

Lecture 2: From Selective Breeding, Mendelian Genetics to Eugenics

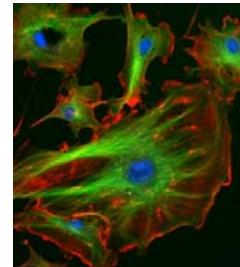
Genes & Society
LSM1302 / GEK 1527

The ‘scientificisation’ of the humanities,
and the humanization of the sciences
—we should have this two-way flow.

-Catherine Lim
(author & political commentator)

The test of a first-rate intelligence is the ability to hold two opposed ideas in the mind at the same time, and still retain the ability to function.

– F. Scott Fitzgerald (Novelist; Poet)



Overview



Timeline

Ancient Time
(30K-5K BC) to
Present Time

1850s

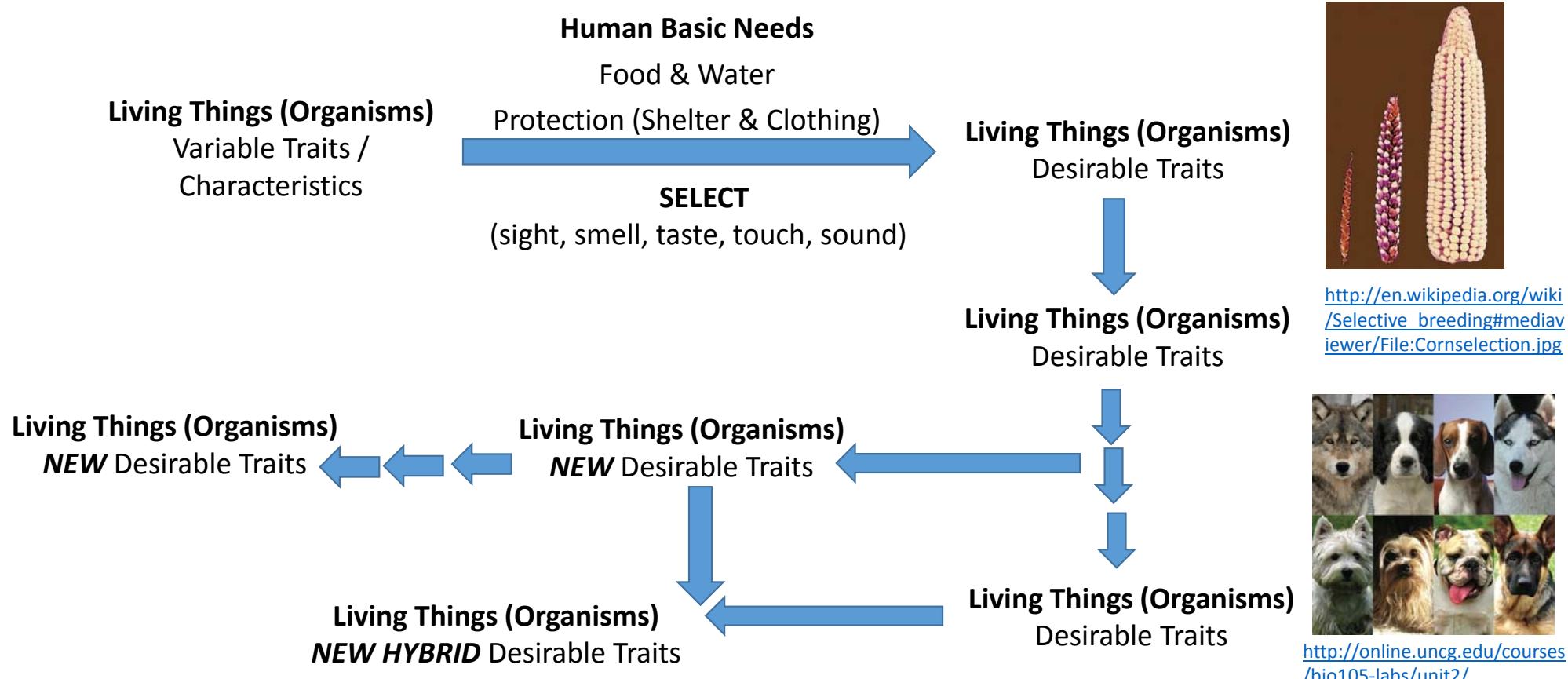
1860s

1880s-present

Outline

- Traditional ‘biotechnology & genetics’ in the form of selective breeding (artificial selection)
- Origin of species by natural selection (Theory of Evolution)
- Origin of genetics
- Eugenics

