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Science, Tech, Math All Science, Tech, Math Humanities All Humanities Languages All Languages Resources All Resources Mechanism of evolution by differential reproduction For other uses, see Natural selection (disambiguation). A diagram demonstrating mutation and selection Part of a series onEvolutionary biologyDarwin's finches by John Gould Index Introduction Main Outline Glossary Evidence History Processes and outcomes Population genetics Variation Diversity Mutation Natural selection Adaptation Polymorphism Genetic drift Gene flow Speciation Adaptive radiation Co-operation Coevolution Coextinction Contingency Divergence Convergence Parallel evolution Extinction Natural history Origin of life Common descent History of life Timeline of evolution Human evolution Recent human evolution Phylogeny Biodiversity Biogeography Classification Evolutionary taxonomy Cladistics Transitional fossil Extinction event History of evolutionary theory Overview Renaissance Before Darwin Darwin Origin of Species Before synthesis Modern synthesis Molecular evolution Evo-devo Current research History of speciation History of paleontology (timeline) Fields and applications Applications of evolution Biosocial criminology Ecological genetics Evolutionary aesthetics Evolutionary anthropology Evolutionary computation Evolutionary ecology Evolutionary economics Evolutionary epistemology Evolutionary ethics Evolutionary game theory Evolutionary linguistics Evolutionary medicine Evolutionary neuroscience Evolutionary physiology Evolutionary psychology Experimental evolution Invasion genetics Island biogeography Phylogenetics Paleontology Selective breeding Speciation experiments Sociobiology Systematics Universal Darwinism Social implications Eugenics Evolution as fact and theory Dysgenics Social effects Creation–evolution controversy Theistic evolution Objections to evolution Level of support Nature-nurture controversy Evolutionary biology portal Categoryvte Natural selection is the differential survival and reproduction of individuals due to differences in phenotype. It is a key mechanism of evolution, the change in the heritable traits characteristic of a population over generations. Charles Darwin popularised the term "natural selection", contrasting it with artificial selection, which is intentional, whereas natural selection is not. Variation of traits, both genotypic and phenotypic, exists within all populations of organisms. However, some traits are more likely to facilitate survival and reproductive success. Thus, these traits are passed on to the next generation. These traits can also become more common within a population if the environment that favours these traits remains fixed. If new traits become more favoured due to changes in a specific niche, microevolution occurs. If new traits become more favoured due to changes in the broader environment, macroevolution occurs. Sometimes, new species can arise especially if these new traits are radically different from the traits possessed by their predecessors. The likelihood of these traits being 'selected' and passed down are determined by many factors. Some are likely to be passed down because they adapt well to their environments. Others are passed down because these traits are actively preferred by mating partners, which is known as sexual selection. Female bodies also prefer traits that confer the lowest cost to their reproductive health, which is known as fecundity selection. Natural selection is a cornerstone of modern biology. The concept, published by Darwin and Alfred Russel Wallace in a joint presentation of papers in 1858, was elaborated in Darwin's influential 1859 book On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life. He described natural selection as analogous to artificial selection, a process by which animals and plants with traits considered desirable by human breeders are systematically favoured for reproduction. The concept of natural selection originally developed in the absence of a valid theory of heredity; at the time of Darwin's writing, science had yet to develop modern theories of genetics. The union of traditional Darwinian evolution with subsequent discoveries in classical genetics formed the modern synthesis of the mid-20th century. The addition of molecular genetics has led to evolutionary developmental biology, which explains evolution at the molecular level. While genotypes can slowly change by random genetic drift, natural selection remains the primary explanation for adaptive evolution. Main article: History of evolutionary thought Aristotle considered whether different forms could have appeared, only the useful ones surviving. Several philosophers of the classical era, including Empedocles[1] and his intellectual successor, the Roman poet Lucretius,[2] expressed the idea that nature produces a huge variety of creatures, randomly, and that only those creatures that manage to provide for themselves and reproduce successfully persist. Empedocles' idea that organisms arose entirely by the incidental workings of causes such as heat and cold was criticised by Aristotle in Book II of Physics.[3] He posited natural teleology in its place, and believed that form was achieved for a purpose, citing the regularity of heredity in species as proof.[4][5] Nevertheless, he accepted in his biology that new types of animals, monstrosities (τερας), can occur in very rare instances (Generation of Animals, Book IV).[6] As quoted in Darwin's 1872 edition of The Origin of Species, Aristotle considered whether different forms (e.g., of teeth) might have appeared accidentally, but only the useful forms survived: So what hinders the different parts [of the body] from having this merely accidental relation in nature? as the teeth, for example, grow by necessity, the front ones sharp, adapted for dividing, and the grinders flat, and serviceable for masticating the food; since they were not made for the sake of this, but it was the result of accident. And in like manner as to the other parts in which there appears to exist an adaptation to an end. Wheresoever, therefore, all things together (that is all the parts of one whole) happened like as if they were made for the sake of something, these were preserved, having been appropriately constituted by an internal spontaneity, and whatsoever things were not thus constituted, perished, and still perish.—Aristotle, Physics, Book II, Chapter 8[7] But Aristotle rejected this possibility in the next paragraph, making clear that he is talking about the development of animals as embryos with the phrase "either invariably or normally come about", not the origin of species: ... Yet it is impossible that this should be the true view. For teeth and all other natural things either invariably or normally come about in a given way; but of not one of the results of chance or spontaneity is this true. We do not ascribe to chance or mere coincidence the frequency of rain in winter, but frequent rain in summer we do; nor heat in the dog-days, but only if we have it in winter. If then, it is agreed that things are either the result of coincidence or for an end, and these cannot be the result of coincidence or spontaneity, it follows that they must be for an end; and that such things are all due to nature even the champions of the theory which is before us would agree. Therefore action for an end is present in things which come to be and are by nature.—Aristotle, Physics, Book II, Chapter 8[8] The struggle for existence was later described by the Islamic writer Al-Jahiz in the 9th century, particularly in the context of top-down population regulation, but not in reference to individual variation or natural selection.[9][10] At the turn of the 16th century Leonardo da Vinci collected a set of fossils of ammonites as well as other biological material. He extensively reasoned in his writings that the shapes of animals are not given once and forever by the "upper power" but instead are generated in different forms naturally and then selected for reproduction by their compatibility with the environment.[11] The more recent classical arguments were reintroduced in the 18th century by Pierre Louis Maupertuis[12] and others, including Darwin's grandfather, Erasmus Darwin. Until the early 19th century, the prevailing view in Western societies was that differences between individuals of a species were uninteresting departures from their Platonic ideals (or typus) of created kinds. However, the theory of uniformitarianism in geology promoted the idea that simple, weak forces could act continuously over long periods of time to produce radical changes in the Earth's landscape. The success of this theory raised awareness of the vast scale of geological time and made plausible the idea that tiny, virtually imperceptible changes in successive generations could produce consequences on the scale of differences between species.[13] The early 19th-century zoologist Jean-Baptiste Lamarck suggested the inheritance of acquired characteristics as a mechanism for evolutionary change; adaptive traits acquired by an organism during its lifetime could be inherited by that organism's progeny, eventually causing transmutation of species.[14] This theory, Lamarckism, was an influence on the Soviet biologist Trofim Lysenko's ill-fated antagonism to mainstream genetic theory as late as the mid-20th century.[15] Between 1835 and 1837, the zoologist Edward Blyth worked on the area of variation, artificial selection, and how a similar process occurs in nature. Darwin acknowledged Blyth's ideas in the first chapter on variation of On the Origin of Species.[16] Main articles: Inception of Darwin's theory and Development of Darwin's theory Further information: Coloration evidence for natural selection Modern biology began in the nineteenth century with Charles Darwin's work on evolution by natural selection. In 1859, Charles Darwin set out his theory of evolution by natural selection as an explanation for adaptation and speciation. He defined natural selection as the "principle by which each slight variation [of a trait], if useful, is preserved".[17] The concept was simple but powerful: individuals best adapted to their environments are more likely to survive and reproduce. As long as there is some variation between them and that variation is heritable, there will be an inevitable selection of individuals with the most advantageous variations. If the variations are heritable, then differential reproductive success leads to the evolution of particular populations of a species, and populations that evolve to be sufficiently different eventually become different species.[18][19] Part of Thomas Malthus's table of population growth in England 1780–1810, from his Essay on the Principle of Population, 6th edition, 1826 Darwin's ideas were inspired by the observations that he had made on the second voyage of HMS Beagle (1831–1836), and by the work of a political economist, Thomas Robert Malthus, who, in An Essay on the Principle of Population (1798), noted that population (if unchecked) increases exponentially, whereas the food supply grows only arithmetically; thus, inevitable limitations of resources would have demographic implications, leading to a "struggle for existence".[20] When Darwin read Malthus in 1838 he was already primed by his work as a naturalist to appreciate the "struggle for existence" in nature. It struck him that as population outgrew resources, "favourable variations would tend to be preserved, and unfavourable ones to be destroyed. The result of this would be the formation of new species."[21] Darwin wrote: If during the long course of ages and under varying conditions of life, organic beings vary at all in the several parts of their organisation, and I think this cannot be disputed; if there be, owing to the high geometrical powers of increase of each species, at some age, season, or year, a severe struggle for life, and this certainly cannot be disputed; then, considering the infinite complexity of the relations of all organic beings to each other and to their conditions of existence, causing an infinite diversity in structure, constitution, and habits, to be advantageous to them, I think it would be a most extraordinary fact if no variation ever had occurred useful to each being's own welfare, in the same way as so many variations have occurred useful to man. But if variations useful to any organic being do occur, assuredly individuals thus characterised will have the best chance of being preserved in the struggle for life; and from the strong principle of inheritance they will tend to produce offspring similarly characterised. This principle of preservation, I have called, for the sake of brevity, Natural Selection.—Darwin summarising natural selection in the fourth chapter of On the Origin of Species[22] Once he had this hypothesis, Darwin was meticulous about gathering and refining evidence of consilience to meet standards of methodology before making his scientific theory public.[13] He was in the process of writing his "big book" to present his research when the naturalist Alfred Russel Wallace independently conceived of the principle and described it in an essay he sent to Darwin to forward to Charles Lyell. Lyell and Joseph Dalton Hooker decided to present his essay together with unpublished writings that Darwin had sent to fellow naturalists, and On the Tendency of Species to form Varieties; and on the Perpetuation of Varieties and Species by Natural Means of Selection was read to the Linnean Society of London announcing co-discovery of the principle in July 1858.[23] Darwin published a detailed account of his evidence and conclusions in On the Origin of Species in 1859. In later editions Darwin acknowledged that earlier writers—like William Charles Wells in 1813,[24] and Patrick Matthew in 1831—had proposed similar basic ideas.[25] However, they had not developed their ideas, or presented evidence to persuade others that the concept was useful.[13] Charles Darwin noted that pigeon fanciers had created many kinds of pigeon, such as Tumblers (1, 12), Fantails (13), and Pouters (14) by selective breeding. Darwin thought of natural selection by analogy to how farmers select crops or livestock for breeding, which he called "artificial selection"; in his early manuscripts he referred to a "Nature" which would do the selection. At the time, other mechanisms of evolution such as evolution by genetic drift were not yet explicitly formulated, and Darwin believed that selection was likely only part of the story: "I am convinced that Natural Selection has been the main but not exclusive means of modification."[26] In a letter to Charles Lyell in September 1860, Darwin regretted the use of the term "Natural Selection", preferring the term "Natural Preservation".[27] For Darwin and his contemporaries, natural selection was in essence synonymous with evolution by natural selection. After the publication of On the Origin of Species,[28] educated people generally accepted that evolution had occurred in some form. However, natural selection remained controversial as a mechanism, partly because it was perceived to be too weak to explain the range of observed characteristics of living organisms, and partly because even supporters of evolution balked at its "unguided" and non-progressive nature,[29] a response that has been characterised as the single most significant impediment to the idea's acceptance.[30] However, some thinkers enthusiastically embraced natural selection; after reading Darwin, Herbert Spencer introduced the phrase survival of the fittest, which became a popular summary of the theory.[31][32] The fifth edition of On the Origin of Species published in 1869 included Spencer's phrase as an alternative to natural selection, with credit given: "But the expression often used by Mr. Herbert Spencer of the Survival of the Fittest is more accurate, and is sometimes equally convenient."[33] Although the phrase is still often used by non-biologists, modern biologists avoid it because it is tautological if "fittest" is read to mean "functionally superior" and is applied to individuals rather than considered as an averaged quantity over populations.[34] Main article: Modern synthesis (20th century) Natural selection relies crucially on the idea of heredity, but developed before the basic concepts of genetics. Although the Moravian monk Gregor Mendel, the father of modern genetics, was a contemporary of Darwin's, his work lay in obscurity, only being rediscovered in 1900.[35] With the early 20th-century integration of evolution with Mendel's laws of inheritance, the so-called modern synthesis, scientists generally came to accept natural selection.[36][37] The synthesis grew from advances in different fields. Ronald Fisher developed the required mathematical language and wrote The Genetical Theory of Natural Selection (1930).[38] J. B. S. Haldane introduced the concept of the "cost" of natural selection.[39][40] Sewall Wright elucidated the nature of selection and adaptation.[41] In his book Genetics and the Origin of Species (1937), Theodosius Dobzhansky established the idea that mutation, once seen as a rival to selection, actually supplied the raw material for natural selection by creating genetic diversity.[42][43] Evolutionary developmental biology relates the evolution of form to the precise pattern of gene activity, here gap genes in the fruit fly, during embryonic development.[44] Main article: Evolutionary developmental biology § History Ernst Mayr recognised the key importance of reproductive isolation for speciation in his Systematics and the Origin of Species (1942).[45] W. D. Hamilton conceived of kin selection in 1964.[46] This synthesis cemented natural selection as the foundation of evolutionary theory, where it remains today. A second synthesis was brought about at the end of the 20th century by advances in molecular genetics, creating the field of evolutionary developmental biology ("evo-devo"), which seeks to explain the evolution of form in terms of the genetic regulatory programs which control the development of the embryo at molecular level. Natural selection is here understood to act on embryonic development to change the morphology of the adult body.