
 - the overall environment
 - experience
 - behavior

Genome

- the set of complete instructions for making an organism.
- It contains all the genes in that organism.
- The human genome makes us human (and the genome for *drosophila* makes it a common house fly).

Molecular Behavior Genetics

- Heredity influences body weight, but there is no single “fatness gene.”
 - “I’m full” gene
 - How many calories your muscles burn gene
 - How much fuel your muscle needs gene
 - ...

≡ Genes typically are not solo players.

The genetic basis

- **Genotype**

- an organism's specific set of genes

- **Phenotype**

- the overt traits and behaviors of an organism
- it is determined by genotype x environment (experience, past, present etc.)

The genetic basis



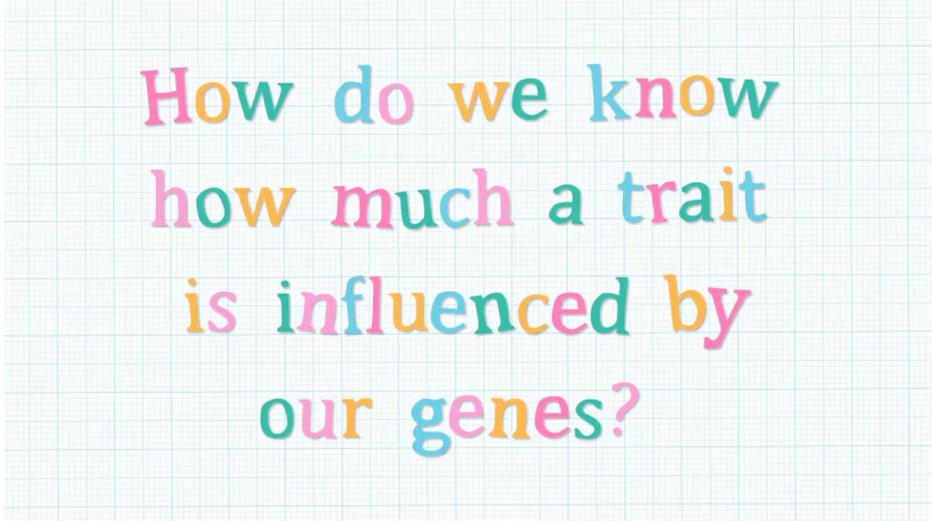
Monozygotic (identical) twins have the same genotype but different environments.



Nature or Nurture: Estimate of Heritability

Study:

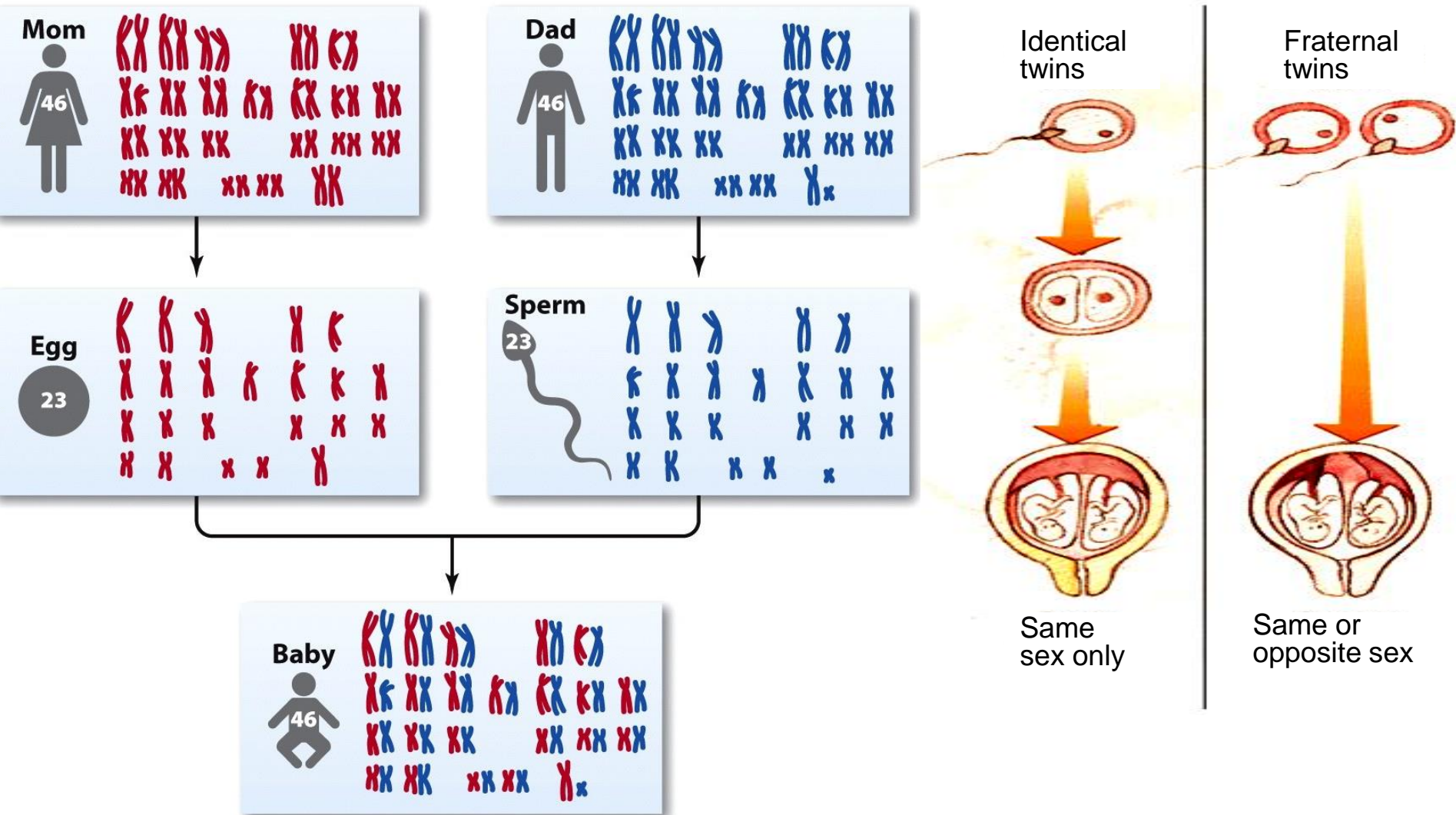
1. Fraternal twins (dizygotic)
2. Identical twins (monozygotic)
3. Adopted children



