Outline of Biology
May 20, 2013

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BIOL>Biology

biology
Sciences {biology} can include botany, cell biology, development, ecology, evolution, genetics, and zoology.

BIOL>Biology>Subjects

anatomy
organism structures {anatomy}|.

natural history
nature {natural history, nature}|.

physiology
organism functions {physiology}|.

BIOL>Biology>Subjects>Agriculture

animal husbandry
farm animals {animal husbandry}| {husbandry}.

horticulture
gardening {horticulture}|.

hydroponics
Food can grow in aerated nutrient-rich water {hydroponics}|, with no soil.

viticulture
wine {viticulture}|.

BIOL>Biology>Subjects>Animal

embryology
organism development {embryology}|.

entomology
insects {entomology}|.

ethology

Animals have natural behaviors {ethology}|, such as aggression, imprinting, instincts, innate releasing mechanisms, and fixed action patterns, which evolve, develop, and have purposes. Environmental stimuli trigger innate complex behaviors. Perhaps, humans have innate behaviors or behavioral tendencies, such as aggression.

ichthyology
fish {ichthyology}|.

ornithology
birds {ornithology}|.

palmistry
palm reading {palmistry}|.

phrenology
skull regions {phrenology}|.

taxidermy
stuffing animal skins and mounting heads {taxidermy}|.

BIOL>Biology>Subjects>Cell Biology

cytology
cells {cytology}|.

enzymology
enzymes {enzymology}|.

BIOL>Biology>Subjects>Evolution

morphology in biology
structures {morphology, biology}|.

paleontology
ancient times {paleontology}|.

scatology
People study excrement {scatology}|. People study obscenities.

taxonomy
classification {taxonomy}|.

BIOL>Biology>Subjects>Medicine

anesthesiology
sedation {anesthesiology}|.

bacteriology
bacteria {bacteriology}|.

cardiology
heart {cardiology}|.

chiropractic
spine manipulation {chiropractic}|.

dermatology

skin {dermatology}|.

endocrinology
hormones {endocrinology}|.

epidemiology
infectious diseases {epidemiology}|.

etiology
disease causes {etiology, disease causes}|.

geriatrics
old age {geriatrics}|.

gerontology
old age {gerontology}|.

gynecology
women {gynecology}|.

histology
tissues {histology}|.

immunology
immune system {immunology}|.

internal medicine
general disease {internal medicine}|.

neurology
nervous system {neurology}|.

obstetrics
pregnancy {obstetrics}|.

oncology
cancer {oncology}|.

ophthalmology
eye medical problems {ophthalmology}|.

optometry
eyesight {optometry}|.

orthopedics
bones and muscles {orthopedics}|.

osteopathy
bones {osteopathy}|.

otolaryngology
ear and throat {otolaryngology}|.

parasitology
Organisms can live on other organisms {parasitology}|.

pathology
disease {pathology}|.

pediatrics
children {pediatrics}|.

pharmaceutics
drug development {pharmaceutics}|.

pharmacology
drug information {pharmacology}|.

physical therapy
rehabilitation {physical therapy}|.

plastic surgery
Surgeons can reshape {plastic surgery}| nose, breasts, ears, eye sockets, and penis.

podiatry
feet {podiatry}|.

proctology
colon {proctology}|.

psychiatry
mind diseases {psychiatry}|.

radiology
irradiation {radiology}|.

serology
blood {serology}|.

tetralogy
development diseases {tetralogy}|.

therapeutics
therapy {therapeutics}|.

toxicology
poisons {toxicology}|.

urology
urinary tract {urology}|.

virology
viruses {virology}|.

BIOL>Biology>Subjects>Medicine>Dentistry

orthodontics
teeth alignment {orthodontics}|.

periodontics
gums {periodontics}|.

prosthodontics

mouth and teeth devices {prosthodontics}|.

BIOL>Biology>Subjects>Plant

mycology

fungi {mycology}|.

phycology

algae {phycology}| {algology}.

phytology

plants {phytology}|.

BIOL>Biology>Life

life in biology

Self-contained, integrated structures {life}| have mechanisms for gathering and using energy and matter, to build mechanisms and reproduce similar structures. Living organism species come from one or two genetically similar organisms. Species communities live in local regions. Community ecosystems live in large geographic regions or climate zones. Living things adapt, grow, have irritability, and reproduce. Living things have sizes, shapes, biochemical reactions, molecules, and movements.

organism

Biochemical molecules, organelle molecular structures, cell molecular systems, tissue cell types, and organ-system tissue groups can work as units {organism}| {individual}. Organisms eat each other, live in different environments, and use oxygen differently.

euthanasia

Killing can be for the sake of mercy {euthanasia}|, either by letting people die or by painless killing.

irritability of organism

Organisms can react to stimuli {irritability, organism}|.

life force

Perhaps, living things need special energy {life force} for motion and organization. However, molecules and physical laws can make life. Organic molecules, cells, organisms, species, and all life can be purely physical and require no extra information or non-physical energy.

spontaneous generation

Perhaps, living things can arise directly from molecules or decaying matter {spontaneous generation}|. However, organisms are too complex to arise directly from molecules or decaying matter. Organisms arise only from other living things, which contain information needed to initiate and develop life through complex processes. At life's origin, more-complex molecules, between living and non-living, arose from complex molecules by moderately complex processes.

BIOL>Biology>Life>Body Locations

cephalic side

head {cephalic}.

cranial side

about head {cranial}.

humoral body fluids

about body fluids {humoral}.

medial side
middle {medial}|.

BIOL>Biology>Life>Body Locations>Front And Back

dorsal side
back {dorsal}.

ventral side
abdominal, anterior, or lower {ventral}|.

BIOL>Biology>Life>Body Locations>Head And Tail

caudal side
tail {caudal}.

rostral side
head {rostral}|.

BIOL>Biology>Life>Body Locations>Lateral

lateral side
side {lateral, side}|.

contralateral side
opposite side {contralateral}|.

ipsilateral side
same side {ipsilateral}|.

BIOL>Biology>Life>Origin

origin of life
Experiments simulating primitive Earth conditions can make small organic molecules. Under special conditions, these molecules can make large stable proteins, ribonucleic acids (RNA), and deoxyribonucleic acids (DNA) {origin of life}|. DNA has optimum mutation rate, crossing-over, hybridization, and long length and so can be replication templates.
early-Earth molecules
Experiments replicating early-Earth conditions make formaldehyde, formic acid, lactic acid, acetic acid, urea, sugars, and hydrogen cyanide. From nitrogen, methane, ammonia, water, and hydrogen-gas mixtures, lightning or ultraviolet light can produce amino acids. Metallic carbides and water can react to form acetylene. Formaldehyde can polymerize to make ribose and other sugars.
replication
Living things replicate, so life requires replicating molecules. Proteins cannot be templates, because most amino acids can have no hydrogen bonding. RNAs are easy to create. However, RNA is also easy to hydrolyze, so only short RNA regions can replicate. DNA does not hydrolyze, because deoxyribonucleotides have no oxygen atom and prevent hydrolysis. DNAs are harder to create but can be templates.
cell functions
After DNA formation, DNA regions able to make functional RNAs and proteins arose. To these exons, evolution added and subtracted introns. Archaebacteria have tRNA and rRNA introns. Cyanobacteria eubacteria have leucine-tRNA introns. Eukaryote RNAs typically have introns. Eukaryote DNA has different intron types, such as self-splicing introns. Currently, gene exons have 1000 to 7000 functional DNA regions.
cell functions: photosynthesis
Earth life needs photosynthesis, using metals, enzymes, carbon dioxide, and water.
chirality
Perhaps, chirality is necessary.

sexual reproduction

Earth life needs sexual reproduction, for more variation and more competition. Sexual reproduction began 2.2 x 10^9 years ago. Sexual intercourse began 2 x 10^8 years ago.

mutation

Different DNA types change at different rates. Mitochondrial DNA mutates ten times faster than nuclear DNA. Mitochondrial DNA mostly comes from mother, but some paternal genes can enter and recombine. DNA-change rates can be faster if codon changes do not change amino acids produced. DNA-change rate is slower for histones and other fundamental proteins. DNA-change rate is slower in humans than in other species.

gene duplication

With sexual reproduction, genes can duplicate by unequal crossing over at recombination. If genes duplicate, one copy can change while the other still provides original functions, thus allowing genetic drift.

complexity

DNA amount and gene number can increase for whole genome, tRNA, rRNA, mitochondrial DNA, and globin DNA, increasing organism complexity.

Drake equation

Percentage of planets that can have intelligent life depends on star formation rate, fraction of stars that have planets, percentage of planets that are suitable for life, fraction where life actually exists, intelligent-life probability, and average civilization longevity {Drake equation} (Frank Drake) [1961]. For planets to have life, they must be like Earth and have stars like Sun.

star

Sun is a yellow-orange class-G0 star. Only class F, G, and K stars can have suitable planets, because liquid-water zone is too small for smaller stars, and bigger stars have no rocky planets in that zone. Such stars have masses 0.7 to 1.5 times Sun mass. Lifetimes are long enough, and masses are big enough, for planets. Stars sufficiently like Sun are 1% of all stars.

Stars younger than Sun have time too short for life. Stars older have too few heavy elements. Time range is 3 to 7 billion years, one-third of all stars.

Multiple stars can have no planets. Single stars are one-fifth of all stars.

Stars with slow spins possibly indicate planets. Probably, one sixth of all stars qualify.

Stars must be in galactic arms. Galaxy centers have too much radiation. Edges have low metals and low star-formation rates. Galactic habitable zone is far from center and edge.

orbit

Circular orbits make temperature swings not too great. Probably 100% of planets at correct distance from star have circular orbits.

size

Earth size is big enough to retain oxygen and nitrogen and small enough to lose hydrogen and helium, so as not to have too much gas. Surface gravity is not too strong or too weak for living things. Diameter is 5000 km to 15000 km. Probably, one tenth of all planets have correct size. Therefore, 0.001% of all stars have Earth-like planets. Galaxy has 2.5 x 10^11 stars and so 2.5 x 10^6 habitable planets.

rotation

Planet rotation must not be too fast or slow. Probably 100% of planets at correct distance from star have Earth-like rotation speeds.

atmosphere

On early Earth, volcanoes gave off steam, nitrogen, methane, hydrogen cyanide, ammonia, carbon dioxide, and sulfur dioxide or hydrogen sulfide. If iron was already at core, atmosphere was carbon dioxide, nitrogen, and sulfur dioxide. Soon after Earth formed, atmosphere layered into decreasing-density gases. Ultraviolet light reaching Earth decreased, and temperature lowered. Crust cooled quickly, and lower temperature led to more atmosphere layering. Hydrogen, ammonia, and methane were no longer in oceans, so processes no longer formed organic molecules. Temperature became too low to make organic molecules. All gases can dissolve in oceans.

temperature

If planet surface temperature is hotter than 40 C, proteins denature and water evaporation is too high. If surface temperature is colder than ice, no water is available. Planets must be in circumstellar habitable zones. If planet forms too close to star, it has little water and large greenhouse effect, like Venus. If planet forms too far from star, surface is ice. Distance from star is 10^7 km for optimum temperature. Probably, one tenth of planetary systems have such planets. Composition, size, wind, rain, and sunlight cause tectonic and erosion processes.

minerals

If planet is at correct distance from star, mineral composition is similar to Earth mineral composition.

radiation

Cosmic radiation can react water and carbon dioxide to make organic acids.

energy

3,800,000,000 years ago, ultraviolet light, lightning, meteor impacts, thunder, volcanic heat, and hydrothermal vents provided energy.

meteors and comets

Perhaps, some organic molecules came to Earth in meteors and comets. Meteors have saturated hydrocarbons, porphyrin rings, and organic acids. Spores cannot come from space, because ultraviolet and ionizing radiation kill them.

ocean

First life probably arose in shallow seas or tidal areas. Oceans probably had water, gases, proteins, nucleic acids, carbohydrates, fats, and adenosine phosphate.

tides

Shallow seas with high evaporation rates allow molecule concentration. Tides add water. Large moons can cause tides. On Earth, tides were 30-meters high when Moon formed.

other factors

Probably, Earth life needs continental drift, orbital changes, star evolution, seasons, days and nights, major climactic changes, and magnetic fields.

catastrophe

Earth life needs no life-ending catastrophes, like too many comets or meteors, too much volcanism and earthquakes, too much erosion, or too much greenhouse effect.

life factors

Earth life needs brains, hands, vocal chords, speech centers, forebrains, vision, immune systems, and societies. Earth life must be large enough, be long-lived enough, be few in number, have slow reproduction cycles, and have long childhoods. Earth life must have no mass destruction, optimum competition, optimum population, enough energy and resources, few radioactive wastes, few chemical wastes, optimum ozone, and social cohesion.

number of times

On Earth-like planets, life has probability, possibly 10^-6. Perhaps, galaxies have 10^6 suitable planets. Therefore, galaxies have one planet with life. If other planets have intelligent life, they can send probes to Earth, but there is no evidence for this. Therefore, no other intelligent life forms are in Milky Way Galaxy yet.

first cells

Life began as non-photosynthetic one-celled bacteria-like organisms. First cells reproduced themselves, protected themselves, and found energy.

membrane

All cells have cell membranes. Cell membranes have lipids with embedded proteins. Cells can control membrane-molecule amounts and ratios. All cells have voltage differences across cell membranes, because inner and outer sodium, potassium, and chloride salt concentrations differ.

energy and entropy

Life can overcome dissipative forces and persist. Living systems have high order {negentropy} in small regions, surrounded by large energy sources that they can tap. Living systems must gather energy faster than surroundings can dissipate energy. Sunlight energy, planet interior heat, and lightning can make locally high temperature, for anabolic and catabolic chemical reactions.

Small cells have small fast energy changes. Fast heat and material exchanges among physical compartments allow rapidly removing order from surroundings. High combination and division rates make many new organic molecules and cells. Equilibrium conditions in oceans or tide pools allow reversible chemical reactions.

Fermi paradox

If life is abundant in universe, why have people not seen other intelligent life {Fermi paradox}?

BIOL>Biology>Life>Origin>Planet

circumstellar habitable zone

Planets must have liquid water, not ice or steam {circumstellar habitable zone} (CHZ).

galactic habitable zone

Galaxy centers have too much radiation. Galaxy edges have low metals and low star-formation rates. Stars must be in galactic arms {galactic habitable zone} (GHZ).

hydrothermal vent

Hot water rich in sulfur, iron, hydrogen, and carbon flows from sea floor holes {hydrothermal vent}|. Bacteria-like organisms began there.

reducing atmosphere

If surface had iron 3,800,000,000 years ago, reduction reactions caused methane, ammonia, and hydrogen sulfide {reducing atmosphere}.

BIOL>Biology>Life>Origin>Molecule

carbon-based life

Carbon compounds {carbon-based life} can be soluble or insoluble and have intermediate-stability chemical bonds, so they can form and break at moderate energies.

organic molecules

Organic molecules formed in seas. Stable forms persisted. Persisting molecules aggregated.

nucleic acids

When nucleotide concentrations were great enough, nucleotides linked. Nucleic acids used themselves as templates to make copies. Good copiers persisted and used more nucleotides. Mutations resulted in populations with property ranges.

peptides

When amino-acid concentrations were great enough, amino acids linked. Peptides assisted chemical reactions and formed structures.

oxygen

Later, photosynthesis added oxygen to atmosphere, using water, sunlight, and atmosphere carbon dioxide.

silicon-based life

Silicon compounds {silicon-based life} cannot substitute for carbon compounds, because silicon compounds are insoluble, silicon makes shorter bonds, and silicates are too stable.

chirality in molecules

In living organisms, sugars and amino acids are in only one of two possible stereochemical forms {chirality, molecule}|. Sugar and amino-acid chirality probably had survival value, but people do not yet know cause [Gardner, 1960].

panspermia

Perhaps, living things or organic molecules are in cosmic dust, meteors, comets, asteroids, and planets and then travel to Earth in dust, meteors, or comets {panspermia}.

BIOL>Biology>Life>Origin>Molecule>Kinds

coascervate

Glycerin molecules mixed with other molecules can clump together to make stable gels {coascervate}| [1926]. Other molecules can enter, interact inside, and leave.

proto-virus

Nucleic acid and protein can combine. Perhaps, dissolved genes in early oceans evolved to make genes with protein shells {proto-virus}. Proto-viruses can acquire lipid layers, making micelles. Proteins can embed in lipids, to make cell membranes. Food can pass from seawater into simple cells. Chemosynthesis can evolve. Simple cells can replicate. Later, photosynthesis can evolve.

RNA world

Perhaps, RNAs had genetic codes, were enzymes, and formed structures {RNA world}. RNAs folded and unfolded to perform functions.

BIOL>Biology>Life>Origin>Cell

endosymbiosis theory

Eukaryote-cell organelles can come from eubacteria incorporated into cells {endosymbiosis theory}. Plant chloroplasts came from cyanobacteria. Animal mitochondria came from purple photosynthetic bacteria. For example, Cryptomonas phytoflagellate combines eukaryotic nucleus, photosynthetic prokaryote, and eukaryotic cell.

exon shuffling

Evolution has added introns to, and subtracted introns from, DNA, possibly to aid exon recombination {exon shuffling} and combine protein functions.

monoploid

Bacteria have one circular chromosome {monoploid}|. Polyploid protozoa have several linear-chromosome copies. Perhaps, bacteria are simplified polyploid protozoa.

BIOL>Biology>Evolution

evolution in biology

New species develop from existing species {species evolution} {evolution, species}|.

cells

On early Earth, heat, light, lightning, and meteor collisions formed carbon-containing molecules {organic molecule, life} with attached hydrogen, oxygen, nitrogen, sulfur, and phosphorus atoms. Simple organic molecules combined to make sugars, amino acids, nucleotides, and fatty acids, which combined to make carbohydrates, proteins, nucleic acids, and lipids. Large molecules can have shapes and structures and can have multiple binding and reaction sites. Structural molecules combined to form cells, viruses, and bacteriophages.

species

The first cells were the first species. Cells evolved into single-cell Archaea. Archaea evolved into bacteria and single-cell plants and animals. Single-cell organisms evolved into multicellular plants and animals. Multicellular animals evolved into invertebrates. One invertebrate species evolved into vertebrates. One vertebrate species evolved into fish. One fish species evolved into amphibians. One amphibian species evolved into reptiles. One reptile species evolved into mammals. One mammal species evolved into primates. One primate species evolved into monkeys. One monkey species evolved into apes. One ape species evolved into anthropoid apes (great apes) (hominids). One hominid species evolved into hominins (human ancestors) and Homo sapiens.

features

Prokaryotes have no nucleus. Eukaryotes have nuclei. Multicellular eukaryotes have neurons, sense cells, and muscle cells. Invertebrates can have bilateral symmetry, as in flatworms. Prechordates have notochord beginnings. Chordates have notochord in one development stage. Vertebrates have vertebrae. First fish have cartilage. Bony fish have bones. Lobe-finned fish have fin stumps. Fresh-water lobe-finned fish live in fresh water. Amphibians live on land and in water. Reptiles can live only on land. Mammals make milk. Primates have forward eyes. Old World monkeys have tricolor vision. Hominids, hominins, Homo, Homo habilis, Homo erectus, and Homo sapiens follow.

requirements

Evolution requires objects that carry coded information about how to build and maintain structures and functions and about how to replicate themselves. Evolution requires mechanisms to build objects, maintain objects, replicate objects faithfully, and provide slight variations in coded information. Evolution requires environment that has scarce resources. Evolution requires competition among similar objects. Objects then replicate more or better.

levels

Evolution can affect whole Earth, biomes, ecosystems, clades, or demes. Evolution can act on kingdoms, phyla, classes, orders, families, genuses, species, and varieties. Evolution can act on organs, tissues, cell lines, chromosomes, genes, exons, DNA functional regions, and nucleotides. Different levels can have different selection laws.

environment

If organisms change, other organisms change in response, and relations between other organisms and environment change. Change can cause exponential change. However, change is disruptive and decreases survival for most organisms.