[47][48][49][50] The term natural selection is most often defined to operate on heritable traits, because these directly participate in evolution. However, natural selection is "blind" in the sense that changes in phenotype can give a reproductive advantage regardless of whether or not the trait is heritable. Following Darwin's primary usage, the term is used to refer both to the evolutionary consequence of blind selection and to its mechanisms.[28][38][51][52] It is sometimes helpful to explicitly distinguish between selection's mechanisms and its effects; when this distinction is important, scientists define "(phenotypic) natural selection" specifically as "those mechanisms that contribute to the selection of individuals that reproduce", without regard to whether the basis of the selection is heritable.[53][54][55] Traits that cause greater reproductive success of an organism are said to be selected for, while those that reduce success are selected against.[56] During the Industrial Revolution, pollution killed many lichens, leaving tree trunks dark. A dark (melanic) morph of the peppered moth largely replaced the formerly usual light morph (both shown here). Since the moths are subject to predation by birds hunting by sight, the colour change offers better camouflage against the changed background, suggesting natural selection at work. Main article: Genetic variation Natural variation occurs among the individuals of any population of organisms. Some differences may improve an individual's chances of surviving and reproducing such that its lifetime reproductive rate is increased, which means that it leaves more offspring. If the traits that give these individuals a reproductive advantage are also heritable, that is, passed from parent to offspring, then there will be differential reproduction, that is, a slightly higher proportion of fast rabbits or efficient algae in the next generation. Even if the reproductive advantage is very slight, over many generations any advantageous heritable trait becomes dominant in the population. In this way the natural environment of an organism "selects for" traits that confer a reproductive advantage, causing evolutionary change, as Darwin described.[57] This gives the appearance of purpose, but in natural selection there is no intentional choice.[a] Artificial selection is purposive where natural selection is not, though biologists often use teleological language to describe it.[58] The peppered moth exists in both light and dark colours in Great Britain, but during the Industrial Revolution, many of the trees on which the moths rested became blackened by soot, giving the dark-coloured moths an advantage in hiding from predators. This gave dark-coloured moths a better chance of surviving to produce dark-coloured offspring, and in just fifty years from the first dark moth being caught, nearly all of the moths in industrial Manchester were dark. The balance was reversed by the effect of the Clean Air Act 1956, and the dark moths became rare again, demonstrating the influence of natural selection on peppered moth evolution.[59] A recent study, using image analysis and avian vision models, shows that pale individuals more closely match lichen backgrounds than dark morphs and for the first time quantifies the camouflage of moths to predation risk.[60] Main article: Fitness (biology) The concept of fitness is central to natural selection. In broad terms, individuals that are more "fit" have better potential for survival, as in the well-known phrase "survival of the fittest", but the precise meaning of the term is much more subtle. Modern evolutionary theory defines fitness not by how long an organism lives, but by how successful it is at reproducing. If an organism lives half as long as others of its species, but has twice as many offspring surviving to adulthood, its genes become more common in the adult population of the next generation. Though natural selection acts on individuals, the effects of chance mean that fitness can only really be defined "on average" for the individuals within a population. The fitness of a particular genotype corresponds to the average effect on all individuals with that genotype.[61] A distinction must be made between the concept of "survival of the fittest" and "improvement in fitness". "Survival of the fittest" does not give an "improvement in fitness", it only represents the removal of the less fit variants from a population. A mathematical example of "survival of the fittest" is given by Haldane in his paper "The Cost of Natural Selection".[62] Haldane called this process "substitution" or more commonly in biology, this is called "fixation". This is correctly described by the differential survival and reproduction of individuals due to differences in phenotype. On the other hand, "improvement in fitness" is not dependent on the differential survival and reproduction of individuals due to differences in phenotype, it is dependent on the absolute survival of the particular variant. The probability of a beneficial mutation occurring on some member of a population depends on the total number of replications of that variant. The mathematics of "improvement in fitness was described by Kleinman.[63] An empirical example of "improvement in fitness" is given by the Kishony Mega-plate experiment.[64] In this experiment, "improvement in fitness" depends on the number of replications of the particular variant for a new variant to appear that is capable of growing in the next higher drug concentration region. Fixation or substitution is not required for this "improvement in fitness". On the other hand, "improvement in fitness" can occur in an environment where "survival of the fittest" is also acting. Richard Lenski's classic E. coli long-term evolution experiment is an example of adaptation in a competitive environment, ("improvement in fitness" during "survival of the fittest").[65] The probability of a beneficial mutation occurring on some member of the lineage to give improved fitness is slowed by the competition. The variant which is a candidate for a beneficial mutation in this limited carrying capacity environment must first out-compete the "less fit" variants in order to accumulate the requisite number of replications for there to be a reasonable probability of that beneficial mutation occurring.[66] Main article: Competition (biology) In biology, competition is an interaction between organisms in which the fitness of one is lowered by the presence of another. This may be because both rely on a limited supply of a resource such as food, water, or territory.[67] Competition may be within or between species, and may be direct or indirect.[68] Species less suited to compete should in theory either adapt or die out, since competition plays a powerful role in natural selection, but according to the "room to roam" theory it may be less important than expansion among larger clades.[68][69] Competition is modelled by r/K selection theory, which is based on Robert MacArthur and E. O. Wilson's work on island biogeography.[70] In this theory, selective pressures drive evolution in one of two stereotyped directions: r- or K-selection.[71] These terms, r and K, can be illustrated in a logistic model of population dynamics:[72] d N d t = r N (1 − N K) {\displaystyle {\frac {dN}{dt}}=rN\left(1-{\frac {N}{K}}\right)\qquad \!} where r is the growth rate of the population (N), and K is the carrying capacity of its local environmental setting. Typically, r-selected species exploit empty niches, and produce many offspring, each with a relatively low probability of surviving to adulthood. In contrast, K-selected species are strong competitors in crowded niches, and invest more heavily in much fewer offspring, each with a relatively high probability of surviving to adulthood.[72] 1: directional selection: a single extreme phenotype favoured.2, stabilizing selection: intermediate favoured over extremes.3: disruptive selection: extremes favoured over intermediate.X-axis: phenotypic traitY-axis: number of organismsGroup A: original populationGroup B: after selection Natural selection can act on any heritable phenotypic trait,[73] and selective pressure can be produced by any aspect of the environment, including sexual selection and competition with members of the same or other species.[74][75] However, this does not imply that natural selection is always directional and results in adaptive evolution; natural selection often results in the maintenance of the status quo by eliminating less fit variants.[57] Selection can be classified in several different ways, such as by its effect on a trait, on genetic diversity, by the life cycle stage where it acts, by the unit of selection, or by the resource being competed for. Selection has different effects on traits. Stabilizing selection acts to hold a trait at a stable optimum, and in the simplest case all deviations from this optimum are selectively disadvantageous. Directional selection favours extreme values of a trait. The uncommon disruptive selection also acts during transition periods when the current mode is sub-optimal, but alters the trait in more than one direction. In particular, if the trait is quantitative and univariate then both higher and lower trait levels are favoured. Disruptive selection can be a precursor to speciation.[57] Alternatively, selection can be divided according to its effect on genetic diversity. Purifying or negative selection acts to remove genetic variation from the population (and is opposed by de novo mutation, which introduces new variation.[76][77] In contrast, balancing selection acts to maintain genetic variation in a population, even in the absence of de novo mutation, by negative frequency-dependent selection. One mechanism for this is heterozygote advantage, where individuals with two different alleles have a selective advantage over individuals with just one allele. The polymorphism at the human ABO blood group locus has been explained in this way.[78] Different types of selection act at each life cycle stage of a sexually reproducing organism.[79] Another option is to classify selection by the life cycle stage at which it acts. Some biologists recognise just two types: viability (or survival) selection, which acts to increase an organism's probability of survival, and fecundity (or fertility or reproductive) selection, which acts to increase the rate of reproduction, given survival. Others split the life cycle into further components of selection. Thus viability and survival selection may be defined separately and respectively as acting to improve the probability of survival before and after reproductive age is reached, while fecundity selection may be split into additional sub-components including sexual selection, gametic selection, acting on gamete survival, and compatibility selection, acting on zygote formation.[79] Selection can also be classified by the level or unit of selection. Individual selection acts on the individual, in the sense that adaptations are "for" the benefit of the individual, and result from selection among individuals. Gene selection acts directly at the level of the gene. In kin selection and intragenomic conflict, gene-level selection provides a more apt explanation of the underlying process. Group selection, if it occurs, acts on groups of organisms, on the assumption that groups replicate and mutate in an analogous way to genes and individuals. There is an ongoing debate over the degree to which group selection occurs in nature.[80] The peacock's elaborate plumage is mentioned by Darwin as an example of sexual selection,[81] and is a classic example of Fisherian runaway,[82] driven to its conspicuous size and coloration through mate choice by females over many generations. Further information: Sexual selection Finally, selection can be classified according to the resource being competed for. Sexual selection results from competition for mates. Sexual selection typically proceeds via fecundity selection, sometimes at the expense of viability. Ecological selection is natural selection via any means other than sexual selection, such as kin selection, competition, and infanticide. Following Darwin, natural selection is sometimes defined as ecological selection,[83] in which case sexual selection is considered a separate mechanism.[84] Sexual selection as first articulated by Darwin (using the example of the peacock's tail)[81] refers specifically to competition for mates,[85] which can be intrasexual, between individuals of the same sex, that is male–male competition, or intersexual, where one gender chooses mates, most often with males displaying and females choosing.[86] However, in some species, mate choice is primarily by males, as in some fishes of the family Syngnathidae.[87][88] Phenotypic traits can be displayed in one sex and desired in the other sex, causing a positive feedback loop called a Fisherian runaway, for example, the extravagant plumage of some male birds such as the peacock.[82] An alternate theory proposed by the same Ronald Fisher in 1930 is the sexy son hypothesis, that mothers want promiscuous sons to give them large numbers of grandchildren and so choose promiscuous fathers for their children. Aggression between members of the same sex is sometimes associated with very distinctive features, such as the antlers of stags, which are used in combat with other stags. More generally, intrasexual selection is often associated with sexual dimorphism, including differences in body size between males and females of a species.[86] Selection in action: resistance to antibiotics grows through the survival of individuals less affected by the antibiotic. Their offspring inherit the resistance. Further information: Antimicrobial resistance Natural selection is seen in action in the development of antibiotic resistance in microorganisms. Since the discovery of penicillin in 1928, antibiotics have been used to fight bacterial diseases. The widespread misuse of antibiotics has selected for microbial resistance to antibiotics in clinical use, to the point that the methicillin-resistant Staphylococcus aureus (MRSA) has been described as a "superbug" because of the threat it poses to health and its relative invulnerability to existing drugs.[89] Response strategies typically include the use of different, stronger antibiotics; however, new strains of MRSA have recently emerged that are resistant even to these drugs.[90] This is an evolutionary arms race, in which bacteria develop strains less susceptible to antibiotics, while medical researchers attempt to develop new antibiotics that can kill them. A similar situation occurs with pesticide resistance in plants and insects. Arms races are not necessarily induced by man; a well-documented example involves the spread of a gene in the butterfly Hypolimnas bolina suppressing male-killing activity by Wolbachia bacteria parasites on the island of Samoa, where the spread of the gene is known to have occurred over a period of just five years.[91][92] Main articles: Evolution and Darwinism A prerequisite for natural selection to result in adaptive evolution, novel traits and speciation is the presence of heritable genetic variation that results in fitness differences. Genetic variation is the result of mutations, genetic recombinations and alterations in the karyotype (the number, shape, size and internal arrangement of the chromosomes). Any of these changes might have an effect that is highly advantageous or highly disadvantageous, but large effects are rare. In the past, most changes in the genetic material were considered neutral or close to neutral because they occurred in noncoding DNA or resulted in a synonymous substitution. However, many mutations in non-coding DNA have deleterious effects.[93][94] Although both mutation rates and average fitness effects of mutations are dependent on the organism, a majority of mutations in humans are slightly deleterious.[95] Some mutations occur in "toolkit" or regulatory genes. Changes in these often have large effects on the phenotype of the individual because they regulate the function of many other genes. Most, but not all, mutations in regulatory genes result in non-viable embryos. Some nonlethal regulatory mutations occur in HOX genes in humans, which can result in a cervical rib[96] or polydactyly, an increase in the number of fingers or toes.[97] When such mutations result in a higher fitness, natural selection favours these phenotypes and the novel trait spreads in the population. Established traits are not immutable; traits that have high fitness in one environmental context may be much less fit if environmental conditions change. In the absence of natural selection to preserve such a trait, it becomes more variable and deteriorate over time, possibly resulting in a vestigial manifestation of the trait, also called evolutionary baggage. In many circumstances, the apparently vestigial structure may retain a limited functionality, or may be co-opted for other advantageous traits in a phenomenon known as preadaptation. A famous example of a vestigial structure, the eye of the blind mole-rat, is believed to retain function in photoperiod perception.[98] Main article: Speciation Speciation requires a degree of reproductive isolation—that is, a reduction in gene flow. However, it is intrinsic to the concept of a species that hybrids are selected against, opposing the evolution of reproductive isolation, a problem that was recognised by Darwin. The problem does not occur in allopatric speciation with geographically separated populations, which can diverge with different sets of mutations. E. B. Poulton realized in 1903 that reproductive isolation could evolve through divergence, if each lineage acquired a different, incompatible allele of the same gene. Selection against the heterozygote would then directly create reproductive isolation, leading to the Bateson–Dobzhansky–Muller model, further elaborated by H. Allen Orr[99] and Sergey Gavrilets.[100] With reinforcement, however, natural selection can favour an increase in pre-zygotic isolation, influencing the process of speciation directly.