How do we know
how much a trait
is influenced by
our genes?

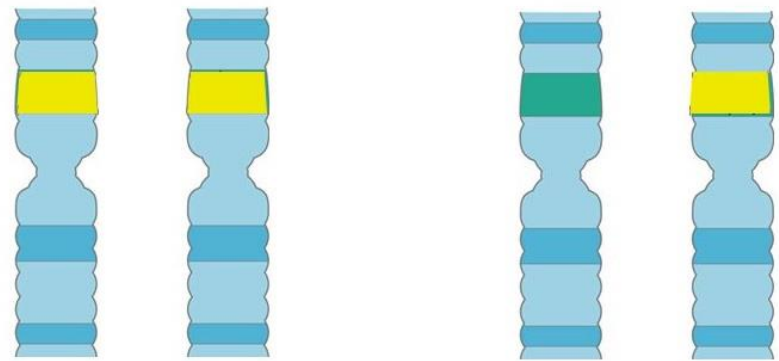
https://www.youtube.com/watch?v=BTYCv1ObZrI&ab_channel=OpenLearnfromTheOpenUniversity

The genetic basis



The genetic basis

- Each gene is paired with another gene.
 - The pairs are located at corresponding positions on pairs of chromosomes.
 - **Allele** is one specific variant of a gene.
 - dominant
 - recessive



Homozygote: alleles
on locus are the same

Heterozygote: alleles
on locus are different

The genetic basis

- A specific trait or behavior is determined by the interaction between the environment (past and present) and
 - one gene pair.
 - multiple gene pairs: polygenetic inheritance.

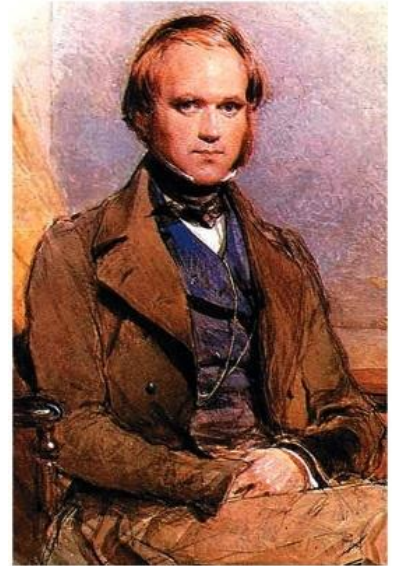
Nature *and* Nurture

Gene-Environment Interaction

- Some human traits are fixed, such as having two eyes.
- However, most psychological traits are liable to change with environmental experience.
- Genes and environment affect our traits individually, but more important are their **interactive effects**.

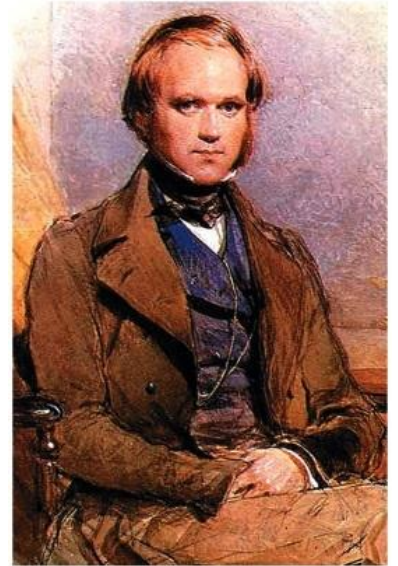
The genetic basis

- Where do our parent's sets of genes come from?
 - from their parents
 - and theirs?
 - from their parents
 - and theirs?
 - from their parents etc. etc. etc. etc.
- The genome is shaped by evolution over the years -> Darwin's evolution theory



Evolution by natural selection

- Charles Darwin hypothesized that all modern organisms
 - are descended from a small set of shared ancestors.
 - have merged over time through the process of evolution.