Traditional Genetics & Biotechnology: Selective Breeding

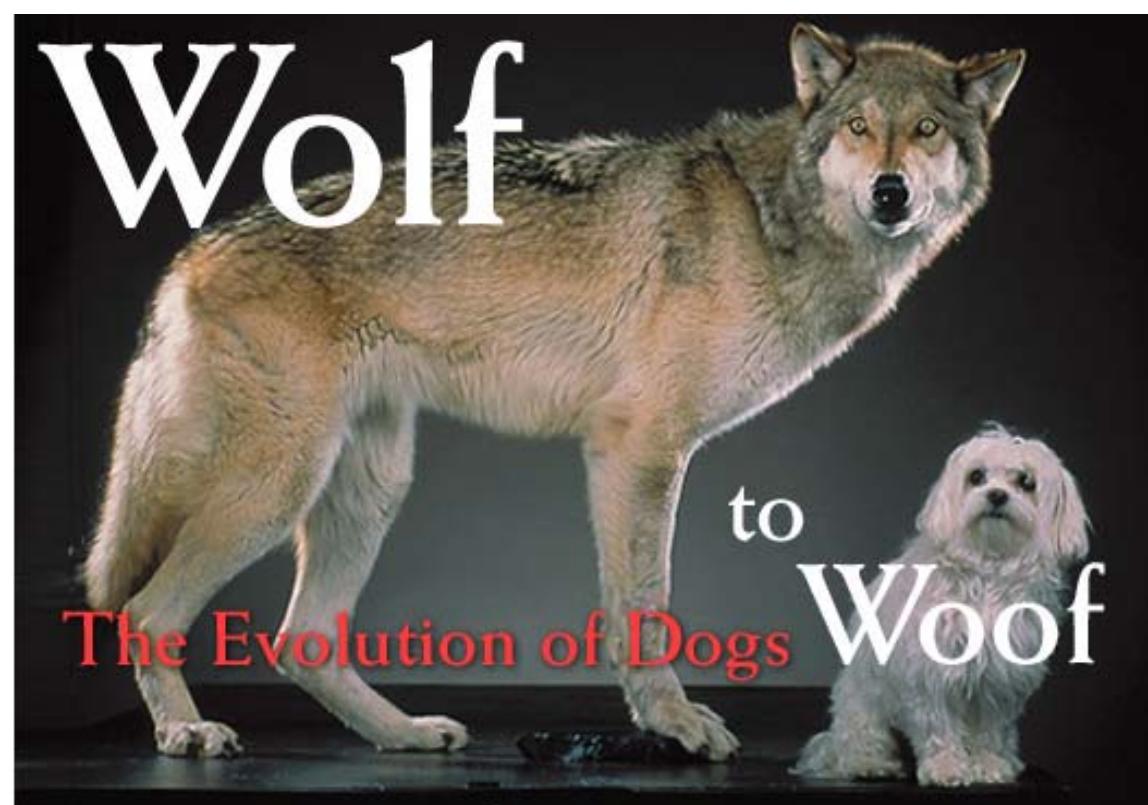


Selective breeding

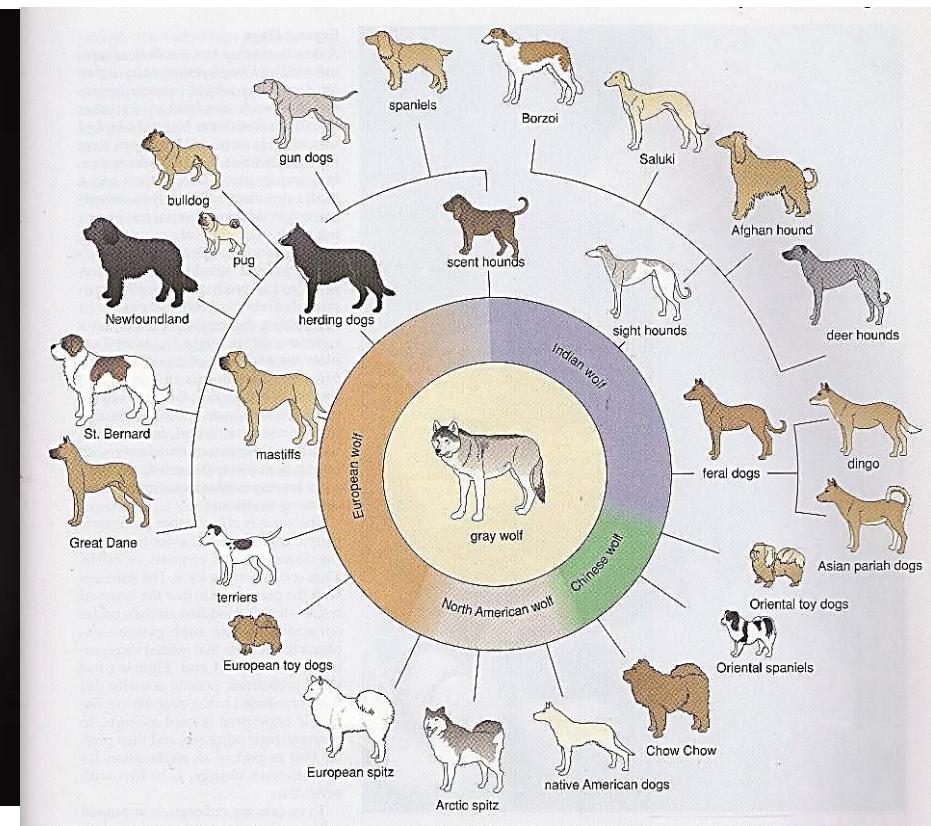
- In this process, a phenotype (trait/characteristic) is chosen and individuals with this phenotype are used for further breeding.
- Phenotype: The observable physical or biochemical characteristics of an organism as determined by both genetic make-up and environmental influences. ('Pheno' in Greek: to show, to appear, or to display; making evident; literally, "to come to light" or "to bring to light").
- If this characteristic is inheritable, i.e. determined by specific gene(s) – the genotype (the gene(s) encoding that characteristic) will get passed on to the off-spring.
- Genotype: The genetic constitution or genetic make-up that determine a specific phenotype in an individual/organism. It can refer to a specific gene or combination of many genes. ('Geno' in Greek: race, kind, line of descent, birth, origin).
- Carefully controlled selective breeding is responsible for many of the collective changes associated with plant & animal domestication.



Selective breeding of Animals: From Wolves to Dogs



http://ngm.nationalgeographic.com/ngm/data/2002/01/01/html/ft_20020101.1.html



<http://lib.znate.ru/docs/index-27507.html>

How did wolves become dogs?

<https://www.youtube.com/watch?v=n04VhzQlcrM>

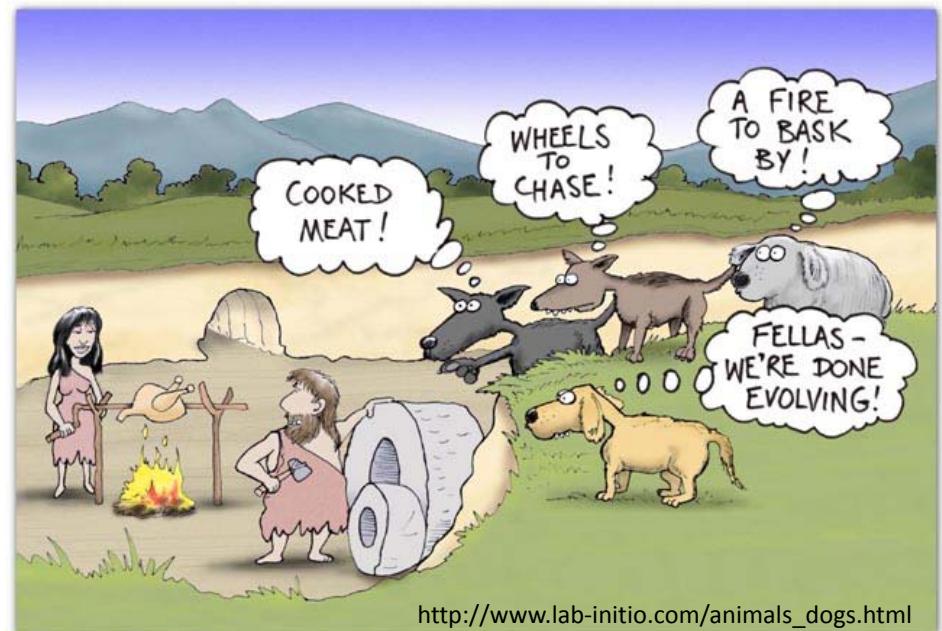
<http://online.uncg.edu/courses/bio105-labs/unit2/>