Universal Darwinism

Systems that make copies, have variations, and have a selection mechanism can evolve {Universal Darwinism} [Dawkins, 1976] [Dawkins, 1986] [Dawkins, 1995].

intelligent design

Religionists can believe that God helped form some species. God used special structures and functions that distinguish humans from other species. However, intelligent design does not seem to allow human-appendix creation or maintenance. Complex life forms need to eat less complex forms. Intelligent design allows arbitrary changes and so has no testable hypotheses.

criticisms

Perhaps, both intelligent design and evolution are incorrect. Really, physical laws determine all, with no higher principles. Evolution works only haphazardly, with most species dying out.

macroevolution

Natural selection can make more-complex higher-level organisms {macroevolution}.

orthogenesis

Structural constraints allow special forms {orthogenesis}| and guide evolution. Evolution can proceed directly from primitive species to higher species, without side branches. Evolution can jump to new species, without gradual steps.

phylogenetic inertia

Food specializations, migrations, and dangerous predators increase ecological-or-environmental pressures and increase evolution. Available genes, gene variability, adaptable behaviors, and food types resist evolution {phylogenetic inertia}.

BIOL>Biology>Evolution>Species

species in ecology

Interbreeding organisms {species, ecology}| are basic biological units. Similar organisms share gene sets. Related species share similar structures, functions, and genes.

speciation

New species can arise from existing species {speciation}|.

hybridization

Hybrids between two different species sum chromosome-pair numbers. If eggs are fertile, self-fertilization starts new species intermediate between parent species. Chromosome doubling created many plant species and some animal species.

chromosome change

New species can arise through chromosome-number or gene-order change. Human chromosomes differ from chimpanzee chromosomes by inversions in nine chromosomes and by fusion of two chromosomes.

divergence principle

New species can appear if species diverge {principle of divergence} {divergence principle}. Typically, species gradually diverge into varieties, then subspecies, and then species. Behavior traits can diverge in ten generations. Major changes, such as brain development, diverge in 100 generations. New species diverge in 2000 generations. Species formation by divergence typically requires subspecies geographic isolation, to prevent gene dilution by other subspecies. Species diverge if organisms have different niches in same geographic area. Species converge if organisms live in separate areas with similar niches.

holotype

Species have original varieties {holotype}.

homoplasy

Organisms can perform similar functions using different structures {homoplasy}.

homology of organisms

Organisms can have similar internal structures {homogeny} {homology, organism}|. Homology can result from keeping fundamental internal structure during evolution {parallelism, evolution} or having same external pressures during evolution and evolving to similar structures {convergence, evolution}.

endosymbiont hypothesis

Early eukaryotes incorporated primitive bacteria {endosymbiont hypothesis}, which evolved to mitochondria and chloroplasts.

heterochrony

Larval stages can become sexually mature {heterochrony}, to make new species.

paedomorphosis

Larval stages can become sexually mature, to make new species {paedomorphosis}.

peramorphosis

Adult stages can add features, to make new species {peramorphosis}.

BIOL>Biology>Evolution>Classification

classification in biology

Earth has 2,500,000 species in many categories {classification, biology}. Earliest life was one-celled organisms. Archaea included thermophiles. Bacteria included proteobacteria and later cyanobacteria blue-green algae. Eukaryota included metamonad, parabasalid, trypanosoma, ciliates, and flagellates. Multicellular organisms arose from eukaryotes.

metazoa

Many-celled organisms {metazoa}| {multicellular organism} include fungi, plants, and animals. Metazoa have specialized tissues.

evolution

Only eukaryotes can be multicellular organisms. About 650 million years ago, protozoa clustered, and cells differentiated into different tissues. Later eukaryotes evolved neurons. Later, jellyfish evolved sodium-ion channels for action potentials, which allow neurons to communicate over any distance.

gene transfer

Early eukaryotes incorporated early alpha-proteobacteria to make mitochondria. Early eukaryotes incorporated early cyanobacteria to make chloroplasts. Perhaps, eukaryote cytoskeleton and internal membranes came from early spirochetes, flagellates, or ciliates.

binomial nomenclature

Organism names are genus name followed by species name {binomial system} {binomial nomenclature}|, such as Escherischia coli.

BIOL>Biology>Evolution>Classification>Cell Nucleus

prokaryote

One-celled organisms {prokaryote}| {Monera} {Prokaryota} can have no distinct nucleus or other cell organelles. Prokaryotes include archaebacteria and eubacteria. Eubacteria include blue-green-algae cyanobacteria.

eukaryote

Cells {eukaryote}| (Eukaryota) (Eukarya) can have one cell nucleus surrounded by membrane. Eukaryotes include protozoa, fungi, plants, and animals. Eukaryotes are not Archaea, bacteria, blue-green algae, viruses, or bacteriophages.

BIOL>Biology>Evolution>Classification>Levels

kingdom of organisms

The largest organism groups {kingdom, classification}| include non-nucleated single-cell archaebacteria (Archaea), non-nucleated single-cell eubacteria (Bacteria), nucleated single-cell protozoa (Protista) {protist}, nucleated fungi (Fungi), nucleated multi-cell plants (Plantae), and nucleated multi-cell animals (Animalia).

domains

Domains are Archaea, Bacteria, and Eukaryota. Archaea include thermophiles. Bacteria include proteobacteria, cyanobacteria, and other bacteria. Eukaryota include protozoa, yeast and other fungi, algae and other plants, and animals.

algae

Bacteria include cyanobacteria blue-green algae. Other algae are plants.

yeast

Fungi include yeast.

division of organisms

Kingdoms have major organism types {phylum} {phyla} {division, classification}|.

class of organisms

Divisions/phyla have subdivisions {class, classification}|.

order of organisms

Classes have subclasses {order, classification}|.

family of organisms

Orders have suborders {family, classification}|.

genus of organisms

Families have subfamilies {genus, classification}|.

species of genus

Genuses have interbreeding subgenuses {species, classification}|.

BIOL>Biology>Evolution>Classification>Levels>Race

variety of organisms

Species have subspecies {variety}|.

race

Humans have varieties {race, people}, such as north European white {Caucasian, people}, south European white {Mediterranean, people}, European and American Indian {mestizo}, Spanish-speaking or Portuguese-speaking country of South and Central America {Hispanic}, Central America {Latino}, Mexico {Chicano}, Africa {Negro} {black, person} {African-American}, and Asia {Asian} {Oriental, people} {Asian-American}.

types

People have three races, totaling 30 varieties.

Races {Caucasoid race} can include the varieties Mediterranean, Nordic, Alpine, Armenoid, and Dinaric. It can have more pale red, white, or light brown skin color, be taller, have longer or broader head, have light to dark hair, and have higher nosebridge. Armenoid has Caucasian and Mongoloid. Dinaric has Caucasian, Negroid, and Mongoloid.

Races {Negroid race} can include the varieties African, South Pacific, Melanesian, Oceania, White Hottentots, Bushmen, extinct Tasmanian, and Negritos or pygmies. It can have browner skin color, longer head, thicker lips, darker and coarser hair, darker eyes, lower nosebridge, and broader nostrils.

Races {Asiao-American Race} {Yellow Race} {Mongoloid race} can include the varieties Tungus in Siberia, Oriental, Eskimo, Indonesian, American Indian, Ainu in Japan, Australoid, and Veddoid, as well as Beijing Man, Lantian Man, and Jinniushan Man. Oriental has Chinese and Japanese. Oceanian has New Guinean, Australian, and Aborigine. Eskimos are more separate from Oriental than Oceanian. Mongoloid race started in Central and East Asia and went to South Asia and Southeast Asia. It can have more yellow or red skin color, be average height, have broader head, have less body hair, have darker eyes, have more epicanthic fold, have lower nosebridge, have higher eye sockets, have flat face bones, have higher superciliary arches, have more spade-shaped incisor insides, and have darker, straighter, and coarser hair.

Aborigines in Australia, Dravidians in south India, Polynesians in South Pacific Ocean, and Ainu in north Japan are hard to classify.

dispersion

Gene differences show that original Homo sapiens split into proto-Africans-and-Europeans, proto-Oceania, proto-American Indians, and proto-Oriental peoples. Then African Negritos and Bushmen separated from European Germanic and Mediterranean, so Europeans were intermediate between proto-African and proto-Oriental peoples.

Alu-repeat and short-tandem-repeat polymorphisms divide people into sub-Saharan Africa, Europe and West Asia, East Asia, Polynesia, and Americas groups. Perhaps, sub-Saharan Africa had two groups, including Mbuti pygmies. Genetic variants are 90% same, so group differences are maximum 10%.

cold adaptations

In cold regions, people tend to have shorter limbs, larger bodies, thicker eyelids, flatter noses, flatter foreheads, and broader cheeks.

factors

Decreased environmental pressures, increased mutation-causing agents, more socially-useful genes, greater specialization, and faster environment changes affect human evolution.

multiregional hypothesis

Y-chromosome studies indicate that modern human did not arise from multiple origins {multiregional hypothesis}.

out-of-Africa hypothesis

Y-chromosome studies indicate that modern human races arose from African population [-89000 to -35000] {out-of-Africa hypothesis}.

BIOL>Biology>Evolution>Classification>Cladistics

cladistics

Organism-classification systems {cladistics}| can depend on evolutionary, gene, structural, and functional features.

clade

Species can split into independently evolving lines {clade}|. Different clades have different speciation rates, which can change over time. Clades determine classes and hierarchies, shown in branching diagrams {cladogram}. Cladogram nodes represent shared homologies.

BIOL>Biology>Evolution>Selection

natural selection

Species members make species members similar to themselves. Among variations, surviving and reproducing member adaptations increase percentages {natural selection, evolution}|. Natural selection affects phenotypes, which relate to genotypes, which vary by mutation or allele recombination.

purpose

Natural selection has no goals. Natural selection is not progress.

creation

Natural selection explains species diversity and adaptations materialistically. Creation mechanisms need have no creator.

examples

Peppered moths become darker or lighter in industrial or rural areas, because birds eat lighter or darker moths in industrial or rural areas. Bacteria develop antibiotic resistance. Insects develop insecticide resistance. Rats develop rat-poison resistance. People still have sickle-cell anemia, because it helps fight malaria. People still have tuberculosis, because it has vitamin-D-receptor gene. People still have cystic-fibrosis CTFR gene, because it helps fight typhoid.

selection types

In unpredictable environments, organisms tend to have fast development, many offspring, and offspring with few defenses {r-selection} {r selection} {opportunistic selection}, so population can increase in favorable periods. Unpredictable environments have fewer species. In predictable environments, organisms tend to have slower development, few offspring, and offspring with defenses {k-selection} {K selection}, so population is stable. Predictable environments have more species {selection, evolution}.

social evolution

Societies evolve through time {social evolution}. Social evolution includes new defenses against predators, higher feeding efficiencies, higher reproductive efficiencies, lower child death rates, more population stability, and new territories and environmental changes. Social evolution is more in stable environments. Social evolution seldom happens in variable environments.

survival of the fittest

Species members with best adaptations have highest percentage of survival to reproductive age {survival of the fittest, selection}|.

extinction of species

Species die out {extinction, species}|. Extinction typically happens soon after species formation. Extinction can happen if environment capacity is not enough. Increased speciation increases species extinction. Better adaptation prevents extinction. Slow variation and slow environmental change prevent extinction.

kin selection

Parents can care for relatives' children, or relatives {kinship group} can help each other {kin selection}.

BIOL>Biology>Evolution>Selection>Competition

competition in species

Species members compete for food, mates, and territory {competition, evolution}. Different species compete as predators and prey. Territory competition can cause convergence in dominant species and divergence in dominated species. Species typically relinquish habitat to competitors to keep preferred food, rather than staying and eating new foods.

predation

Animals {predator} can eat other animals {predation, competition}|. Predators kill young, weak, and sick population members.

aggression in evolution

Aggressive behavior {aggression, ecology} protects territory, establishes dominance, protects sexual property, gets sex partners, disciplines, weans, imposes morals, predates, prevents predation, causes fear, expresses anger, and irritates. Most aggressions happen in competitions between species members. Examples are sexual aggression and food, territory, and status competition. Aggressive behavior patterns and levels evolve to adapt to environments. Species members vary in aggression levels.

Gause principle

In one ecosystem, competition can separate two similar species into separate niches {competition exclusion principle} {Gause's principle} {Gause principle}.

BIOL>Biology>Evolution>Variation

variation in species

Species members have different gene-allele combinations and so have different trait combinations {variation, species}|.

causes

Mutations or allele recombinations cause genetic variation. Sex increases variation by increasing gene combination.

causes: selection

Evolution typically changes population allele ratios. Climate changes increase variation by increasing environment variety. Isolation increases variation by increasing environment variety.

amount

On average, 6% of vertebrate genes vary from wild type. On average, 15% of plant and invertebrate genes vary from wild type.

effects

Most changes are not adaptive. Species with greater genetic variation evolve faster, because they can use more environmental niches.

effects: duplication

Gene duplication and body part duplication allow duplicates to perform new functions, while originals perform old functions.

effects: whole body

Isolated changes can happen, but, to be adaptive, changes must work together with whole body, which then evolves in response to changes. For example, brain and body evolved together. Finger muscles, bone, nerves, blood supply, and brain motor-and-sensory finger regions evolved together, because dexterity required linked development.

microevolution

Populations have gene-frequency changes {microevolution}. Microevolution includes gene flow, mutation pressure, and segregation distortion.

natural selection

Natural selection causes most gene-frequency changes. Natural selection can cause adaptations in constant environments or make new genes in fluctuating environments. Natural selection typically stabilizes gene frequencies and decreases homozygote percentage. New species arise from microevolutionary changes by accumulated changes in one direction {progressive evolution}.

drift

Random gene-splicing errors can cause heterozygosity loss by genetic drift, but this factor only affects small populations with inbreeding and consanguinity.

canalizing

Allele mutations can negatively affect other alleles {canalizing}.

gene flow

Immigrations into populations {gene flow} have major and fast gene-frequency effects, mainly through hybridization.

hybrid strain

Strain combinations {hybrid}| generally show the good results of outbreeding {hybrid vigor}.

Mongolian spot

Bluish pigmented areas {Mongolian spot} {Mongol spot} {blue spot}, near spine bases, are present at birth in some Asian, south European, American Indian, and black infants and typically disappears during childhood.

mutation pressure

Minor gene-frequency-change factors {mutation pressure} include differing allele-mutation rates.

segregation distortion

Minor gene-frequency-change factors {segregation distortion} {meiotic drive} include unequal allele production by heterozygous parents.

sexual dimorphism

Males typically have larger size and different shape than females {sexual dimorphism}|.

proximate factor

Trait presence depends on making trait {proximate factor} and keeping trait during reproduction. Trait survival in species members depends on environment, reproduction accuracy, and protection from change {ultimate factor}.

BIOL>Biology>Evolution>Adaptation

adaptation of organism

In environments, organisms can adjust behavior {adaptation, organism}| to survive and reproduce.

survival

To reproduce, species members must survive to sexual maturity. They must get food, avoid predators, fight disease, and maintain temperature, in a struggle for survival.

adaptation

To optimize environment use, species can use different foods, decrease development time, increase temperature range, increase air or water pressure range, use protective coloration, use warning coloration, use mimicry, and use other species.

varieties

Genes alleles vary proportions and interactions. Alleles remain available to survive slow, catastrophic, or cyclic environmental changes and to use different environment niches.

adaptive radiation

Species evolve to new varieties that can occupy surrounding environments {adaptive radiation} {radiation, adaptive}.

cooptation

As structures shift, functions and adaptations can be different {functional shift} {cooptation}. Small structure shifts are not necessarily adaptive.

Cope rule

Organisms tend to evolve to larger size {Cope's rule} {Cope rule}. Larger organisms typically compete better for sex and food and have better protection from predators. Evolution tends to build larger and more complex organisms.

countershading

Animal tops and bottoms can have different colors {countershading}|. For example, bottoms can be light to match sky, and tops dark to match sea.

environment

Organisms can alter their surroundings {environment} [Bateson, 1916] [Cosmides et al., 1992].

grade in development

Species can pass through trait-development stages {grade, development}.

homeostasis in animals

Negative feedback keeps involuntary muscle actions and chemical levels within normal ranges {homeostasis, animal}.

longevity

Longer lives {longevity}| are adaptive in stable environments, harsh and unpredictable environments, low progeny-survival-rate conditions, and low-fertility conditions.

mimicry

Species can imitate other species {mimicry}|.

preadaptation

Organism features {preadaptation} can find new uses in new environments.

protective coloration

Species can change color for disguise {protective coloration}|.

warning coloration

Species can change skin or coat color and pattern to scare predators {warning coloration}|.

BIOL>Biology>Evolution>Adaptation>Direction

convergent evolution

Evolution can make similar structures and functions in different species {convergent evolution}, to adapt to similar environments.

divergent evolution

Evolution can make new species varieties, then subspecies, and then new species {divergent evolution}, to adapt to environment niches.

BIOL>Biology>Evolution>Adaptation>Habitat

habitat tracking

Species try to stay in environment niches {habitat tracking}.

polygenesis

Different habitats cause differences among people {polygenesis}.

BIOL>Biology>Evolution>Adaptation>Habitat>Patry

allopatry

New species arise in geographic isolation {allopatry}.

sympatry

New species do not arise in same location {sympatry}.

BIOL>Biology>Evolution>Adaptation>Fitness

fitness

Reproductive fitness {fitness} is adaptations that maximize offspring that live to make offspring. Fitness maximizes number of genes passed to offspring, which pass those genes to offspring.

differential fitness

Replicate number and adaptability depend on how well environment and species members interact {differential fitness}.

epistasis

Gene alleles can affect other-allele fitness {epistasis} {epistasy} {epistatic coupling}. Gene mutation can affect mutation expression at other loci.

evolutionary stable strategy

Ecosystems can maintain stable alleles in stable species {evolutionary stable strategy}. Evolutionary stable strategies apply game-theory Nash equilibria to ecosystems. If allele change reduces other-species fitness, it reduces species fitness.

BIOL>Biology>Evolution>Reproduction

reproduction in evolution

One or two organisms can make new organisms {reproduction, organism}|, by sexual or asexual reproduction. Reptiles determine sex by egg temperature, not by Y-chromosome. Birds and mammals determine sex by chromosome. More sexual selection, higher fecundity, and higher rates of survival to reproducing age {differential reproduction} improve survival.

reproductive effort

Reproductive processes take time and energy {reproductive effort} away from predation and protection and escape from predation. Reproductive effort is more if reproductive rate is more. Higher non-social animals have low reproductive effort, but higher social animals have high reproductive effort. Societies perform predation and food gathering most, anti-predation next, and reproduction least. Function time varies with food shortage, danger, or mating season.

reproductive rate

Net population growth rate {reproductive rate} depends on death rate and birth rate. Young, weak, and sick population members have low reproduction. Older population members have high reproduction, producing more offspring and guarding them better. Stronger and more active population members have high reproduction, especially if they start new colonies and occupy new habitats. Species have optimum fertility rates, based on reproductive rates.

replication

Natural objects {replicator} can copy themselves {replication, nature}, using available resources.

similarity

Replicators and replicates are alike. If replicate survives, it is like replicator survives.

mechanism

Replication requires reproduction mechanisms to assemble parts. Replication requires template patterns to copy.

comparison

Organisms use resources for replication, eating, and escaping, so they must balance these activities. Survival to reproductive age requires eating and escaping.

properties

Replicators are purposive, because they replicate. They are selfish, because they use resources to replicate. They are problem solving, because they gather and use resources to replicate. They are decision making, because they decide when and whether to replicate.

superfecundity

Species members must reproduce more organisms than environment can support {superfecundity, reproduction}. Superfecundity forces species members to compete against each other for mates and food, as well as other resources needed to reproduce. Species members must survive until sexual maturity, with strength to reproduce and win competitions for mates.

sexual maturity

Species members must reach reproductive age and development to reproduce {sexual maturity}. Before that stage, species members cannot reproduce {sexual immaturity}.

parental investment

Parents use energy and time {parental investment} to bring offspring to reproductive age. Children survive better if parents protect, feed, and teach them longer. However, parents can transmit more genes if they have more children, so parental investment is in equilibrium with children number.

factors

Stable predictable environment, longevity, regular reproduction, large size, territoriality, few offspring, difficult environments, many predators, and food specialization favor more and longer parental investment.

kin

Child raising by parents and relatives is altruistic kin selection. In many societies, non-relatives raise offspring, to gain child-raising experience and to limit aggression.

insects

Societies typically have high societal investment in offspring. Insect societies have no parental investment, because adults do not directly affect offspring behavior.