Evolution by natural selection

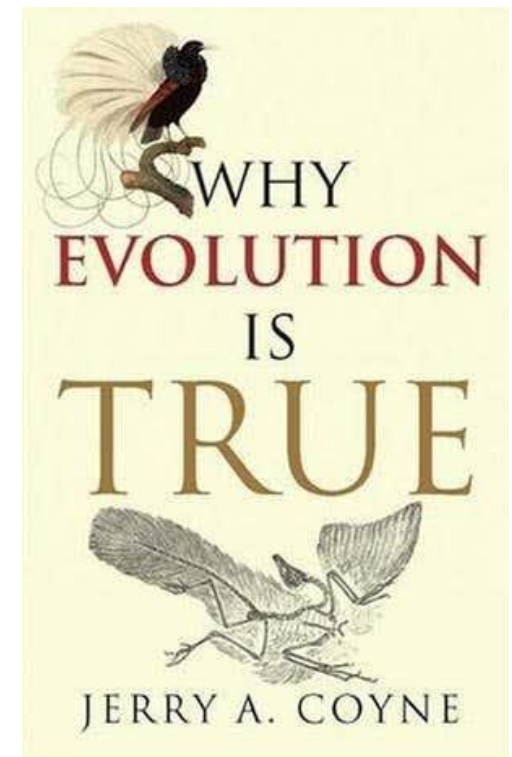
- The key mechanism of evolution is natural selection.
 - Three conditions
 - There is variation among individuals of a populations
 - Individuals with a certain trait survive and reproduce at higher rates than others
 - The trait associated with this advantage is passed from parents to offspring
 - Specific traits will be better represented in the next generation.

Evolution by natural selection

- Organisms differ in genotype and variations in genotype are passed from generation to generation.
- What matters is the survival of genes, **not** the survival of individuals.

Evolution by natural selection

- The evidence for modern evolutionary theory comes from many sources
 - The fossil record