[101] Main article: Genotype–phenotype distinction Natural selection acts on an organism's phenotype, or physical characteristics. Phenotype is determined by an organism's genetic make-up (genotype) and the environment in which the organism lives. When different organisms in a population possess different versions of a gene for a certain trait, each of these versions is known as an allele. It is this genetic variation that underlies differences in phenotype. An example is the ABO blood type antigens in humans, where three alleles govern the phenotype.[102] Some traits are governed by only a single gene, but most traits are influenced by the interactions of many genes. A variation in one of the many genes that contributes to a trait may have only a small effect on the phenotype; together, these genes can produce a continuum of possible phenotypic values.[103] Main article: Directional selection When some component of a trait is heritable, selection alters the frequencies of the different alleles, or variants of the gene that produces the variants of the trait. Selection can be divided into three classes, on the basis of its effect on allele frequencies: directional, stabilizing, and disruptive selection.[104] Directional selection occurs when an allele has a greater fitness than others, so that it increases in frequency, gaining an increasing share in the population. This process can continue until the allele is fixed and the entire population shares the fitter phenotype.[105] Far more common is stabilizing selection, which lowers the frequency of alleles that have a deleterious effect on the phenotype—that is, produce organisms of lower fitness. This process can continue until the allele is eliminated from the population. Stabilizing selection conserves functional genetic features, such as protein-coding genes or regulatory sequences, over time by selective pressure against deleterious variants.[106] Disruptive (or diversifying) selection is selection favouring extreme trait values over intermediate trait values. Disruptive selection may cause sympatric speciation through niche partitioning. Some forms of balancing selection do not result in fixation, but maintain an allele at intermediate frequencies in a population. This can occur in diploid species (with pairs of chromosomes) when heterozygous individuals (with just one copy of the allele) have a higher fitness than homozygous individuals (with two copies). This is called heterozygote advantage or over-dominance, of which the best-known example is the resistance to malaria in humans heterozygous for sickle-cell anaemia. Maintenance of allelic variation can also occur through disruptive or diversifying selection, which favours genotypes that depart from the average in either direction (that is, the opposite of over-dominance), and can result in a bimodal distribution of trait values. Finally, balancing selection can occur through frequency-dependent selection, where the fitness of one particular phenotype depends on the distribution of other phenotypes in the population. The principles of game theory have been applied to understand the fitness distributions in these situations, particularly in the study of kin selection and the evolution of reciprocal altruism.[46][107] Main articles: Genetic variation and Genetic drift A portion of all genetic variation is functionally neutral, producing no phenotypic effect or significant difference in fitness. Motoo Kimura's neutral theory of molecular evolution by genetic drift proposes that this variation accounts for a large fraction of observed genetic diversity.[108] Neutral events can radically reduce genetic variation through population bottlenecks.[109] which among other things can cause the founder effect in initially small new populations.[110] When genetic variation does not result in differences in fitness, selection cannot directly affect the frequency of such variation. As a result, the genetic variation at those sites is higher than at sites where variation does influence fitness.[104] However, after a period with no new mutations, the genetic variation at these sites is eliminated due to genetic drift. Natural selection reduces genetic variation by eliminating maladapted individuals, and consequently the mutations that caused the maladaptation. At the same time, new mutations occur, resulting in a mutation–selection balance. The exact outcome of the two processes depends both on the rate at which new mutations occur and on the strength of the natural selection, which is a function of how unfavourable the mutation proves to be.[111] Genetic linkage occurs when the loci of two alleles are close on a chromosome. During the formation of gametes, recombination reshuffles the alleles. The chance that such a reshuffle occurs between two alleles is inversely related to the distance between them. Selective sweeps occur when an allele becomes more common in a population as a result of positive selection. As the prevalence of one allele increases, closely linked alleles can also become more common by "genetic hitchhiking", whether they are neutral or even slightly deleterious. A strong selective sweep results in a region of the genome where the positively selected haplotype (the allele and its neighbours) are in essence the only ones that exist in the population. Selective sweeps can be detected by measuring linkage disequilibrium, or whether a given haplotype is overrepresented in the population. Since a selective sweep also results in selection of neighbouring alleles, the presence of a block of strong linkage disequilibrium might indicate a 'recent' selective sweep near the centre of the block.[112] Background selection is the opposite of a selective sweep. If a specific site experiences strong and persistent purifying selection, linked variation tends to be weeded out along with it, producing a region in the genome of low overall variability. Because background selection is a result of deleterious new mutations, which can occur randomly in any haplotype, it does not produce clear blocks of linkage disequilibrium, although with low recombination it can still lead to slightly negative linkage disequilibrium overall.[113] Main article: Universal Darwinism Darwin's ideas, along with those of Adam Smith and Karl Marx, had a profound influence on 19th century thought, including his radical claim that "elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner" evolved from the simplest forms of life by a few simple principles.[114] This inspired some of Darwin's most ardent supporters—and provoked the strongest opposition. Natural selection had the power, according to Stephen Jay Gould, to "dethrone some of the deepest and most traditional comforts of Western thought", such as the belief that humans have a special place in the world.[115] In the words of the philosopher Daniel Dennett, "Darwin's dangerous idea" of evolution by natural selection is a "universal acid," which cannot be kept restricted to any vessel or container, as it soon leaks out, working its way into ever-wider surroundings.[116] Thus, in the last decades, the concept of natural selection has spread from evolutionary biology to other disciplines, including evolutionary computation, quantum Darwinism, evolutionary economics, evolutionary epistemology, evolutionary psychology, and cosmological natural selection. This unlimited applicability has been called universal Darwinism.[117] Main article: Abiogenesis How life originated from inorganic matter remains an unresolved problem in biology. One prominent hypothesis is that life first appeared in the form of short self-replicating RNA polymers.[118] On this view, life may have come into existence when RNA chains first experienced the basic conditions, as conceived by Charles Darwin, for natural selection to operate. These conditions are: heritability, variation of type, and competition for limited resources. The fitness of an early RNA replicator would likely have been a function of adaptive capacities that were intrinsic (i.e., determined by the nucleotide sequence) and the availability of resources.[119][120] The three primary adaptive capacities could logically have been: (1) the capacity to replicate with moderate fidelity (giving rise to both heritability and variation of type), (2) the capacity to avoid decay, and (3) the capacity to acquire and process resources.[119][120] These capacities would have been determined initially by the folded configurations (including those configurations with ribozyme activity) of the RNA replicators that, in turn, would have been encoded in their individual nucleotide sequences.[121] In 1881, the embryologist Wilhelm Roux published Der Kampf der Theile im Organismus (The Struggle of Parts in the Organism) in which he suggested that the development of an organism results from a Darwinian competition between the parts of the embryo, occurring at all levels, from molecules to organs.[122] In recent years, a modern version of this theory has been proposed by Jean-Jacques Kupiec. According to this cellular Darwinism, random variation at the molecular level generates diversity in cell types whereas cell interactions impose a characteristic order on the developing embryo.[123] Main article: Evolutionary psychology The social implications of the theory of evolution by natural selection also became the source of continuing controversy. Friedrich Engels, a German political philosopher and co-originator of the ideology of communism, wrote in 1872 that "Darwin did not know what a bitter satire he wrote on mankind, and especially on his countrymen, when he showed that free competition, the struggle for existence, which the economists celebrate as the highest historical achievement, is the normal state of the animal kingdom."[124] Herbert Spencer and the eugenics advocate Francis Galton's interpretation of natural selection as necessarily progressive, leading to supposed advances in intelligence and civilisation, became a justification for colonialism, eugenics, and social Darwinism. For example, in 1940, Konrad Lorenz, in writings that he subsequently disowned, used the theory as a justification for policies of the Nazi state. He wrote "... selection for toughness, heroism, and social utility ... must be accomplished by some human institution, if mankind, in default of selective factors, is not to be ruined by domestication-induced degeneracy. The racial idea as the basis of our state has already accomplished much in this respect."[125] Others have developed ideas that human societies and culture evolve by mechanisms analogous to those that apply to evolution of species.[126] More recently, work among anthropologists and psychologists has led to the development of sociobiology and later of evolutionary psychology, a field that attempts to explain features of human psychology in terms of adaptation to the ancestral environment. The most prominent example of evolutionary psychology, notably advanced in the early work of Noam Chomsky and later by Steven Pinker, is the hypothesis that the human brain has adapted to acquire the grammatical rules of natural language.[127] Other aspects of human behaviour and social structures, from specific cultural norms such as incest avoidance to broader patterns such as gender roles, have been hypothesised to have similar origins as adaptations to the early environment in which modern humans evolved. By analogy to the action of natural selection on genes, the concept of memes—"units of cultural transmission," or culture's equivalents of genes undergoing selection and recombination—has arisen, first described in this form by Richard Dawkins in 1976[128] and subsequently expanded upon by philosophers such as Daniel Dennett as explanations for complex cultural activities, including human consciousness.[129] In 1922, Alfred J. Lotka proposed that natural selection might be understood as a physical principle that could be described in terms of the use of energy by a system,[130][131] a concept later developed by Howard T. Odum as the maximum power principle in thermodynamics, whereby evolutionary systems with selective advantage maximise the rate of useful energy transformation.[132] The principles of natural selection have inspired a variety of computational techniques, such as "soft" artificial life, that simulate selective processes and can be highly efficient in 'adapting' entities to an environment defined by a specified fitness function.[133] For example, a class of heuristic optimisation algorithms known as genetic algorithms, pioneered by John Henry Holland in the 1970s and expanded upon by David E. Goldberg,[134] identify optimal solutions by simulated reproduction and mutation of a population of solutions defined by an initial probability distribution.[135] Such algorithms are particularly useful when applied to problems whose energy landscape is very rough or has many local minima.[136] Main article: Evolution in fiction Darwinian evolution by natural selection is pervasive in literature, whether taken optimistically in terms of how humanity may evolve towards perfection, or pessimistically in terms of the dire consequences of the interaction of human nature and the struggle for survival. Among major responses is Samuel Butler's 1872 pessimistic Erewhon ("nowhere", written mostly backwards). In 1893 H. G. Wells imagined "The Man of the Year Million", transformed by natural selection into a being with a huge head and eyes, and shrunken body.[137]

^ In sexual selection, a female animal making a choice of mate may be argued to be intending to get the best mate; there is no suggestion that she has any intention to improve the bloodline in the manner of an animal breeder. ^ Empedocles 1898, On Nature, Book II ^ Lucretius 1916, On the Nature of Things, Book V ^ Aristotle, Physics, Book II, Chapters 4 and 8 ^ Lear 1988, p. 38 ^ Henry, Devin (September 2006). "Aristotle on the Mechanism of Inheritance". Journal of the History of Biology. 39 (3): 425–455. doi:10.1007/s10739-005-3058-y. S2CID 85671523. ^ Ariew 2002 ^ Darwin 1872, p. xiii ^ Aristotle, Physics, Book II, Chapter 8 ^ Zirkle, Conway (25 April 1941). "Natural Selection before the 'Origin of Species'". Proceedings of the American Philosophical Society. 84 (1): 71–123. JSTOR 984852. ^ Agutter & Wheatley 2008, p. 43 ^ Leonardo, Codex C. Institut of France. Trans. Richter. 2016. ^ Maupertuis, Pierre Louis (1746). 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Scientists at the time realized that evolution took place but did not know how species evolved. After this introduction of natural selection, Darwin elaborated on the subject with his theory of evolution and his book, On the Origin of Species, published in 1859. His work with Darwin's finches and his ideas on survival of the fittest explained the mechanism of natural selection and how it could lead to a proliferation of many different kinds of organisms. Evolution is the cumulative change in the characteristics of an organism or a population over the next generations. It is sometimes summarized as **descent with modification**. Natural selection is one of the mechanisms that drives evolution. To be an active characteristic or trait causing natural selection to take place, the trait has to have the following features: **Heritability.** A trait can only influence evolution through natural selection if it is passed on from parents to descendants. **Functionality.** The trait must have a function. Traits must do something for natural selection to take place. **Advantage.** To be selected for passing on to descendants, the trait must confer an advantage on the organism that has it, or make the organism more fit for survival in its environment. **Origin.** The trait must have caused the organisms to evolve because it made the organisms that had it more fit for survival. If the organisms changed due to another mechanism, such as genetic mutation, it was not due to natural selection. Based on the fossil record, it is clear that species change over time and new species develop while others die off. Before Darwin, there was no explanation of how such changes could take place. The **theory of evolution** describes what happens as the characteristics of some individuals of a species become predominant and natural selection describes how this predominance comes about. Darwin studied natural selection in finches. Even when another mechanism such as mutation changes a population, if the mutation does not confer a natural advantage, it may die out due to natural selection. Within a species, a typical population includes individuals with varying traits because they receive half their _genetic code_ from the father and half from the mother. For traits with a genetic basis, this combination of genes from parents results in a wide variety of characteristics in the individuals of the population. The combination of traits in some individuals gives them an advantage in looking for food, reproducing or withstanding predators or disease. Other individuals receive traits that place them at a disadvantage. The advantaged individuals will live longer and produce more descendants. Their descendants will mostly receive genes that result in the advantaged traits. Over time, most of the population will evolve with the advantaged traits, and the traits giving a disadvantage will disappear. Natural selection has selected the individuals with positive characteristics. In 1831, the British navy sent survey vessel the HMS Beagle on a mapping expedition around the world. Charles Darwin came on board as the naturalist assigned to observe local fauna and flora. The expedition took five years and spent a lot of time along the Atlantic and Pacific coasts of South America. Upon leaving South America for the Pacific crossing to New Zealand, the ship spent five weeks exploring the Galapagos Islands. As he did everywhere, Darwin took extensive notes about the characteristics of the plants and animals he found. Eventually these notes would form the basis for his development of the concept of natural selection and his theory of evolution. Back in England, Darwin and an ornithologist associate examined Darwin's notes on the finches of the Galapagos Islands. Apparently the islands were home to 13 different species of finches while the nearest South American land mass 600 miles away had only one species. The main difference between the species was the size and shape of the beaks. Darwin's analysis of his notes led him to draw the following conclusions: The finches had different beaks because they lived on different islands in different environments. The environment did not cause the differences in beaks because there was no mechanism for such an influence. The different beak characteristics must have all been present in the original finch population. As the finches from the original population settled on an island, the finches with the beaks best adapted to the local food supply would have an advantage. The finches with beaks best suited to the food source on their island would survive in greater numbers than the less adapted finches. Eventually, over many generations, the finches on an island would form a distinct species with a distinct beak size and shape because finches with those beaks would be the fittest for their environment. With these conclusions, Darwin explained the evolution of the finch beaks in the Galapagos Islands by proposing the mechanism of natural selection. He summarized this mechanism as survival of the fittest, where fitness was defined as reproductive success. For his conclusions, Darwin relied on his notes, his own observations and his interpretation of the writings of Thomas Robert Malthus. Malthus was an English scholar who, in 1798, published his theory that population growth will always outpace the food supply. The corollary is that, in any population, many individuals will die off due to competition for a limited supply of food. The three observations that allowed Darwin to develop his theory of evolution and natural selection were: 1. The individuals in a population display a variation in traits such as color, behavior, size and shape due to genetic variation. 