BIOL>Biology>Evolution>Reproduction>Mating

mating

Two opposite-sex animals can produce {mating}| offspring by uniting sperm and egg. Sexual reproduction allows more variation and more sexual selection.

polygamy

Animals can have more than one mate. Polygamy is typical, because parental investment in children is typically unequal. Abundant food at least once a year, heavy predation, precocious young, greater longevity, different gender maturation ages, and different gender niches favor polygamy. High competition for mates leads to polygamy and mate monopolization. Polygamous species tend to have high sexual dimorphism.

monogamy

Animals can have one mate. Monogamy is rare. Monogamy happens in territories with scarce resources that require two animals to maintain or defend. Monogamy happens in difficult environments. Monogamy happens in species with early breeding. Monogamous species tend to have low sexual dimorphism.

breeding

Mating {breeding}| related individuals {inbreeding, alleles} tends to pair recessive alleles. Mating unrelated individuals {outbreeding} mixes alleles more.

selective breeding

Species can choose mates for good survival characteristics {selective breeding}|. High competition for mates leads to polygamy and mate monopolization.

sexual selection

Organisms select mates {sexual selection}|. Sexual behaviors tend to resist social evolution.

males

Sexual behaviors can be strategies to ensure that parent has conceived cared-for offspring. For males, sexual selection can involve keeping other males away from females, to prevent reproduction. Males can transmit more genes if they produce more females, rather than males.

males: displays

In many species, male pattern and behavioral displays lure females. Displays are fewer if food is scarcer or predators are more numerous.

females

For females, sexual selection involves selecting mates. Species with more receptive females have less fighting among males. Females can transmit more genes if they produce one male.

BIOL>Biology>Evolution>Reproduction>Asexual

asexual reproduction

One organism can make copies {asexual reproduction}| by budding, cell fission, regeneration, sporulation, or parthenogenesis.

budding reproduction

Asexual reproduction can have growth of special cells {budding}|, as in plants, hydra, and yeast.

fission of cells

Asexual reproduction can split cells {fission, cell}|, as in most cells.

regeneration reproduction

Asexual reproduction can have differential growth in broken-off pieces {regeneration, reproduction}, as in flatworms and starfish.

sporulation

Asexual reproduction can uses special haploid or diploid cells {spore} that detach from organisms {sporulation}|, as in most plants and some animals.

parthenogenesis

Reproduction can be haploid egg developing into adult {parthenogenesis}|, as in honeybee, wasp, and other arthropods.

BIOL>Biology>Evolution>Reproduction>Sexual

sexual reproduction

Two organisms can make organisms similar to themselves by uniting their DNA {sexual reproduction}|, using conjugation, copulation, or hermaphroditism.

fertilization in reproduction

In hermaphroditism and copulation, haploid sperm enter haploid eggs {fertilization, reproduction} to form diploid cells. Fertilization can happen in oceans, rivers, or lakes {external fertilization} or inside bodies {internal fertilization}.

gonad

Sex organs {gonad}| produce sperm or eggs.

BIOL>Biology>Evolution>Reproduction>Sexual>Kinds

conjugation for reproduction

Sexual reproduction can use DNA-region exchange, after temporary union of two one-celled organisms {conjugation, reproduction}, as in bacteria.

hermaphroditism

Sexual reproduction can use mutual egg fertilization by sperm from two individuals that have both sex organs {hermaphroditism}|, as in oysters, tapeworms, and earthworms.

BIOL>Biology>Evolution>Theory

evolution theory

New species develop from existing species {evolution theory} {organic evolution} {theory of organic evolution} {theory of evolution}.

reproduction

Species members can make one or more organisms similar to themselves. Species members must reach sexual maturity to reproduce. Species members vary in fecundity.

competition

Species members reproduce more organisms than environment can support {superfecundity, evolution}, so species members compete against each other for mates and food. In environments, species members must get food, avoid predators, fight disease, and maintain temperature {struggle for survival} to reach sexual maturity, have health and strength to reproduce, and win competitions for mates.

adaptation

Species members have traits that affect the struggle for survival.

variation

Species members differ over species-characteristic ranges. Parents and reproduced organisms typically have similar values. Mutation, crossing over, and development can change values, add new values, or add or subtract characteristics. Characteristics and values can affect adaptation, competition, and fecundity by altering strength, size, or skill. See Figure 1. Species members with best-adapted characteristics and values have highest percentage of survival to reproductive age {survival of the fittest, evolution}.

environment

Environments have food sources, predators, diseases, climates, and cycles. Environments constrain species-member reproduction. Environments do not have enough food for all species members to stay alive, or be healthy and strong enough, to reproduce at reproductive age. Predators and diseases eat, kill, or harm species members, so they cannot reproduce at reproductive age. Environments have temperature cycles. Environments affect reproductive methods, such as how mates get together. See Figure 1.

natural selection

Species members compete for resources to reach reproductive age and reproduce. Species members vary in characteristics, so some species members have higher probability to win competitions and reproduce. Species members typically make members similar to themselves, so their characteristics increase percentages {natural selection, evolution theory}. Evolution shifts allele frequencies. See Figure 1. Evolution can also cause new genes.

species

Natural selection makes higher percentage of better-adapted species members, so species are better able to avoid extinction. Natural selection typically makes more surviving species members than before. Competition for food and mates becomes greater, causing higher pressure for survival. Over time, new species varieties arise. Over time, species varieties differ enough to be new species. For sexually reproducing species, new species members cannot reproduce with old species members. New species typically arise in isolated environments different from previous environments. New species can arise by combining two closely related species to make hybrids.

genes

Cells, body, and environment supply energy and needed chemicals to make DNA physical structures that can be stable, vary slightly, replicate accurately, copy more or less, and contain enough information. DNA has four different nucleotides chemically bonded in long or short sequences. DNA positions can have any nucleotide. Genes are templates for making DNA by replication, RNA by transcription, and protein by translation. Copying mechanisms have one error per million DNA units. Besides copying errors, DNA and RNA can suffer physical and chemical mutation damage that changes nucleotides or disrupts sequence {rearrangement}. In sexual reproduction, combining DNA from two sexes mixes sequence segments by crossing-over. These processes cause sequence changes. DNA reproduces, varies, and depends on environment and individual, so it faces competition, has adaptation, and goes through natural selection. Different species have different genes and alleles.

copying instructions

Copying instructions is more accurate than copying products, because products have more and different parts than instructions, and products typically have damage [Blackmore, 1999].

selection levels

Perhaps, natural selection applies to cell lines, organisms, demes, species, and clades, as well as genes. Selection levels can work synergistically, in opposition, or independently.

history

Evolution is not best or perfectly adapted but constrained by history, random effects, and physical laws [Feynman, 1965].

evolution theory: Summary 1

Objects that can reproduce same structures and functions with small changes, and that occupy environments in which they can die before reproduction, tend to evolve characteristics that fit environment. Objects retain only changes that make them survive better.

evolution theory: Summary 2

Organisms produce more offspring than survive to reproduce. Though people can think that God makes organisms that almost all survive to reproduce, except for natural accidents, or that match reproduction rate with death rate, all species actually produce extra offspring, as shown by Darwin. Offspring vary traits. It is easily observable fact that species members vary in observable traits. Observable traits have microscopic traits that vary. Offspring pass microscopic and so observable traits to offspring. It is easily observable fact that all organisms try to reproduce and that offspring typically resemble reproducers. Offspring with traits more favorable for survival to reproductive age produce more offspring with same traits.

evolution theory: Summary 3

Natural selection removes unfit and designs fit. Organisms vary in random ways. Variations typically are harmful but can be adaptive. Variations can accumulate over generations. Natural selection can make more-complex higher-level organisms.

evolution theory: Summary 4

Because organisms over-reproduce, nature has competing organisms and species, so new ones must replace or push aside existing ones {wedge, evolution}, leading to better adapted species. Typically, environment changes slowly compared to species changes.

evolution theory: Summary 5

In geographic areas, organism number increases geometrically through reproduction, but food and mating resources have limits. Species members and all organisms have struggle for existence. Individuals have various trait values. On average, process selects individuals with the most-fit trait values. Over time, natural selection causes organism gene-frequency changes [Darwin, 1859] [Darwin, 1871] [Judson, 1979] [Gould, 2002] [Huxley, 1884] [Ridley, 2003].

Figure 1
This species has four members that are the same but vary in font style:

S1 **S2** *S3* S4

S1 reproduces exactly. **S2** changes an existing value. *S3* makes a new value. S4 makes a new quality:

S1 *S3* ***S5*** S4T1

A species requires a limited resource R1 to reproduce. A species produces more offspring than can reproduce. The members must compete for that resource:

S1 *S3* ***S5*** S4T1

R1

If the resource is reusable, only one species member can reproduce at a time. If the resource is usable only once, only one species member can reproduce. The best-adapted member will reproduce:

S1 *S3* ***S5***

R1-S4T1

That one species member will pass on its qualities and quality values, but the others will not:

R1-S4T1

R1-S4T1

The frequencies of quality values will change in each generation of offspring.

gene theory

Specialized germ plasm reproductive cells transmit protein-coding genes that underlie physiological traits {gene theory}. Body cells do not affect germ-plasm genes, so genes cannot directly inherit learned behaviors {acquired characteristic} [Dubos, 1968] [Keller, 2000].

generalized theory of evolution

Evolution has general requirements {generalized theory of evolution}.

variation

Evolution requires objects with properties, such as size or color, with different values. Evolution requires mechanisms to switch among property values and/or mechanisms that can make new values or new properties.

reproduction

Evolution requires objects to have mechanisms that produce new objects with similar property values. Reproductive mechanisms typically use templates that carry coded information about object properties. Reproductive mechanisms do not copy perfectly but allow unit changes, such as mutations.

competition

Objects and reproductive mechanisms require resources. Object reproductions produce more objects than environment resources can support.

species

Systems can have only one object type or can have multiple objects, object groups, and/or hierarchies.

environment

Random events from inside or outside objects can affect objects, to cause new properties and values or affect reproduction.

evolution

Selective systems with variations among reproducing individuals who can pass on traits always evolve.

punctuated equilibrium

In small populations, new species can arise quickly under new environmental conditions {punctuated equilibrium} {quantum speciation}. Nature has many small populations. Fossils show many rapid species-evolution examples.

BIOL>Biology>Evolution>Theories

Lamarckianism

Lamarck said that organism actions cause body changes {Lamarckianism}. For example, giraffes have long necks through continual neck stretching. This theory is false in general, but organism actions can affect evolution in small ways by affecting mutation, crossing-over, and translocation.

learning

Perhaps, neurohormones and neurotransmitters sent from brain can affect germ cells by changing gene expression or causing structural changes. Thus, learned behaviors can trigger chemicals that can alter germ cells. Alterations can correspond to learned behavior.

strength

Perhaps, fittest individuals can sustain useless or harmful innovations that weaker individuals cannot have. Innovations can then evolve into useful traits, and species can evolve.

energy

Perhaps, fittest individuals have more energy, matter, and organization to implement innovations that have no chance in weaker individuals. Innovations can then evolve into useful traits, and species can evolve.

panadaptationism

Perhaps, all traits are adaptive {panadaptationism}. This theory is not true, because most traits are side effects and some traits are not good adaptations [Gould and Lewontin, 1979].

BIOL>Biology>Techniques

animal model

Animal diseases can model human diseases {animal model} {model, animal}. Germ-free animals are useful.

variables

Disease progress and outcome depend on species, strain, genotype modifications, gender, and age. Disease agents and treatments have different locations and administration methods.

problems

Animals contract other diseases regularly in laboratory settings, so animals must have no bacteria, such as Helicobacter and Camphlylobacter, or worms, such as Helminthes. Outside organisms can elicit immunologic, inflammatory, and cancerous effects to obviate experiment.

association study

Studies {association study} can compare allele frequency in disease and control populations. Frequency difference indicates that allele relates to disease. Genetic-linkage algorithms compare disease and control allele frequencies to find marker locus. Studies can compare allele frequencies among phenotypes.

carbon dating

Carbon-isotope ratios can date objects up to 100,000 years old {carbon dating}|.

instrument

Mass spectroscopy can measure isotope amounts in very small samples.

location

Lower-atmosphere carbon dioxide has radioactive carbon-14 {radiocarbon} to non-radioactive carbon-12 ratio. Living things have same carbon-isotope ratio as lower atmosphere.

time

Lower-atmosphere carbon-isotope ratio varies over time. Measuring air trapped in glaciers at different depths shows ratios at past times. Carbon-isotope ratio decreases after organisms die, because carbon-14 decays to nitrogen-14. Comparing current reduced ratio to atmosphere ratio at death indicates time of death.

age

Carbon dating is only useful up to 100,000 years ago, because almost all carbon-14 decays in 100,000 years.

changes

Older carbon-dating methods needed more mass and used fire ashes or other organic materials adjacent to formerly living things, not living things themselves. Older carbon-dating methods assumed that atmospheric carbon-isotope ratio is constant. Because ratios actually changed, carbon-dating dates in scientific literature before 1990 are typically too recent. For example, earlier-reported -9000 is actually -11000 or 13,000 years ago.

calibration

Actual lower-atmosphere carbon-isotope ratios, measured at different glacier depths, can find correct dates {calibrated carbon dating}.

dissection

Techniques {dissection}| can open plants and animals to observe parts.

gene insertion

Shooting gold or tungsten particles carrying genes into cereal seeds {gene insertion} can cause gene insertion into cereal DNA.

leaf disk technique

Agrobacterium tumefaciens can attach to plant leaves and then transfer DNA, including foreign genes, into leaves {leaf disk technique}.

limb movement

Placing lights on joints and limbs allows filming limb movements {limb movement}.

monoclonal antibody

Injecting antigens into mice or rats causes immune responses and makes antibodies {monoclonal antibody}| in spleen lymphocytes.

hybrid cells

In cell culture, lymphocytes can mix with myeloma cell lines to make hybrid cells {hybridoma}. Polyethylene glycol helps hybridization.

screening

Screening can find hybrid cells with large antibody quantities.

antibodies

Rituxan works against lymphoma.

Herceptin {trastuzumab} works against breast cancer. Epidermal-growth-factor receptors (EGFR) make dimerization signals, which tell cells to divide. Herceptin binds to HER2 cell-surface epidermal-growth-factor receptors and prevents dimerization signals. Dimercept binds to HER cell-surface-receptor dimerization sites. Lapatinib kinase inhibitor inhibits HER2 receptors.

Kinase inhibitors inhibit PI3K, AKT, and mTOR in cell-survival pathway.

Letrozole aromatase inhibitor inhibits estrogen synthesis. Tamoxifen aromatase inhibitor inhibits estrogen and progesterone synthesis.

Bevacimuzab inhibits tumor blood-vessel formation at VEGF receptors.

Monoclonal antibodies can inhibit IGF-1 receptors.

nanobodies

Llamas and camels make half their antibodies {nanobody} using only heavy chains, which supply variable segments.

optical coherence tomography

Coherent light sources can split into reflected beams and beams that enter tissue, and then beams can interfere {optical coherence tomography}.

surface plasmon resonance

Techniques {surface plasmon resonance} (SPR) can measure protein site-binding strength.

BIOL>Biology>Techniques>Nerve

axon flow

Squeezing nerve fibers causes axoplasm to accumulate on both sides, showing that nerve-fiber axoplasm flows {axon flow} in both directions.

Nauta technique

Techniques {Nauta technique} can stain degenerating axons with silver. First, electrodes stimulate neurons with electric current, or fine pipettes stimulate neurons with chemicals. Then fine pipettes inject dye into cells. After axon cutting, dye blackens dying-axon branches.

positron emission tomography

Techniques {positron emission tomography} (PET) can use radioactive oxygen or carbon isotopes to measure cerebral blood flow or metabolic activity. Oxygen isotopes in glucose or neurotransmitters emit positrons as they decay. Patients receive radioactive tracers by injection or in food. Scanners localize radioactivity to within several millimeters and within one minute. Localized radioactivity shows increased oxygen-metabolism and glucose-metabolism sites. Brain blood flow varies with metabolic activity, so PET indicates locations with increased blood flow.

xenon

Alternatively, patients can receive radioactive xenon by injection into blood. The most active neurons become the most radioactive.

carbon 14

Carbon(14) 2-deoxyglucose is similar to glucose. Neurons can absorb the radioactive compound but cannot metabolize it. Neurons that absorb the most radioactivity are the most metabolically active.

retrograde marking

Techniques {immunohistofluorescence} {retrograde marking} [1970] can stain neurons backward from injection site using horseradish peroxidase, colloidal gold wheat-germ agglutin, and fluorescent dyes.

single channel recording

Techniques {single channel recording} {patch clamping} can measure single-neuron electrical activity.

single photon emission computed tomography

Techniques {single photon emission computed tomography} (SPECT) can measure cerebral blood flow or metabolic activity, using light.

BIOL>Biology>History

biology in history
biologist
Earth
1500 to 2007
Biology includes anatomy, botany, cell biology, genetics, nutrition, physiology, and zoology.

BIOL>Biology>History>Anatomy

Alcmaeon or Alcmaeon of Croton
doctor
Crotona, Italy
-500 to -450
Dissections [-500]; On Nature [-500 to -450]
He lived -535 to -440 and dissected animals. Body has opposing powers, hot/cold and wet/dry, which balance in health. Galen later used this idea.

Hippocrates
doctor
Cos, Greece
-430 to -400
On Ancient Medicine [-430 to -400]; On Wounds of the Head [-430 to -400]
He lived -460 to -377. The "father of medicine" wrote case histories, disease observations, and Hippocratic oath. He described trephining skull holes. Disease results from humor essence imbalance.

Herophilus
anatomist
Alexandria, Egypt
-300 to -280
He lived -335 to -280, dissected human body, and compared to other animal bodies. He described brain, brain ventricles, heart, heart valves, nervous system, sense and motor nerves, cornea, sclera, choroid, retina, and lens. He founded medical school at Alexandria.

Erasistratus
anatomist
Alexandria, Egypt
-280 to -250
He lived -304 to -250, dissected animals and humans, and described brain, brain ventricles, heart, heart valves, nervous system, sense and motor nerves, cornea, sclera, choroid, retina, and lens.

Galen
doctor
Pergamon, Asia Minor/Greece
175 to 190
On the Elements According to Hippocrates [175 to 190]; On the Usefulness of the Parts of the Human Body [175 to 190: Body parts are as good as they can be for the purpose]
He lived 131 to 201 and probably developed the fourth syllogism figure. He diagnosed disease by pulse, dissected animals, and observed living and dead nerves, blood, and organs. Blood flows back and forth through body. Following Erasistratus [-280], body has three spirit types {pneuma, Galen}: natural spirit from liver, vital spirit from left heart ventricle, and animal spirit from brain. The four temperaments {temperaments, Galen} are choleric, melancholic, phlegmatic, and sanguine.

Andreas Vesalius [Vesalius, Andreas]
biologist

Flanders/Basel, Switzerland
1543
On the Structure of the Human Body [1543]
He lived 1514 to 1564 and studied animal and human anatomy.

Zacharias Janssen [Janssen, Zacharias]
physicist
Netherlands
1595
compound microscope [1595]
He lived 1580 to 1638. With his father, he helped invent compound microscopes and used them.

Marcello Malpighi [Malpighi, Marcello]
biologist
Bologna, Italy
1666 to 1671
On Visceral Structure [1666]; Plant Anatomy [1671]
He lived 1628 to 1694, observed plant and animal tissues under microscope, and started embryology and histology.

Anton Leeuwenhoek [Leeuwenhoek, Anton]
biologist
Delft, Netherlands
1674 to 1716
Letter to Leibniz [1716]
He lived 1632 to 1723 and observed bacteria [1674], yeast, protozoa, sperm, and capillary blood corpuscles under microscope.