Humans approach Dogs Hypothesis: Humans adopted wolf pups by selecting or favoring those less aggressive and better at begging for food.



<http://phenomena.nationalgeographic.com/2013/01/23/people-and-dogs-a-genetic-love-story/>

Dogs approach Humans hypothesis: Dogs domesticated themselves by adapting to a new niche—human refuse dumps. Scavenging canids that were less likely to flee from people survived in this niche, and succeeding generations became increasingly tame.



http://www.lab-initio.com/animals_dogs.html

Forget the experts: domestication of the dog only took about 8 seconds.

What was the important trait selected for?



<http://burnspet.co.uk/petcare/burns-pet-nutrition-advice/evolution.html>

HOW GENE CHANGES DOMESTICATED DOG

Domestication of dogs started at least 10,000 years ago



DOGS AND WOLVES BELONG TO THE CANIDAE FAMILY

- Morphological differences between wolves and dogs
- Reduced skull
- Reduced teeth
- Reduced brain size

- Behavioural differences between wolves and dogs
- Dogs are less aggressive than wolves
- Dogs have altered social cognition capabilities

STARCH BREAKDOWN HAPPENS IN 3 STAGES

- 1 Starch broken down to maltose and oligo-saccharides

- 2 Oligosaccharides broken down to glucose

- 3 Glucose transported into cells

Selection was at 3 genes with key roles in starch digestion



Ability to digest starch was in response to rise in agriculture

GRAPHIC: J.A. PREMKUMAR

Axelsson et al. The genomic signature of dog domestication reveals adaptation to a starch-rich diet. Nature 495: 360–364.

The genomics of selection in dogs and the parallel evolution between dogs and humans by Wang et al. *Nat Commun.* 2013;4:1860.

Dog and Human Genomes Evolved Together:
Evolution shaped genes in humans and dogs that correspond to diet, behavior, and disease, according to a new study. Living closely in similar environments has caused these genes to be selected in genomes of both species.

Dogs continue to be involved prominently in human society :-

Work dog: pulling sleds & herding.

Guard dog: protecting flocks and property.

Track dog: tracking and hunting animals.

Police dog: detecting narcotics or prohibited substances or CSI

Military dog: locating explosives and weapons

Search & Rescue dog e.g. Locating disaster victims

Service dog e.g. assisting disabled people as their eyes, ears, stabilizers and guardians.

Therapy dog: rehabilitation & recovery from illness/injury or psychological disorder (also in children reading program).

Performing dog: in entertainment

Pet dog: for companion.

Selective Breeding of Plants: From Grass to Crop



Transformation of Teosinte's few fruit-cases into the modern maize's rows of exposed kernels.

The genetic difference between teosinte and maize is about 5 genes.

- 1) http://www.nsf.gov/news/news_images.jsp?cntn_id=104207&org=NSF
- 2) <http://learn.genetics.utah.edu/content/selection/corn/>
- 3) http://en.wikipedia.org/wiki/Selective_breeding#mediaviewer/File:Cornselection.jpg

From Domesticates to Civilization & Societies

- Significant threshold in human history; transition from hunting to herding; from foraging to farming.
- Enable human to stay put at a place to multiply in numbers and build cities – The Dawn of Civilization.
- Radical restructuring of human societies (agrarian societies) and rise of agricultural economies.
- Global alterations in biodiversity.
- Significant changes in the Earth's land use and environment.

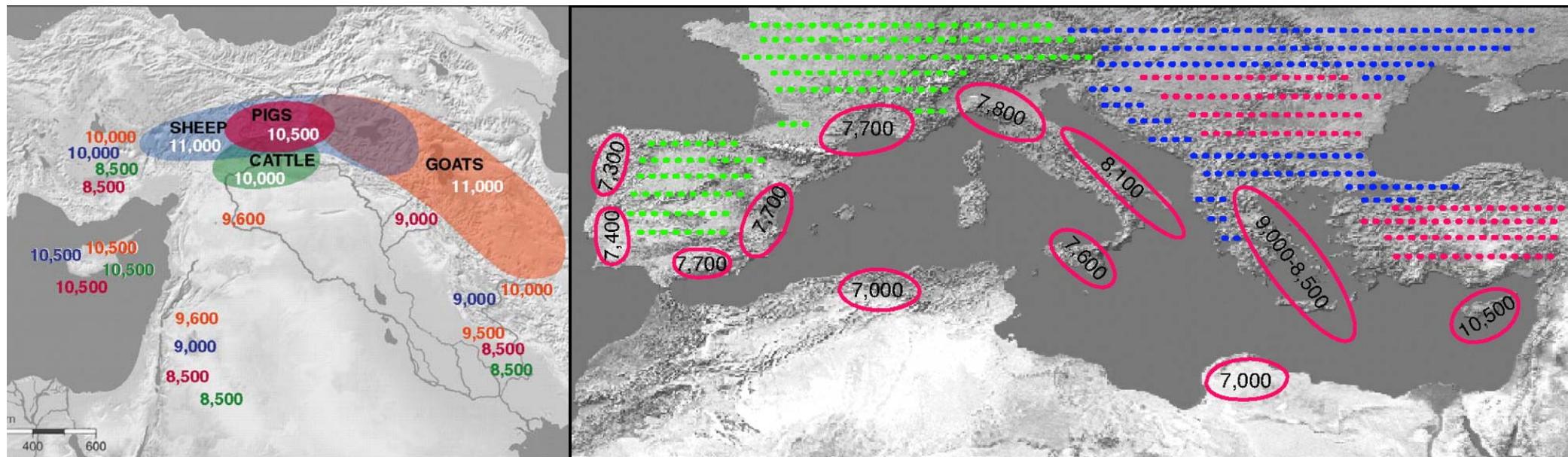
Animal	Where Domesticated	Date
Dog	undetermined	~30K-14K BC?
Sheep	Western Asia	8500 BC
Cat	Fertile Crescent	8500 BC
Goats	Western Asia	8000 BC
Pigs	Western Asia	7000 BC
Cattle	Eastern Sahara	7000 BC
Chicken	Asia	6000 BC