2. Some of the traits are passed down from parents to descendants and are heritable. 3. The parents in a population overproduce offspring so that some will not survive. Based on these observations, Darwin proposed that those individuals with traits that made them fitter would be the ones to survive while the least fit would die off. Over time, the population would be dominated by individual with the traits that made them fitter. Populations of bacteria exhibit very strong natural selection because they can multiply rapidly. They usually multiply until they reach a constraint such as lack of food, space or other resources. At that point, those bacteria best suited to their environment will survive while the rest will die off. One example of natural selection in bacteria is the development of _antibiotic resistance_. When bacteria cause an infection and the individual is treated with antibiotics, any bacteria that have the antibiotic-resistance trait will survive while all others will die off. The proliferation of antibiotic-resistant bacteria is a major medical problem. Plants evolve to become suited to their environment through natural selection. Some plants evolve flower colors to attract pollinators of a specific kind and develop special mechanisms to spread their seeds. They have to adapt to more or less sunlight and fight off pests. Cacti are an example of natural selection in plants. In the desert where they live, there is lots of sunlight, little water and occasionally an animal that would love a juicy bite. As a result, cacti have developed compact bodies or small, succulent leaves with thick skins to protect against the strong sun and minimize water loss. They can also store water and have sharp spikes to discourage animals. The cacti with these traits were the fittest, and they are still evolving. Another example is the change in the field mustard plant caused by the drought in Southern California. To survive a drought, plants must grow, flower and distribute their seeds quickly. The Southern California field mustard plants that flowered early became dominant while those flowering later died out. Animals have more scope for influencing their survival because they can engage in complex behavior patterns. Traits that can determine fitness fall under three main categories. The ability to find enough food through hunting or foraging is a key for survival. Most animals have predators, and specific traits allow them to avoid being eaten. Finally, the ability to find and attract a mate allows them to pass their positive traits on to offspring. Typical characteristics that influence natural selection include: **Movement.** The ability to run, swim or fly fast determines whether an animal can hunt successfully or escape predators. **Camouflage.** If an animal can hide successfully, it can evade predators or ambush prey. **Immunity.** Some animals will be more resistant to a disease than others and will survive. **Strength.** Competing for a mate often involves tests of strength with other members of the same species. **Senses.** Animals that can see, smell or hear better may have a better chance of survival. **Sexual characteristics.** Natural selection in animals depends on successful reproduction after attracting a mate. Animals evolve continuously, first to better adapt to a given environment and then, if the environment changes, to the new environment. Natural selection can cause evolutionary changes in existing populations and can also favor one species over another if two species are competing for the same space and resources. Natural selection in animals is best seen when the environment changes in some way, and animals with specific characteristics become better suited and soon become dominant. For example, the peppered moth in London was light-colored with dark spots. During the industrial revolution, buildings became darkened with soot. Birds could easily see the light-colored moths against the dark background, and soon only dark-colored moths were left. Natural selection favored the moths with more and larger dark spots. In another example, say some insects become resistant to a chemical pesticide very quickly. Even if only a few individuals are resistant, the rest will die off, and the resistant insects will survive. Insects typically produce large numbers of offspring, so the insects with the resistant genes will rapidly take over. In an example of reproductive preference, female peacocks choose mates based on the size and brightness of their tails. After the effects of natural selection, almost all peacock males today have large, brightly colored tails. While Darwin is best known for his publications on the theory of evolution, it is natural selection that powers change and adaptation in species. Charles Darwin's 1858 paper, with contributions from Alfred Russel Wallace whose paper was published at the same time, forever changed how people viewed evolution and the natural changes in plants and animals that continuously took place around them. Markgraf, Bert. "Natural Selection: Definition, Darwin's Theory, Examples & Facts" sciencing.com, . 4 June 2019. APA Markgraf, Bert. (2019, June 4). Natural Selection: Definition, Darwin's Theory, Examples & Facts. sciencing.com. Retrieved from Chicago Markgraf, Bert. Natural Selection: Definition, Darwin's Theory, Examples & Facts last modified August 30, 2022. Natural selection is Darwin’s most famous theory; it states that evolutionary change comes through the production of variation in each generation and differential survival of individuals with different combinations of these variable characters. Individuals with characteristics which increase their probability of survival will have more opportunities to reproduce and their offspring will also benefit from the heritable, advantageous character. So over time these variants will spread through the population. For natural selection to work, it has to occur along with a bunch of other things. Historians and biologists who have analysed Darwin’s work, for example Ernst Mayr, have identified fivetheories which Darwin outlined in On the Origin of Species, and which work together to bring about evolution. Darwin’s five theories were: Evolution: species come and go through time, while they exist they change. Common descent: organisms are descended from one, or several common ancestors and have diversified from this original stock Species multiply: the diversification of life involves populations of one species diverging until they become two separate species; this has probably occurred billions of times on earth! Gradualism: evolutionary change occurs through incremental small changes within populations; new species are not created suddenly. Natural selection: evolutionary change occurs through variation between individuals; some variants give the individual an extra survival probability. Darwin considered all these theories as parts of one grand idea; they all occur together. Scientists however took a while to see this; they weren’t accepted as a package until the modern synthesis of the 1930/40s. Before then scientists would favour some ideas but propose alternatives to fill in the gaps, natural selection was one of the least popular, to find out why click here. Eventually, as more evidence accumulated and these different ideas were tested it became clear that Darwin was right all along! Natural selection was Darwin’s most novel and revolutionary idea, but in truth (like all the best ideas) it is very simple. Despite its simplicity, since the publication of the theory right up until today, it has widely been misunderstood. Ernst Mayr, in his book One Long Argument (1991) provides a useful way of breaking down the process into just five facts and three inferences, or conclusions, drawn from the five facts; they can be linked in a flow diagram: Figure: modified from One Long Argument by Ernst Mayr (1991) The first inference is drawn from three facts which Darwin observed in the natural world around him. He saw that organisms produce more offspring than is required to replace themselves, so population sizes should increase rapidly (think about the number of frogspawn laid each year, or how many eggs a spider lays). That’s fact one: a fancy word for this over-reproduction is ‘super fecundity’. However Darwin saw for himself, and confirmed his observation with others, that population numbers tend to stay at about the same level (you don’t see a doubling of the number of frogs or mice in your garden each year do you?): that’s fact two. What accounts for this disparity? Darwin found the answer with another fact: resources, such as food, water or places to sleep or mate, are limited. A major influence on Darwin observing this fact was his reading the work of Thomas Malthus who published a paper stating that the human population was increasing at a rapid pace and would soon run out of food, water and space. These are three simple facts which Darwin put together to draw a simple conclusion: individuals compete with each other for scarce resources. Next, Darwin made two other observations about individuals. First he had come to the conclusion through his work on theH.M.S. Beagle, when he was working on barnacles and later pigeons, that individuals are unique and that individuals vary in almost every aspect: that’s fact four, and you only need to take a cursory glance round a group of people to see that it is true! Finally fact five: Darwin had taken to breeding pigeons to investigate variability further. He performed many crosses between different breeds of fancy pigeons to look at whether their offspring had the same variations. He also collected lots of observations from various animal and plant breeders to help him draw out the conclusion that these individual differences are heritable: they are passed on from parent to offspring. The next two inferences demonstrate Darwin’s genius. Darwin could see that if individuals must compete, and if they are all unique, some individuals will have variations which give them a survival boost so they will have more opportunity to reproduce and leave a greater number of offspring. These offspring will inherit the variations which made their parents successful, so they too will have an advantage. Over time these successful variantions will spread through the population – the population will change: that is evolution! Simple, isn’t it? Darwin himself wrote ‘an unverified hypothesis is of little or no value’. To verify his ‘hypothesis’ Darwin collected a vast number of facts from a wide range of fields. He assembled reports from other naturalists, as well as from his own work and observation, to support his five facts. His greatest challenge perhaps, was to convince people that species really are variable and that this variation is suitable for natural selection to act. Darwin chose to demonstrate this using artificial selection and production of various breeds of domestic animals and plants as an analogy for natural selection. You can read more about how he did this by clicking here. Darwin added to his bulk of evidence throughout his lifetime, for example with studies on humans. Since 1859 the scientific community has been busy testing his theories, and alternatives, to see what best holds up. The wealth and diversity of evidence is now vast and includes evidence from the DNA record, fossil record, and from case studies section. Written by Stephen Montgomery A nice article on how to understand natural selection can be found here. Almost Like a Whale by Steve Jones, Doubleday: 1999 The Autobiography of Charles Darwin by Charles Darwin (Edited by Francis Darwin), The Thinker's Library: 1929 Darwin by John van Wyhe, Andre Deutsch: 2009 Darwin by Adrian Desmond & James Moore, Penguin: 1991 Darwin: Discovering the Tree of Life by Niles Eldredge, WW Norton & Co.: 2005 On the Origin of Species by Charles Darwin, 1859 (any reprint - 2nd edition preferable) Evolution by Carl Zimmer, Arrow: 2003 Evolution by Mark Ridley, Wiley Blackwell: 2003 Evolution by Nick Barton, Derek Briggs & Jonathan Eisen, Cold Spring Harbour: 2007 Evolution: What the Fossils Say and Why it Matters by Donald Prothero, Columbia University Press: 2007 One Long Argument by Ernst Mayr, Allen Lane: 1991 What Evolution Is by Ernst Mayr, Phoenix: 2002 Why Evolution is True by Jerry Coyne, OUP: 2009 Natural selection is one of the basic mechanisms of evolution, along with mutation, migration, and genetic drift. Darwin’s grand idea of evolution by natural selection is relatively simple but often misunderstood. To see how it works, imagine a population of beetles: There is variation in traits. For example, some beetles are green and some are brown. There is differential reproduction. Since the environment can’t support unlimited population growth, not all individuals get to reproduce to their full potential. In this example, green beetles tend to get eaten by birds and survive to reproduce less often than brown beetles do. There is heredity. The surviving beetles (more of which are brown) have offspring of the same color because this trait has a genetic basis. End result:The more advantageous trait, brown coloration, which allows the beetle to have more offspring, becomes more common in the population. If this process continues, eventually, all individuals in the population will be brown. If you have variation, differential reproduction, and heredity, you will have evolution by natural selection as an outcome. It is as simple as that. More DetailsEvo ExamplesTeaching Resources Next Natural selection at work Welcome to our blog post on the fascinating topic of Darwin’s natural selection! In this post, we will be delving into Charles Darwin’s groundbreaking theory of evolution and exploring the five key points of natural selection that he proposed. If you’ve ever wondered about the mechanisms that drive the diverse array of species on our planet and how they adapt to their environments, this is the perfect read for you! Darwin’s theory revolutionized our understanding of how life evolves and provided a comprehensive framework to explain the incredible biodiversity we observe today. From his meticulous observations during his voyage on the HMS Beagle to his in-depth analysis of various species’ anatomical and behavioral characteristics, Darwin unveiled a remarkable perspective on the mechanisms that drive the adaptation and survival of species. So let’s dive in and discover the five points that underpin Darwin’s theory of natural selection! What Are the 5 Points of Darwin Natural Selection Charles Darwin, the British naturalist and father of evolution, proposed the theory of natural selection, which revolutionized our understanding of how species evolve over time. This theory is based on several key points that explain the mechanisms behind the process of natural selection. In this subsection, we will delve into the five essential points of Darwin’s theory in a fun and engaging way. Point 1: Variation Favors the Funky Natural selection starts with variation, and let’s face it – life would be pretty boring without it. Within a species, individuals possess unique traits, like funky beaks or fancy feathers. Some of these variations may give certain individuals a better chance of survival or reproductive success. So, if you’ve got a dance move that stands out on the crowded disco floor, you might just catch the attention of potential mates. Point 2: Struggle for Survival – Evolution’s Ultimate Dance-Off Imagine you’re at a party and the only way to stay on the dance floor is by showing off your moves. This is exactly what happens in nature. Resources like food, shelter, or even that sweet spot under the disco ball are limited. This creates competition among individuals, leading to a struggle for survival. Those individuals with variations that give them an edge in this dance-off for resources have a higher chance of making it to the next song (or generation). Point 3: Survival of the Fittest – It’s All About That Adaptation Survival of the fittest doesn’t mean the strongest or fastest will dominate the dance floor. It’s about being the best fit for the environment. If the party moves to a tropical beach, you wouldn’t want to be caught wearing a parka, right? Similarly, in nature, those individuals with traits that make them well-suited for their environment have a greater chance of being chosen as the dance partners of evolution. Point 4: Pass It On – Genes in the Dance Circle At the end of a groovy night, the fun doesn’t have to end, thanks to the power of reproduction. Individuals who successfully