Julien Offray de La Mettrie [La Mettrie, Julien Offray de]
philosopher/surgeon
France
1745 to 1748
Natural History of the Soul [1745]; Man the Machine [1748]
He lived 1709 to 1751, was materialist, and was Boerhaave's student. Cells have intrinsic motion. Human and animal brains are similar.

Johann Kaspar Lavater [Lavater, Johann Kaspar]
biologist
Zurich, Switzerland
1775 to 1778
Physiognomy Fragment [1775 to 1778]
He lived 1741 to 1801.

Charles Bell [Bell, Charles]
anatomist/surgeon
London, England
1806 to 1833
Essay on the Anatomy of the Expressions or The Anatomy and Philosophy of Expression as Connected with Fine Arts [1806]; Animal Mechanics or Proofs of Design in the Animal Frame [1828]; Nervous System of the Human Body [1833]; Hand: its Mechanism and Vital Endowments as evincing Design [1833]
He lived 1774 to 1842, studied reciprocal innervation and haptic perception, and related muscles to facial expressions. Spinal-nerve anterior and posterior roots have separate functions {Bell-Magendie law, Bell}: dorsal root is sensory, and ventral root is motor [1822].

Franz Joseph Gall [Gall, Franz Joseph]
anatomist
Germany/Paris, France

1810 to 1825

Anatomy and Physiology of the Nervous System in General [1810 to 1819: four volumes, first two with Johannes Caspar Spurzheim]; On the Functions of the Brain [1822 to 1825: six volumes]

He lived 1758 to 1828, founded phrenology, and studied brain white matter, gray matter, and ganglia.

Jan Evangelista Purkinje [Purkinje, Jan Evangelista]

anatomist

Spain/Germany

1821 to 1839

Observations and Experiments Investigating the Physiology of Senses [1821]; New Subjective Reports about Vision [1825]

He lived 1787 to 1869 and studied brain neurons. He said fingerprints are unique [1823]. As light intensity decreases, red objects fade faster than blue objects {Purkinje effect} [1825]. He discovered germinal vesicles [1825], skin sweat glands [1833], Purkinje cells [1837], and Purkinje fibers [1839]. He digested protein with pancreatic extract [1836].

Marie Jean Pierre Flourens [Flourens, Marie Jean Pierre]

physiologist/anatomist

France

1824

Experimental Researches on the Properties and Functions of the Nervous System in Vertebrates [1824]

He lived 1794 to 1867, studied brain and concluded that cortex acts as one unit, and ablated brain areas to investigate brain function. Cerebellum is for muscle coordination. Medulla is for respiration. Central nervous system has diverse and localized psychological functions.

Karl Ernst von Baer [Baer, Karl Ernst von]

naturalist

Königsberg, Germany

1827 to 1837

Letter on the Mammalian Egg and Human Genesis [1827]; History of the Evolution of Animals [1828 and 1837: two parts]

He lived 1792 to 1876 and discovered ovum in mammals [1826]. Embryos of various vertebrates are similar {Baer laws}.

Lambert Adolphe Jacques Quetelet [Quetelet, Lambert Adolphe Jacques]

statistician/astronomer

Brussels, Belgium

1835 to 1871

On Man [1835]; Anthropometry [1871]

He lived 1796 to 1874 and developed social and human statistics.

James Braid [Braid, James]

physician/surgeon

Britain

1841 to 1843

Neurypnology [1843]

He lived 1795 to 1860 and studied how to induce hypnosis.

Paul Pierre Broca [Broca, Paul Pierre]

surgeon/anthropologist

Paris, France

1861 to 1878

On the principal of cerebral localizations [1861]; New observation of aphasia produced by lesion in the posterior part of second and third convolution of the left frontal lobe [1861]; Memoranda of Anthropology [1871 to 1878: three volumes]

He lived 1824 to 1880, developed skull-measuring instruments, and studied prehistoric skull trephining. He first described Cro-Magnon and Aurignacian man. He disproved theory {Celtic myth} that Celts constituted a racial group with inherited characteristics [1866]. Frontal-lobe-third or inferior-gyrus damage {Broca's area, Broca} makes people unable to speak [1861].

Guillaume Duchenne [Duchenne, Guillaume]
biologist
Paris, France
1862
Mechanism of Human Physionomy [1862]
He lived 1806 to 1875 and located innervated muscles for behaviors, gestures, and expressions. He studied locomotor ataxia and tried electrical stimulation therapy.

Friedrich Miescher [Miescher, Friedrich]
biologist
Germany
1869
He lived 1844 to 1895 and discovered DNA in trout sperm [1869]. Blood carbon dioxide level regulates breathing.

Gustav Fritsch [Fritsch, Gustav]/Eduard Hitzig [Hitzig, Eduard]
biologist
Germany
1870
On the Electrical Excitability of the Cerebrum [1870]
Fritsch lived 1838 to 1927. Hitzig lived 1838 to 1907. They studied Broca's-area localized motor functions.

Camillo Golgi [Golgi, Camillo]
biologist
Italy
1873 to 1909
Nerves of the Spinal Column [1873]
He lived 1843 to 1926 and found Golgi cells [1883] and Golgi apparatus [1909]. If silver chromate stains neural tissue, some nerve cells stain black and become visible among unstained, transparent cells [1873].

Santiago Ramon y Cajal [Ramon y Cajal, Santiago]
anatomist
Spain
1894 to 1904
Textbook of the Human and Vertebrate Nervous System [1894 to 1904]
He lived 1852 to 1934 and studied neurons and brain microscopic structure. Nerve signal goes from neuron axon to next-neuron dendrite.

Paul Emil Flechsig [Flechsig, Paul Emil]
biologist
Leipzig, Germany
1896
Brain and Mind [1896]
He lived 1847 to 1929. Cortex association areas myelinate after birth, while sense and motor areas myelinate before birth.

Charles Scott Sherrington [Sherrington, Charles Scott]
physiologist
Britain
1897 to 1946
Synapse [1897]; Integrative Action of the Nervous System [1906]; Mammalian Physiology [1919]; Reflex Activity in the Spinal Cord [1932: with Richard S. Creed]; Man on His Nature [1942]; Endeavor of Jean Fernel [1946]

He lived 1857 to 1952, named neuron junctions "synapses", showed that transmission slowed there, and studied antagonistic-muscle reciprocal innervation. He studied peripheral and spinal reflexes, including dog scratch reflex, and relations between reflexes and behavior patterns.

He studied sense exteroceptors, interoceptors, and proprioceptors. Exteroceptive distance receptors detect movements and are at animal leading edges. Distance receptors receive stimuli far from physical source. Brains can build space-time relations to represent environment. Interoceptive receptors receive stimuli where physical sources contact body surface. Proprioceptive receptors receive stimuli from inside body.

Precurrent receptors initiate behavior, and non-precurrent receptor activity stops behavior. Behavior relies on body hierarchical spatio-temporal subsystems that evolution built and linked for survival. Body-limit perception affects behavior.

Organisms evolved to allow more exploration and autonomy, as distance receptors and brain integration evolved. Organisms had more prey and predator knowledge. Anticipatory responses extended control over space and time, so reaction time increased and immediate receptor responses lasted longer.

Korbinian Brodmann [Brodmann, Korbinian]

biologist

Germany

1903 to 1909

Comparative Localization Studies on the Neocortex in their Differentiation on the Basis of Cell Density [1909]

He lived 1868 to 1918 and mapped 52 cortical areas [1903 to 1908].

Robert Barany [Barany, Robert]

physiologist

Austria

1909 to 1913

On the Ear Labyrinth [1906]; Tests [1910]; Clinic on the Vestibular Apparatus [1913]

He lived 1876 to 1936 and studied ear labyrinth functions.

Abraham Flexner [Flexner, Abraham]

biologist

USA

1910

Experimental poliomyelitis in monkeys: active immunization and passive serum protection [1910: with Paul A. Lewis]; Medical Education in the United States and Canada [1910]

He lived 1866 to 1959. He studied polio [1910].

Gordon Morgan Holmes [Holmes, Gordon Morgan]

neurologist

Ireland

1911 to 1941

Sensory disturbances from cerebral lesions [1911: with Henry Head]

He lived 1876 to 1965 and studied sensation locations and spinal and head injuries. He found Adie's syndrome and Holmes' syndrome [1941], with William Adie.

George Riddoch [Riddoch, George]

neurologist

Scotland

1917

He lived 1888 to 1947. He studied brain injuries [1917]. Blind patients, with V1 area damage, can consciously perceive fast moving highly contrasting stimuli {Riddoch syndrome}.

Salomon Henschen [Henschen, Salomon]

biologist

Uppsala, Sweden

1919

dyscalculia [1919]

He lived 1847 to 1930. Occipital lobes have topological maps [1919]. People can lose ability to calculate but retain other abilities.

Henry Head [Head, Henry]

neurologist

Britain

1926

Aphasia and Kindred Disorders of Speech [1926]

He lived 1861 to 1940 and studied cerebral cortex and sensation. Cortical memory stores flexible experience representations {schema, Head}.

Walter Rudolph Hess [Hess, Walter Rudolph]

biologist

Germany

1928

He lived 1881 to 1973. Hypothalamic stimulation causes emotions and controls internal organs [1928].

Raymond Dodge [Dodge, Raymond]

psychologist

USA

1931

Conditions and Consequences of Human Variability [1931]

He lived 1871 to 1942 and studied human variation.

Egas Moniz [Moniz, Egas]

neurologist

Portugal

1935

He lived 1875 to 1955 and started frontal lobotomy for mental illness [1935].

Warren Sturgis McCulloch [McCulloch, Warren Sturgis]

neurophysiologist

USA

1943 to 1959

Logical Calculus of the Ideas Immanent in Nervous Activity [1943: with Pitts]; How We Know Universals: the Perception of Visual and Auditory Forms [1947: with Pitts]; What the Frog's Eye Tells the Frog's Brain [1959: with Maturana, Lettvin, and Pitts]

He lived 1899 to 1972 and studied chimpanzee isocortex. He invented Perceptrons, with Walter H. Pitts. Neuron model sends unit output if input is above threshold. Finite device combinations, including loops, can perform any algorithm. Neural networks can recognize figures, so any input feature from figure produces same output. Reliable neural networks can come from unreliable components using redundancy.

John C. Eccles [Eccles, John C.]

biologist

England

1951 to 1994

Brain and the Unity of Conscious Experience [1965]; Understanding of the Brain [1977]; Human Psyche [1980]; Evolution of the Brain: Creation of the Self [1989]; How the Self Controls Its Brain [1994]

He lived 1903 to 1997 and studied cerebellum [1967]. Connections between sense and motor nerves in spinal-cord gray matter are responsible for reflexes [1951]. Matter and mind are separate substances, and interact in synapses {interactionism, Eccles}. Mind has units {psychon, Eccles}.

Joe Hin Tjio [Tjio, Joe Hin]

biologist

Java/Sweden/USA

1955

human chromosome number

He lived 1919 to ?. Human chromosome number is 46, rather than 44 or 48 [1955].

Werner E. Reichardt [Reichardt, Werner E.]

biologist

Germany

1957 to 1986

He lived 1924 to 1992 and developed neuron motion-detector models, to explain how flies detect motion.

Russell Brain [Brain, Russell]

biologist

England

1959

Nature of Experience [1959]

He lived 1895 to 1966 and studied brain.

Jerome Y. Lettvin [Lettvin, Jerome Y.]

biologist

USA

1959

What the Frog's Eye Tells the Frog's Brain [1959: with Maturana, McCulloch, and Pitts]

He lived 1920 to ?. Axons from frog retinal ganglion cells have four groups that respond differently to different stimuli and that end in four distinct optic-tectum layers, all with same topographic map. Frog is normally motionless, so detectors detect environment changes.

Sustained contrast detectors make immediate and prolonged signals when object edge, either lighter or darker than background, moves into receptive field and stops.

Net convexity detectors make immediate and temporary signals when large dark-object small or convex edges pass through visual field. Smooth movement has less effect than jerky movement.

Moving-edge detectors respond to edges moving through receptive field. Net dimming detectors make immediate and prolonged signals with sudden illumination reduction. Frogs can recognize prey and enemy categories.

Lennart Heimer [Heimer, Lennart]

biologist

Sweden/USA

1971

Pathways in the Brain [1971]

Heimer lived 1930 to 2007.

Horace B. Barlow [Barlow, Horace B.]

biologist

USA

1972 to 1995

Single units and sensations [1972]; Neuron Doctrine in Perception [1995]

He studied frog-retina bug-detector ganglion cells. Thousands of cardinal cells code percepts [Barlow, 1972] [Barlow, 1995]. Qualia are not basic phenomena but brain-developed sensations that depend on memory and processing. Consciousness comes from social communication.

John Szentágothai [Szentágothai, John]/Michael A. Arbib [Arbib, Michael A.]

biologist/psychologist

USA

1975

Conceptual Models of Neural Organization [1975]

They studied brain and neural networks.

John C. Eccles [Eccles, John C.]/Masao Ito [Ito, Masao]/John Szentagothai [Szentagothai, John]

biologist

England
1976
Cerebellum as a Neuronal Machine [1976]
Szentagothai lived 1912 to 1994.

Theodore H. Bullock [Bullock, Theodore H.]/Richard Orkand [Orkand, Richard]/Alan Grinnell [Grinnell, Alan]
biologist
USA
1977
Introduction to Nervous Systems [1977]

Robert A. Weale [Weale, Robert A.]
biologist
USA
1978
Vertebrate Eye [1978]
He studied vertebrate eye.

Richard H. Adrian [Adrian, Richard H.]
biologist
England
1980
Nerve Impulse [1980]
He lived 1927 to ?.

David Caplan [Caplan, David]
biologist
USA
1980 to 2003
Biological Studies of Mental Processes [1980: editor]

Werner E. Reichardt [Reichardt, Werner E.]/Tomaso Poggio [Poggio, Tomaso]
biologist
USA
1981
Theoretical Approaches in Neurobiology [1981: editors]

Daniel L. Alkon [Alkon, Daniel L.]
biologist
USA
1983 to 1987
Learning in a Marine Snail [1983]; Memory Traces in the Brain [1987]

Chiye Aoki [Aoki, Chiye]/Philip Siekevitz [Siekevitz, Philip]
biologist
USA
1988
Plasticity in Brain Development [1988]

Ira B. Black [Black, Ira B.]
biologist
USA
1991
Information in the Brain: A Molecular Perspective [1991]

Alan Peters [Peters, Alan]/Sanford Palay [Palay, Sanford]/Henry Webster [Webster, Henry]

physician
USA
1991
Fine Structure of the Nervous System [1991]

William H. Calvin [Calvin, William H.]
biologist
USA
1996
How Brains Think [1996]; Cerebral Code [1996]
Brain works by selection. 0.5-mm-diameter cortical hexagonal columns and their lateral connections represent symbols. Columns vary, compete, and replicate. Symbols integrate and coordinate to make scenes and help each other compete and copy. Consciousness is image or scene that is most populous {scenario spinning}.

James Thomson [Thomson, James]
biologist
USA
1998
He discovered embryonic stem cells [1998].

Rodney M. J. Cotterill [Cotterill, Rodney M. J.]
biologist
USA
1998 to 2003
Enchanted Looms: Conscious Networks in Brains and Computers [1998]
Perhaps, consciousness is in anterior cingulate. Consciousness unifies body actions. Perhaps, ability to make new reflexes is consciousness purpose. He developed computer simulations (CyberChild) to find neural correlates of consciousness. It uses mammalian nervous system circuits grouped into binary composite units. It has two senses, hearing and touch. It controls vocalization, feeding, and bladder-control muscles. It has pain receptors for low stomach-milk level, low blood-sugar level, full bladder, and dirty diaper. Emergent behavior, such as ability to make new reflexes, indicates consciousness.

Rita Carter [Carter, Rita]
journalist
England
1999
Mapping the Mind [1999]
Brain scans associate brain regions with psychological functions.

Stephen G. Waxman [Waxman, Stephen G.]
physician
USA
2000
Correlative Neuroanatomy [2000]

Axel Cleeremans [Cleeremans, Axel]
biologist
USA
2003
Unity of Consciousness: Binding, Integration and Dissociation [2003: editor]
Consciousness unifies by integrative processes among brain parts.

BIOL>Biology>History>Behavior

Thomas H. Burgess [Burgess, Thomas H.]
biologist

England
1839
Physiology or Mechanism of Blushing [1839]
Experiment cannot induce blushing physically. Experiment can induce blushing only mentally. Trying to restrain blushing only increases it.

Henry Walter Bates [Bates, Henry Walter]
biologist
England
1859 to 1862
Contributions to an Insect Fauna of the Amazon Valley [1862]
He lived 1825 to 1892, studied mimicry [1862] {Batesian mimicry}, and was a naturalist in Amazon [1848 to 1859].

Frans Donders [Donders, Frans]
physiologist
Utrecht, Netherlands
1864 to 1870
On the anomalies of accommodation and refraction of the eye with a preliminary essay on physiologic dioptrics [1864]; Proceedings of the Community Meeting of the Koninlijke Academy of Science [1865]; Speed of Mental Processes [1868]; Physiology of speech sounds, in particular those of the Dutch language [1870]
He lived 1818 to 1889 and studied eyes and reaction times.

Jean-Martin Charcot [Charcot, Jean-Martin]
neurologist/psychologist
France
1875 to 1877
On cerebral localizations [1875]; Lectures on the Diseases of the Nervous System [1877]
He lived 1825 to 1893 and studied multiple sclerosis, hysteria, hypnosis, and tabes dorsalis "shooting pains" {lightning pains}.

Eduard Pfluger [Pfluger, Eduard]
physiologist
Bonn, Germany
1877 to 1910
Teleological Mechanics of Nature [1877]
He lived 1829 to 1910. Organisms have goal-directed feedback mechanisms to stabilize output.

George Romanes [Romanes, George]
biologist
England
1881 to 1888
Animal Intelligence [1881]; Physiological Selection: An Additional Suggestion on the Origin of Species [1886]; Mental Evolution in Man [1888]
He lived 1848 to 1894. Animals learn by imitation [1886].

Jacques Loeb [Loeb, Jacques]
biologist
Germany
1900
Comparative Physiology of the Brain and Comparative Psychology [1900]
He lived 1859 to 1924. Simple animals have forced tropism movements. Animals move towards stimulus source {positive tropism} or away from it {negative tropism}. Simple animals have paired receptors, such as eyes, which send signals to paired muscles, such as legs. When both receptors send equal signals, tension balances between both muscles, and animal moves in straight lines {tonus hypothesis}. However, tonus hypothesis is not true for simple or higher animals.

Konrad Lorenz [Lorenz, Konrad]
biologist
Switzerland/Germany
1950 to 1973
King Solomon's Ring [1950]; Man Meets Dog [1954]; On Aggression [1963]; Behind the Mirror: a Search for a Natural History of Human Knowledge [1973]
He lived 1903 to 1989 and studied natural behavior {ethology, Lorenz}, aggression, imprinting, instincts, innate releasing mechanisms, and fixed action patterns.

Nicolas Tinbergen [Tinbergen, Nicolas]
biologist
Norway
1951 to 1973
Study of Instinct [1951]; Animal in Its World [1973]
He lived 1907 to 1988 and studied ethology.

William H. Masters [Masters, William H.]/Virginia E. Johnson [Johnson, Virginia E.]
physician
USA
1965 to 1970
Human Sexual Response [1965]; Human Sexual Inadequacy [1970]
Masters lived 1915 to 2001. Johnson lived 1925 to ?. They studied sexuality.

Barbara Brown [Brown, Barbara]
biologist
USA
1968 to 1978
New Mind, New body [1974]; Critique of biofeedback concepts and methodologies [1978]
People can sense unconscious body behavior by signal biofeedback [1968]. After training, people can control one neuron or can change blood pressure or heartbeat.