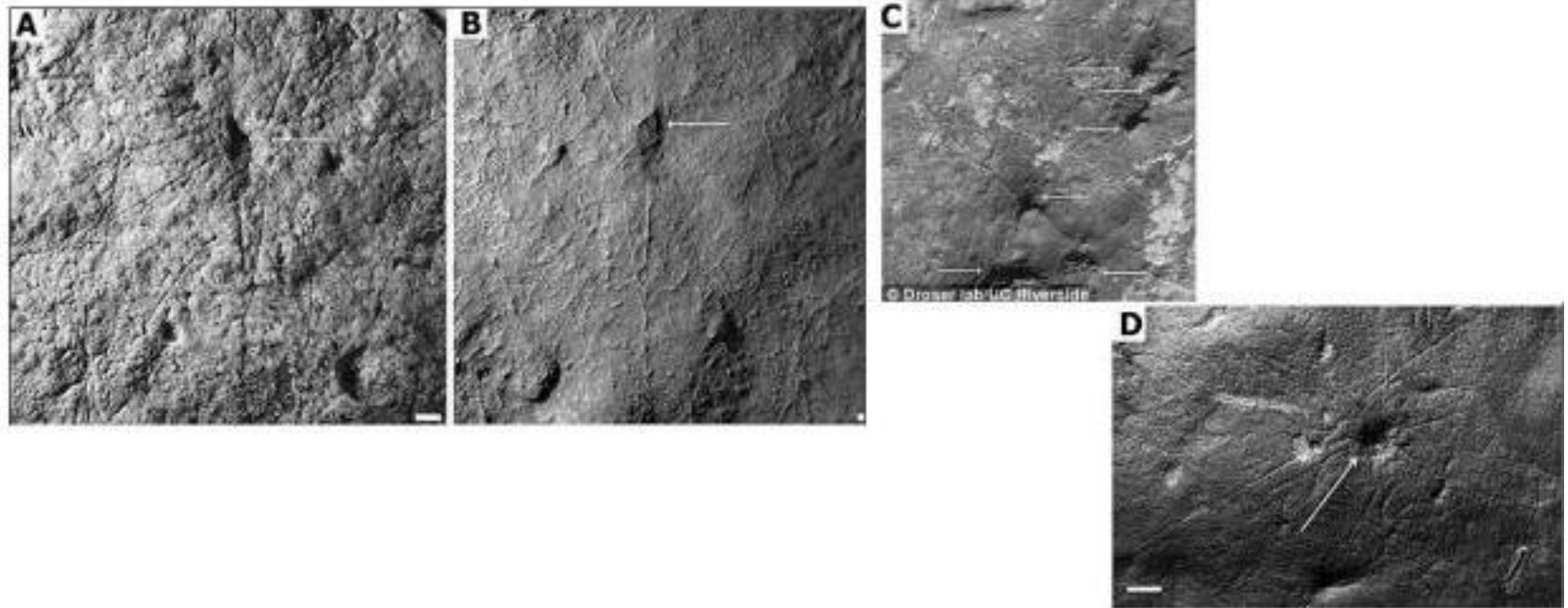


Evolution by natural selection

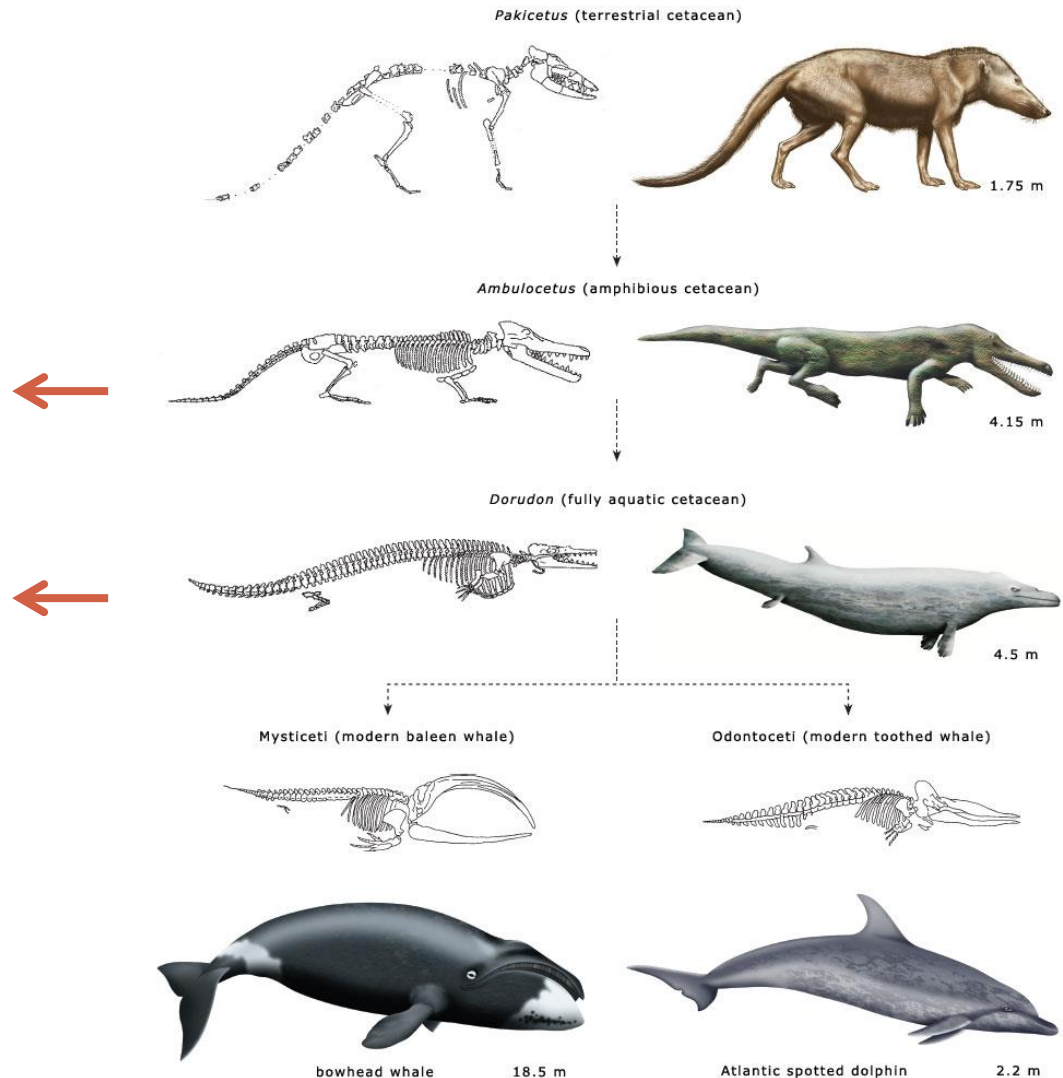
At between 550 and 560 million years old, an animal discovered in South Australia recently is the oldest with a skeleton ever found.

The organism, called *Coronacollina acula*, was found by a team from the University of California.

The finding provides insight into the evolution of life – particularly, early life – on the planet, why animals go extinct, and how organisms respond to environmental changes.



