

In the swashbuckling 2003 film *Master and Commander: The Far Side of The World*, the ship's surgeon Dr. Steven Maturin shared many similarities with a young Charles Darwin. Like Maturin, Darwin was a seagoing naturalist who documented natural wonders as he sailed around the world. Just as Maturin was best friends with the ship's Captain Jack Aubrey, Darwin was a close companion of his ship's Captain Robert FitzRoy. And just like Maturin, the place that most obsessed Darwin was the Galapagos Islands, located hundreds of miles off the west coast of South America.

On these islands, birds had become flightless, tortoises had become giants, and lizards had taken to swimming and feeding in the sea. These unique animal **adaptations**, or characteristic features, bewildered both Darwin and Maturin. How (and why) did these animals acquire such adaptations? If God had created these beautiful and bizarre animals to be admired by mankind, then why did he put them way out here in the Pacific Ocean where nobody could appreciate them? Considering how much these animals closely resembled creatures from the mainland, could they have originated from a mainland ancestor? It was Darwin who came up with an explanation that would forever change the field of biology: his theory of **evolution**.

Darwin never intended to become a champion of evolutionary theory. He dropped out of medical school and wanted to be a clergyman after his 5-year, round-the-world voyage was complete. Regrettably to Darwin, the theory of evolution that he developed and published later in life was seen as a major threat to certain religious beliefs. Such conflict between evolution and religion is still seen today. Perhaps a guilty conscience explains why it took Darwin more than 20 years after the voyage to reluctantly publish his great ideas about evolution. Betrayal was surely on his mind when he confessed that publishing his evolutionary theory was "like confessing a murder."

In Victorian England, Darwin's ideas did not sit well with those who made a strict reading of the Bible. His old friend Captain FitzRoy was among them. FitzRoy declared that reading Darwin's book on evolution, entitled *On the Origins of Species by Means of Natural Selection*, had caused him "the acutest pain." In a departure from the movie *Master and Commander*, the Naturalist and the Captain did not have a happy ending in this real-life story.

Why are Darwin's ideas about evolution so controversial? Are his ideas really a threat to religion and to spiritual faith? What did he actually say? In this chapter, we will investigate his basic theory of evolution so that you can decide for yourself whether Darwin should be considered master of his domain, or should walk the plank instead.

## CHAPTER 16: DARWINISM

### AN INTRODUCTION TO EVOLUTIONARY THEORY



## Evolution: Do We Want to Believe?

Do you believe in evolution? According to recent Gallup Polls, only 33% of Americans believe in evolution, whereas 96% believe in God, and 72% believe in extraterrestrial life. More people even believe in ghosts than in evolution! These statistics are surprising because there is overwhelming, solid evidence that evolution is real but no scientific proof at all that the others exist. Maybe, in contrast to the mantra of X-Files investigator Fox Mulder, we don't want to believe...

Evolution often gets a bad rap as a “dangerous idea.” Most likely, this is the result of general confusion, media hype, and misinformation (see Box 1). When asked, many people cannot clearly define the term, and most confuse it with the origins of life on Earth or the origins of humans. To make matters worse, in the past century the concept of evolution has been misused as justification for the Nazi regime and for the eugenic ambitions of making the human species superior by eliminating the “weakest” individuals. This is unfortunate and tragic, to say the least. Evolution is a basic biological term that carries no hidden agendas or meanings; it simply means that species change over time.

Charles Darwin was by no means the first person to suggest that species evolve. In fact, his grandfather Erasmus Darwin, a best-selling poet, described a process of evolution in which microbes evolve into higher forms of life:

*Organic life beneath the shoreless waves  
Was born and nurs'd the Ocean's pearly caves;  
First forms minute, unseen by spheric glass,  
Move on the mud, or pierce the watery mass;  
Then as successive generations bloom,  
New powers acquire and larger limbs assume.*

Great thinkers had pondered evolution for centuries before Charles was ever born. There were theories of evolution in print for decades before Darwin published his version. What was it, then, that earned him accolades as the Father of Evolution? Very simple: his straightforward theory of evolution provided the best explanation of how and why species change

over time. It has withstood the harshest scientific scrutiny and the trying test of time. His theory stands as firm today (in fact, even more so) as it did when it was first published in 1859.