Jane Goodall [Goodall, Jane]
biologist
England
1972 to 1986
Chimpanzees of Gombe [1986]
She lived 1934 to ? and studied chimpanzee behavior. Chimps grunt, pant, bark, roar, scream, squeak, whimper, laugh, click teeth, and smack lips, in 30 different ways with different meanings [1972].

John R. Napier [Napier, John R.]
biologist
USA
1976 to 1977
Primate Locomotion [1976]; Primates and Their Adaptations [1977]
He lived 1917 to 1987.

Robert M. Seyfarth [Seyfarth, Robert M.]/Dorothy L. Cheney [Cheney, Dorothy L.]
biologist
USA
1990 to 1992
How Monkeys See the World, Inside the Mind of Another Species [1990]; Meaning and Mind in Monkeys [1992]
Monkeys make alarm calls even when they can perceive that other monkeys are not near or that other monkeys are calling already. Monkeys do not have theory of mind. Vervet monkeys make different alarm calls for eagles, leopards, and snakes and use grunts in social interactions.

BIOL>Biology>History>Biochemistry

Jöns Jakob Berzelius [Berzelius, Jöns Jakob]

biologist/physicist

Stockholm, Sweden

1808 to 1838

Chemistry Textbook [1808]; protein discovered [1838]

He lived 1779 to 1848 and discovered proteins [1838] and studied ions and atomic and molecular weights. He invented old chemical symbols [1811] and atomic-weight table [1826].

Gottlieb Sigismund Kirchhoff [Kirchhoff, Gottlieb Sigismund]

biologist

Russia

1812

He lived 1764 to 1833 and discovered enzymes. Wheat gluten enzyme converts starch to sugar and dextrin [1812].

Friedrich Wöhler [Wöhler, Friedrich]

chemist

Berlin, Germany

1825 to 1854

Textbook of Chemistry [1825: four volumes]; Foundations of Inorganic Chemistry [1830]; Foundations of Organic Chemistry [1840]; Practical Experiments of Analytical Chemistry [1854]

He lived 1800 to 1882 and synthesized urea from ammonium cyanate [1828], the first artificial organic-chemical synthesis.

Justus von Liebig [Liebig, Justus von]

biologist

Munich, Germany

1835 to 1865

Organic Chemistry in its Application to Agriculture and Physiology [1840]; Organic Chemistry in its Application to Physiology and Pathology [1842]

He lived 1803 to 1873 and described enzyme action chemically {law of the minimum}. He observed that plants use nitrogen and carbon dioxide from air. He invented nitrogen fertilizer. He invented {Liebig condenser}. He silvered mirrors [1835]. He invented beef extract [1865].

Leonor Michaelis [Michaelis, Leonor]

biologist

Germany

1913

Kinetics of invertase activity [1913]

He lived 1875 to 1940 and studied enzyme kinetics and analyzed enzyme-substrate complexes as chemical equilibria.

Maud Leonora Menten [Menten, Maud Leonora]

biologist

Canada

1913 to 1944

Michaelis-Menten equation [1913]; azo-dye method [1944: for alkaline phosphatase]

She lived 1879 to 1960 and studied enzyme kinetics and analyzed enzyme-substrate complexes as chemical equilibria.

Cornelius B. Van Niel [Van Niel, Cornelius B.]

biologist

USA

1931

He lived 1897 to 1985 and studied anaerobic photosynthesis [1931].

Hans Krebs [Krebs, Hans]
biologist
England
1937 to 1957
Energy Transformation in Living Matter [1957: with Hans Kornberg]
He lived 1900 to 1981 and studied tricarboxylic carbohydrate cycle [1937].

Salvatore Luria [Luria, Salvatore]
biologist
USA
1938 to 1965
He lived 1912 to 1991 and studied enzymes [1938 to 1965].

Arthur Kornberg [Kornberg, Arthur]
biologist
USA
1955 to 1958
He lived 1918 to ? and synthesized DNA molecules using DNA polymerase I [1955 to 1958].

Sydney Brenner [Brenner, Sydney]/Matthew Meselson [Meselson, Matthew]/François Jacob [Jacob, François]
biologist
USA
1960
mRNA discovered [1960]
Brenner lived 1927 to ?. Meselson lived 1930 to ?. Jacob lived 1920 to ?.

Dorothy Crowfoot Hodgkin [Hodgkin, Dorothy Crowfoot]
biologist
England
1960
She lived 1910 to 1994 and determined insulin structure.

Ghobind Khorana [Khorana, Ghobind]
biologist
India/USA
1960 to 1970
He lived 1922 to ? and synthesized yeast gene [1960].

Werner Arber [Arber, Werner]
biologist
Switzerland
1968
restriction enzymes discovered [1968]
He lived 1929 to ?.

David Lane [Lane, David]
biologist
Scotland
1979
TP53 gene kills cell if cell has broken DNA or has low oxygen, by making p53 protein [1979].

David Botstein [Botstein, David]/Ron Davis [Davis, Ron]/Ray White [White, Ray]/Mark Skolnick [Skolnick, Mark]
biologist
USA

1980
genetic markers for genome mapping [1980]

Thomas Cech [Cech, Thomas]/Sidney Altman [Altman, Sidney]
biologist
USA
1982
They found ribozyme RNA that can act as enzymes to cut other RNA [1982]. RNA was first molecule able to replicate, because RNA can be catalyst. DNA bases and sugars came from RNA bases and sugars. For example, thymine can come from uracil. RNA works with ribosomal proteins, amino acids, and many enzymes.

David Baltimore [Baltimore, David]
biologist
USA
1985
He studied RNA viruses [1985].

BIOL>Biology>History>Botany

Luther Burbank [Burbank, Luther]
biologist
USA
1871 to 1921
Burbank potato [1871]; Shasta daisy [1901]; July Elberta peach [1905 to 1910]; Santa Rosa plum [1905 to 1910]; Flaming Gold nectarine [1905 to 1910]; How Plants Are Treated to Work for Man [1921]
He lived 1849 to 1926 and developed new plant varieties.

George Washington Carver [Carver, George Washington]
biologist/inventor
USA
1896 to 1923
peanut products [1897 to 1930]; crop rotation [1897 to 1930]
He lived 1864 to 1943 and developed soil improvements and new peanut, soybean, and cotton uses. He rotated peanuts with cotton.

BIOL>Biology>History>Development

William Harvey [Harvey, William]
doctor
England
1628
Anatomical Study of the Motion of the Heart and of the Blood in Animals [1628]
He lived 1578 to 1657 and studied embryology. Blood flows through blood vessels from and to heart.

Ernst Haeckel [Haeckel, Ernst]
biologist
Berlin, Germany
1862 to 1868
Radiolaria [1862]; History of Creation [1868]
He lived 1834 to 1919 and studied marine invertebrates. Ontogeny recapitulates phylogeny {theory of recapitulation}. Sperm are mostly nucleic acid [1868].

Hans Driesch [Driesch, Hans]
biologist/philosopher
France/Jena, Germany
1895 to 1905

History and Theory of Vitalism [1905]

He lived 1867 to 1941. Cell from 2-cell, 4-cell, 8-cell, or 16-cell frog embryo can develop into complete adult, which can spawn complete children [1895]. Cell non-material transcendental order moves animal development toward adulthood {entelechy, Driesch}.

D'Arcy Thompson [Thompson, D'Arcy]

naturalist

England

1917 to 1940

On Growth and Form [1917 and 1940]

He lived 1860 to 1948. Dynamical forces and energies make a few main growth and development patterns and determine organism shapes.

Nicholas Humphrey [Humphrey, Nicholas]

philosopher

England

1976 to 1992

Social Function of Intellect [1976]; Consciousness Regained [1983]; Inner Eye [1986]; History of the Mind [1992]; Mind Made Flesh [2002]

He studied brain development from social interactions. People {natural psychologist} talk to themselves to think what to do in different social situations and so understand, predict, and control what other people do. People then evolved systems {inner eye} to image brain processes and states. Such imaging is consciousness. Consciousness emerged abruptly as existing features combined. Sensations are actions and their thoughts.

Lewis Wolpert [Wolpert, Lewis]

biologist

USA

1977 to 1991

Development of Pattern and Form in Animals [1977]; Triumph of the Embryo [1991]

He lived 1929 to ?.

Myron Winick [Winick, Myron]

biologist

USA

1978

Early Nutrition and Brain Development [1978]

Richard Alexander [Alexander, Richard]

biologist

USA

1979

Darwinism and Human Affairs [1979]

He studied brain development from social interactions.

William McGinnis [McGinnis, William]

biologist

USA

1983

Hox regulatory genes govern fruitfly development [1983].

Henry Harris [Harris, Henry]

biologist

England

1985

MYC, BCL-2, APC, and RAS genes check cell division [1985].

Dennis Selkoe [Selkoe, Dennis]
biologist
USA
1992
Aging Brain, Aging Mind [1992]

Carla Shatz [Shatz, Carla]
biologist
USA
1992
Developing Brain [1992]

BIOL>Biology>History>Ecology

Hans Berger [Berger, Hans]
psychiatrist
Germany
1924
He lived 1873 to 1941 and invented electroencephalogram [1924]. Electrodes can measure scalp electrical potentials {electroencephalography, Berger}. Alpha waves are regular 10-Hz oscillations that happen when people relax and close their eyes. Beta waves are faster and less synchronous oscillations that replace alpha waves when people perform mental activity and keep their eyes open.

Loren Eiseley [Eiseley, Loren]
biologist
USA
1946
Immense Journey [1946]
He lived 1907 to 1977 and studied ecology.

Barry Commoner [Commoner, Barry]
biologist
USA
1952 to 1980
Closing Circle: Nature, Man and Technology [1971: including his Laws of Ecology]
He lived 1917 to ? and studied ecology and population. He opposed above-ground nuclear testing [1952].

BIOL>Biology>History>Evolution

Carolus Linnaeus [Linnaeus, Carolus] or Carl von Linné [Linné, Carl von]
biologist
Sweden/Amsterdam, Netherlands
1735
System of Nature [1735]
He lived 1707 to 1778, classified plants and animals by structures, and named organisms as genus and species {binomial nomenclature, Linnaeus}.

Abraham Trembley [Trembley, Abraham]
naturalist
Switzerland/Netherlands
1744
Memoirs concerning the natural history of a type of Freshwater Polyp [1744]
He lived 1710 to 1784 and related hydra and jellyfish. Hydra and jellyfish parts can move and bud.

Georges Cuvier [Cuvier, Georges]
biologist

Paris, France
1817 to 1825
Animal Kingdom [1817]; Discourse on the Revolutionary Upheavals on the Surface of the Earth [1825]
He lived 1769 to 1832 and studied fossils, differentiated animals by body structures and nervous systems, and noted adaptations to environment.

Étienne Geoffroy Saint-Hilaire [Saint-Hilaire, Étienne Geoffroy]
biologist
Paris, France
1818
Anatomical Philosophy [1818]
He lived 1772 to 1844 and studied fossils and compared fish and land animals, vertebrates and insects, and cephalopods and vertebrates. Fossils have structure homologies {unity of type}. Body type depends on vertebral structure.

Louis Agassiz [Agassiz, Louis]
biologist
Neuchâtel, Switzerland/USA
1840 to 1851
Study of Glaciers [1840]; Essay on Classification [1851]
He lived 1807 to 1873. Species form hierarchies, with form laws {taxonomy, Agassiz}.

Richard Owen [Owen, Richard]
physician/naturalist
Britain
1849
On Parthenogenesis [1849]
He lived 1804 to 1892 and found horse intermediate fossils. All vertebrates have body plans based on repeating vertebrae, which can evolve.

Charles Robert Darwin [Darwin, Charles Robert]
naturalist
Britain
1859 to 1872
On the Origin of Species by Means of Natural Selection [1859]; Descent of Man and Selection in Relation to Sex [1871]; Expression of the Emotions in Man and Animals [1872]
He lived 1809 to 1882. He developed plant and animals evolution theory. Natural selection of variations leads to the most-successful reproduction {survival of the fittest, Darwin}. Species evolved from earlier species, making branching evolutionary trees. Evolution has caused changes without needing causer. Evolution has support from organism location, because similar environments in different locations have different organisms, and similar, mutually accessible, locations with different environments have similar organisms. Evolution has support from comparative anatomy, because different species have similar hand bones, and species have vestigial structures. Evolution has support from embryology, because segmented-worm and unsegmented-mollusc larvae are similar, and vertebrate embryos have gills. Evolution has support from the fossil record, which shows intermediate forms. Changes have billions of years to happen. Ancient rocks and environment differ from now, and fossil life forms differ from now. Current animals adapted to present environment, not to ancient one. Finches of Galapagos Islands and barnacles were test cases.
He also studied emotions. Human emotional-response and facial-expression origins are pre-human species behaviors.

Alfred Russel Wallace [Wallace, Alfred Russel]
naturalist
Britain
1870 to 1903
Contributions of the Theory of Natural Selection [1870]; Geographical Distribution of Animals [1876]; Island Life [1880]; On Miracles and Modern Spiritualism [1881]; Darwinism [1889]; Man's Place in the Universe [1903]

He lived 1823 to 1913 and independently developed evolution theory with survival of fittest. He studied animal geography and life in Amazon River basin and Malay Archipelago.

Vito J. Volterra [Volterra, Vito J.]
mathematician/ecologist
Italy
1883 to 1930
Theory of Functionals and of Integral and Integro-Differential Equations [1930]
He lived 1860 to 1940 and studied integral equations [1883]. Mating, dying, or other-species effects cause predator-number and prey-number change rates {Lotka-Volterra differential equations, Volterra} [1926]. In ecosystems, predator and prey numbers can oscillate until reaching steady state, can continue to oscillate, or can become zero, so species is extinct.

Raymond Dart [Dart, Raymond]
biologist
South Africa
1924
He lived 1893 to 1988 and found Taung child, Australopithecus africanus [1924].

Alfred James Lotka [Lotka, Alfred James]
ecologist
Italy
1925 to 1926
Elements of Physical Biology [1925]
He lived 1880 to 1949. Mating, dying, or other-species effects cause predator-number and prey-number change rates {Lotka-Volterra differential equations, Lotka} [1926]. In ecosystems, predator and prey numbers can oscillate until reaching steady state, can continue to oscillate, or can become zero, so species is extinct.

Robert Yerkes [Yerkes, Robert]
biologist
USA
1929 to 1943
He lived 1876 to 1956 and studied primates [1929 to 1943].

Sewall Wright [Wright, Sewall]
biologist
England
1931 to 1978
Evolution in Mendelian Populations [1931]; Evolution and the Genetics of Populations [1978]
He lived 1889 to 1988 and discovered genetic drift. Species arise randomly even within clade that has evolutionary direction {Wright's rule}. Selection changes allele frequencies.

Julian Huxley [Huxley, Julian]
biologist
England
1932 to 1953
Problems of Relative Growth [1932]; Evolution, the Modern Synthesis [1942]; Evolution in Action [1953]
He lived 1887 to 1975 and developed cladistics. Organism characteristics are clade units that determine classes and hierarchies. Organisms have homologies, and cladogram nodes represent shared homologies. Cladistics can use property absences.

Theodosius Dobzhansky [Dobzhansky, Theodosius]
biologist
USA
1937
Genetics and the Origin of Species [1937]

He lived 1900 to 1975 and studied evolutionary theory.

Conrad H. Waddington [Waddington, Conrad H.]
biologist
England
1939 to 1978
Introduction to Modern Genetics [1939]
He lived 1905 to 1975 and studied evolution [1939].

Ernst Mayr [Mayr, Ernst]
biologist
USA
1942 to 1988
Systematics and the Origin of Species [1942]; Evolution and the Diversity of Life [1976]; Toward a New Philosophy of Biology [1988]
He lived 1904 to 2005 and examined differences between historical and non-historical sciences. New species result from variety geographic isolation {allopatry, Mayr} [1960 to 1970], rather than arising in same location {sympatry, Mayr}.

Trofim Lysenko [Lysenko, Trofim]
biologist
Russia
1948 to 1965
He lived 1898 to 1976 and opposed evolution by natural selection.

Louis S. Leakey [Leakey, Louis S.]
biologist
England
1949 to 1959
He lived 1903 to 1972 and found fossil hominins [1949 to 1959].

Manfred Eigen [Eigen, Manfred]
biologist
Germany
1954 to 1993
Hypercycle: A principle of natural self-organization [1979: with Peter Schuster]; Steps toward Life [1992: with Ruthild Winkler-Oswatitsch]; Rules of the Game [1993: with Ruthild Winkler-Oswatitsch]
He lived 1927 to ? and developed relaxation methods, to measure 10^-10 second reaction rates [1954]. High mutation rates prevent natural selection [1992].

Christian de Duve [Duve, Christian de]
biologist
USA
1955 to 1965
He lived 1917 to ? and discovered lysosomes [1955] and peroxisomes [1965].

William Hamilton [Hamilton, William]
biologist
England
1963 to 1996
He lived 1936 to 2000. Sexual reproduction results from competition between parasite and host [1963].

Carl Woese [Woese, Carl]
biologist
USA
1965 to 1967

Genetic Code [1967]
He lived 1928 to ?. Small subunit ribosomal RNA can classify organisms [1965].

George C. Williams [Williams, George C.]
biologist
USA
1966 to 1992
Adaptation and Natural Selection [1966]; Sex and Evolution [1975]; Natural Selection: Domains, Levels, and Challenges [1992]
Genes are natural-selection units, and organisms passively contain them. Evolution changes gene frequency and can make new genes.

René Dubos [Dubos, René]
biologist
France
1968
So Human an Animal [1968]
He lived 1901 to 1982 and studied evolution.

Niles Eldridge [Eldridge, Niles]
biologist
USA
1968 to 1985
Pattern of Evolution [1968]; Time Frames [1985]
New speciation is at range fringes in isolated places. Species change little at other times.

John Maynard Smith [Smith, John Maynard]
biologist
USA
1968 to 1995
Mathematical Ideas in Biology [1968]; Major Transitions in Evolution [1995: with E. Szathmáry]
He lived 1920 to 2004 and studied population-biology relations {logistic difference equation, Smith}.

Lynn Margulis [Margulis, Lynn]
biologist
USA
1970 to 1981
Origins of Eukaryotic Cells [1970]; Symbiosis in Cell Evolution [1981]
Early bacteria incorporated into eukaryotes to make mitochondria and chloroplasts {endosymbiont hypothesis, Margulis} [1970].

Lewis Thomas [Thomas, Lewis]
biologist
USA
1974 to 1979
Lives of a Cell: Notes of a Biology Watcher [1974]; Medusa and the Snail [1979]
He lived 1913 to 1993.

Richard Leakey [Leakey, Richard]
biologist
England
1974 to 1994
Origin of Humankind [1994]
He discovered genus Homo fossils [1974].

Gavin de Beer [Beer, Gavin de]

biologist
USA
1975
Evolution of Flying and Flightless Birds [1975]
He lived 1899 to 1972.

Edward Wilson [Wilson, Edward]
biologist
USA
1975 to 1998
Insect Societies; Sociobiology [1975]; On Human Nature [1978]; Consilience [1998]
He invented sociobiology.

Richard Dawkins [Dawkins, Richard]
biologist
USA
1976 to 1995
Selfish Gene [1976]; Blind Watchmaker [1986]; River out of Eden [1995]

Ideas or concepts {meme} {mimeme} can exist in brain, replicate, and have selection. Thoughts and ideas in memory or culture replicate themselves in other minds by imitation and transmission. Memes compete for entry into minds. Selective forces act directly on meme physical substrates, because memes restructure brains to make better habitats for themselves and to modify input and output. Perceptions, skills, feelings, and memories have no copies.

Meme sets {memeplex, Wilson} {co-adapted meme complex} can affect survival and reproduction [Dawkins, 1976]. He wrote about Universal Darwinism and replicators [Dawkins, 1995].

Meme copies behavior from another same-species animal {imitation, Dawkins}, but copying varies more than for genes. Memory ties abstractions and agreements together, so imitation is only small part. However, copy does not have same meaning, because brain does not just imitate but processes information. It involves selection and non-selective processes.