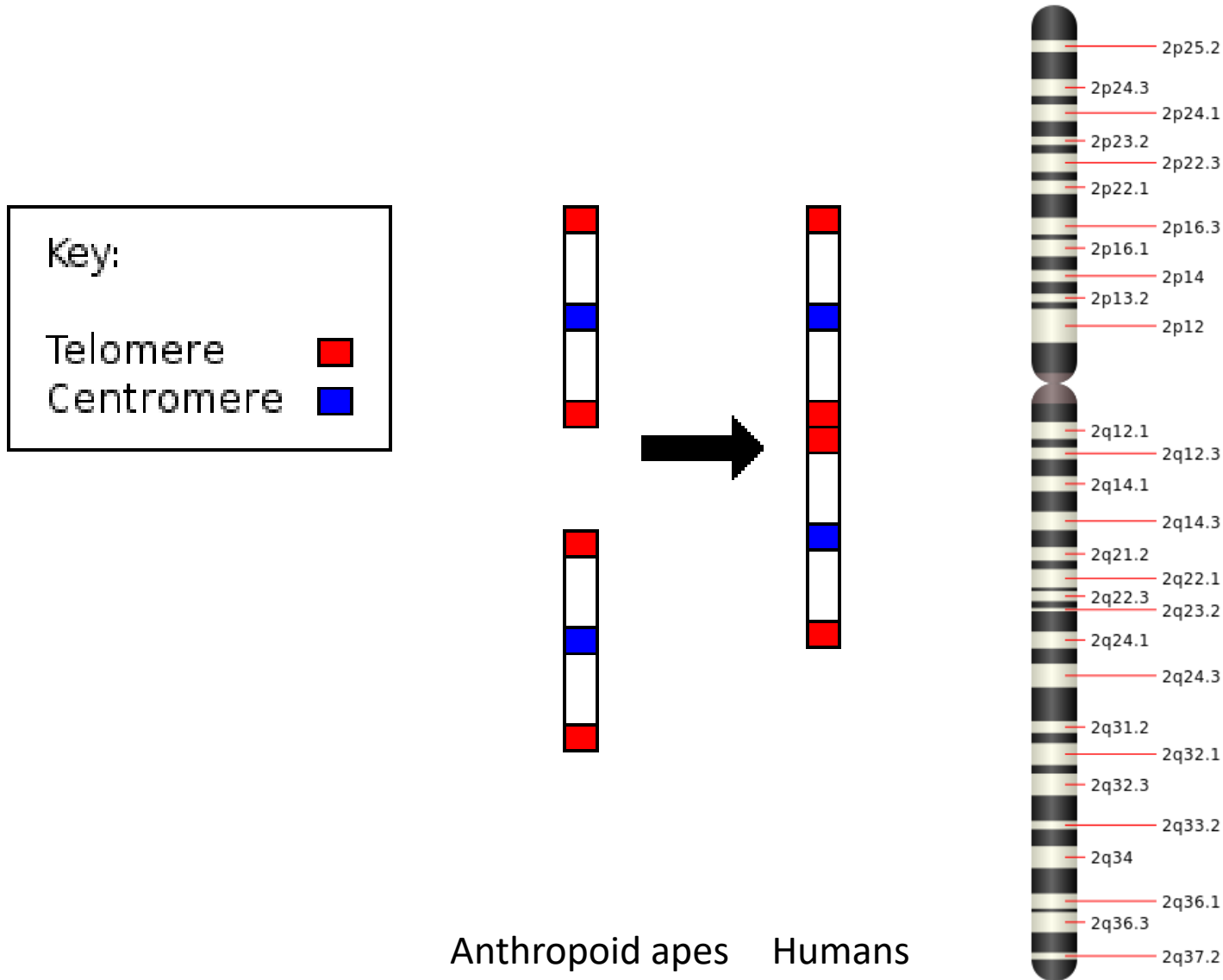
Evolution by natural selection



Evolution by natural selection

- The evidence for modern evolutionary theory comes from many sources
 - the fossil record
 - the resemblance between genomes of various organisms

Evolution by natural selection



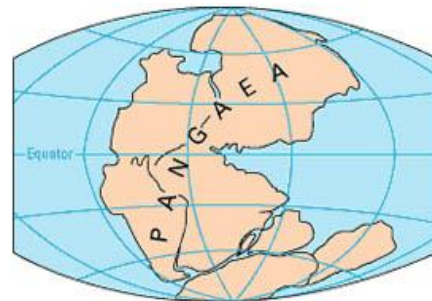
Evolution by natural selection

- The evidence for modern evolutionary theory comes from many sources
 - the fossil record
 - the resemblance between genomes of various organisms
 - pseudogenes

Evolution by natural selection

- The evidence for modern evolutionary theory comes from many sources
 - the fossil record
 - the resemblance between genomes of various organisms
 - pseudogenes
 - distribution of species across the world
 - Continental islands versus oceanic islands