<http://archaeology.about.com/od/dterms/a/domestication.htm>

Plant	Where Domesticated	Date
Fig trees	Near East	9000 BC
Emmer wheat	Near East	9000 BC
Flax	Near East	9000 BC
Barley	Near East	8500 BC
Chickpea	Anatolia	8500 BC
Rice	Asia	8000 BC
Potatoes	Andes Mountains	8000 BC
Beans	South America	8000 BC
Maize	Central America	7000 BC

http://archaeology.about.com/od/domestications/a/plant_domestic.htm

From Domesticates to Civilization & Agrarian Societies



Zeder M A PNAS 2008;105:11597-11604

The origin and dispersal of domestic livestock and expansion of Neolithic farming.

The location of colonist farming enclaves is shown in the red ellipses. Approximate dates of these enclaves are given inside the ellipses in calibrated years B.P. (Before Present time). Red dots represent areas that are proposed to have been settled by colonist farmers; green dots indicate areas where indigenous foragers adopted elements of the Neolithic package; and blue dots indicate areas of proposed integration of colonist farmers with indigenous foraging groups

From collecting, classifying to the origin of species

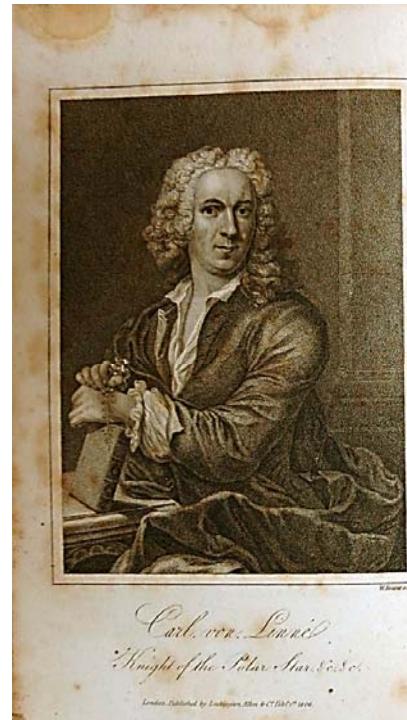
Hans Sloane's collection provided a glimpse of the diversity of life (1753)

Carl Linnaeus classified life into species (1735-1755)

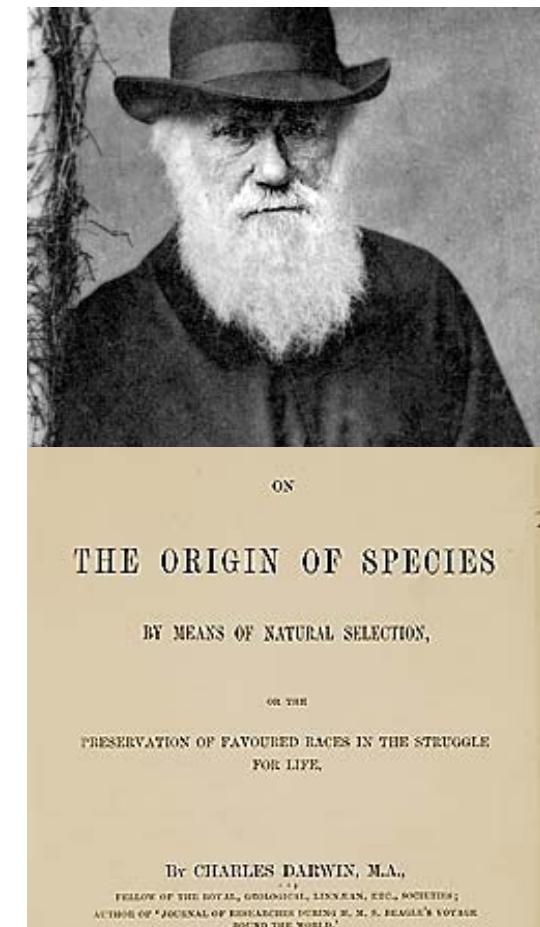
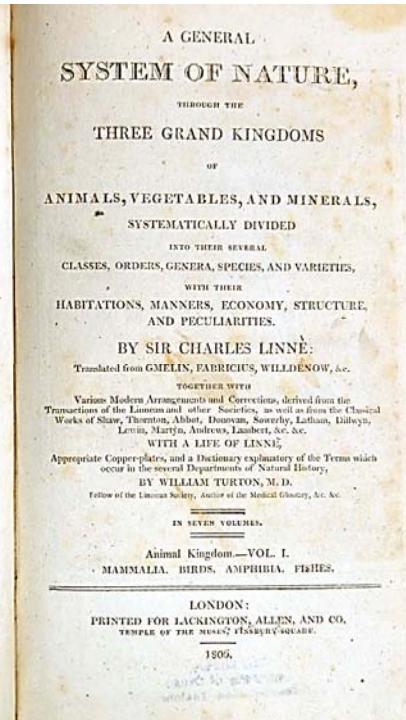
Charles Darwin published the origin of species by natural selection (1859)



<http://www.hanssloane.com/history/>



<http://pegsandtails.wordpress.com/2013/05/23/carl-linnaeus/>



<http://sqapo.com/darwin.htm>

Evolution by Natural Selection

Evolution by natural selection requires the following criteria to occur.