out-dance their peers and survive pass their advantageous traits to their offspring, ensuring that the funky genes stay in the dance circle. Over time, these beneficial traits become more frequent in the population, while those who missed out on the dance moves fade into the background. Point 5: Evolution Busts a Move Throughout generations, small changes accumulate like stylish dance moves, leading to the formation of entirely new species. It’s like when a dance routine undergoes a remix – you end up with a completely different rhythm. This continuous process of accumulation and remixing gives rise to the incredible diversity of life on Earth. So, the next time you spot a peacock or witness a shark doing the Macarena, you have Darwin’s natural selection to thank for the show! Wrap-Up Understanding the five points of Darwin’s natural selection offers us a peek behind the scenes of the amazing dance of evolution. From funky variations to survival struggles and the reproduction disco, these points highlight the dynamic nature of life on Earth. So, let’s embrace the dance of evolution and celebrate the ways in which our world continues to bust a move. FAQ: What are the 5 Points of Darwin’s Natural Selection Charles Darwin’s theory of natural selection is one of the foundations of modern evolutionary biology. In this FAQ-style section, we will explore the key points of Darwin’s theory and provide answers to common questions about natural selection. So, grab a cup of tea, put on your thinking cap, and let’s dive into the fascinating world of natural selection! What Are the Four Conditions of Natural Selection Condition 1: Variation In any population, individuals have different traits and characteristics. This variation can be physical, behavioral, or genetic. It is this diversity within a species that provides the building blocks for natural selection to occur. Condition 2: Overproduction Populations have the potential to produce more offspring than the environment can support. This leads to competition for limited resources, such as food, shelter, and mates. Not all individuals will survive and reproduce, creating a “struggle for existence.” Condition 3: Heredity Traits that are advantageous for survival and reproduction can be passed down from one generation to the next. Offspring inherit traits from their parents, and favorable traits become more common in a population over time, while unfavorable traits become less common. Condition 4: Differential Reproduction Individuals with traits that increase their chances of survival and reproduction have a higher likelihood of passing those traits on to future generations. This “survival of the fittest” leads to the accumulation of beneficial traits in the population over time. What Were Darwin’s Most Important Observations Observation 1: The Diversity of Life Darwin observed that there is an incredible diversity of organisms on Earth, with each species adapted to its own unique environment. From the smallest microorganisms to the largest mammals, the natural world is teeming with life in all its magnificent forms. Observation 2: Fossils and Extinct Species By studying fossils, Darwin realized that many species that once lived on Earth are now extinct. This suggested that the current organisms are not fixed and unchangeable, but rather have evolved over time. Observation 3: Geographical Distribution Darwin noticed that different regions of the world have distinct species that are well-suited to their environments. For example, animals living on isolated islands often have unique adaptations not found elsewhere. This led him to propose that species change over time to better fit their specific surroundings. Who Disproved Lamarck’s Theory of Evolution While Charles Darwin is widely revered for his theory of evolution, it was actually a later scientist named August Weismann who disproved Lamarck’s theory of evolution. Weismann conducted experiments on mice to show that acquired traits, such as a mouse losing its tail during its lifetime, are not passed on to offspring. This experiment challenged the idea that evolution could be driven solely by the changes that individuals acquire during their lifetime. What are the 5 Main Points of Evolution Point 1: Evolution is a Gradual Process Evolution occurs over long periods of time through the gradual accumulation of small changes in populations. It is a slow and ongoing process that can be difficult to observe directly. Point 2: Common Ancestry All living organisms on Earth are believed to share a common ancestor. By studying similarities in anatomy, genetics, and developmental patterns, scientists have been able to reconstruct the evolutionary relationships between different species. Point 3: Natural Selection Natural selection is the driving force of evolution. It is the process by which individuals with traits that are favorable for survival and reproduction have a higher chance of passing those traits on to future generations. Point 4: Genetic Variation Genetic variation is essential for natural selection to occur. It provides the raw material for evolution by introducing new traits into a population. Point 5: Adaptation Adaptation refers to the process by which organisms become better suited to their environment over time. Through natural selection, individuals with traits that enhance their survival and reproductive success in a given environment are more likely to pass on those traits to future generations. What Are the Three Principles of Natural Selection Principle 1: Variation As mentioned earlier, variation is a fundamental condition for natural selection. Without variation, there would be no differences in traits for natural selection to act on. Principle 2: Heredity Traits that increase an organism’s chances of survival and reproduction can be passed down to future generations. This principle underscores the importance of genetics in the process of natural selection. Principle 3: Differential Reproduction Individuals with advantageous traits will have a higher likelihood of reproducing and passing on those traits. This leads to the gradual accumulation of beneficial traits in a population over time. What Are Four Types of Evolution Type 1: Divergent Evolution Divergent evolution occurs when two or more species evolve from a common ancestor, becoming increasingly different over time. This can result in the formation of new species with distinct adaptations. Type 2: Convergent Evolution Convergent evolution is the process by which unrelated species develop similar traits or adaptations due to living in similar environments. This can lead to the convergence of similar forms or functions in different lineages. Type 3: Coevolution Coevolution happens when two or more species influence each other’s evolution. This mutual influence can occur through processes such as predator-prey interactions or symbiotic relationships. Type 4: Parallel Evolution Parallel evolution occurs when closely related species independently evolve similar traits or adaptations. This can happen when different populations of the same species face similar selective pressures in their respective environments. And there you have it! Hopefully, this FAQ-style subsection has helped clarify the main points of Darwin’s natural selection for you. Understanding these principles is crucial to comprehending the intricate web of life on Earth. So, the next time you spot a well-adapted creature or marvel at the beauty of biodiversity, remember the incredible power of natural selection shaping our world. Happy evolving! Natural selection and evolution are largely accepted by the scientific community. But until the 1800s, researchers knew nothing of natural selection. What they were aware of, though, were two other concepts that describe evolution. These are: Descent with modification Common descent. The first is an observable fact. Children look different from their parents and siblings. Despite being descendants of their parents, children are modified versions of them. The common descent theory suggests that living beings on Earth all share a common ancestor. Descent with modification over numerous years has resulted in all the species variety we see. But, it’s also a theory we can’t observe. Over the years, scientists have described a model common descent. However, at the time, researchers could not fathom how random genetic changes could guide descent with modification to create species variety from a single ancestor. Charles Darwin’s theory of natural selection changed all of that. He suggested that while random variations may have been wrought by nature, nature had also helped select organisms that were most likely to survive. Over time, organisms that do well, flourish, as do their offspring. Eventually, enough of the offspring with useful characteristics survive and alter the species as a whole. Darwin’s belief in natural selection being an essential step for evolution has been proven, to some degree. Researchers have observed it in the lab and outside, making natural selection an observable fact. Common descent is a bit harder to prove. How was Natural Selection Discovered? In 1859, Darwin laid the foundation for the field of evolution when he put forward his theory of natural selection. His travels to South America and Europe aboard the H.M.S. Beagle had brought the variety of the natural world into his line of vision. He theorized that differences in needs and responses to one’s environment led to certain traits being favored over others. This ability to adapt to one’s surroundings made one more or less likely to survive. Naturally, during reproduction, organisms with those traits outperformed those without. Gradually, such organisms flourished and evolved. How Does Natural Selection Work? According to Darwin, the adaptation of organisms to their environs happened through natural selection. This process arises from a random accumulation of favorable genes. The fittest individuals were those who possessed the genes needed to survive their environment. The theory of natural selection was the crux of Darwin’s proclamations during the 19th century. Simply put, genes that increase an organism’s chances of survival are more likely to appear in a population. Eventually, genes that reduce fitness are ruled out. A well-known example is that of the evolution of dark moths in England. Prior to the industrial revolution, a light grey moth, which was easily camouflaged between the lichen growing on trees was the most common variety in the country. But after the industrialization of the nation, pollution turned the barks of trees black, making darker moths more likely to survive scavenging birds. Over time, natural selection made black moths a more common feature in cities as opposed to the rural areas that still bear witness to the lighter variants. Thus, environmental constraints had weeded out the “weaker” moths. “Fitter” moths that could withstand predation eventually overtook the natural population. Natural selection vs artificial selection While natural selection occurs well, naturally, artificial selection requires a helping hand—most often from man. The domestication of the dogs we have as pets and the crops we like to eat are a direct result of man’s interference in evolution. Humans have selectively bred many species useful to them by choosing to breed only those with traits we valued. Horses have been bred for speed, cows for milk production, and dogs for size, cuteness or ferocity. Artificial selection has not interfered with nature in multiple ways. For example, the wild mustard of yore is the ancestor of not only the cabbage of today but also that of brussel sprouts, kale, cauliflower, and kohlrabi. 3 Requirements for Natural Selection For natural selection to occur, certain requirements need to be met: Organisms within a species can differ from one to the other. These variations can include color, size, markings, etc. But other traits, say the number of chambers in a human’s heart, will remain constant within the species. Certain traits are heritable and passed from parent to offspring. Populations tend to overproduce but are kept in check by disease, famine, or other limitations. Individuals within a species must compete for resources. Variations that help organisms adapt to their environs are retained and herited. Thus, over time, populations evolve through natural selection. Only those individuals who can adapt to their environment pass on suitable traits to their progeny and survive. Natural selection in humans The mechanisms of natural selection are well observed, however explaining human origins gets more complex. Historically, it was thought modern humans evolved to beat out other species. Researchers long suspected that one reason humans may have vanquished Neanderthals is because we were more adaptable. However Neanderthal DNA in modern human genes show that’s not exactly the case. Humans have colonized the far corners of the world. These varying environments have left their mark on the human genome in the form of adaptations. Till date, close to 3000 regions associated with natural selection being identified in the human genome. These include changes in the genes that help people digest milk or acclimate to high altitudes. One example of natural selection in humans is the skin tone gradient seen across the world. To begin with, humans were likely pale under thick fur. As we lost most of our body hair—likely to keep us cool in hot Africa—we grew darker-skinned. Today we can explain these changes via epigenetics. A genes ability to shift its expression with environmental changes. It adds a level of complexity to ‘random’ mutations. Melanin, the pigment in our skin kept us protected from the sun’s UV rays. Dark skin in the tropics help prevent the breakdown of folate, an important vitamin. As humans spread out of Africa, lighter skin evolved in regions of the world where sunlight is not as harsh. Light skin in the temperate zone helps in vitamin D storage. Another example is human tolerance of lactose, the sugar in milk. When domestication had not made milk easily accessible to humans, lactose intolerance was widespread. Now, large scale dairy farming has almost led to the disappearance of this trait. Conclusion Natural selection in evolution is an observed phenomena. However, new advances in biological diversity and genetics, show there are still many things to learn to explain the evolution of a complex species like the human race. Today you can still detect the vestige of these legacies in our genome. When we consider evolution an explanation for all life on earth, it must be acknowledged that part of the theory is still being uncovered by scientists. Further reading: � � � � � � Azcolvin429/Wikimedia Commons/CC by SA 3.0 Charles Darwin, the father of evolution, was the first to publish the idea of natural selection. Natural selection is the mechanism for how evolution occurs over time. Basically, natural selection says that individuals within a population of a species that have favorable adaptations for their environment will live long enough to reproduce and pass down those desirable traits to their offspring. The less favorable adaptations will die off eventually and be removed from the gene pool of that species. Sometimes, these adaptations cause new species to come into existence if the changes are large enough. Even though this concept should be pretty straightforward and easily understood, there are several misconceptions about what natural selection is and what it means for evolution. Most likely, most of the misconceptions about natural selection come from this single phrase that has become synonymous with it. "Survival of the fittest" is how most people with only a superficial understanding of the process would describe it. While technically, this is a correct statement, the common definition of "fittest" is what seems to create the most problems for understanding the true nature of natural selection. Although Charles Darwin did use this phrase in a revised edition of his book On the Origin of Species, it was not intended to create confusion. In Darwin's writings, he intended for the word "fittest" to mean those who were most suited to their immediate environment. However, in the modern use of language, "fittest" often means strongest or in best physical condition. This is not necessarily how it works in the natural world when describing natural selection. In fact, the "fittest" individual may actually be much weaker or smaller than others in the population. If the environment favored smaller and weaker individuals, then they would be considered more fit than their stronger and larger counterparts. Nick Youngson/Wikimedia Commons/CC by SA 3.0 This is another case of common use of language that causes confusion in what is actually true when it comes to natural selection. A lot of people reason that since most individuals within a species fall into the "average" category, then natural selection must always favor the "average" trait. Isn't that what "average" means? While that is a definition of "average," it is not necessarily applicable to natural selection. There are cases when natural selection does favor the average. This would be called stabilizing selection. However, there are other cases when the environment would favor one extreme over the other (directional selection) or both extremes and NOT the average (disruptive selection). In those environments, the extremes should be greater in number than the "average" or middle phenotype. Therefore, being an "average" individual is actually not desirable. There are several things incorrect about the above statement. First of all, it should be pretty obvious that Charles Darwin did not "invent" natural selection and that it had been going on for billions of years before Charles Darwin was born. Since life had begun on Earth, the environment was putting pressure on individuals to adapt or die out. Those adaptations added up and created all of the biological diversity we have on Earth today, and much more that has since died out through mass extinctions or other means of death. Another issue with this misconception is that Charles Darwin was not the only one to come up with the idea of natural selection. In fact, another scientist named Alfred Russel