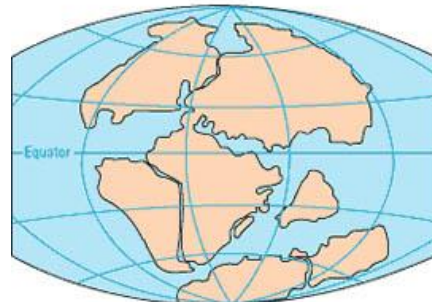
Evolution by natural selection



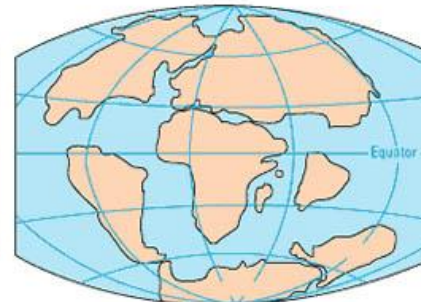
PERMIAN
225 million years ago



TRIASSIC
200 million years ago



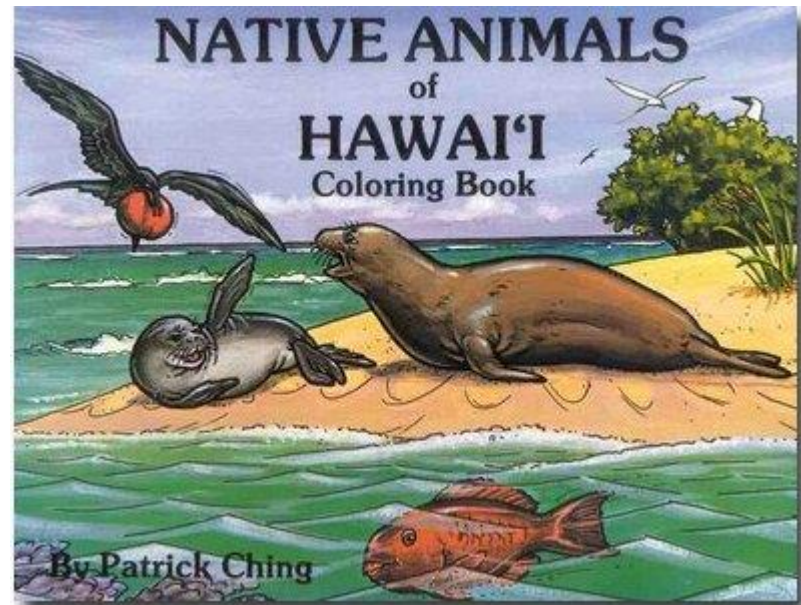
JURASSIC
135 million years ago



CRETACEOUS
65 million years ago



Evolution by natural selection

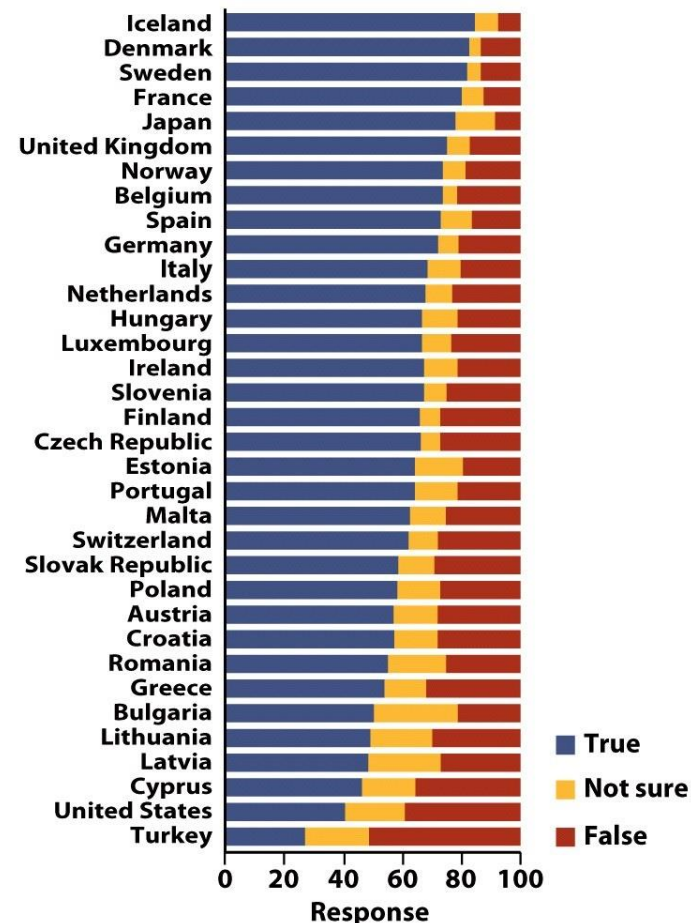


Evolution by natural selection

- Despite overwhelming evidence, many people remain skeptical about the theory of evolution.

Results of a survey (2005):

“human beings, as we know them, developed from earlier species of animals.”



Evolution by natural selection

- Despite overwhelming evidence, many people remain skeptical about the theory of evolution.

The New York Times

BOARD FOR KANSAS DELETES EVOLUTION FROM CURRICULUM

By PAM BELLUCK AUG. 12, 1999

The Kansas Board of Education voted yesterday to delete virtually any mention of evolution from the state's science curriculum, in one of the most far-reaching efforts by creationists in recent years to challenge the teaching of evolution in schools.

While the move does not prevent the teaching of evolution, it will not be included in the state assessment tests that evaluate students' performance in various grades, which may discourage school districts from spending time on the subject.

Evolution by natural selection

- Despite overwhelming evidence, many people remain skeptical about the theory of evolution.

Science

Is Holland Becoming the Kansas of Europe?

Martin Enserink

AMSTERDAM—Well, not quite Kansas—after all, this is the country that legalized euthanasia and invented gay marriage. But when science and education minister Maria van der Hoeven recently announced plans to stimulate an academic debate about “intelligent design” (ID)—the movement that believes only the existence of a creator can explain the astonishing complexity of the living world—she triggered an uproar not unlike that raging in the sunflower state.

Prominent biologists have denounced Van der Hoeven, a member of the Christian-Democratic Party and a Catholic, for blurring the line between church and state. Last week, she faced a barrage of hostile questions in the House of Representatives of the Dutch Parliament, where she was compared to the Kansas school board members who want to introduce ID in the classroom. “Does she want to go back to the Dark Ages?” the usually sober daily *NRC Handelsblad* lamented in an editorial. The minister has called the issue a “storm in a teacup” and claims she has been misunderstood.

June 3, 2005

Evolution by natural selection

- Despite overwhelming evidence, many people remain skeptical about the theory of evolution.



New wave of anti-evolution bills hit states

BY REID WILSON - 01/27/17 11:48 AM EST

New legislation introduced in a handful of states would allow alternatives to the theory of evolution to be taught in classrooms, the latest wave of measures backed by religious conservatives targeting broadly accepted scientific curriculum.



The measures could also allow teachers to question whether humans are contributing to climate change, something widely accepted by the scientific community.

South Dakota's Senate this week approved a measure that prohibits school boards from preventing teachers from questioning established scientific theories. Similar bills are making their way through legislatures in Oklahoma and Indiana.

The bills represent something of an evolution themselves: They do not specifically mention creationism or intelligent design, two alternatives to evolution theory advanced by religious conservatives. Instead, they allow teachers to address the "strengths and weaknesses" of material being taught to students.

Evolution by natural selection

- Despite overwhelming evidence, many people remain skeptical about the theory of evolution.

The screenshot shows the Education Week website header with the date July 11, 2019, and navigation links for LOGIN, REGISTER, and SUBSCRIBE. Below the header is a navigation bar with a dropdown menu for 'Browse archived issues', a link to 'Current Issue', and links for TOPICS, BLOGS, and REPORTS & DATA. The main content area features the section 'NEWS IN BRIEF' and the article title 'Arizona's Final Science Standards Restore Evolution, Climate Change' dated October 30, 2018. The article text states that Arizona's school board approved new science and history standards, capping a tumultuous few months of policymaking. A red oval highlights the sentence: 'The final draft restores language related to the teaching of evolution and climate change, some of which had been removed or weakened in earlier versions of the science standards. Now, among other references, it requires students to "gather and communicate evidence on how the process of natural selection provides an explanation of how new species can evolve," language that the Arizona Science Teachers Association had urged the board to restore.' To the right of the article text is a sidebar titled 'ARTICLE TOOLS' with links for 'Printer-Friendly', 'Email Article', 'Reprints', and 'Comments'.

July 11, 2019

EDUCATION WEEK

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NEWS IN BRIEF

Arizona's Final Science Standards Restore Evolution, Climate Change

October 30, 2018

Arizona's school board last week approved new science and history standards, capping a tumultuous few months of policymaking.