### Box 1: Theoretically Speaking.

Perhaps one reason so many people do not believe in Darwin's theory of evolution is because of a misunderstanding of the term “theory.” In the scientific community, a **theory** is a well-proven, fully-supported explanation for a phenomenon. It is used much like the term “law” is used in the field of physics. Darwin's theory has been supported by hundreds of examples and thousands of scientific studies. Still, the phrase “theory of evolution” makes it sound as if it evolution is merely an untested and unproven idea.

Another term that is misused in everyday life is “hypothesis.” A **hypothesis** is a statement that a scientist makes, based on some preliminary information. A hypothesis is an educated guess that goes on to be tested until it is either proven wrong (and rejected) or supported enough to be called a theory. Scientists are very cautious not to fully accept a hypothesis, because evidence from a future study may prove it wrong. Instead, they “fail to reject” it (and unofficially accept it) as a theory.

Scientists often use terms that are poorly understood by the general public. This is a barricade that should be torn down like the Berlin Wall was 1989. When it comes to communicating with the public, scientists should use terms that the average layperson will appreciate. For example, imagine how different it would sound if scientists referred to it as “Darwin's Law of Evolution” instead of “Darwin's Theory of Evolution.”

## Evolutionary Thinking Before Darwin

Several Greek philosophers believed in a gradual evolution of species. For example, around 600 B.C., **Anaximander** wrote that simpler life forms preceded complex life forms and that species evolve. But who ever heard of this guy? His evolutionary beliefs didn't even get as far as Howard Dean did in the 2004 Presidential election campaign. The philosophers that most influenced Western culture, such as Plato and Aristotle, ruled out evolution. Therefore, for the subsequent two millennia, most scientists believed in the **fixed species concept**: that species did not change over time.

In the early 1800s, a naturalist at the National Museum of Paris was the first to hypothesize a “reasonable” scientific mechanism of evolution. His full name was Jean-Baptiste Pierre Antoine de Monet, chevalier de Lamarck (but let's just call him **Lamarck**). He published his ideas on evolution in 1809, the year Darwin was born. There were 2 major components of his evolutionary hypothesis:

**1. Use and Disuse** -- Lamarck believed that the parts of the body used to cope with the environment become larger and stronger. For example, a bodybuilder who does biceps curls with heavy weights at the gym will develop larger muscles in that arm.

**2. Inheritance of Acquired Characteristics** -- Lamarck also believed that any changes in an organism that occur during its lifetime can be passed on to its offspring. By Lamarck's reasoning, the weightlifter with large biceps will pass on large biceps to his or her offspring.

Lamarckian evolution was quite appealing to the scientists who were looking for an explanation of how species can change over time. Based on fossil evidence, scientists in the 1800s knew that species such as giraffes had changed over time; in the case of giraffes, their necks and legs got longer and longer, thus allowing them to reach higher and higher into the trees for leaves to eat. These adaptations clearly allowed giraffes to prosper in their environment, but how did they arise (no pun intended)?

According to Lamarck's hypothesis, ancestral short-necked giraffes stretched their necks and legs in order to eat the leaves that were higher up on the trees. This was presumably due to fierce competition for food resources on the African savanna. Some giraffes acquired longer necks and legs through such constant stretching. Then, Lamarck reasoned, those giraffes passed on their long necks and long legs to their offspring. This is his so-called *Inheritance of Acquired Characteristics*.