- There must be ***variation for a particular trait*** within a population.
- The variation in the ***trait must be inheritable***, capable of being passed from parents to offspring.
- Individuals with one particular version of the trait ***must produce more offspring*** (as a result of advantages) than those with a different version of the trait within a certain environment.
- Given enough ***time*** for breeding offspring for multiple generations within this environment, a shift in the proportion of individuals with the trait that produces more offspring will occur in the population, and the trait will be more common in the population.
- Read ‘Evolution caught in the Act’ by Heidi Ledford
- Read the ‘Silver Fox experiment’ & ‘Taming the Wild’

How did those variations in trait come about?
Darwin proposed ‘Pangenesis’

Selective Breeding / Artificial Selection



Organisms
Variable Traits
In population



Select



Organisms
Desirable Traits



Select

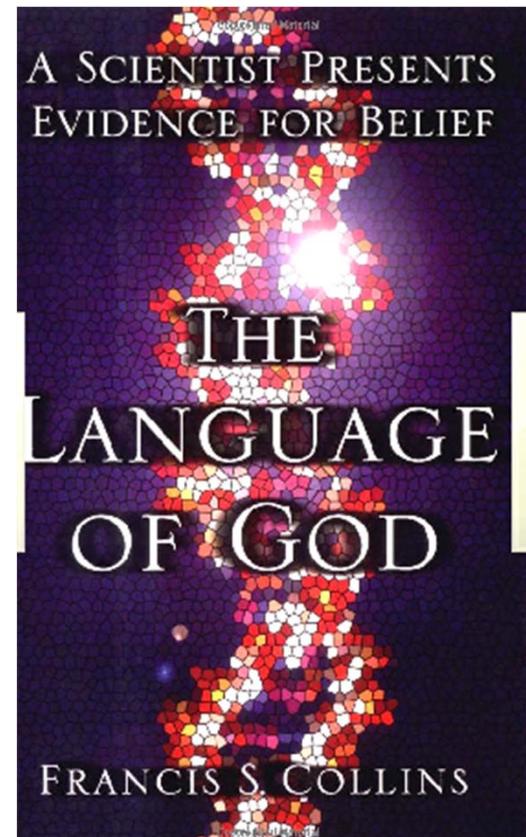
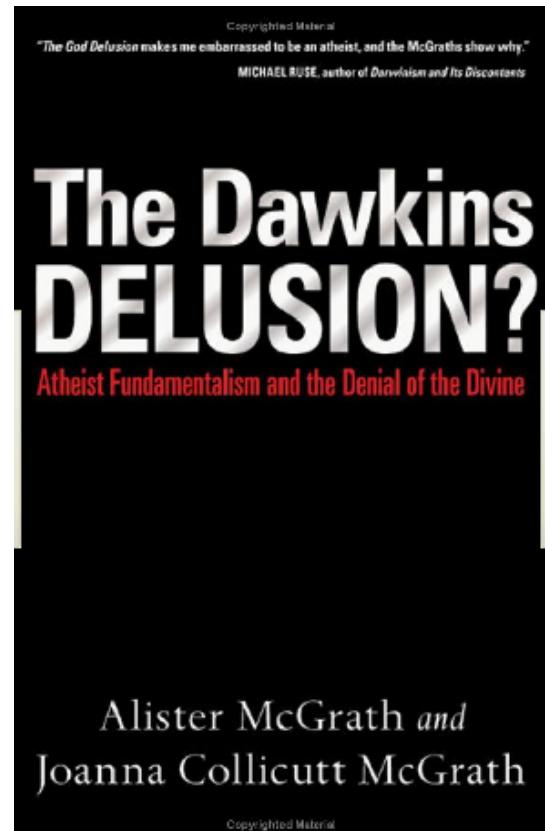
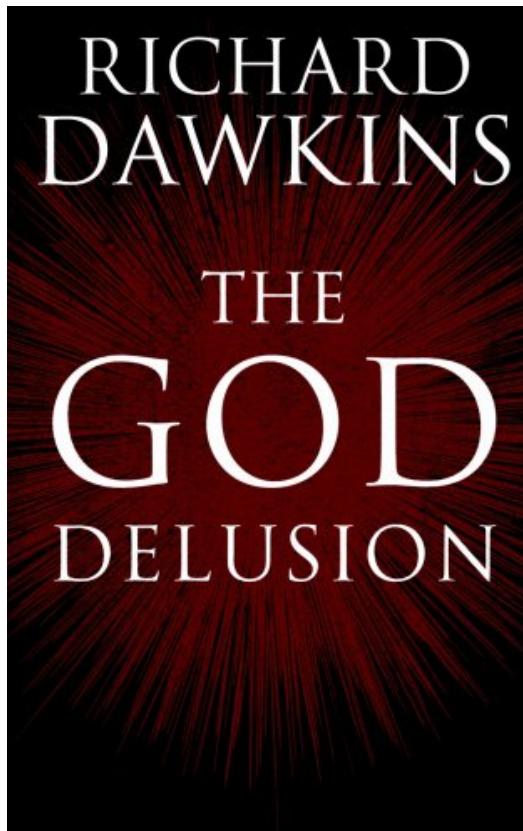
Organisms
Desirable Traits



Common Ancestor?



Genes vs. Society Evolution vs. Creation Science vs. Religion (Monotheistic)



Any Solution?

The Telegraph

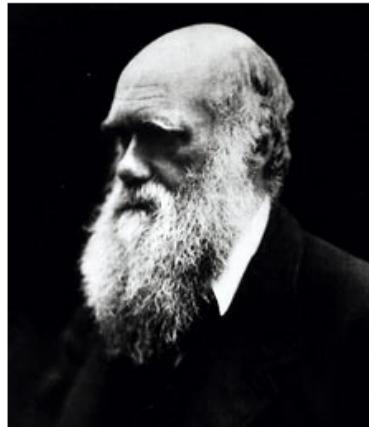
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HOME » NEWS » RELIGION

Charles Darwin to receive apology from the Church of England for rejecting evolution

The Church of England is to apologise to Charles Darwin for its initial rejection of his theories, nearly 150 years after he published his most famous work.