Culture also involves sharing knowledge {schema, Dawkins}, not by imitation but by abstraction. Culture also involves sharing beliefs and values {social construction}, not by imitation but by agreement. Culture depends on having a theory of mind and knowing that other people have beliefs, intentions, and desires. Genes {selfish gene} use bodies to reproduce themselves.

Stephen Jay Gould [Gould, Stephen Jay]
biologist
USA
1977 to 2002
Ever Since Darwin [1977]; Ontogeny and Phylogeny [1977]; Spandrels of San Marco and the Panglossian Paradigm [1978: with Richard Lewontin]; Urchin in the Storm [1987]; Wonderful Life: The Burgess Shale and the Nature of History [1989]; Structure of Evolutionary Theory [2002]

Evolution repeats and modifies animal forms {bauplan, Gould}. Evolutionary changes can be in bursts {punctuated equilibrium, Gould}, even after 20,000 years with no change. Most traits are side effects. Timing changes during development cause evolutionary changes.

Organisms produce more offspring than survive to reproduce {superfecundity, Gould}. Darwin defended this idea against people that thought God is more benevolent. Offspring vary in traits. All accept this idea. Offspring pass their traits to offspring. All accept this idea. Therefore, offspring with traits more favorable for survival to reproductive age will produce more offspring with same traits {natural selection, Gould}.

Darwin's evolutionary theory has three main principles to explain natural-selection mechanisms. Natural selection applies to organisms, not classes, genuses, species, tissues, organs, or genes.

Darwin suggested that altruism in humans was trait outside this idea. Perhaps, altruism can explain hybridization and worker-insect sterility. Modern theory suggests genes, cell lines, organisms, demes, species, and clades evolve using selection and drift to change frequencies and parts. They can work synergistically, in opposition, or independently of nearby levels. Other possibilities can be entropy effect or complex system spontaneous ordering.

Natural selection removes unfit and designs fit, because variations from typical or average are small, random, and numerous and not always negative. Small and large variations accumulate over many generations. Variations can have different kinds and sizes {microevolution, Gould}. Modern theory adds structural, historic, and developmental factors.

Natural selection gradually makes more-complex organisms and can make new higher-level organism species. However, modern theory adds mass extinctions, species sorting by punctuated equilibrium to alter clades, and other processes taking different times. Other possibilities can be inorganic and organic comparisons or new species-formation ideas.

Because organisms overproduce, nature has competing organisms and species, so new ones must replace or wedge aside existing ones, leading to better-adapted species. This requires that environment changes slowly compared to evolution and observed species changes.

Interactors, rather than replicators, can define selection. Emergent fitness, rather than emergent traits, causes higher-level selection. Species selection is main macroevolution method.

Evolutionary theory involves same framework as other scientific explanations. It involves causation vs. association. Event sequences relate or do not relate. Related events are consequences or not. Structures and functions exist. Logical conclusions come from premises. People can find causation direction. Determinism comes from fundamental-unit laws versus independent-level interactions. Changes are gradual, spurt, maintain stasis, are exponential, or rise and fall. It involves fundamental units, structure hierarchies, change rates, space scales, and time scales.

Darwin felt that nature had progressed, because organism and ecosystem design was good (Paley) and complexity was increasing. Besides, nature ordered itself in the most-efficient way by survival of fittest (Adam Smith).

Increased speciation leads to increased extinction.

Clade selection, species habitat tracking, and grouping in populations can cause stasis.

Organisms tend to evolve to larger size, from individual size advantages and structural factors {Cope's rule, Gould}.

Slow variation and slow environmental change helped ancient organisms alive today survive. Their clades had low speciation.

Clades have various speciation rates, which can change over time and mimic seemingly progressive linear species changes, as in horses and humans.

Humans are stable genetically if punctuated equilibrium is true.

Drift can go into available niches, but bacteria dominate life.

Geometric patterns and physical laws, such as surface-to-volume ratios and coordinate transformations, constrain structures and allow few alternatives. Historical development can impose homologies and regulations. Adaptation consequences {exaptation, Gould} can have later advantages.

Homology is internal structure similarity {homogeny, Gould}. Homology can result from fundamental internal structure {parallelism, Gould} or same external pressures {convergence, Gould}. Organisms can also perform similar functions with different structures {homoplasy, Gould}.

Darwin held that small structure shifts were adaptive, but cumulative-shift adaptations can be different {functional shift, Gould} {cooptation, Gould}. Initial stages have unpredictable uses, constrain future adaptation, and form sequence. Non-adaptive structures {spandrel, Gould} arise in association with adaptive structures, and these structures can later be for adaptation, at all hierarchy levels. Adaptive structures tend to limit further evolution through specialization, but adaptive structures make many more non-adaptive structures with which evolution can work.

Quentin Bone [Bone, Quentin]

biologist
USA
1979
Origin of Chordates [1979]

Motoo Kimura [Kimura, Motoo]

biologist
England
1983
Neutral Theory of Molecular Evolution [1983]

Gene DNA evolves at constant rate in all species over all history. Molecular changes that have less control by natural selection evolve more rapidly, because they have no effects, while harmful ones die out and good ones are rare {Kimura's rule}.

L. Luca Cavalli-Sforza [Cavalli-Sforza, L. Luca]

biologist
Italy
1984 to 1995

Neolithic Transition and the Genetics of Populations in Europe [1984: with Albert Ammerman]; History and Geography of Human Genes [1994: with Paolo Menozzi and Alberto Piazza]; Great Human Diasporas [1995: with Francisco Cavalli-Sforza]

He studied human gene frequencies, race, and population migrations.

David M. Raup [Raup, David M.]

biologist

USA

1991

Extinction: Bad Genes or Bad Luck [1991]

Catastrophe has happened at mass-extinction level, and clades, species, demes, organisms, cell lines, and genes can have extinctions {field of bullets model}.

Paul W. Ewald [Ewald, Paul W.]

biologist

USA

1993 to 2000

Evolution of Infectious Disease [1994]; Plague Time [2000]

Infections that use intermediate hosts, such as cholera and malaria, evolve to be stronger [1993]. Infections that infect directly evolve to be weak enough to maintain the host. Infections cause most genetic and chronic diseases.

Matt Ridley [Ridley, Matt]

journalist

USA/England

1996 to 2003

Origins of Virtue [1996]; Genome [1999]; Nature Via Nurture [2003]

Ian Tattersall [Tattersall, Ian]

anthropologist

England

1997 to 1998

Becoming Human [1998]

He studied human origins from hominins [1997].

John Morgan Allman [Allman, John Morgan]

biologist

USA

1998

Evolving Brains [1998]

He studied brain evolution. Brains allow animals to account for environment variations in space and time and make appropriate responses. More advanced brains allow wider spaces and longer times. Brains require much energy and are in animals that can find more and/or better food at higher rate. Complex brains require longer time to develop. Family and group structures were necessary for humans to have advanced brains.

Brains can sense water, food, sexual partners, shelter, and safe locations, as well as predators and dangerous locations. Brains can assign priorities to input. Brains can perform activities to get food or water, reproduce, gain shelter and safe locations, and avoid predators and dangerous locations. Brains can remember input and output.

Brains are more complex if environmental niche is more variable. Animals use larger energy amounts, because warm-blooded. Water, food, sexual partners, shelter, and safe locations are scarcer and predators and dangerous locations are more numerous. Maximize age is higher.

BIOL>Biology>History>Genetics

Gregor Mendel [Mendel, Gregor]

biologist

März, Austria

1863 to 1866

Experiments in Plant Hybridization [1865]
He lived 1822 to 1884 and developed Mendel's inheritance laws by studying dominant and recessive characteristics of pea-plant independent and discrete heredity units.

Francis Galton [Galton, Francis]
biologist
England
1869 to 1883
Hereditary Genius [1869]; English Men of Science [1874]; Inquiries into Human Faculty and Its Development [1883]
He lived 1822 to 1911 and studied human mental-property and physical-property genetics. He collected and classified fingerprints {fingerprinting}. He studied human individual differences, using imagery, psychological questionnaires, twin life histories, and family and talented-people educational backgrounds. He developed the correlation coefficient. He participated in scientific exploration to unexplored Africa.
He discovered air pressure systems and invented weather maps [1875]. He invented a polyhedron {Galton's Polyhedron} of possible structural forms to which organisms can jump. More intellectually gifted people have less vivid imagery [1883].

Walter Flemming [Flemming, Walter]
biologist
USA
1870 to 1879
He lived 1843 to 1905 and studied mitosis [1870], meiosis, and chromatin role [1879].

August Weismann [Weismann, August]
biologist
Germany
1883 to 1902
On Inheritance [1883]; Essays upon Heredity and Kindred Biological Problems [1889]; Lecture on Descendency Theory [1902]
He lived 1833 to 1914. Specialized cells carry genetic information {germ line} {germ plasm theory} [1883]. Selection can operate at levels below and above organisms.

Hugo de Vries [de Vries, Hugo]
botanist
Netherlands
1889 to 1905
Theory of Mutations [1901]; Species and Varieties: Their Origin by Mutation [1905]
He lived 1848 to 1935, studied evening-primrose mutations [1900], and developed inheritance laws based on cell factors {pangenesis, de Vries} [1889]. Plants can jump from form to form, unconstrained by structures. Phylogenesis results from species selection.

William Bateson [Bateson, William]
biologist
England
1894
Materials for the Study of Variation [1894]
He lived 1861 to 1926 and invented the word genetics for heredity study. Genes carry genetic information and are in chromosomes. New species come from repeated-body-segment structure and number changes. Such modifications can lead to similarity with existing part {homeosis, Bateson}. Parts can have jumps. For example, upper thoracic vertebrae can have no ribs or lower cervical vertebrae can have ribs.

Frans Alfons Janssens [Janssens, Frans Alfons]
biologist
Germany
1909

Theory of Crossing-over [1909]
He lived 1863 to 1924 and studied crossing-over.

Thomas Hunt Morgan [Morgan, Thomas Hunt]
biologist
USA
1909 to 1915
Mechanism of Mendelian Heredity [1915]
He lived 1866 to 1945, studied gene linkage, and invented linkage maps, using fruit flies [1909 to 1915]. Genes are in chromosomes.

Archibald E. Garrod [Garrod, Archibald E.]
biologist
England
1909 to 1923
Inborn Errors of Metabolism [1923]
He lived 1857 to 1936 and studied genetics [1909].

Ronald Aylmer Fisher [Fisher, Ronald Aylmer]
statistician/geneticist
Scotland
1920 to 1938
Statistical Methods for Research Workers [1925]; Genetical Theory of Natural Selection [1930]; Design of Experiments [1935]; Statistical Tables for Biological, Agricultural, and Medical Research [1938]
He lived 1890 to 1962. He developed statistical-significance methods {analysis of variance, Fisher} and Fisher experiment-design theory [1920]. Mendelian inheritance in large populations with great variety can result in gradual evolution, but blending inheritance does not work. Variation frequency varies inversely with variation magnitude. Natural selection can increase allele frequency.

Hermann J. Muller [Muller, Hermann J.]
biologist
USA
1926 to 1951
Development of the Gene Theory [1951]
He lived 1890 to 1967. X-rays mutate fruitfly cells [1926]. Many mutations cause cancer [1951].

Richard Goldschmidt [Goldschmidt, Richard]
biologist
Germany/USA
1940
Material Basis of Evolution [1940]
He lived 1878 to 1958 and studied gypsy moths. Genes {rate gene} can control rates and regulate other genes.

George Beadle [Beadle, George]
biologist
USA
1941
Genetic Control of Biochemical Reactions in Neurospora [1941: with Edward L. Tatum]
He lived 1903 to 1989. One gene makes one protein [1941].

Edward Tatum [Tatum, Edward]
biologist
USA
1941
Genetic Control of Biochemical Reactions in Neurospora [1941: with George Beadle]
He lived 1909 to 1975. One gene makes one protein.

Oswald Avery [Avery, Oswald]
biologist
USA
1943 to 1944
He lived 1877 to 1955. DNA transfers from cell to cell in chromosomes. DNA contains gene information to transform cells. He studied pneumococcus deadly S strain, with smooth surface, and mild R strain, with rough surface.

George Gaylord Simpson [Simpson, George Gaylord]
biologist
USA
1944 to 1964
Tempo and Mode in Evolution [1944]; Meaning of Evolution [1949]; Major Features of Evolution [1953]; Principles of Animal Taxonomy [1961]; This View of Life [1964]
He lived 1902 to 1984. DNA transfers from cell to cell in chromosomes. DNA contains information to transform cells.

Barbara McClintock [McClintock, Barbara]
biologist
USA
1951
She lived 1902 to 1992 and studied corn transposable elements {jumping gene, McClintock} [1951].

Rosalind Franklin [Franklin, Rosalind]
biologist
England
1953
She lived 1920 to 1958 and performed x-ray crystallography of DNA indicating it was double helix [1953].

James Watson [Watson, James]
biologist
USA
1953 to 1980
Double Helix [1980]
He lived 1928 to ? and calculated that DNA was double helix [1953].

Francis H. C. Crick [Crick, Francis H. C.]
biologist
England/USA
1953 to 1994
Thinking about the Brain [1979]; Problem of Consciousness [1992: with Christof Koch]; Astonishing Hypothesis: The Scientific Search for the Soul [1994]
He lived 1916 to 2004 and calculated that DNA was double helix [1953]. Perhaps, consciousness depends on thalamus and cortex layers 4 and 6 [1994].

Jacques Monod [Monod, Jacques]
biologist
France
1961 to 1971
Chance and Necessity: An Essay on the Natural Philosophy of Modern Biology [1971]
He lived 1910 to 1976 and studied DNA repression and expression in Lac operon [1961].

Marshall Nirenberg [Nirenberg, Marshall]
biologist
USA
1962

He lived 1927 to ? and found DNA and RNA triplet code [1962].

Ralph Brinster [Brinster, Ralph]
biologist
USA
1969 to 1974
He lived 1932 to ?, cloned foreign genes, and expressed repressed genes in mice [1974].

R. Wall [Wall, R.]/Philip Leder [Leder, Philip]
biologist
USA
1978
Genes rearrange themselves in early infancy [1978]. Antibody genes can join joining gene by deleting DNA between them. Joining genes join to trunk genes, which determine mobility level. Joined genes determine antigen.

Sidney Brenner [Brenner, Sidney]
biochemist
USA
1983
He lived 1927 to ? and helped determine worm and human genetic codes [1982].

Richard H. Scheller [Scheller, Richard H.]/Richard Axel [Axel, Richard]
biologist
USA
1984
How Genes Control an Innate Behavior [1984]

Mario Capecchi [Capecchi, Mario]/Oliver Smythies [Smythies, Oliver]
biologist
USA/Canada
1990
They invented gene knockouts in mice [1990].

Craig Venter [Venter, Craig]
biologist
USA
1995 to 2001
He organized scientists to sequence a free-living organism [1995] and the human genome [2001]. Haemophilus influenzae bacterium has 1000 genes with 1,800,000 bp.

Robert Waterston [Waterston, Robert]/John Sulston [Sulston, John]
biologist
USA/England
1998
C. elegans genome
They organized scientists to sequence C. elegans animal genome [1998].

Richard Gibbs [Gibbs, Richard]/Eric Green [Green, Eric]/Eric Lander [Lander, Eric]/Richard McCombie [McCombie, Richard]/Douglas Smith [Smith, Douglas]/Bruce Roe [Roe, Bruce]/Elbert Branscomb [Branscomb, Elbert]/Ian Jackson [Jackson, Ian]/Steve Brown [Brown, Steve]/Peter Little [Little, Peter]/Jane Rogers [Rogers, Jane]/Duncan Campbell [Campbell, Duncan]
biologist
USA
2002
They organized scientists to sequence mouse genome.

BIOL>Biology>History>Immunology

MacFarlane Burnet [Burnet, MacFarlane]

biologist
England
1953 to 1959
Natural History of Infectious Disease [1953]; Clonal selection theory of acquired immunity [1959]
He lived 1899 to 1985 and suggested clonal-selection theory.

Peter Medawar [Medawar, Peter]

biologist
England
1967
Art of the Soluble [1967]
He lived 1915 to 1987 and studied immunology.

BIOL>Biology>History>Invention

William Cheselden [Cheselden, William]

surgeon/inventor
Britain
1713 to 1723
Anatomy of the Human Body [1713]; Anatomy of Bones [1733: human skeleton]; Treatise on the High Operation for the Stone [1723: kidney stone removal]
He lived 1688 to 1752, developed artificial pupil, and removed kidney stones {kidney stone removal} and cataracts.

Edward Jenner [Jenner, Edward]

doctor/inventor
England
1797
smallpox vaccine [1797]
He lived 1749 to 1823 {smallpox vaccine}.

Hermann Ludwig Ferdinand von Helmholtz [Helmholtz, Hermann Ludwig Ferdinand von]

physiologist/physicist/inventor
Germany
1850 to 1867
Treatise on Physiological Optics [1856 to 1867]; On the Sensations of Tone [1863]; ophthalmoscope [1851]; ophthalmometer
He lived 1821 to 1894 and founded perceptual physiology {ophthalmoscope, Helmholtz}. He developed Young-Helmholtz trichromatic color-vision theory and studied lens accommodation. He first timed nerve-signal conduction rate and muscle-action times [1850]. Speed at which electrical impulses travel along nerve fibers limits human reaction time. Pitch discrimination depends on resonance {fixed pitch theory}.

Epistemology

People cannot know external physical events and only have neural signals. Neural signals from senses gain meaning from learned associations, which depend on assumptions that can be incorrect. Perceptions are unconscious inferences. People cannot experience or introspect how they perceive or think. People cannot know data on which brain bases perceptions and beliefs. During perceptions and decisions to perform muscle movements, nerve signals switch. Body sense receptors receive and analyze physical energies from outside world to make independent, simple, and unnoticeable sensations, and brains learn to perceive objects and events that probably produced sensations {classical theory of psychology}.

Carl Gustav P. Laval [Laval, Carl Gustav P.]

biologist/inventor
Sweden
1878 to 1883

cream separator [1878]; centrifuge [1883]
He lived 1845 to 1913.

Ross Granville Harrison [Harrison, Ross Granville]
inventor
England
1907
tissue culture [1907]
He lived 1870 to 1959 {tissue culture}.

Georg von Bekesy [Bekesy, Georg von]
physicist/physiologist/linguist/inventor
Hungary
1928 to 1962
Theory of Audition [1928 to 1932]; Experiments in Hearing [1962]; Bekesy audiometer
He lived 1899 to 1972. Sound vibrations travel from one inner-ear basilar-membrane end toward the other [1928 to 1932]. For sound frequencies, different membrane positions have maximum vibration.

Frederick Sanger [Sanger, Frederick]
biologist/inventor
England
1950 to 1977
He lived 1918 to ?, determined insulin amino-acid sequence [1950], and developed method to sequence DNA [1977].

William Grey Walter [Grey Walter, William]
physiologist/inventor
Britain/USA
1953 to 1960
Living Brain [1953]; Neurophysiological Aspects of Hallucinations and Illusory Experience [1960]; two-channel evoked potential averager; helical scanner; 22-channel toposcope
He lived 1910 to 1976 and studied body electrical behavior {toposcopy}, muscle contraction, electroencephalograms, electroconvulsive therapy, frequency analysis, and evoked potentials. He implanted brain electrodes to study epilepsy and treat psychiatric illness in conscious humans.
Brain-function electromechanical models, with two control systems and several interacting units, can produce life-like behavior, including learning, as in electromechanical tortoise called M. speculatrix.
Brain electrical potential has negative shift between associated stimuli just before decision becomes public {contingent negative variation} (CNV). Motor cortex sends output before people act [Walter, 1953]. Helical scanner measures and displays frequencies and phases on short time-scales from many brain electrodes.

Jonas Salk [Salk, Jonas]
doctor/inventor
USA
1954
polio vaccine [1954]
He lived 1914 to 1995 {polio vaccine}.

Albert Sabin [Sabin, Albert]
doctor/inventor
Poland/USA
1959
oral polio vaccine [1959]
He lived 1906 to 1993 {oral polio vaccine}.

John Shine [Shine, John]
inventor

Wales
1961 to 1982
human insulin from cloned cells [1982]
He found Shine-Dalgarno sequence [1961].