At first, this makes perfect sense. Some people, in fact, make their necks much longer over a lifetime of stretching. The women of the Ndebele tribe of Africa and the Padaung tribe of Thailand gradually stretch their necks by stacking many layers of metal rings around their throats. The result is a decidedly longer neck; even their neck muscles and bones are lengthened!

The major problem with Lamarckian evolution is that the *Inheritance of Acquired Characteristics* is **NOT TRUE!** For example, let's assume that Mark McGuire, Barry Bonds, and other Major League Baseball players pumped steroids to build big arm muscles (as alleged by Jose Canseco in his “tell-all” book, *Juiced: Wild Times, Rampant 'Roids, Smash Hits & How Baseball Got Big*). If so, their children will not inherit such big arm muscles, right? If Lamarck was correct, then why are the female offspring of the Ndebele and Padaung tribes born with normal (and relatively short) necks? Why do they need to place rings around their necks, if they inherited their mothers' acquired characteristics?

Also, if Lamarckian evolution was correct, then shouldn't the loss of an anatomical characteristic during an individual's lifetime be heritable? For example, in *Star Wars: Attack of the Clones*, Anakin Skywalker (the future Darth Vader) suffered a severed arm from a light saber duel with Count Dooku. Years after this accident, when his kids were born (Luke Skywalker and Princess Leia), they were not missing their arms. Luke lost a hand in *Star Wars: The Empire Strikes Back*, but it was not due to an inherited acquired characteristic. It was due to -- big surprise -- a light saber duel.

As unsatisfying as it was, Lamarck's hypothesis stood for some 50 years until Darwin published his version of how evolution happens.

## Darwin Declares an Evolutionary War

Let's continue pondering how giraffes evolved. Charles Darwin's theory says that some giraffes happened to be born with longer necks and longer legs than others. Such variation is based on genetics and is seen in many populations, including human populations. For example, some of your classmates are probably much taller than average (we will discuss this in more detail at the end of this chapter).

Back on the savanna, those giraffes born with longer necks and longer legs would have survived during times of food scarcity, because they could reach leaves that were unavailable to shorter giraffes. By good fortune and good genes, those naturally longer-necked giraffes survived while the shorter giraffes starved to death. The longer-necked giraffes survived long enough to mature into adults and to reproduce. Furthermore, because their long necks and legs were based on genetics, they passed on their advantageous adaptations to their offspring. The result: subsequent populations of longer-necked and longer-legged giraffes.

Darwin called this theory of evolution **Natural Selection** (where Nature is the **selective agent**, selecting for and against individuals based on their traits). In Darwin's words, Natural Selection is "the preservation of favourable variations and the rejection of injurious variations." Let's put it another way: differences in survival and reproduction, due to natural variation in traits within a population, results in a change in a species over time. See Box 2 for another modern analogy of Natural Selection, as seen in today's cyber-environment.

### Box 2. Evolution of Spam by Natural Selection.

Junk email (spam) has become much more than a minor inconvenience in the modern age. For example, America Online estimates that spam accounts for more than 30 percent of email to its members -- roughly 24 million messages a day! Furthermore, a California study estimated that spam cost the United States more than \$10 billion in 2004, in terms of the combined efforts applied at fighting spam.