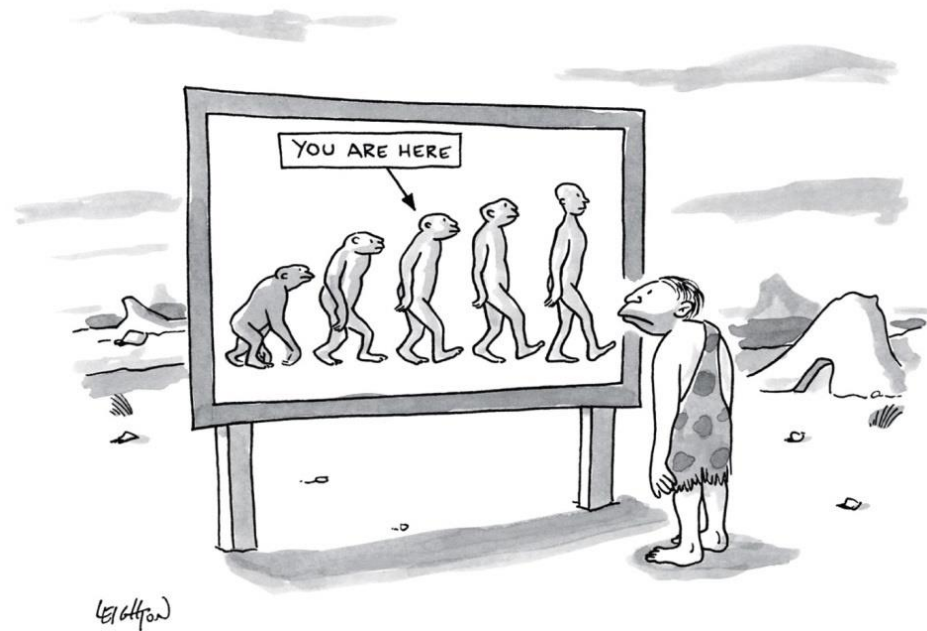
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ARTICLE TOOLS

- Printer-Friendly
- Email Article
- Reprints
- Comments

Evolution by natural selection

- It does **not** follow that evolution
 - somehow improves organisms
 - can only lead to rigid behavioral patterns



Genes and behavior

- Nature (genes) versus Nurture (environment)
 - The nature nurture debate has become increasingly irrelevant.
- Instead, there is a continuous interaction between genes and environment!

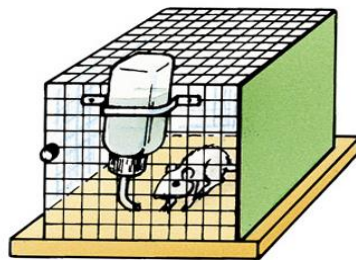
Evolution through natural selection means:

- a) Individuals undergo changes in their genes during their lifespan.
- b) Populations getting new characteristics or losing old ones after at least one generation.
- c) It is exclusively the change of one species to another.

Experience and Brain Development

Early postnatal experiences affect brain development.

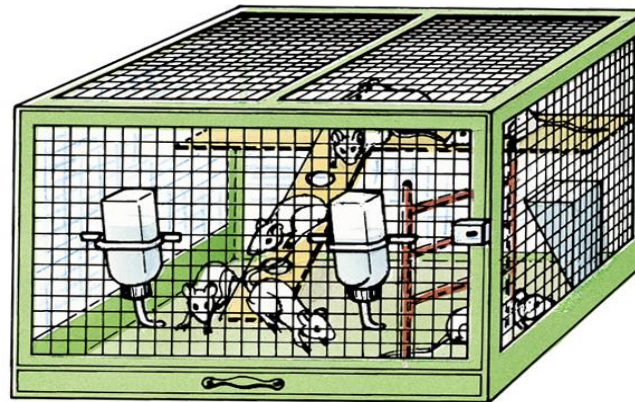
Rosenzweig et al. (1984) showed that rats raised in enriched environments developed thicker cortices than those in impoverished environment.