Wallace was working on the exact same thing at the exact same time as Darwin. The first known public explanation of natural selection was actually a joint presentation between both Darwin and Wallace. However, Darwin gets all the credit because he was the first to publish a book on the topic. Ragnar Schmuck/Getty Images While natural selection is the largest driving force behind evolution, it is not the only mechanism for how evolution occurs. Humans are impatient and evolution through natural selection takes an extremely long time to work. Also, humans seem to not like to rely on letting nature take its course, in some cases. This is where artificial selection comes in. Artificial selection is a human activity designed to choose the traits that are desirable for species whether it be color of flowers or breed of dogs. Nature is not the only thing that can decide what is a favorable trait and what is not. Most of the time, human involvement and artificial selection are for aesthetics, but they can be used for agriculture and other important means. While this should happen, theoretically, when applying knowledge of what natural selection is and what it does over time, we know this is not the case. It would be nice if this did happen because that would mean any genetic diseases or disorders would disappear out of the population. Unfortunately, that does not seem to be the case from what we know right now. There will always be unfavorable adaptations or traits in the gene pool or natural selection would not have anything to select against. In order for natural selection to happen, there has to be something more favorable and something less favorable. Without diversity, there is nothing to select or to select against. Therefore, it seems like genetic diseases are here to stay. Evolution is a combination of descent with modification and natural selection. Descent with modification is the evolutionary mechanism that produces change in the genetic code of living organisms. There are three mechanisms for such changes and the fourth mechanism, natural selection, determines which descendants survive to pass on their genes, based on environmental conditions. When people are aware of the four evolutionary mechanisms of evolutionary change, they can understand how evolution works and how humans and other animals have evolved from primitive living organisms. Living things change according to evolutionary principles, and there are four mechanisms of evolutionary change. Mutation is the process in which genes change randomly due to accidental damage or external factors. Genetic drift is the change in the frequency of particular genes due to random changes in the population. Migration is the change in the genetic pool due to shifting populations. These three mechanisms result in genetic evolutionary change and are defined as descent with modification because the descendants have a slightly changed genetic code due to one or several of the change mechanisms. Natural selection is the fourth evolutionary mechanism, and it is the "survival of the fittest" process in which the organisms whose changes are best suited to their environment survive and reproduce while the others die or reproduce less. The descent with modification definition is the passing on of the genetic code from parent to offspring with changes that are in turn hereditary. The three mechanisms that can change the genetic code of a population are mutation, migration and genetic drift. In each case, the offspring in the population will have slightly different genes than the parents and, as a result, will have different characteristics. Mutation is the classic gene-changing process in which the offspring inherit changed genes due to mistakes in the gene copying process, broken chromosomes carrying the genes or external influences that damage genes. The offspring will have a slightly different genetic code than the parents, and they will therefore have new or changed features. For example, green beetle parents may experience a mutation and produce a brown beetle offspring. Migration means that populations of species with different characteristics and slightly different genetic codes may migrate to mix and change the general population that existed before. For example, brown beetles of a certain type may migrate to join a population of green beetles. The resultant population will have a mix of brown and green beetles. Genetic drift is a random change in the number of occurrences of a particular characteristic. For example, in a group of mixed green and brown beetles most of the brown beetles may have been on the side of the group close to a bird and might have been eaten. The population then has more green beetles. These three mechanisms of evolutionary descent with modification result in genetic changes in populations over time. Natural selection completes the evolutionary process but operates slightly differently. Darwin's theory of natural selection detailed how survival of the fittest gives direction to the random descent with modification process. Once the random changes of mutation, migration and genetic drift produce their results, natural selection makes sure that the changes that are passed on to subsequent generations are those most suited to living in the current environment of the species. For example, if green and brown beetles live on the ground and green beetles are easier to see, birds might eat more green beetles than brown beetles. Eventually there will be mostly brown beetles in the population. If the ground turns green at this point, perhaps through climate change to a wet period, the birds will see the brown beetles and the few green beetles that are left will eventually become the majority as they are the best suited to survive in their new environment. In this way, the random effects of descent with modification become the evolution of living things to adapt to their environment through natural selection. The changes resulting in better adaptation to the environment are passed on while the living things with changes that are not well-adapted don't survive. Markgraf, Bert. "Difference Between Natural Selection & Descent With Modification" sciencing.com, . 30 July 2018. APA Markgraf, Bert. (2018, July 30). Difference Between Natural Selection & Descent With Modification. sciencing.com. Retrieved from Chicago Markgraf, Bert. Difference Between Natural Selection & Descent With Modification last modified August 30, 2022. Share — copy and redistribute the material in any medium or format for any purpose, even commercially. Adapt — remix, transform, and build upon the material for any purpose, even commercially. The licensor cannot revoke these freedoms as long as you follow the license terms. Attribution — You must give appropriate credit , provide a link to the license, and indicate if changes were made . You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use. ShareAlike — If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original. No additional restrictions — You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits. You do not have to comply with the license for elements of the material in the public domain or where your use is permitted by an applicable exception or limitation . No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. Natural selection is the adaptation strategy of living organisms on Earth. It occurs when they acquire and evolve a trait with time that provides them a distinct advantage for their survival and reproduction over other organisms in the population. Darwin called them ‘survival of the fittest.’ Organisms with better adaptive traits survive better than the less adapted ones in a specific environment. These favorable traits are then passed on to their offspring, which become common in the subsequent generations over time. This phenomenon can lead to speciation, developing a new species from the existing ones. Thus, natural selection and other processes like mutation, migration, and genetic drift drive evolution. Charles Darwin and Alfred Wallace proposed the theory of natural selection in 1858. However, Charles Darwin is considered the developer of the theory published in the famous work ‘On the Origin of Species’ after a five-year voyage to study plants, animals, and fossils of South America and Pacific islands. Some common examples of natural selection are: Industrial Melanism in Peppered Moths: During the Industrial Revolution in England, pollution caused trees to darken with soot. Light-colored peppered moths became easy targets for predators, while dark moths were better camouflaged and survived. Over time, the population shifted towards darker moths.Different-sized Beak in Galapagos Finches: Charles Darwin observed that in the Galapagos Islands, the different species of finches developed distinct beak shapes based on the types of food available on their respective islands. Finches with long, slender beaks are better adapted to feeding on insects, while those with short, stout beaks are better suited for cracking seeds.Antibiotic Resistance in Bacteria: Bacteria can evolve resistance to antibiotics. When exposed to antibiotics, bacteria with resistant traits survive and reproduce, leading to the emergence of antibiotic-resistant strains. Natural selection will occur when the following 4 conditions are fulfilled. They are described in steps: Overproduction: An organism produces more offspring than can survive and reproduce. It helps perpetuate the race and reduces the possibility of being extinct.Variation: Within any population, there are differences or variations in traits. These traits can be physical, like the size of a bird’s beak, or behavioral, like how a predator hunts. For natural selection to happen, a population should have various individuals with different traits.Adaptations: Not all individuals in a population reproduce equally. Those organisms that have more beneficial adaptations are more likely to survive and reproduce.Selection: Over time, the traits that offer a survival or reproductive advantage become more prevalent in the population. Some desirable characteristics like hair color, skin color, eye color, and height are selected and passed on to the next generation. This simulation increases the chances of survival in the individuals. Several other factors or components like rate of development, mating success, fertility, and lifecycle are also found to affect natural selection in nature. There are three modes of natural selection: This type of selection favors one extreme of a trait over the other. An example is the evolution of longer necks in giraffes, enabling them to reach higher leaves on trees for food. Here, the average or intermediate traits in a population are selected. For example, in human birth weights, very low or very high birth weights are less common because babies with average weights have a better chance of survival. In disruptive selection, both extremes of a trait are favored, while the intermediate forms are at a disadvantage. It often leads to the formation of two distinct subgroups within a population. Apart from the three types, there is a special form of natural selection called sexual selection, in which a member of one sex chooses a mate of the other sex and competes with members of the sex for access to the member of the other sex. The extravagant tail feathers of a peacock are an example. Natural selection is how organisms adapt to their environment to increase their chances of survival in the changing climate. In contrast, artificial selection is the selective breeding imposed by humans to increase the frequency of the desired traits. Article was last reviewed on Friday, November 10, 2023 The genetic code is a nearly universal "language" that encodes directions for cells. The language uses DNA nucleotides, arranged in "codons" of three, to store the blueprints for amino acid chains. These chains in turn form proteins, which either comprise or regulate every other biological process in every living thing on the planet. The code used to store this information is almost universal, which implies that all living thing that exist today share a common ancestor. The fact that all organisms more-or-less share a genetics code strongly implies that all organisms shared a distant common ancestor. According to the National Center for Biotechnology Information, computer models have suggested that the genetic code that all organisms use is not the only way a genetic code could work with the same components. In fact, some may even resist errors better, meaning that it is theoretically possible to make a "better" genetic code. The fact that despite this, all organisms on Earth use the same genetic code suggests that life on Earth appeared once, and all living organisms are descended from the same source. Exceptions to the "universal" genetic code do exist. However, none of the exceptions are more than minor changes. For example, human mitochondria use three codons, which normally code for amino acids, as "stop" codons, telling cellular machinery that an amino acid chain is done. All vertebrates share this change, which strongly implies that this happened early in vertebrate evolution. Other minor changes to the genetic code in jellyfish and comb jellies (Cndaria and Ctenophora) are not found in other animals. This suggests that this group developed this change not long after splitting off from other animal groups. However, all variations are believed to be ultimately derived from the standard code. There is an alternate hypothesis to explain the universality of the genetic code. This idea, called the sterochemical hypothesis, holds that the arrangement of the genetic code stems from chemical constraints. This means that the genetic code is universal because it's the best way to set up a genetic code under Earthly conditions. The evidence for this idea is inconclusive. While some evidence supports this idea, changes to the genetic code, both natural and artificial, suggest that other genetic codes might work just as well. More importantly, the sterochemical hypothesis is not mutually exclusive to the idea that the genetic code is universal due to common descent; both concepts could contribute. According to a paper published by Princeton biologist Dr. Dawn Brooks and colleagues in the journal "Molecular and Biological Evolution," the fact that all organisms are descended from a common ancestor means that researchers can extrapolate some characteristics of that common ancestor. Based on the "oldest" genes in living organisms, those common to all modern living things, researchers can discern which proteins and amino acids were most common when the last common ancestor of all living things existed. Of the 22 "standard" amino acids — those found in the universal genetic code — about a half-dozen very rarely appear in the last common ancestor's proteins, implying that either these amino acids were very rare or they were added to the genetic code later. Boumis, Robert. "What Is The Evolutionary Significance Of The Genetic Code's Near Universality?" sciencing.com, . 24 April 2017. APA Boumis, Robert. (2017, April 24). What Is The Evolutionary Significance Of The Genetic Code's Near Universality?. sciencing.com. Retrieved from Chicago Boumis, Robert. What Is The Evolutionary Significance Of The Genetic Code's Near Universality? last modified August 30, 2022. The evolution of life on Earth has been a subject of intense debate, various theories and elaborate studies. Influenced by religion, early scientists agreed with the theory of divine conception of life. With the development of natural sciences such as geology, anthropology and biology, scientists developed new theories of evolution using natural laws rather than divine instrument. Our modern understanding of evolution is the product of hundreds of years of study by many naturalists, geologists and biologists. In the 18th century, Swedish botanist Carolus Linnaeus based his categorization of species on the theory of unchanging life created by God. Initially, he believed that all organisms appeared on Earth in their present form and never changed. Linnaeus studied the organisms as wholes, and categorized them based on similarities that individuals shared. Linnaeus is known as the "father of modern taxonomy" for his work in establishing a formal naming system for organisms, in which species are assigned scientific names with two parts. Unable to consider that organisms might change in time, he couldn't provide an explanation for the plant hybrids that resulted from cross-pollination processes with which he experimented. He concluded that life forms could evolve after all, but he could not say why or how. In the late 18th century, naturalist George Louis Leclerc suggested that life on Earth was 75,000 years old and that men had descended from apes. Another step in evolution theory was taken by Erasmus Darwin, Charles Darwin's grandfather, who said the Earth was millions of years old and that species did evolve, even if he could not explain how. Jean-Baptiste de Lamarck, the first evolutionist to publicly defend his ideas, believed that organisms had evolved constantly, from inanimate to animate organisms and on to humans. His theory was that evolution was based on a continuous chain of inherited characteristics passed from parents to offspring that had evolved with each generation until it produced the ultimate, perfect species: humans. In the early 19th century, French scientist Georges Cuvier explained evolution through violent catastrophic events or "revolutions" that had contributed to extinction of old species and the development of species to replace them in the newly created environment. He based his theory on the discovery in the same place of fossils of different species. Cuvier's theory was challenged by the English geologist Charles Lyell, developer of the uniformitarianism theory. He said evolution had been influenced by slow changes since the beginning of time in the shape of the terrestrial surface that could not be perceived by the human eye. This perspective was built upon by the English biologist Charles Darwin. The mid-19th century was marked by a new theory, that of Charles Darwin, who based his theory of evolution on the concepts of natural selection and survival of the fittest. According to the Charles Darwin book, _On the Origin of Species_, published in 1859, the process of natural selection enables individuals with the most suitable characteristics in a species not only to survive, but also to transmit those characteristics to their offspring, producing evolutionary changes in the species over time as less suitable traits disappear and more suitable traits endure. Darwin also believed that nature produces a larger-than-necessary number of individuals of a species to allow natural selection to take place. Survival of the fittest represents nature's preservation instinct to ensure that only the strongest and most well-suited individuals survive and propagate in a constantly changing environment. Adaptations come from random genetic mutations, some of which give individuals evolutionary advantages. Populations of species continue to reproduce and adapt through the process of natural selection. Paduraru, Carmen. "What Are The Different Theories Of Evolution?" sciencing.com, . 30 September 2021. APA Paduraru, Carmen. (2021, September 30). What Are The Different Theories Of Evolution?. sciencing.com. Retrieved from Chicago Paduraru, Carmen. What Are The Different Theories Of Evolution? last modified August 30, 2022. Home / Zoology / Evolutionary Biology /