 22K  1K  6  22  23K  Email



<http://www.telegraph.co.uk/news/religion/2910447/Charles-Darwin-to-receive-apology-from-the-Church-of-England-for-rejecting-evolution.html>

Charles Darwin: 200 years from your birth, the Church of England owes you an apology for misunderstanding you and, by getting our first reaction wrong, encouraging others to misunderstand you still. We try to practice the old virtues of 'faith seeking understanding' and hope that makes some amends. But the struggle for your reputation is not over yet, and the problem is not just your religious opponents but those who falsely claim you in support of their own interests. Good religion needs to work constructively with good science - and I dare to suggest that the opposite may be true as well.

<https://www.churchofengland.org/our-views/medical-ethics-health-social-care-policy/darwin/malcolmbrown.aspx>

The test of a first-rate intelligence is the ability to hold two opposed ideas in the mind at the same time, and still retain the ability to function.

—F. Scott Fitzgerald (Novelist; Poet)

Origin of Genetics: From the monastery to the laboratory

Gregor Mendel is an Augustinian monk - the Father of a monastery (St. Thomas's Abbey) - a.k.a. the 'Father of Genetics', who discovered the fundamental laws of inheritance through his work on pea plants.



Gregor Mendel Garden /03-mendel-characters2.jpg



<http://global.britannica.com/EBchecked/topic/374739/Gregor-Mendel>

- Found that individual traits in pea plants are determined by discrete "factors," later known as genes, which are inherited from the parents.
- Worked with true-bred parents of known genetic background — to provide a baseline against which to compare patterns of inheritance in the resulting offspring.
- Carefully counted the numbers of individuals showing the various traits in successive generations of offspring.
- Recognized the mathematical patterns of inheritance from one generation to the next.
- Proposed 'Paired Hereditary Factors' & basic Laws of Heredity'

Seven pairs of contrasting traits and the results of Mendel's crosses of the garden pea (*Pisum sativum*). In each case, pollen derived from true-bred plants exhibiting one trait was used to fertilize the ova of true-bred plants exhibiting the other trait. In the F₁ generation, one of the two traits was exhibited by all plants. The contrasting trait reappeared in approximately 1/4 of the F₂ plants (progenies of F₁).

Character	Contrasting traits		F ₁ results	F ₂ results	F ₂ ratio
Seeds	Smooth/wrinkled yellow/green		all round all yellow	5474 round 1850 wrinkled 6022 yellow 2001 green	2.96:1 3.01:1
Pods	full/constricted green/yellow	 	all full all green	882 full 299 constricted 428 green 152 yellow	2.95:1 2.82:1
Flower color	violet/white	 	all violet	705 violet 224 white	3.15:1
Flower position	axial/terminal		all axial	651 axial 207 terminal	3.14:1
Stem length	tall/dwarf		all tall	787 tall 277 dwarf	2.84:1

"If 'A' denotes the dominating trait, 'a' the recessive trait, and the 'Aa' the hybrid form in which both are united, then the expression:

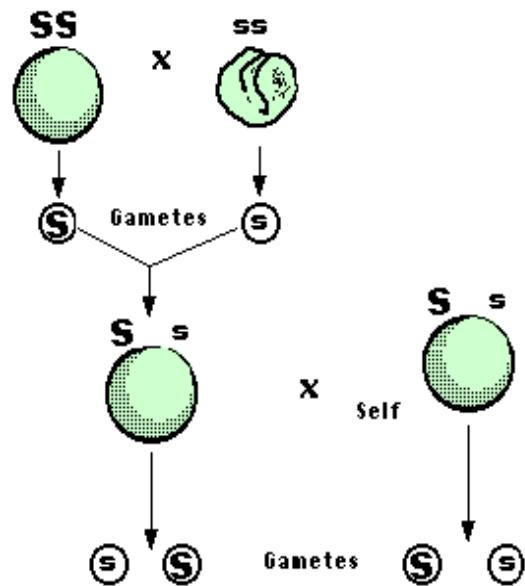
$$A + 2Aa + a$$

gives the series for the progeny of plants hybrid in a pair of differing traits.

In the offspring , along with the dominating traits, the recessive ones also reappear, their individuality fully revealed, and they do so in the decisively expressed average proportion of 3:1, so that among each four plants of this generation three receive the dominating and one the recessive trait."

'Experiments on Plant Hybrids' (1865). From *The Origin of Genetics: A Mendel Source Book* (1966), page 10 & 16.

Parental generation
(True-bred)



F₁ generation
(Offspring of True-bred)

(Offspring Of Hybrids)

F₂ generation



		Sperm	s
Eggs	S	SS	Ss
	s	Ss	ss
Punnett square			



A discrete paired-factor exists for each trait. The 'discrete factor' that control the texture of the pea is the 'texture gene'.

The alternate forms of the 'texture gene', whether S or s, are refer to as alleles. [Alleles are alternate forms of a gene or an allele is one form of a gene]

Genotype refers to the combination of alleles for a pair of discrete factors in an individual.

Homozygous genotype has combination of identical alleles.

Heterozygous genotype has combination of non-identical alleles (alternate forms)

Phenotype refers to the traits (appearance/can be detected): Dominant vs recessive traits

For F₂ generation, how many genotypes and phenotypes are there? What are their ratio?

1 SS: 2 Ss: 1 ss (genotype)

3 smooth: 1 wrinkle (phenotype)

Mendel's three laws of heredity:

1. Law of Segregation:

Genetic traits are controlled by paired unit factors (later known as genes) which one form (allele) of each paired unit factor is randomly segregated into the sex cell (e.g. allele for smooth/wrinkled; green/yellow; tall/dwarf into one sex cell)

2. Law of Dominance:

One form of the gene (i.e. allele) will be dominant. (e.g. S vs s, G vs g and T vs. t)

3. Law of Independent Assortment:

Different traits are sorted and inherited independently from each other (e.g. texture is not dependent on color or height i.e. can be smooth, green, tall or wrinkled, green, tall)

[Note: Mendel's laws are not always true in nature and there are exceptions]

Mendelian genetics was not appreciated until its rediscovery by three independent plant studies in 1900.