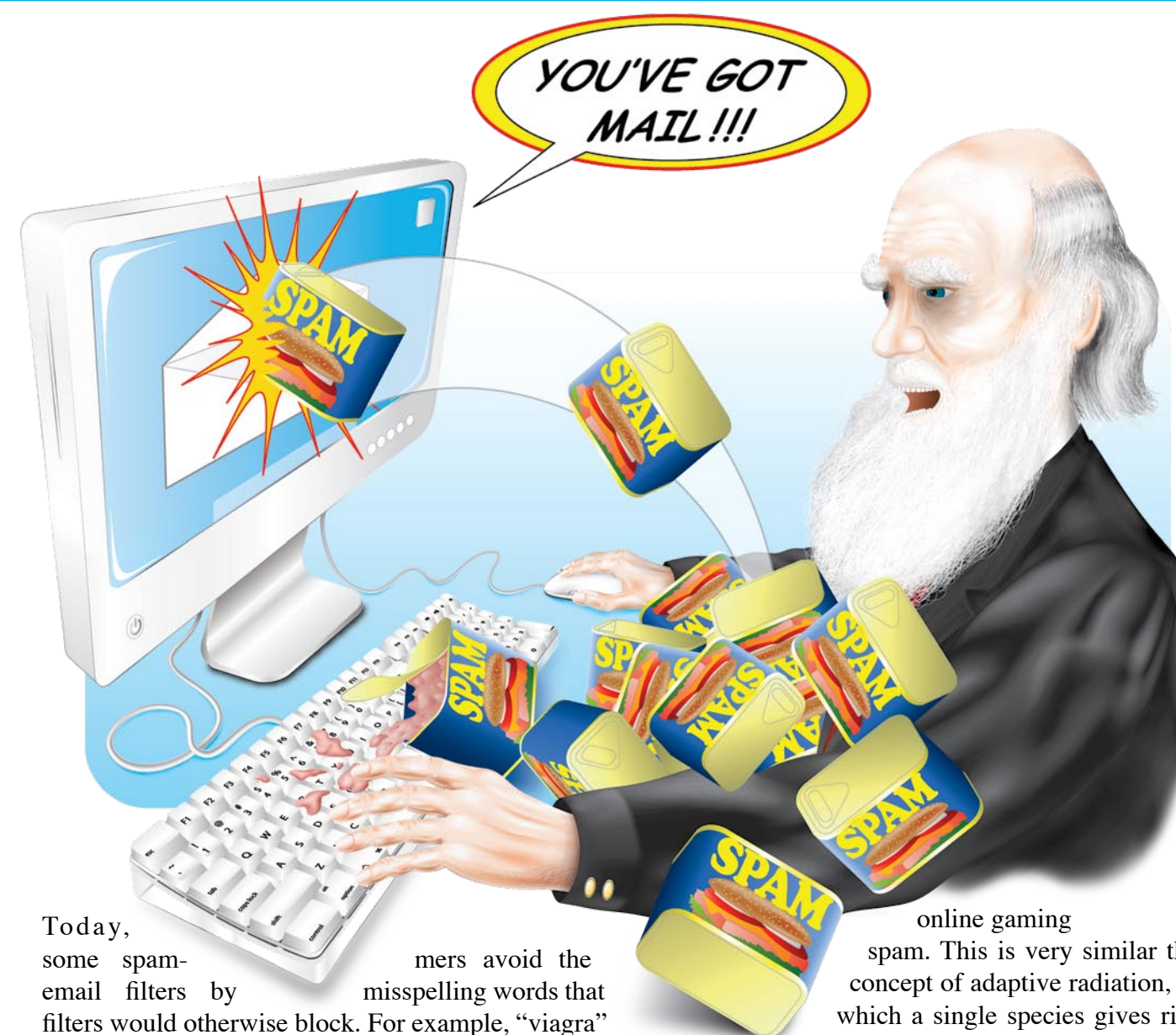
But why is spam such a problem? How can it be getting worse, if the technological advances against it keep getting better? After all, companies offering "anti-spam" software have become overnight, multimillion-dollar industries that are determined to can spam.

Enter the concept of the Natural Selection of Spam.

In the early years of spam, spammers sent out large numbers of email messages advertising almost anything imaginable (everything from nude pictures of tennis celebrities to the infamous Nigerian business scam). Anything was fair game, and consumers were left to delete each piece of spam as it was received.

However, the battle against spam soon kicked into high gear. Prompted by a lust for the mighty dollar (roughly 25% of polled AOL users were willing to pay extra for spam-blocking), companies raced to create software that could filter spam before it reached the inbox. Software designed for this purpose was initially successful. How did it work? Content filters scanned the subject lines of incoming messages for common spam-like phrases, such as "penis enlargement" and "Britney Spears."