Natural Selection – Definition, Theory, Types, Examples Natural selection is a fundamental biological process through which organisms adapt to their environment, resulting in evolutionary changes over generations. First described by Charles Darwin and Alfred Russel Wallace in the 19th century, natural selection explains how organisms with traits better suited to their environment are more likely to survive and pass these advantageous traits to their offspring.The theory was profoundly influenced by Darwin's extensive observations during his voyage aboard the HMS Beagle, where he studied a wide array of plant and animal species. His findings suggested that variations among individuals within a species could influence their survival. By drawing on the works of other thinkers like Jean-Baptiste Lamarck, Charles Lyell, and Thomas Malthus, Darwin shaped the concept that organisms face a "struggle for existence" due to limited resources. Malthus's work, which discussed population pressures, showed Darwin that competition for survival could naturally lead to selection, while Lyell's geological findings suggested Earth was old enough for such gradual processes to occur.Natural selection works through a few core principles. First, there is variation among individuals within a population, meaning organisms possess different characteristics due to random genetic mutations. Some of these variations may offer certain individuals an advantage in surviving environmental challenges, such as finding food, evading predators, or coping with climate changes. These advantageous traits, known as adaptations, are likely to be passed on because the individuals possessing them tend to live longer and reproduce more.Over successive generations, these beneficial traits become more common within the population. This process, termed "differential reproduction," drives the gradual adaptation of species to their specific environments. Importantly, natural selection is not goal-oriented; it simply favors traits that enhance survival and reproduction in a given set of environmental conditions. Because environments can change, an organism's adaptations may not be permanently advantageous, and selection pressures can shift over time, promoting different traits as advantageous.A key concept within natural selection is "fitness," which Darwin defined as an organism's relative ability to survive and produce offspring. Fitness is influenced by the specific environmental context, so an organism considered fit in one setting may not be in another. This continuous cycle of adaptation and selection is essential to the evolutionary process, leading to the incredible diversity of life seen today.Natural selection is the process by which organisms with traits better suited to their environment tend to survive, reproduce, and pass those beneficial traits to future generations, leading to gradual evolutionary changes in a population.History of Natural SelectionNatural selection, the central concept of Darwin's theory of evolution, was shaped by both direct observations and earlier evolutionary ideas. Charles Darwin's journey as a naturalist aboard the HMS Beagle from 1831 to 1836 allowed him to observe organisms in diverse environments, where he noted that species displayed variations suited to specific geographic locations. From these observations, Darwin began to theorize that such physical changes were adaptive responses to different environmental pressures. Yet, before Darwin developed his theory, several pre-existing ideas about evolution influenced the development of natural selection.Pre-Darwinian Theories:Lamarckian Evolution: Jean-Baptiste Lamarck was among the first to propose a theory of biological change. His ideas, often termed Lamarckianism, suggested that organisms could acquire characteristics in response to environmental pressures and pass these changes to offspring. For example, Lamarck theorized that giraffes developed long necks because their ancestors stretched to reach high leaves, and these elongated necks were inherited across generations.Cuvier's Ideas on Extinction: French scientist Georges Cuvier, an expert on fossils, documented the extinction of ancient animals and argued that while species do not change, earlier life forms existed that are now extinct. This idea of extinction challenged the notion of a fixed, unchanging creation and opened possibilities for new theories on life's diversity.Catastrophism and Uniformitarianism: The idea of Catastrophism, advocated by naturalists like Joseph Fourier and Comte de Buffon, suggested that Earth's geological features formed due to sudden catastrophic events. Charles Lyell countered this with his theory of Uniformitarianism, which proposed that slow, continuous processes shaped Earth. Lyell's view, which was influenced by James Hutton, indicated that Earth's age and gradual changes allowed enough time for biological evolution, laying a foundation for Darwin's thinking.Darwin's Observations and Theory Development:Darwin's observations during his voyage included the distribution of unique species, such as the finches on the Galapagos Islands, which varied in beak shape and size depending on their diet and habitat. While initially unaware of their relationship, he later concluded that these birds shared a common ancestor and had diversified through gradual adaptation to different environmental niches on each island.Inspired by these patterns, Darwin formulated his Theory of Evolution by Natural Selection. He proposed that species could change over time, with new species arising from pre-existing ones through gradual modification. This process implied that all species could trace their lineage back to common ancestors, diverging over time due to adaptations.Core Principles of Darwin's Theory:Darwin's theory of evolution by natural selection relies on a few essential concepts:Heritability of Traits: Traits can be passed from parents to offspring, and these inherited characteristics help organisms survive and reproduce under specific environmental conditions.Overproduction and Competition: Species tend to produce more offspring than the environment can support, leading to competition for resources such as food and habitat.Survival of the Fittest: Organisms with traits that offer advantages in survival and reproduction are more likely to thrive, leading to those traits becoming more common in successive generations—a process Darwin called "descent with modification."Principles of Natural SelectionNatural selection is the mechanism through which species evolve by favoring traits that enhance survival and reproduction within specific environments. It is environment-dependent, meaning that the traits beneficial in one setting may not be advantageous in another. Natural selection relies on variations that already exist within a population, driven by genetic mutations that produce new, inheritable traits. Charles Darwin outlined the core principles of natural selection, which include variation, inheritance, high population growth, and reproductive advantage.Variation:Within any population, individuals exhibit differences in appearance and behavior, known as variations. These may include physical characteristics such as color, size, and body structure. Such variation provides the foundation for natural selection, as traits that better suit an individual to its environment can become more common in the population.For example, among moths of the same species, those whose wing colors closely match tree bark are more likely to survive by blending in with their surroundings. This camouflage provides protection from predators, increasing the likelihood that these moths will reproduce and pass on their advantageous traits to their offspring.Inheritance:Traits that increase survival chances are passed down from one generation to the next, allowing beneficial adaptations to persist within a population. For natural selection to operate effectively, these traits must be inheritable and must interact with environmental conditions.Over time, individuals with less favorable traits may become rare or disappear altogether, while those with successful adaptations are more likely to thrive. A classic example of this is Darwin's finches on the Galapagos Islands; each finch species adapted distinct beak shapes suited to its feeding habits, a trait passed down to subsequent generations. This process of adaptation and inheritance can lead to new species formation when enough differences accumulate.High Rate of Population Growth:Most species produce more offspring than the environment can sustain, resulting in competition for resources. High reproduction rates lead to significant mortality within populations, as individuals compete for access to limited food, shelter, and mates.Overproduction can increase the chances of survival despite high mortality rates, as seen in fish and sea turtles, which produce large numbers of offspring, though only a small fraction survive to adulthood. This selective survival supports the principle of "survival of the fittest," ensuring that only those best suited to environmental conditions continue to pass on their genes.Reproductive Advantage:Reproductive advantage refers to traits that increase an individual's chances of reproducing successfully. These advantageous traits, when passed to offspring, can become more prevalent in future generations, driving population changes over time.This principle is evident in various ways across species. For instance, the peacock's vibrant tail feathers help attract mates, giving peacocks with this trait a reproductive advantage. Similarly, moths that blend into tree bark not only avoid predators but also increase their chances of reproducing. Plants, too, can experience reproductive advantages by evolving characteristics that attract a wider range of pollinators. Factors like mate choice, sexual selection, and parental care also play significant roles, influencing reproductive success over generations.Natural selection drives evolution by favoring traits that enhance an organism's fitness within its environment. Traits that improve survival and reproductive success become increasingly common, leading to gradual changes in populations over time.Principles of EvolutionEvolution describes the gradual change in species over generations, shaped by natural pressures and resulting in adaptations that improve survival and reproduction. Charles Darwin outlined four main principles that form the foundation of evolution: competition, heritable differences, survival of the fittest, and descent with modification. Each of these principles plays a crucial role in how species adapt and thrive in varying environments.Competition:In every generation, more individuals are produced than the environment can support, leading to competition for limited resources essential for survival and reproduction. This competition can occur within a species (intraspecific) or between different species (interspecific).For instance, intraspecific competition might involve two lizards of the same species competing for mates within the same area. Such competition pressures individuals to develop better adaptations that improve their chances of survival and reproduction within their population. Conversely, interspecific competition occurs between different species, such as two predators vying for the same prey. In such cases, the less adapted species may face extinction if it cannot secure sufficient resources to survive.Heritable Differences:Genetic diversity within a population leads to differences among individuals, which may be either visible or invisible traits. These genetic variations are crucial because they increase a population's chances of adapting to changing conditions.Heritability refers to how much of a trait's variability within a population is due to genetic factors, which allows certain adaptations to become more common over time. For example, the color variation in England's peppered moths illustrates this principle. Before industrialization, light-colored moths blended with the lichen-covered tree bark, while darker moths were more visible to predators. As pollution darkened the trees, however, dark-colored moths became more camouflaged, allowing them to survive and reproduce more successfully than light-colored moths. This shift illustrates how heritable traits that enhance survival can become prevalent in response to environmental changes.Survival of the Fittest:Fitness in evolutionary terms refers to an individual's ability to survive and reproduce in its specific environment. Traits that improve fitness, such as speed, intelligence, or social behaviors, give individuals an advantage, enhancing their likelihood of passing these traits to the next generation.Variability in fitness among individuals leads to differential survival rates. For example, in polluted environments, the darker peppered moths demonstrated higher fitness by blending into the altered surroundings, giving them a greater chance of surviving and reproducing than their lighter counterparts. Fitness, therefore, drives the propagation of advantageous traits within a population.Descent with Modification:Over generations, a population may diverge from its ancestral species, leading to the development of new species. This process, known as descent with modification, occurs when groups within a species become isolated and accumulate unique adaptations in response to their specific environments.For example, some Galapagos tortoises evolved longer necks than others, enabling them to reach higher foliage in dry lowlands. This adaptation proved beneficial during droughts when food sources became scarce, allowing long-necked tortoises to survive and reproduce more successfully. As long-necked traits were passed to subsequent generations, the population shifted over time, leading to distinct characteristics in the population. This principle highlights how species can gradually change through inherited modifications, adapting in ways that increase their survival and reproductive success across generations.Darwinian Theory of Natural SelectionThe Darwinian theory of natural selection, often called the Darwin-Wallace theory, explains evolution as the gradual change in species driven by survival advantages that specific traits offer in a given environment. These advantageous traits allow individuals to better survive and reproduce, ultimately leading to species adaptation and evolution. The theory identifies several key components fundamental to natural selection.Universal Occurrence of Variation:Variation, the observable differences within populations of plants and animals, is the basis for natural selection. During Darwin and Wallace's time, the origin of variation was unclear; they considered it an inherent trait of organisms. Today, it's understood that these variations result from mutations, which are inheritable changes in an organism's genetic material. These genetic variations are critical, as they introduce new traits into a population, setting the stage for natural selection to act upon them.Excessive Natural Rate of Multiplication:Species have a high reproductive potential, often growing at a geometric rate. In the absence of environmental limitations, populations would grow rapidly. However, if unchecked, this growth would lead to resource shortages, causing overcrowding and creating intense competition for survival. This reproductive pressure introduces a critical check on population size and increases competition among individuals for resources such as food, space, and mates.Struggle for Existence:Within and between species, organisms experience competition, known as the struggle for existence. This struggle includes various challenges, from competing for food and mates to surviving environmental extremes like drought or cold. In this battle for resources, only the fittest individuals survive, those with traits best suited to meet environmental demands. This competition is fundamental to natural selection, as it drives which individuals will reproduce and pass their traits on to the next generation.Elimination of the Unfit and Survival of the Satisfactory Adapted:Natural selection eliminates individuals whose variations make them less suited to their environment, a process known as the "survival of the fittest." Only those with adaptive traits are likely to survive, allowing them to reproduce and contribute to the gene pool. Over time, this selective process shapes the population, favoring the most advantageous traits while reducing the prevalence of less favorable ones.Inheritance of Mutations and Recombination Leading to Success:Individuals who survive the struggle for existence pass down their adaptive traits to their offspring. Through this inheritance, advantageous traits become more common in each successive generation. In this way, populations gradually adapt to their environment, with each generation becoming better suited to survive. If environmental conditions change, natural selection