Stanley Cohen [Cohen, Stanley]/Herbert Boyer [Boyer, Herbert]
biologist/inventor
USA
1973
recombinant DNA technology [1973]
Cohen lived 1922 to ?. Boyer lived 1936 to ?.

Georges Köhler [Köhler, Georges]/César Milstein [Milstein, César]
inventor
Germany
1975
monoclonal antibodies developed [1975]
They started gene engineering {genetic engineering}.

Allan M. Maxam [Maxam, Allan M.]/Walter Gilbert [Gilbert, Walter]
biologist/inventor
USA
1977
DNA sequencing [1977]
They developed method to sequence DNA [1977].

Kary B. Mullis [Mullis, Kary B.]
biologist/inventor
USA
1983
polymerase chain reaction [1982]
Polymerase chain reaction (PCR) developed to make multiple copies of DNA.

Alec Jeffreys [Jeffreys, Alec]
inventor
USA
1984
DNA fingerprinting [1984]
He studied human identification {DNA fingerprinting, Jeffreys}.

William French [French, William]
inventor
USA
1990
gene therapy [1990]
Successful therapy {gene therapy, French} treated adenosine deaminase deficiency {adenosine deaminase deficiency} (ADA).

Ian Wilmut [Wilmut, Ian]
inventor
England
1997
mammal cloned [1997]
He cloned Dolly the sheep from adult sheep cells {mammal cloning}.

BIOL>Biology>History>Medicine

Ali ibn Rabn Tabari [Tabari, Ali ibn Rabn] or Ali Bin Rabn Tabari [Tabari, Ali Bin Rabn]

physician
Persia/Baghdad, Iraq
860
Paradise of Wisdom [860: about Indian and Greek medicine]
He lived 838 to 923.

Thomas Syndenham [Syndenham, Thomas]

physician
Londin, England
1660 to 1682
Epistolary Dissertation to Dr. Cole [1682]; On Hysteria [1682]
He lived 1624 to 1689 and described diseases accurately. Hysteria in women and hypochondrias in men are similar. Hysterical symptoms often accompany depression. He invented opium tincture {laudanum, Syndenham} [1660].

Ignaz Philipp Semmelweis [Semmelweis, Ignaz Philipp]

biologist
Hungary/Vienna, Austria
1847 to 1861
Etiology, Concept, and Prophylaxis of Childbed Fever [1861]
He lived 1818 to 1865 and started hand washing in chlorine solution [1847].

Louis Pasteur [Pasteur, Louis]

biologist
Paris, France
1855 to 1883
Germ Theory and its Application to Medicine and Surgery [1878]
He lived 1822 to 1895 and studied yeast and fermentation [1855], developed pasteurization [1864], and developed rabies vaccine [1883]. Organic molecules can have chirality. Cells come from cells, with no spontaneous generation.

Rudolf Virchow [Virchow, Rudolf]

biologist
Germany
1858
Cell Pathology [1858]
He lived 1821 to 1902 and studied cell theory. Cells arise from each other over continual generations {Omnis cellula e cellula}.

Joseph Lister [Lister, Joseph]

biologist
England
1866 to 1877
He lived 1827 to 1912, used carbolic acid on wounds to prevent infection [1866], and studied bacteria, antiseptics, heat sterilization, and operative techniques [1877].

David Ferrier [Ferrier, David]

physician
Britain
1873 to 1890
Experimental researches in cerebral physiology and pathology [1873]; Croonian Lecture: Experiments on brain of monkeys (second series) [1875]; Croonian Lectures on Cerebral Localisation [1890]
He lived 1843 to 1928 and developed operations to treat brain injuries and diseases. Cerebral functions are in fixed brain areas.

Carl Wernicke [Wernicke, Carl]
neurologist/psychiatrist
Germany
1874
Aphasic Syndrome [1874]
He lived 1848 to 1905, studied sensory aphasia and word-usage and word-choice disorders, and invented language brain-flow diagrams. Alcoholics often have thiamine deficiency, which can cause encephalopathy.

Robert Koch [Koch, Robert]
biologist
Wollstein, Rhineland-Palatinate, Germany
1876 to 1890
Anthrax [1877]
He lived 1843 to 1910, stained bacteria [1877], grew bacterial colonies [1890], studied anthrax [1876], tuberculosis, and cholera, and developed tuberculin test [1890]. He developed Koch's postulates about disease.

Joseph Breuer [Breuer, Joseph]
physician
Vienna, Austria
1880
Case of Anna O. [1880]
He lived 1842 to 1925, studied hysteria using hypnosis, and discussed catharsis. Vagus nerve controls breathing. Semicircular canals are for balance.

John Hughlings Jackson [Jackson, John Hughlings]
neurologist
Britain
1881 to 1887
Croonian Lectures on Evolution and Dissolution of the Nervous System [1881 to 1887]
He lived 1835 to 1911. He noted focal-epilepsy involuntary-movement sequences and deduced motor-cortex excitable-area spatial patterns. Patients can utter words or phrases under stress or during high emotion, though they cannot speak voluntarily.

Richard von Krafft-Ebing [Krafft-Ebing, Richard von]
neurologist
Germany
1886
Psychopathy of Sex [1886]
He lived 1840 to 1902 and studied syphilitic infection, which can cause insanity and paralysis.

Charles Mayo [Mayo, Charles]/William Mayo [Mayo, William]
doctor
USA
1889
Charles lived 1865 to 1939. William lived 1861 to 1939. They performed surgery at Mayo Clinic [1889].

Paul Ehrlich [Ehrlich, Paul]
doctor
Frankfurt, Germany
1891 to 1925
He lived 1854 to 1915. He used methylene blue as antimalarial drug [1891], trypan red and trypaflavin against trypanosomiasis, acriflavine as antibacterial, arsenical compounds (Carbarsone) against amoebas, arsenical compounds (Salvarsan and oxophenarsine) against syphilis bacteria [1907 to 1909]. He discovered drug resistance [1925].

Anton Breinl [Breinl, Anton]/Harold Wolferstam Thomas [Thomas, Harold Wolferstam]
doctor

Germany/England
1905 to 1909
Report on trypanosomes, trypanosomiasis and sleeping sickness [1905]
Breinl lived 1880 to 1944 {sleeping sickness, drug}. Atoxyl kills trypanosomes [1905], which cause human trypanosomiasis. Thomas studied yellow fever.

Peyton Rous [Rous, Peyton]
biologist
USA
1909 to 1910
Sarcoma of the common fowl [1910]
He lived 1879 to 1970 and discovered first oncovirus, Rous sarcoma virus [1909].

Shepherd Ivery Franz [Franz, Shepherd Ivery]
neuropsychologist
USA
1910 to 1923
Functions of the Anterior and Posterior Association Areas of the Cerebrum [1910]; Handbook of Mental Examination Methods [1912]; Nervous and Mental Re-education [1923]
He lived 1874 to 1933 and studied focal cerebral-cortex lesions, frontal-lobe functions, motor-center variability, and aphasia.

Walter Bradford Cannon [Cannon, Walter Bradford]
physiologist
USA
1911 to 1932
Mechanical Factors of Digestion [1911]; Bodily Changes in Pain, Hunger, Fear and Rage [1915 and 1929]; Wisdom of the Body [1932]
He lived 1871 to 1945 and studied psychosomatic disease and fear and rage biochemistry. Body maintains chemical and function equilibrium {homeostasis, Cannon}. Body uses feedback signals to indicate needs and to initiate action to obtain needs.

Alexander Fleming [Fleming, Alexander]
biologist
England
1928
He lived 1881 to 1955. Penicillin is antibacterial drug [1928].

Lionel Sharples Penrose [Penrose, Lionel Sharples]
physician
Britain
1933
Biology of Mental Defect [1933]
He lived 1898 to 1972 and studied mental deficiency and genetics of Down's syndrome and epiloia or tuberous sclerosis. Maternal age increases children's Down's syndrome, but paternal age does not. Subnormality is not qualitatively different than normal intelligence. Mental deficiency has many factors and causes, and people can perform well on some factors. Mental deficiency is more common in parents and relatives of people with IQ 50 or above than it is in parents of people with IQ lower than 50.

Almeida Lima [Lima, Almeida]
surgeon
Spain
1935
He performed prefrontal lobe leucotomy to cure chronic anxiety, depression with suicide risk, and obsessive-compulsive disorder [1935].

Wilder Graves Penfield [Penfield, Wilder Graves]
neurosurgeon
Canada
1938 to 1975
Cerebral Cortex of Man [1950: with Theodore B. Rasmussen]; Epilepsy and the Functional Anatomy of the Human Brain [1954: with H. Jasper]; Mystery of the Mind [1975]
He lived 1891 to 1976, studied local epilepsy, found epileptic brain-lesion locations and extents [1938], and surgically treated local epilepsy. He electrically stimulated brains to find regions needed for language, but he also elicited images and sensations, which are same dream-like sensations that patients experience when epileptic [Penfield, 1975] [Penfield and Perot, 1963]. Removing tissue did not delete sensation.

Benjamin Spock [Spock, Benjamin]
doctor
USA
1946
Baby and Child Care [1946]
He lived 1903 to 1998.

Alfred C. Kinsey [Kinsey, Alfred C.]/Wardell B. Pomeroy [Pomeroy, Wardell B.]/Clyde E. Martin [Martin, Clyde E.]
physician
USA
1948 to 1954
Sexual Behavior in the Human Male [1948]; Sexual Behavior in the Human Female [1954]
Kinsey lived 1894 to 1956. Pomeroy lived 1913 to 2001. Martin lived 1918 to ?. They studied sexual physiology and behavior.

Vernon M. Ingram [Ingram, Vernon M.]
biologist
Germany/Sweden/England
1956
sickle cell anemia protein defect
He lived 1924 to 2006. One amino-acid change in hemoglobin causes sickle cell anemia [1956].

Barry J. Marshall [Marshall, Barry J.]/J. Robin Warren [Warren, J. Robin]
biologist
USA
1982
Helicobacter pylori bacteria cause ulcers [1982].

Stanley B. Prusiner [Prusiner, Stanley B.]
biologist
USA
1982
Misshapen prion proteins cause scrapie [1982].

Robert Gallo [Gallo, Robert]/Luc Montagnier [Montagnier, Luc]
biologist
England
1985
DNA sequence of HIV published [1985].

Robert A. Weinberg [Weinberg, Robert A.]
biologist
USA
1986

He found first tumor suppressor gene, RB gene [1986].

Elliott Gershan [Gershan, Elliott]/Ronald Rieder [Rieder, Ronald]
biologist
USA
1992
Major Disorders of Mind and Brain [1992]

BIOL>Biology>History>Microbiology

Theodor Escherich [Escherich, Theodor]
biologist
Graz, Germany
1885
On Intestinal Bacteria of Infants [1886]; Escherichia coli discovered [1885]
He lived 1857 to 1911.

Frederick W. Twort [Twort, Frederick W.]
biologist
England
1915
bacteriophage discovered [1915]
He lived 1877 to 1950. Félix d'Hérelle discovered it in 1917.

BIOL>Biology>History>Naturalists

John Muir [Muir, John]
naturalist
USA
1868 to 1890
Treasure of the Yosemite [1890]; Features of the Proposed National Park [1890]
He lived 1838 to 1942 and wrote about the beauty and meaning of nature, especially after visiting Yosemite [1868].

John Burroughs [Burroughs, John]
naturalist
USA
1907 to 1910
Camping and Tramping with Roosevelt [1907]; In the Catskills [1910]
He lived 1837 to 1921.

Joseph Wood Crutch [Crutch, Joseph Wood]
naturalist
USA
1929 to 1954
Modern Temper [1929]; Measure of Man [1954]
He lived 1893 to 1970.

BIOL>Biology>History>Origin Of Life

Johann Baptista van Helmont [van Helmont, Johann Baptista]
biologist
London, England
1622 to 1644
On the development of medicine [1622]; Physic Refined [1648: translated into English in 1662]
He lived 1577 to 1644. Plants make organic materials and do not get them from soil, which stays same weight while plant grows.

Francesco Redi [Redi, Francesco]
biologist
Italy
1668
He lived 1626 to 1697 and proved spontaneous generation does not happen, by showing that maggots did not come from meat [1668].

Matthias J. Schleiden [Schleiden, Matthias J.]
anatomist
Jena, Germany
1838
Contributions to Phytogenesis [1838]
He lived 1804 to 1881 and invented plant cell theory. Cells are life units.

Theodor Schwann [Schwann, Theodor]
anatomist
Berlin, Germany
1838
Microscopic Research of the Structure and Growth of Animals and Plants [1838]
He lived 1810 to 1882 and invented animal cell theory. Cells are life units.

John B. S. Haldane [Haldane, John B. S.]
biologist
England
1926 to 1932
Possible Worlds [1926]; Causes of Evolution [1932]
He lived 1892 to 1964. In atmosphere or ocean, ultraviolet radiation, volcanic heat, lightning, and radioactive-nuclei ionizing radiation can make complex organic molecules from nitrogen, methane, ammonia, water, carbon dioxide, and hydrogen {Oparin-Haldane hypothesis, Haldane}.

Aleksandr Ivanovich Oparin [Oparin, Aleksandr Ivanovich]
biologist
Russia
1926 to 1960
Origin of Life [1936]
He lived 1894 to 1980. Glycerin molecules mixed with other molecules can clump together to make stable gel coascervates [1926]. Other molecules can enter, interact inside, and leave glycerin. In atmosphere or ocean, ultraviolet radiation, volcanic heat, lightning, and radioactive-nuclei ionizing radiation can make complex organic molecules from nitrogen, methane, ammonia, water, carbon dioxide, and hydrogen {Oparin-Haldane hypothesis}.

George Wald [Wald, George]
biologist
USA
1934 to 1954
Original Life [1954]
He lived 1906 to 1997, studied life's origin, and studied found retina vitamin A [1934].

Stanley Miller [Miller, Stanley]
biologist
USA
1953 to 1954
He lived 1930 to ?. Methane, ammonia, and water heated by electric arcs make amino acids [1953 to 1954]. However, amino acids only polymerize if conditions are hot and dry.

Leslie Orgel [Orgel, Leslie]

biologist
USA
1963 to 1970
Maintenance of the accuracy of protein synthesis and its relevance to ageing [1963]; Origins of Life: Molecules and Natural Selection [1970]
Freezing can concentrate and align organic molecules to make nucleic acids, such as adenine [1970]. Mutations degrade good working genetic code to make it more varied {error catastrophe, Orgel}, and this process adds to genetic variability [1963].

Clifford N. Matthews [Matthews, Clifford N.]
biologist
USA
1966 to 1975
Serine and threonine-containing heteropolypeptides [1966: with R. E. Moser]; Heteropolypeptides from poly-alpha-cyanoglycine and hydrogen cyanide. Model for origin of proteins [1975]
Heteropolypeptides can come from hydrogen cyanide [1966]. Dry heating HCN makes heteropolyamidines. Water converts them to polypeptides.

Gunter Wachtershauser [Wachtershauser, Gunter]
lawyer
Germany
1988
He studied life's origin [1988]. Hydrothermal-vent iron, nickel, and sulfur ions act as catalysts, templates, and energy sources to form biological molecules. Pyrite surfaces hold molecules.

Paul C. W. Davies [Davies, Paul C. W.]
chemist
USA
1989 to 1998
New Physics [1989: editor]; About Time: Einstein's Unfinished Revolution [1995]; Fifth Miracle: The Search for the Origin of Life [1998]
He studied relativity and life's origin.

Robert M. Hazen [Hazen, Robert M.]
chemist
USA
1996 to 2000
Comparative Crystal Chemistry [1982: with L. W. Finger]; High-Temperature and High-Pressure Crystal Chemistry [2000]
Minerals have crevices in which molecules can hide from ultraviolet light and become concentrated [1996]. Clay and mineral surfaces can be chemical-reaction substrates, catalysts, and templates. Minerals, such as calcite, can have chirality and select for L or R organic molecules. Biological-molecule metal ions can act as catalysts or energy sources. Magnetite can catalyze ammonia formation from nitrogen and hydrogen. Iron, nickel, and sulfur ions are in hydrothermal vents.

Freeman Dyson [Dyson, Freeman]
chemist
England/USA
1999
Origins of Life [1999]
He lived 1923 to ?.

BIOL>Biology>History>Physiology

John Jones [Jones, John]
physician

London, England
1700
Mysteries of Opium Reveal'd [1700]
He studied opium effects.

Luigi Galvani [Galvani, Luigi]
physiologist
Italy
1780
He lived 1737 to 1798 and observed frog muscles twitch when touched by electrified wires {galvanic stimulation} [1780].

Thomas Beddoes [Beddoes, Thomas]
physician
London, England
1793 to 1807
Observations on the Nature of Demonstrative Evidence [1793]; Essay on the Causes, Early Signs and Prevention of Pulmonary Consumption [1799]; Essay on Fever [1807]; Hygeia, or Essays Moral and Medical [1807]
He lived 1760 to 1808 and discovered analgesic effects of nitrous oxide [1798].

Johann Gaspar Spurzheim [Spurzheim, Johann Gaspar]
biologist
Germany
1810 to 1815
Anatomy and Physiology of the Nervous System in General [1810 to 1815: first two volumes, with Gall]
He lived 1776 to 1832 and studied memory storage and retrieval and physiological bases of normal brain function.

François Magendie [Magendie, François]
physiologist
Paris, France
1817 to 1822
Summary of Physiology [1817]
He lived 1783 to 1855, studied emetine and morphine drugs, and studied iodides and bromides in nutrition. He poisoned animals with Javanese arrow poison in various ways, described convulsions and asphyxia, sectioned spinal cord, and isolated strychnine [1818]. Spinal-nerve anterior and posterior roots have separate functions {Bell-Magendie law, Magendie}: dorsal root is sensory, and ventral root is motor [1822].

William Beaumont [Beaumont, William]
biologist
USA
1822 to 1833
Experiments and Observations on the Gastric Juice and the Physiology of Digestion [1833]
He lived 1785 to 1853 and observed stomach functions [1822 to 1833].

Henri Dutrochet [Dutrochet, Henri]
biologist
France
1824 to 1830
Mechanistic Materialism and General Psychology [1830]
He lived 1776 to 1847, studied osmosis [1824], studied plant respiration and light sensitivity [1824 to 1830], and worked on cell theory.

Johannes Peter Müller [Müller, Johannes Peter]
physiologist/anatomist
Berlin, Germany
1833 to 1840

Handbook of Physiology [1833 to 1840]
He lived 1801 to 1858 and founded modern physiology. Sensation type depends on stimulated neurons, not on what stimulates them {doctrine of specific nerve energies, Muller}.

Carlo Matteucci [Matteucci, Carlo]
physiologist
Italy
1842
On a physiological phenomenon produced by contracting muscles [1842]
He lived 1811 to 1868. Muscle cells have electric current [1842].

Horace Wells [Wells, Horace]
dentist
USA
1844
He lived 1815 to 1848 and first used nitrous-oxide anesthetic [1844] when he extracted his tooth.

Emil Heinrich Du Bois-Reymond [Du Bois-Reymond, Emil Heinrich]
physiologist
Germany
1845 to 1877
Researches on Animal Electricity [1848 and 1860: two volumes]
He lived 1818 to 1896. Nerve cells have resting potential [1845] that decreases with nerve impulse. Nerves conduct electricity. Nerve impulses transmit chemically [1877].

Arnold A. Berthold [Berthold, Arnold A.]
biologist
Berlin, Germany
1849
Transplantation of Testes [1849]
He lived 1803 to 1861 and studied hormones [1849] and transplantation.

Claude Bernard [Bernard, Claude]
physiologist
Paris, France
1849 to 1865
Lessons on Phenomena of Life in Animals and Plants [1863]; Introduction to the study of internal medicine [1865]
He lived 1813 to 1878, studied pancreas [1849], studied liver and carbohydrates [1851], and noted curare's effects on nerve transmission to muscle [1853]. Anesthetics affect single cell organisms, such as green slime mold, amoebae, and paramecia [1875]. Internal environments {milieu interieur} can have constancies {homeostasis, Bernard}.