Possible Allelic Combinations in an Individual within a population

TRAITS	GENES (Alleles)
TEXTURE	S and/or s
COLOR	G and/or g
HEIGHT	T and/or t

Possible Allelic Combinations in Sex Cell within a population

		COLOR			
		G		g	
TEXTURE	s	S	S	S	S
	s	G	G	g	g
	t	t	T	t	T
	T	s	s	s	s
		G	G	g	g
		t	t	T	t
		T	t	T	t
HEIGHT					

How is this possible?



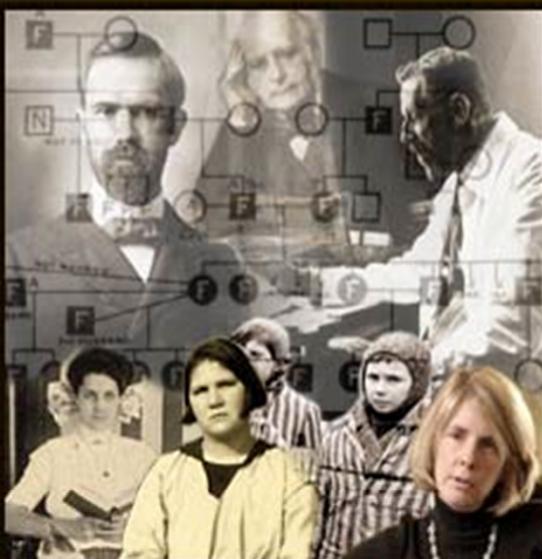
Heather and Marcus have dark hair but their children Lucy and Adam have red hair.

Marcus Pembrey

	Dr	X	Dr
Sperm			
	D		r
D egg	DD	Dr	
r	Dr	rr	

A must visit website if you want to know more...

CHRONICLE



The Human Genome Project has provided the tools to determine the genes that influence human health and behavior. In the face of this knowledge, will society gravitate toward a prescribed definition of the genetic "right stuff?" Will we look with compassion or disdain on people with genes that predispose them to physical or mental illness?

Eugenics was the name of society's first attempt to grapple with these questions. The movement began benignly in England with positive efforts by families to improve their own heredity. Eugenics took a negative turn in America, where 30 states passed sterilization laws in a misguided attempt to limit the spread of mental illnesses and other "dysgenic" traits. Then, the Nazis began their march toward a "final solution" for racial purity with a massive program to sterilize mental patients.

Coming to grips with the past failings of eugenics may allow us to move with greater confidence into the new gene age.

Choose a module to begin:

THREAT of the UNFIT

TRIAL of CARRIE BUCK

IN the THIRD REICH

LIVING WITH EUGENICS

Eugenics: Selective Breeding of Humans & Social Darwinism

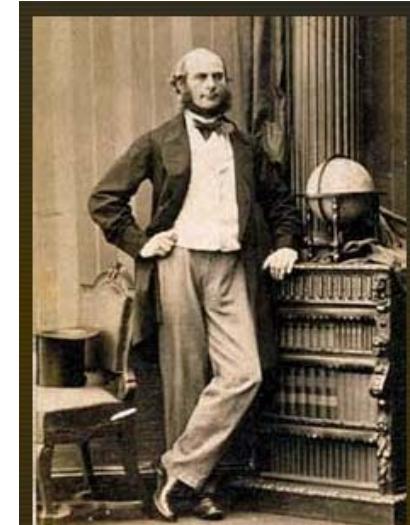
1860s-early 1900s

Francis Galton, the cousin of Charles Darwin, was deeply influenced by the publication 'Origin of Species' especially the chapter on "Variation under Domestication," concerning the breeding of domestic animals.

He published ideas of promoting 'Hereditary Genius' through selective breeding in 1869.

"It would be quite practicable to produce a highly-gifted race of men by judicious marriages during several consecutive generations"

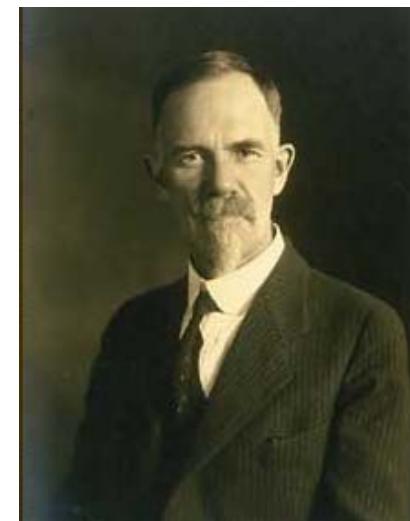
In 1883, he coined the term 'eugenics', meaning 'well-born' and first to use the term 'nature and nurture'.



Early 1900s-1930s

Charles Davenport, a Harvard-trained zoologist, organized eugenics into a scientific field by applying Mendelian genetics in agricultural breeding.

He promoted eugenics movement to a national level in the US and founded the Eugenics Record Office (ERO) that became the epicenter of American eugenics movement.

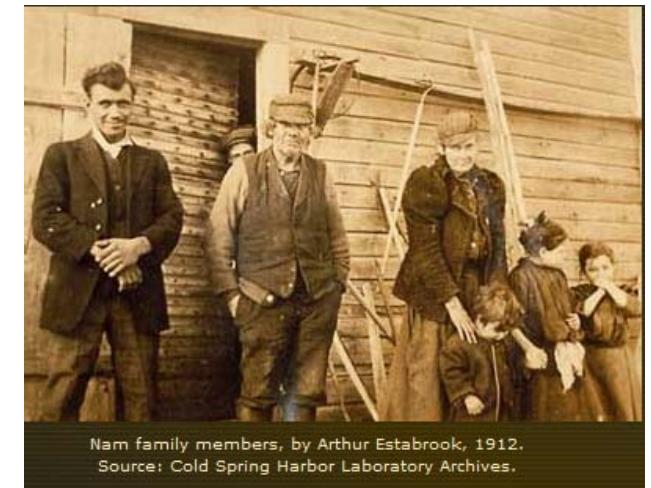


Eugenics: Selective Breeding of Humans

- Positive eugenics highlighted the achievements of "fit" families. The goal was to produce a gifted elite caste by encouraging 'eugenics marriages' between people of good health and high intelligence.
 - Some families were proud to make known their pedigrees of intellectual/artistic achievement, while others sought advice on the eugenical fitness of proposed marriages.
-
- Negative eugenics focused on "unfit" families who were burdened with degenerate traits such as feeble-mindedness, alcoholism, pauperism, and criminality.
 - Led to discrimination and advocate to prevent reproduction or marriage restriction among those deemed to come from lesser/poorer genetic stocks as they were increasing in numbers, especially with increasing migrants from southern and eastern European countries to US and were perceived as a burden and threat to society.