Many millions of spams were thus blocked, and many millions of dollars were lost (yes, millions; believe it or not, enough people actually buy into the spam ads to create millionaires from the relentless peddlers). But spam producers have not taken this lightly. They noticed that certain spam emails -- those with innocent-sounding subject lines like "Re: your message," or those with subject lines that were accidentally misspelled -- were still getting through. In accord with these observations, spam perpetrators rebounded in force with more sophisticated, more resistant spam.



Today, some spam-email filters by misspelling words that filters would otherwise block. For example, "viagra" might be misspelled as "vaigra." Other spammers insert symbols or punctuation marks into the word to allow it to pass the filter. For instance, "viagra" might pass through as "vi/a/g./ra."

Such "spam-resistance" seems an apt example of Natural Selection (albeit in the electronic environment). Whereas the more vulnerable spam emails have been blocked and destroyed, those spams blessed with the good fortune of innocent-sounding subject lines or intentional misspellings have survived and multiplied.

But the evolution of spam doesn't end there. Today, there are many different types of spam, including IM spam ("spim"), blog spam ("blam"), chat spam, newsgroup/forum spam, mobile phone spam, and

online gaming spam. This is very similar the concept of adaptive radiation, in which a single species gives rise to a variety of new species over time. In nature, the Galapagos finches (sometimes called Darwin's finches) are represented by over a dozen species of finches that arose by adaptive radiation from a common ancestor that arrived on the isolated Galapagos Islands a long time ago.

All of this makes one wonder: had Darwin lived long enough to be greeted by such highly-evolved spam in his inbox, would he have been proud?

How does Natural Selection work? I defer to *The Simpsons*. In an early episode (“*Two Cars in Every Garage and Three Eyes on Every Fish*”), Mr. Burns hires an actor to portray Charles Darwin because he is trying to convince the public that a mutated, three-eyed fish caught in his nuclear power plant’s wastewater is actually a good thing:

**Mr. Burns:** Oh, hello, Charles. Be a good fellow and tell our viewers about your theory of Natural Selection.

**Darwin:** Glad to, Mr. Burns. You see, every so often, Mother Nature changes our animals, giving them bigger teeth, sharper claws, longer legs, or in this case, a third eye. And if the variations turn out to be an improvement, the new animals thrive and multiply, and spread across the face of the Earth.

Actually, there is quite a bit more to Darwin’s full theory of evolution by Natural Selection (also known as **Darwinism**). In brief, his explanation goes as follows:

- All populations have the potential to grow rapidly. For example, a few houseflies could produce enough offspring to cover Earth within a few generations if there were no limits to their population growth!

- But, most populations in nature are stable over time.

- Therefore, most offspring in a population must die. After all, predators and decomposers need to eat, too.

- Within a population, all individuals vary. No two individuals are exactly alike; just consider the Olsen twins.

- This variation is inheritable. Scientists now know that this is due to genes, but Darwin was ignorant about genetics and simply knew that traits could be inherited.

- Those individuals that are best suited to their environment survive and pass on their advantageous traits to their offspring. Unlike what the average *Disney* film portrays, not every individual can successfully escape predators, obtain enough food, or live long enough to produce offspring. Death is an important and inevitable aspect of the natural world.

Evolution by Natural Selection can be thought of as the act of editing a population by removing certain individuals. The late Harvard Biologist Stephen Jay Gould said that Natural Selection acts like a sieve, not like a sculptor. You can also think of Natural Selection like casting for a film: great actors and actresses aren’t created for the part, no matter how perfect they seem for the role. Instead, they are chosen from the population that auditioned.

It is also important to remember that individuals do NOT evolve...populations do! So when someone sarcastically tells you to evolve, politely explain to them that individuals cannot evolve, but they can grow up, which is what they should do.