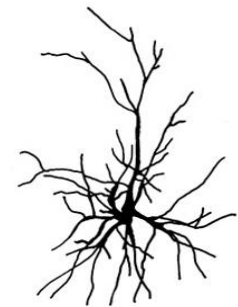
Impoverished environment



Impoverished rat brain cell



Enriched environment



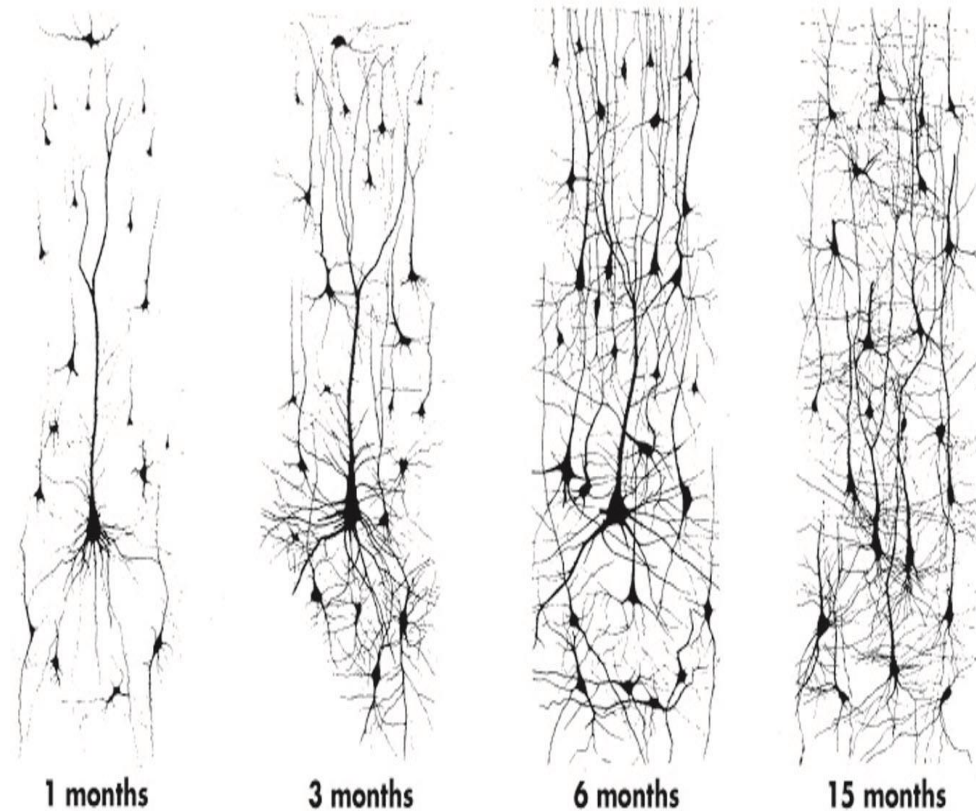
Enriched rat brain cell

Early Stimulation is Critical

The human brain at birth contains most of the neurons it will ever have.

However, it will form new neural connections with experience.

Neural pathways that are not used will disappear.



Early Stimulation is Critical

- Effects of prolonged deprivation
 - Species-universal experiences are required for fine-tuning neural connections.
 - Example: Romanian orphans
- When expected experiences lack in sensitive periods, then the brain will fail to develop normally.



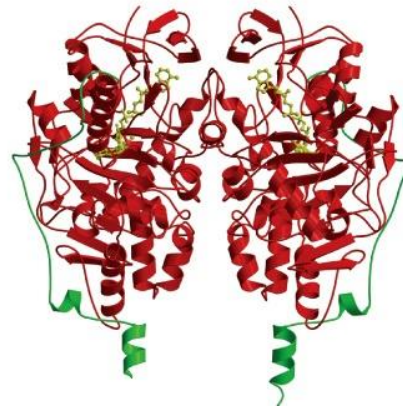
Genes and behavior

- Who we are is determined by how our genes are expressed in distinct environments

HYPOTHESIS: The MAOA gene regulates enzyme monoamine oxidase (MAO) and may be important in determining susceptibility to the effects of maltreatment, because low levels of MAO have been implicated in aggressive behaviors.

RESEARCH METHOD:

- 1 A group of more than 1,000 New Zealanders were followed from birth to adulthood.
- 2 Researchers measured which children were mistreated by their parents (**nurture**).
- 3 Researchers measured the presence of the MAOA gene, which comes in two forms. One form leads to higher levels of MAO, and the other form leads to lower levels (**nature**).



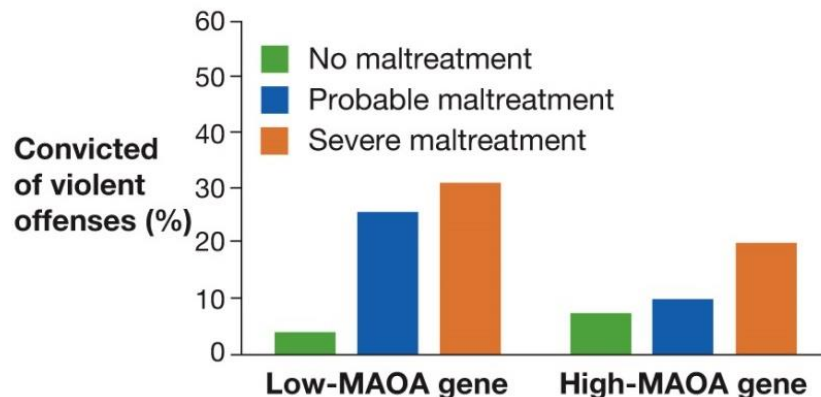
Genes and behavior

- Who we are is determined by how our genes are expressed in distinct environments

4 Researchers measured the tendency toward criminal behavior.



RESULT: Those who had the MAOA gene for low MAO activity were much more likely than others to have been convicted of violent crimes if they had been maltreated as children. The effects of maltreatment had less influence on those with the high-MAOA gene.



CONCLUSION: Nature and nurture can work together to affect human behavior.

SOURCE: Caspi, A., McClay, J., Moffit, T. E., Mill, J., Martin, J., Craig, I. W., et al. (2002). Role of genotype in the cycle of violence in maltreated children. *Science*, 29, 851–854.

Genes and behavior

- Is it correct to claim that “a violent person has violent genes”?

genes \longleftrightarrow environment \longleftrightarrow (criminal) behavior

MAOA allele for low MAO activity \longleftrightarrow severe maltreatment \longleftrightarrow higher probability of being convicted of violent crimes

Reflections on Nature and Nurture

Biological influences:

- Shared human genome
- Individual genetic variations
- Prenatal environment
- Sex-related genes, hormones, and physiology

Psychological influences:

- Gene-environment interaction
- Neurological effect of early experiences
- Responses evoked by our own temperament, gender, etc.
- Beliefs, feelings, and expectations

```
graph TD; A[Biological influences] --> D[Personal development]; B[Psychological influences] --> D; C[Social-cultural influences] --> D;
```

Personal development

Social-cultural influences:

- Parental influences
- Peer influences
- Cultural individualism or collectivism
- Cultural gender norms