may promote further adaptations, allowing the species to continue evolving.Through the ongoing process of natural selection over multiple generations, populations may accumulate enough changes to diverge significantly from their ancestors, eventually leading to the development of new species. This diversification from a common ancestor demonstrates how species adapt and evolve, ensuring survival through variation, reproduction, and adaptation to the environment.Types of Natural SelectionNatural selection acts as a powerful mechanism shaping the traits of organisms to improve survival and reproductive success. This process manifests in multiple forms: stabilizing selection, directional selection, diversifying selection, sexual selection, predator-prey selection, and kin selection. Each type represents a different aspect of how organisms adapt to their environments through natural selection.Stabilizing Selection:Stabilizing selection favors intermediate traits over extreme variations, leading to a reduction in diversity as populations stabilize around an average characteristic. For example, plants with medium heights thrive because shorter plants struggle for sunlight, while taller plants are susceptible to wind damage. Over time, the population's distribution narrows, with small and tall plants decreasing while medium-height plants become more prevalent. This selection results in a population where most individuals exhibit traits near the average, enhancing reproductive success and diminishing extreme traits.Directional Selection:Directional selection favors a single phenotype, causing a population to shift toward one extreme trait. An example of this phenomenon is the peppered moth in England. Before industrialization, light-colored moths camouflaged well against lichen-covered trees. However, as pollution darkened the trees, light moths became more visible to predators, favoring the survival of darker moths. Thus, the population shifted toward darker coloring as a protective adaptation. Directional selection typically occurs when environmental changes create new selective pressures, moving the population's genetic variance in a particular direction to favor more adaptive traits.Diversifying (Disruptive) Selection:This selection favors extreme traits at both ends of a phenotypic range, while intermediate traits are less successful. A classic example is observed in oyster populations: light-colored oysters blend with sand, while dark-colored oysters camouflage in shadows, making both extremes less visible to predators. Conversely, intermediate-colored oysters stand out and are more likely to be preyed upon. This form of selection creates bimodal distributions within the population, often leading to the development of two distinct groups or species through a process known as polymorphism.Sexual Selection:Sexual selection occurs when specific traits increase an organism's chances of securing a mate. In many species, visible traits become preferred characteristics that attract the opposite sex. For instance, Drosophila flies with normal yellowish-gray pigmentation are favored over flies with yellow coloration, as female flies prefer mates with typical pigmentation. In male deer, antlers enhance their advantage in competing for mates, with larger antlers conferring a better chance to secure a mate. This type of selection promotes the development of traits related to reproductive success, such as size, strength, and courtship displays.Predator-Prey Selection:This type of selection arises from interactions between predators and their prey, with both evolving traits that enhance survival. Predators develop improved hunting adaptations, while prey evolve defensive mechanisms. For example, millipedes produce noxious substances and curl into a ball when threatened, and chameleons change color to blend into their surroundings, avoiding detection by predators. These adaptations create a dynamic, often referred to as an "evolutionary arms race," where both predators and prey continually evolve to gain an advantage.Kin Selection:Kin selection involves altruistic behaviors that benefit related individuals within a group. This selection type is evident in worker bees, who spend their lives serving the hive and never reproduce directly. However, because the queen bee produces offspring related to the workers, the workers' efforts indirectly enhance the genetic success of the hive. Though worker bees lack direct reproductive success, their actions increase the survival and reproduction of their genes within the colony, highlighting how altruistic behaviors support overall population fitness.Examples of Natural SelectionNatural selection allows organisms to adapt, survive, and reproduce in response to environmental pressures. Through examples across different species, it becomes clear how certain traits provide advantages that are passed on, while others may lead to decline or extinction.Black-furred vs. Tan-furred Mice:In regions with black rock terrain, hawks prey more easily on tan-furred mice, as they stand out against the dark background. As a result, tan-furred mice are often eliminated from the population, while black-furred mice survive and reproduce. Over generations, the frequency of black-furred mice increases, as they are better camouflaged and more likely to evade predators. This example illustrates "descent with modification," where a population's heritable traits change over time to suit its environment.Longer-tailed vs. Short-tailed Peacocks:The long, ornate tail feathers of male peacocks make them more visible to predators, yet these feathers also attract mates. Females are drawn to males with longer, more colorful tails, increasing those males' reproductive success. As longer-tailed Peacocks produce more offspring, this trait is passed down through generations, eventually becoming a common characteristic in the population. Here, natural selection favors traits that enhance reproductive success, even when they increase predation risk.White, Black, and Brown Mice:In a population of mice with varying fur colors, white mice are more visible and vulnerable to predators, reducing their chance of survival. Conversely, black and brown mice blend better with their surroundings, making them harder for predators to spot. Over time, the genetic traits for black and brown fur become more common, illustrating how natural selection can shift a population's traits toward those that offer better camouflage.Long-necked vs. Short-necked Giraffes:In environments where low-lying vegetation dies out, giraffes with long necks can still reach higher foliage, while short-necked giraffes struggle to find food. Over generations, long-necked giraffes have a survival advantage, leading to an increase in long-necked individuals. In this case, natural selection favors traits that provide access to resources critical for survival in changing environments.Gray vs. Green Treefrogs:On tree bark, gray treefrogs blend in with the environment more effectively than green treefrogs, making green treefrogs more visible to predators like birds and snakes. As green treefrogs are more likely to be preyed upon, their population declines, while gray treefrogs increase in numbers. Natural selection here promotes camouflage as a key survival trait, allowing certain organisms to avoid predation.Red vs. Green Bugs:In an environment where birds prefer red bugs, green bugs become more prevalent as they are less frequently eaten. The increased survival and reproduction of green bugs cause the red bug population to decline or even disappear. In this scenario, predator preference drives natural selection, shaping the population by favoring one trait over another.Penguins (Flightless Birds):Penguins, unable to fly, instead excel at swimming, which is essential for finding food and avoiding water-based predators. Since penguins live in areas where food is primarily aquatic and land predators are scarce, the adaptation of swimming rather than flying provides significant advantages for survival, demonstrating natural selection's role in aligning traits with environmental demands.Venus Flytrap:The Venus flytrap, a carnivorous plant, thrives in nitrogen-poor soil by trapping and digesting insects, which provide an alternative nitrogen source. This adaptation allows the Venus flytrap to survive in an otherwise challenging environment, illustrating how natural selection can drive unique survival strategies in plants.Green and Brown Beetles:Brown beetles are less visible to predators on the ground, while green beetles stand out and are more frequently eaten. However, if the environment shifts to a grassy landscape, brown beetles become more visible, while green beetles blend in. Consequently, green beetles' numbers increase, demonstrating how environmental change can shift which traits are favored by natural selection.Sharks:Sharks exhibit counter-shading, with a blue-gray color on top and white on the underside. This coloration helps them blend into the water when viewed from above, while the white underside makes them less visible to prey from below. This natural camouflage enhances their hunting success and reduces visibility to predators, supporting survival and reproduction. //www.sciencefacts.net/natural-selection.html //biology4alevel.blogspot.com/2016/06/139-natural-selection.html //old-ib.bioninja.com.au/standard-level/topic-5-evolution-and-biodi/52-natural-selection/natural-selection.htmlOur AI will generate interactive flashcards and quizzes from this article to help you practice. You can also ask any question to deepen your understanding!Sourav Pan. (2024, October 26). Natural Selection – Definition, Theory, Types, Examples. Biology Notes Online. Retrieved from Pan. "Natural Selection – Definition, Theory, Types, Examples." Biology Notes Online, 26 October 2024, biologynotesonline.com/natural-selection-definition-theory-types-examples/.Sourav Pan. "Natural Selection – Definition, Theory, Types, Examples." Biology Notes Online (blog). October 26, 2024. . Natural selection is one of the four basic premises of evolutionary theory, alongside mutation, migration and genetic drift. Natural selection works on populations with a variation in traits, such as coloring. Its main premise is that when there is a trait that allows one individual to better survive in an environment than another, the former is more likely to reproduce. Natural selection occurs if four conditions are met: reproduction, heredity, variation in physical characteristics and variation in number of offspring per individual. In order for natural selection to act on a given population, that population must reproduce to create a new generation. Over many generations, individuals with traits most suitable for their environment tend to reproduce more than those that don't. As such, natural selection works to maximize the number of individuals with those favored traits while those with less advantageous traits slowly die off. The higher the reproduction rate of a population, the higher the competitive pressure is on an individual to survive. This pressure ensures that only the most suitable members survive while the weaker members perish. It follows that the population will soon become full of members exhibiting those traits that give the species a better chance of survival. Heredity works hand-in-hand with reproduction since the genes of the parents combine to create the genes of their offspring. Parents with advantageous traits must pass those traits on to their offspring in order for natural selection to act. Otherwise, the genes which create the advantageous traits would die with the parents without being copied to the next generation. Speciation occurs when members of a species are geographically isolated into differing environments, allowing for unrelated lines of heredity. Over time, traits in each population begin to differ to better suit them for different environments. Advantageous genes for one environment begin to differ from those for a different environment and the two populations begin to diverge. Given enough time, the number of differences between the populations can become so great that they can no longer interbreed. Natural selection can only occur within a population when members of the population have a variation in individual traits. For example, a study of natural selection on color within a population requires different individuals to have varying colors. Without a variation in characteristics, there are no traits for nature to "select" over others. In biology, fitness has a more technical meaning than its common definition. Within the context of evolution, fitness is the ability of an organism to survive and reproduce as much as possible. Varying levels of fitness in members of a population is a prerequisite for natural selection to occur. Some individuals must have traits that allow them to better survive and reproduce more often than others. Otherwise, natural selection cannot act to produce more individuals with beneficial traits and fewer with less useful traits. Braybury, Luc. "The Four Factors Of Natural Selection" sciencing.com, . 24 April 2017. APA Braybury, Luc. (2017, April 24). The Four Factors Of Natural Selection. sciencing.com. Retrieved from Chicago Braybury, Luc. The Four Factors Of Natural Selection last modified August 30, 2022. Charles Darwin, famed for his development of the theory of evolution based on natural selection and descent with modification, has been cited countless times since the publication of On the Origin of Species in the mid-1800s and is probably the most famous biologist in history. But Darwin himself cited, among other sources, the essay on population and overall work on the power of population dynamics of another British intellectual, Thomas Robert Malthus, when explaining what inspired and shaped his theory. Malthus believed that the world's food supply was and could be never be sufficient to keep pace with the rate of population growth in his day. He criticized the laws of the land and the overall political economy for promoting larger communities of poor people without genuinely providing for a quality of life among the needy. This is similar to endless arguments about the "welfare state" in Western civilization today, and advocated for both a higher level of "moral restraint" (i.e., abstinence) and synthetic birth control, especially among the lower classes, to help achieve this aim. Thomas Malthus was born in 1766. By the standards of his or any era, he was a highly educated academic. By trade, he was an economist and population scientist as well as a cleric. In 1798, Malthus anonymously published his now-famous paper An Essay on the Principle of Population. While not a trained biologist, Malthus had observed that plants, animals and people often "overproduce" offspring via an inflated birth rate – that is, their numbers exceed the level of sustenance available in their environment that is adequate to support the population. He predicted that there would arise an inability of resources (particularly food) to keep up with increasing population growth worldwide. Malthus viewed poverty, hunger and lack of sufficient food production to feed all of the world's people as an inevitable part of the human experience. In accordance with the less secular standards of the science-minded during his lifetime, he believed this arrangement was put in place by God to keep people from being lazy. His ideas went against the prevailing wisdom at the time, which was that with enough laws and the proper social structures, human ingenuity could overcome any level of sickness, hunger, poverty and so on. Malthus, in fact, failed to foresee the technological advances that have allowed humanity to keep pace with exponential population growth (at least so far). As a result, at least as of the second decade of the 21st century, Malthus' predictions have not been borne out in reality. Before Malthus and Darwin, the scientific consensus was that organisms produced just enough food to maintain their population, meaning that production and consumption were closely and efficiently matched. Darwin, who was also from England but did much of his field work outside Great Britain, connected Malthus' ideas to how things survive in the wild, concluding that organisms overproduce by default because many of them are eliminated before reaching reproductive age owing to factors such as predation and lethal illnesses. Darwin saw that certain individuals in this scheme of overproduction were better suited to survive than to others. He attributed this realization to Malthus' description of the inherent struggle for existence, and Darwin connected this to his notion of "survival of the fittest." This idea is widely misunderstood and refers not to individuals willfully becoming fitter, but to those who happen to have inherited traits that make them more likely to survive and reproduce in a given environment. With no small degree of smugness, modern scholars have suggested that Malthus' doomsday predictions were predicated on flimsy ideas and a flawed and cynical understanding of the ingenuity of future generations of human beings, as occurred in the Industrial Revolution in Europe (especially Britain) and the United States after his death in the 1800s. Still, if the world's population continues to grow at its present rate, factors other than increased food production may be necessary to sustain population growth beyond 9 or 10 billion people, about 2 to 3 billion in excess of the world total as of 2019. Many scientists believe that even if the food supply can be maintained at adequate levels per se, the environmental consequences will be such that sustainability measures will fail for secondary reasons (e.g., climate change, pollution, etc.). In some ways, these arguments appear to parallel Malthus' own in that they may fail to account for technological leaps capable of surmounting such challenges. Beck, Kevin. "Thomas Malthus: Biography, Population Theory & Facts" sciencing.com, . 28 May 2019. APA Beck, Kevin. (2019, May 28). Thomas Malthus: Biography, Population Theory & Facts. sciencing.com. Retrieved from Chicago Beck, Kevin. Thomas Malthus: Biography, Population Theory & Facts last modified March 24, 2022. Join 217475217475 in the Search for Truth