"On the towpath we met and had to pass a long line of imbeciles. It was perfectly horrible. They certainly should be killed."

- Virginia Woolf



Eugenics promoted forcible sterilization of genetically unfit

- Eugenicists needed a test case to uphold the legality of sterilization to curb the rise of the genetically unfit in the U.S.
- The 17 year-old, Carrie Buck, who has a child out of wedlock and whose mother is in a mental asylum was a 'perfect case'.
- Carrie Buck was pitted against an array of doctors, lawyers, and eugenicists who were intent on sterilizing her. To convince the judge that unfit traits were inherited, biased-interpretation of evidence and false science were employed. Carrie was not promiscuous, as charged, and her daughter Vivian was surely not an imbecile.
- The judge of US Supreme Court Oliver Wendell Holmes, Jr. decreed, "It is better for all the world, if instead of waiting to execute degenerate offspring for crime, or to let them starve for their imbecility, society can prevent those who are manifestly unfit from continuing their kind. The principle that sustains compulsory vaccination is broad enough to cover cutting the Fallopian tubes. Three generations of imbeciles are enough."
- Following the Supreme Court decision, Carrie Buck was sterilized and ultimately 30 states adopted eugenic laws under which an estimated 60,000 Americans were sterilized before finally outlawed in 1970s.



From force sterilization, euthanasia to genocide

- Eugen Fischer, collaborated with Charles Davenport in the management of the International Federation of Eugenics Organizations. Fischer published a textbook on 'Principles of Human Heredity and Race Hygiene'.
 - Hitler read Fischer's textbook and used eugenical notions to support the ideal of a pure Aryan society in his manifesto, Mein Kampf (My Struggle). This further provided 'scientific' legitimacy to his cause and affirmed his beliefs.
 - Hitler believed that protecting the 'genetically unfit' is unnatural as nature intended the 'unfit' to perish as only the fit will survive, therefore euthanizing the unfit is a natural thing to do as a way of natural cleansing.
 - When Hitler came to power in Germany, the Nazi went further with the idea from force-sterilizing 400,000, to euthanasia of the disabled, mentally ill and ultimately holocaust in the name of 'racial hygiene' killing more than 6 million Jews.
-
- Read '**The Horrifying American Roots of Nazi Eugenics**' by Edwin Black.



EUGENICS ARCHIVE HOME DOLAN DNA LEARNING CENTER COLD SPRING HARBOR LABORATORY

Image Archive on the American Eugenics Movement

<http://www.eugenicsarchive.org/eugenics/>

Virtual Exhibits

Mouse over the images to open essays that introduce the key events, persons, and social conditions that contributed to the development of eugenics. We suggest you visit these exhibits before searching the images in the Archive.

[MENU of Virtual Exhibits](#)

SEARCH the Image Archive
Click to explore the image database.

Funded by a grant from: Ethical, Legal, & Social Implications Research Program, National Human Genome Research Institute

[Project overview](#) [Contributing archives](#) [Advisory panel and staff](#) [Editorial policy](#) [Author information](#) [References](#) [Contact](#) [Awards](#)

Will history be repeated?

Those who cannot remember the past are condemned to repeat it.
-George Santayana
(Philosopher; Essayist)

Are there modern day eugenics or is it a matter of the past?

Many prominent Americans saw eugenics as a progressive solution to social problems – including Theodore Roosevelt (26th. US president), Alexander Graham Bell (inventor of telephone), Luther Burbank (the California seed producer), Henry Fairfield Osborn (president of the American Museum of Natural History), H.G. Wells (author) and David Starr Jordan (first president of Stanford University). Geneticists – including Thomas Hunt Morgan, Hermann Muller, and William Ernest Castle – supported eugenics at one time or another, but rejected coercive legislation based on an incomplete knowledge of genes involved in complex behaviors.

Summary & Conclusion

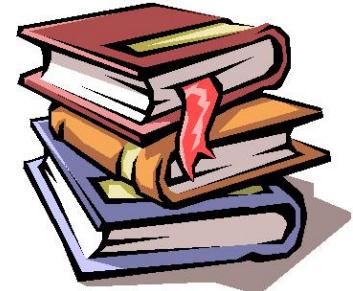


- Humans have been practicing biotechnology i.e. use of living organism or their products for their own benefits since ancient time.
- Humans have been selecting phenotypes encoded by genes for breeding and cross-breeding of animals and plants hence influencing the genotypes found in a population.
- Natural selection provides a scientific explanation for the evolution and diversity of life.
- Mendelian genetics provides a scientific explanation for heredity.
- Eugenics applied both Darwin's theory and Mendel's genetics to society for improvement of human race via selective breeding.
- Science by itself has no resources to tell what is good or bad, right or wrong for mankind.
- Science will impact lives (society & environment) and therefore imperative for all to be involved at the appropriate levels.

With great power comes great responsibility...

- Voltaire (writer & philosopher)
- Spiderman 's uncle Ben

Additional Enrichment Materials



- ‘Evolution caught in the Act’ by Heidi Ledford
- ‘Farmed Fox experiment’ by Lyudmila N. Trut
- ‘Taming the Wild’ by Evan Ratliff
- ‘The Horrifying American Roots of Nazi Eugenics’ by Edwin Black
- The Farmed Fox Experiment.

<https://www.youtube.com/watch?v=Vehd7eDIS7o>

- The Making of a Theory: Darwin, Wallace, and Natural Selection
<https://www.youtube.com/watch?v=XOjUZ3ycZwU&feature=youtu.b>