Bernhard A. von Gudden [Gudden, Bernhard A. von]
biologist
Germany
1870 to 1874
Anomalies of the Human Skull [1870]; Experimental Studies of Skull Growth [1874]
He lived 1824 to 1886. After axons are cut, neuron cell bodies often die and disappear {retrograde cell degeneration} [1870], providing method to study nerve pathways.

Louis-Antoine Ranvier [Ranvier, Louis-Antoine]
anatomist
Paris, France
1878
Lessons on the histology of the nervous system [1878]
He lived 1835 to 1922 and studied neuron axons and conduction [1878].

Francis Gotch [Gotch, Francis]
biochemist
England
1899
He lived 1853 to 1913 and studied nerve impulse, which has refractory period [1899].

Shelford Bidwell [Bidwell, Shelford]
barrister
Britain
1899 to 1909
Curiosities of Light and Vision [1899]
He lived 1848 to 1909. Alternating flashing lights can make afterimages {Bidwell's ghost}.

Julius Bernstein [Bernstein, Julius]
biochemist
Germany
1902 to 1912
Investigations into the Thermodynamics of Bioelectrical Currents [1902]; Electrobiology [1912]
He lived 1839 to 1917 and measured nerve-impulse conduction speed [1902]. Neural ion concentrations change slightly during nerve impulses and cause nerve potential differences and action potentials {membrane theory} [1902 to 1912]. Local electric current flows between axon resting region and impulse region and causes depolarization {local circuit hypothesis}. This was idea of Ludimar Hermann.

Ivan Petrovich Pavlov [Pavlov, Ivan Petrovich]
physiologist
St. Petersburg, Russia
1902 to 1927
Work of the Digestive Glands [1902]; Conditional Reflexes [1927]
He lived 1849 to 1936 and studied neurosis, peripheral nerves, digestion physiology, classical conditioning, and reflexes.
Contradictory stimuli can disturb balance between nervous-system excitatory and inhibitory processes, and personality affects whether neurosis develops.
Vagus nerve controls blood pressure, and four nerves control and vary heartbeat rhythm and intensity. Depending on saliva and food, tasting food {sham feeding} can release gastric juice, which has enzymes {enterokinase}.
Dogs associate neutral stimulus with reflex. Conditional reflex forms more easily if unconditional stimulus, such as food, follows conditional stimulus, such as bell, than if they are simultaneous or if conditional stimulus follows unconditional stimulus. Conditional reflex forms more easily if conditional stimulus is nearer in time to unconditional stimulus. Conditional stimulus that starts just before unconditional stimulus is as effective as conditional stimulus that started long before unconditional stimulus and lasted until just before. More intense conditional and unconditional stimuli cause greater conditioned responses. Training conditional stimulus allows testing similar conditional stimuli to investigate animal sense discriminations. External inhibition, internal inhibition, new environments, and new stimuli affect conditioning. If conditional and unconditional stimuli no longer pair, conditioned reflex gradually decreases. Maintaining conditioned reflex requires regular reinforcement. Conditioned reflex is similar to other reflexes. Conditional reflex formation is adaptation whereby animal can survive better in changing environment.

Frederick Frost Blackman [Blackman, Frederick Frost]
biologist
England
1905 to 1922
Optima and Limiting Factors [1905]; Problem of Plant Respiration considered as a Catalytic Process [1922]
He lived 1866 to 1947 and studied light and dark photosynthesis [1905].

Harvey Cushing [Cushing, Harvey]
biologist
USA
1908 to 1912

Pituitary Body and its Disorders [1912]
He lived 1869 to 1939, stimulated brains and elicited sensation without movement [1908], and described Cushing's syndrome [1912].

Keith Lucas [Lucas, Keith]
biochemist
England
1909
He lived 1879 to 1916 and studied nerve impulse, with Francis Gotch. Nerve impulse is all-or-nothing, with refractory period afterward [1909].

Hans Henning [Henning, Hans]
biologist
Germany
1916 to 1924
Smell [1916 and 1924]; Qualities of Tastes [1916]; New Example of Complex Synaesthesia [1923]
He lived 1885 to 1946. He identified four bitter, salty, sour, and sweet primary tastes [1924], which he put at tetrahedron corners. He identified six primary smells [1916], which he put at prism corners.

Herbert McLean Evans [Evans, Herbert McLean]/Joseph Abraham Long [Long, Joseph Abraham]
biologist
USA
1921
Evans lived 1882 to 1971. Long lived 1879 to 1953. They isolated human growth hormone [1921].

Otto Loewi [Loewi, Otto]
biochemist
Graz, Austria
1921
He lived 1873 to 1961, proved that neurotransmitters cross junction between nerve cells, using vagus nerve to heart, and so proved that synapses were chemical not electrical [1921], and studied acetylcholine chemical synapse.

Edgar D. Adrian [Adrian, Edgar D.]
doctor
England
1925 to 1928
Basis of Sensation [1928]
He lived 1889 to 1977 and recorded afferent-nerve impulses, with Lucas' capillary electrometer [1925]. Neurons use impulse-frequency modulation.

Karl Spencer Lashley [Lashley, Karl Spencer]
neuropsychologist
USA
1930 to 1956
Brain Mechanisms and Intelligence [1930]; Functional Determinants of Cerebral Localization [1937]; Cerebral Organization and Behavior [1956]
He lived 1890 to 1958 and studied cerebral-cortex lesion effects on intelligence, rat maze learning [1920 to 1930], and mass-action law [Lashley, 1956].

Louis Flexner [Flexner, Louis]
biologist
USA
1933 to 1963
Some problems of the origin, circulation, and absorption of the cerebrospinal fluid [1933]; Chemistry and Nature of the Cerebrospinal Fluid [1934]; Memory in mice as affected by intracerebral puromycin [1963: with J. B. Flexner and E. Stellar]

He lived 1902 to 1996. Long-term memory needs protein synthesis.

Henry Dale [Dale, Henry]
physiologist
England
1936
He lived 1875 to 1968 and studied chemical synapses [1936].

Alan Hodgkin [Hodgkin, Alan]/Andrew F. Huxley [Huxley, Andrew F.]
biochemist
England
1937 to 1952
Currents carried by sodium and potassium ions [1952]
Hodgkin lived 1914 to 1998. Huxley lived 1917 to ?. They used squid giant axons to prove that ions flow across membrane rather than down axon {local circuit hypothesis, Hodgkin}, by locally increasing and decreasing extracellular-fluid conductivity [1937]. Sodium ions have ion channels, and potassium ions have separate ion channels. During action potentials, membranes are first more permeable to sodium ions, flowing in, and then potassium ions, flowing out, so potential becomes negative {Hodgkin-Huxley theory} [1952].

Nicholas A. Bernstein [Bernstein, Nicholas A.]
physiologist
Russia
1947 to 1966
On the Construction of Movements [1947]; Coordination and Regulation of Movements [1967]
He lived 1896 to 1966 and developed sensation fields {afferent field, Bernstein}. He studied feedback and feedforward mechanisms. He studied human coordination and movement physiology by photographing lights fastened to arms and legs. Human movements have patterns and structures, and people maintain basic patterns no matter which organ or limb they use [Bernstein, 1947].

Bernard Katz [Katz, Bernard]
biologist
England
1948 to 1949
He lived 1911 to 2003. Action potentials open calcium-ion channels, and calcium inflow leads to release of 5000-transmitter-molecule packets from synaptic vesicles into synapse.

John Cade [Cade, John]
biologist
Australia
1949
He lived 1912 to 1980 and used lithium carbonate to treat mania [1949].

José Delgado [Delgado, José]
psychologist
USA
1952 to 1969
Physical Control of the Mind [1969]
He lived 1915 to ?. Amygdala stimulation by electrodes {stimoceiver} can trigger aggressive behavior [1955].

Stephen Kuffler [Kuffler, Stephen]
biochemist
USA
1953
He lived 1913 to 1980. Cat-retina ON-center and OFF-center ganglion cells respond to illumination changes [1953].

Vincent du Vigneaud [Vigneaud, Vincent du]

biologist
France
1953
He lived 1901 to 1978 and discovered vasopressin [1953].

René Couteaux [Couteaux, René]
biologist
France
1961 to 1970
He lived 1909 to 1999. Synaptic vesicles release transmitter packets only at active synapse zones {active zone}, where calcium ion channels are [1961].

Bernard W. Agranoff [Agranoff, Bernard W.]
psychologist
USA
1967
Memory and protein synthesis [1967]
He lived 1926 to ?. Long-term memory needs protein synthesis.

Seymour Benzer [Benzer, Seymour]
biologist
USA
1967
Behavioral mutants of Drosophila isolated by counter current distribution [1967]
He lived 1921 to ?, studied fruit flies, and mutated single genes to affect courtship rituals, vision, circadian rhythms, memory, and learning. He found proteins used in non-declarative memory.

Vernon Rowland [Rowland, Vernon]/Robert Blumenthal [Blumenthal, Robert]
biologist
USA
1974
Dynamic Patterns of Brain Cell Assemblies [1974]

Eric R. Kandel [Kandel, Eric R.]
biologist
USA
1974 to 2000
Small Systems of Neurons [1974]; Cellular Basis of Behavior [1976]; Behavioral Biology of Aplysia [1979]; Biological Basis of Learning and Individuality [1992: with Robert Hawkins]; Memory from Mind to Molecules [2000: with Larry Squire]
He studied learning and memory in marine snails.

James S. Albus [Albus, James S.]
biologist
USA
1975
He developed Cerebellar Model Articulation Controller [1975].

Russell L. DeValois [DeValois, Russell L.]
biologist
USA
1975 to 1988
Spatial Vision [1988: with Karen K. DeValois]
He showed that visual cortical neurons respond to frequency rather than edges or lines {direct spatial information} [1975]. They detect fundamental frequency and higher frequencies, together with orientation. He used gratings, checkerboards, and plaid patterns. Results matched results expected from analysis by Fourier transforms.

Michael A. Arbib [Arbib, Michael A.]
psychologist
England/USA
1975 to 1995
Metaphorical Brain [1972]; Handbook of Brain Theory and Neural Networks [1995]
He lived 1940 to ?.

Bruce S. McEwen [McEwen, Bruce S.]
biologist
USA
1976
Interactions between Hormones and Nerve Tissue [1976]

E. George Gray [Gray, E. George]
biologist
England
1977
Synapse [1977]

Imrich Friedmann [Friedmann, Imrich]
biologist
USA
1979
Human Ear [1979]

Gunther Palm [Palm, Gunther]
biologist
Germany
1982
Neural Assemblies [1982]

Franz Huber [Huber, Franz]/John Thorson [Thorson, John]
biologist
USA
1985
Cricket Auditory Communication [1985]

Francisco Varela [Varela, Francisco]
biologist
USA
1988 to 1999
Embodied Mind [1991]; View from Within [1999]
He lived 1946 to 2001 and studied neurophenomenology. Living cells rebuild themselves {autopoiesis, Varela} [1988], with Maturana.

J. Allan Hobson [Hobson, J. Allan]
biologist
USA
1989 to 2002
Sleep [1989]; Chemistry of Conscious States [1994]; Dreaming as Delirium [1999]; Consciousness [1999]; Dreaming [2002]
He studied sleep and developed AIM model [Hobson, 2002].

Roger Nicoll [Nicoll, Roger]
biologist

USA
1991
Special neuron stimulation can cause excitation over hours, involving protein-kinase phosphorylation after calcium-ion influx [1991].

Richard Morris [Morris, Richard]
biologist
Scotland
1997
Only active synapses can take up protein to permanently alter synapse [1997], with Uwe Frey.

Hans Flohr [Flohr, Hans]
neuroscientist
Germany
2000
Inhibition or blocking of NMDA receptor complexes, as done by ketamine and nitrous oxide, causes unconsciousness [2000]. Consciousness is a high-level representation that brain has representations, using NMDA-receptor-linked cell assemblies firing synchronously [Flohr, 2000]. However, NMDA receptors are just as involved in non-conscious processes [Hardcastle, 2000]. Many anesthetics, such as etomidate, act on other sites [Franks and Lieb, 2000].

BIOL>Biology>History>Sensation

Ernst Heinrich Weber [Weber, Ernst Heinrich]
physiologist
Leipzig, Germany
1820 to 1846
On vision and hearing in humans and animals [1820]; Additions to the Theory of Construction and Function of the Genital Organs [1846]
He lived 1795 to 1878, studied psychophysics, invented theory of signs {Lokalzeichentheorie}, measured skin sensitivity to separated stimuli [1826], studied inhibition by vagus nerve [1845], and developed law of sensation [1834], with Fechner. People can distinguish between two similar sensations {just-noticeable difference}. For each sense, ratio of just-noticeable-difference to intensity is approximately constant for all intensities. Subjective sensation increases as logarithm of physical-stimulus magnitude. Just-noticeable difference increases in direct proportion to stimulus intensity. If I is sensation intensity, intensity change divided by intensity equals constant {Weber-Fechner law} {Weber's law}: (I2 - I1) / I1 = Weber's constant. Weber's constant {Weber fraction} represents smallest stimulus intensity difference that people can perceive. If intensity is higher, differences must be larger for people to perceive them. Weber's constant is typically greater than one to three percent, differs for different senses, and tends to increase with age.

Jean A. Brillat-Savarin [Brillat-Savarin, Jean A.]
judge
France
1825
Physiology of Taste [1825: about food and philosophy]
He lived 1755 to 1826.

Willy Kuhne [Kuhne, Willy]
physiologist
Heidelberg, Germany
1877 to 1900
On the red of the retina [1877]
He lived 1837 to 1900 and found rhodopsin retinal pigment {visual purple} in rod photoreceptors for twilight vision [1877].

Ewald Hering [Hering, Ewald]

physiologist
Austria
1878
Theory of Light Sensing [1878]
He lived 1834 to 1918. Lung receptors signal distension, stop inspiration {Hering-Breuer reflex}, and partly control respiration.

He explained brightness perception, color vision, afterimages, and complementary colors by starting from neutral point and moving in anabolic or catabolic direction {opponent color theory, Hering}. Yellow does not subjectively appear to mix green and red and is stable over intensity changes, so yellow is a primary-color complement. Eye-movement, color-detection, and brightness-detection mechanisms are inborn. People see unique blue, unique green, and unique yellow, because they affect all three cones and, at that wavelength, people perceive no other color mixed in. People do not see unique red, because only two cones affect red.

Brain substance can contain memories, and memory is a material process, because memory survives unconsciousness and sleep.

Jean Henri Fabré [Fabré, Jean Henri]
entomologist
Paris, France
1879 to 1907
Souvenirs of Entomology [1879 to 1907]
He lived 1823 to 1915 and studied insect behavior and sense capacities.

Max von Frey [Frey, Max von]
physiologist
Göttingen, Germany
1885 to 1904
Journal of Mathematical Physics [1896]; Four Cutaneous Senses [1904]; heart-lung machine [1885]
He lived 1852 to 1932 and studied pain and touch sensations.

Karl Ritter von Frisch [von Frisch, Karl Ritter]
ethologist
Austria/USA
1940 to 1974
Bees: Their Vision, Chemical Senses, and Language [1950]; Animal Architecture [1974]
He lived 1886 to 1983. Fish can have color vision and can hear. Special honeybees {scout honeybee} convey information about food-source direction and distance by performing symbolic dances after they return to hive floor. Bee determines direction in reference to Sun or to sky light-polarization angle, detectable by bee compound eye. Dances have a symmetry line, which indicates food-source direction. Dance kinds and speeds indicate food-source distance: slow and round for near and fast, and waggly for far.

Humberto R. Maturana [Maturana, Humberto R.]
biologist
USA
1959 to 1992
What the Frog's Eye Tells the Frog's Brain [1959: with Lettvin, McCulloch, and Pitts]; Tree of Knowledge [1992: with Francisco Varela]
He lived 1928 to ?. Living cells rebuild themselves {autopoiesis, Maturana}.

Torsten Nils Wiesel [Wiesel, Torsten Nils]
physiologist/biologist
Sweden/USA
1962 to 1968
Receptive Fields, Binocular Interaction and Functional Architecture in the Cat's Visual Cortex [1962 with Hubel]; Receptive Fields and Functional Architecture of Monkey Striate Cortex [1968: with Hubel]

He lived 1924 to ? and studied visual-cortex organization, with David Hubel. Not using eye during critical or sensitive period to detect stimulus feature makes visual cortex unable to detect stimulus feature {sensory deprivation, Wiesel}.

David H. Hubel [Hubel, David H.]
biologist
USA
1962 to 1988
Receptive Fields, Binocular Interaction and Functional Architecture in the Cat's Visual Cortex [1962: with Wiesel]; Receptive Fields and Functional Architecture of Monkey Striate Cortex [1968: with Wiesel]; Eye, Brain, and Vision [1988]
He lived 1926 to ? and studied visual-cortex organization, with Torsten Wiesel. Not using eye during critical or sensitive period to detect stimulus features makes visual cortex unable to detect stimulus features.
Brain detects color in round vertical columns, located 0.5 mm apart in regular arrays between primary-visual-cortex orientation columns, using double-opponent neurons, with both ON-center and OFF-center circular fields, to compare colors. He found blobs by staining primary visual cortex with cytochrome oxidase (CO), with Margaret Livingstone. Interblob regions detect orientation.

Geoffrey V. T. Matthews [Matthews, Geoffrey V. T.]
biologist
USA
1973
Orientation and Position-finding by Birds [1973]

Christof Koch [Koch, Christof]
biologist
USA
1994 to 2004
Large-Scale Neuronal Theories of the Brain [1994: with Joel L. Davis]; Biophysics of Computation [1999]; Quest for Consciousness [2004]
He lived 1956 to ?. Neural activity differs in dreaming, awake, or brain-damaged {activity principle, Koch}. Different animal types can have different neural-activity patterns. Perhaps, some neuron set has same ion channels, shape, receptors, axons, or biochemistry {neuronal correlates of consciousness, Koch}.

BIOL>Biology>History>Surgery

William Osler [Osler, William]
surgeon
USA
1892 to 1905
Principles and Practice of Medicine [1892]; Fixed Period [1905]
He lived 1849 to 1919.

BIOL>Biology>History>Zoology

Jean-Baptiste de Lamarck [Lamarck, Jean-Baptiste de]
anatomist
Paris, France
1778 to 1822
French Flora [1778]; Animal Philosophy [1809]; Natural History of the Invertebrates [1815 to 1822]
He lived 1744 to 1829 and studied invertebrate paleontology and invertebrate classification. Environment forces animals to acquire new characteristics through learning. What individual experience learns, offspring can inherit {Lamarckianism, Lamarck}. However, Lamarckianism is only true for minor specialized cellular transmittance.

Erasmus Darwin [Darwin, Erasmus]
physician/scientist

Britain
1794 to 1796
Zoonomia or The Laws of Organic Life [1794 to 1796]
He lived 1731 to 1802.

Thomas Vernon Wollaston [Wollaston, Thomas Vernon]
anatomist
England
1856
Variation of Species [1856]
He lived 1822 to 1878.

Herbert Spencer Jennings [Jennings, Herbert Spencer]
zoologist
USA
1904 to 1906
Contributions to the Study of the Behavior of Lower Organisms [1904]; Behavior of the Lower Organisms [1906]
He lived 1868 to 1947 and studied invertebrates.

Charles Beebe [Beebe, Charles]
biologist
USA
1918 to 1934
Monograph of the Pheasants [1918 to 1922]; bathysphere [1934]
He lived 1877 to 1962 and deep-sea dived.

Roger Tory Peterson [Peterson, Roger Tory]
biologist
USA
1934 to 1980
Field Guide to the Birds [1934 to 1980]
He lived 1908 to 1996 and studied birds.

Marston Bates [Bates, Marston]
biologist
USA
1949 to 1950
Natural History of Mosquitoes [1949]; Nature of Natural History [1950]
He lived 1906 to 1974 and studied mosquitoes.

James L. Gould [Gould, James L.]
biologist
USA
1988
Honey Bee [1988]

Brock Fenton [Fenton, Brock]
biologist
USA
1992
Bats [1992: Facts on File]