It may surprise you to learn that this theory of evolution was actually published a year *before* Darwin published his famous book, by a man called Alfred Russell **Wallace**. Like Darwin, Wallace was an adventuresome naturalist who traveled the world and thought deeply about evolution. But Darwin gets all the praise because of his long-term deliberation on the topic; Darwin’s notebooks proved that he formulated his theory 15 years before Wallace did. Undoubtedly, though, even if Darwin had never been born, a similar description of evolution would have likely occurred around the same time.

Natural Selection is only one mechanism of evolution. As we will see in the Chapter 17, for instance, the long legs and necks of giraffes evolved not only through Natural Selection, but through another mode of evolution called Sexual Selection. But for now, let’s continue with our discussion of Darwin’s basic evolutionary debate.

### Darwin’s Argument Involved “Artificial” Intelligence

Keep in mind that evolution simply means that species change over time. Everyone should agree that species can evolve! Consider the domestication of animals and plants by humans. This example is one Darwin used to convert the masses, so to speak.

According to fossil and genetic evidence, dogs were first domesticated by humans around 10,000 years ago. Humans likely formed bonds with wild dogs for several purposes, including companion-

ship, guarding, and assistance in hunting. It didn’t take long for our ancestors to select certain varieties (“breeds”) of wild dogs that they liked. These breeds were different from wild dogs, due to normal variations among individuals; consider how the adorable runt in a litter of puppies differs from its siblings. Over many generations, humans created new forms of domestic dogs through **Artificial Selection**. Artificial Selection involves mating certain individuals of animals or plants to create a desired breed.

Artificial Selection goes something like this: remember Cruella DeVil from the movie *101 Dalmatians*? Her obsession with dalmatians (for the morbid purpose of making a fur coat) seems to be insatiable. Imagine that Cruella rounds up a large population of dalmatians. She mercilessly kills all of the dogs except for one unusual pup whose pattern of spots happens to resemble the Holy Cross. Even Cruella couldn’t kill that one! Instead, the pup survives, grows up, mates, and has a litter of dalmation puppies of its own. Cruella then discovers that some of the puppies have the same Holy Cross pattern of spots. Through the process of Artificial Selection, Cruella could develop a new breed of dog worth far more money than a coat made from their fur would bring in. Box 3 describes a real-life situation in which Artificial Selection like this actually occurred.

Okay, so Cruella is a fictitious character. In the real world, can certain breeds of canines be selected for and domesticated by people? Absolutely. Back in the 1940s a group of Russian scientists studied the process of canine domestication. They started out by observing foxes in fur farms. Most foxes in this population were difficult to handle and behaved like wild foxes. Only those individuals that did not exhibit fear or aggression towards humans were chosen and allowed to mate with each other. After 18 generations, the captive-bred offspring looked and acted very different from the original foxes: they were extremely affectionate towards people, their ears were floppy, and they grew curly tails. They had become domesticated through Artificial Selection.

Dogs, too, have evolved by Artificial Selection. As the Westminster Kennel Club Dog Show highlights, we now have hundreds of different types of dogs that never existed in nature, such as collies, pit bulls, retrievers, huskies, poodles, and chihuahuas.

Remarkably, they are all members of the same species. In very little time, geologically speaking, humans have changed a single species of wild dog into many different forms. This is also true for cats, birds, fish, mice, livestock, and many crop plants that humans have domesticated. Remember, when species change over time, we call it evolution! The fact that species can change over time (evolve) should NOT be the subject of debate or doubt...rather, we should discuss HOW and WHY those changes occur over time.

### Box 3. Made in America.

In 1981, Joe and Grace Ruga discovered two kittens on their doorstep in suburban California. Grace began feeding the kittens and noticed that their ears curled back in an unusual way. Although one kitty ran away, the other stayed. Shulamith, as the Rugas called her, enjoyed her new home and matured into an adult cat. She mated with another (normal) cat and gave birth to a litter of kittens, all of which had curled-back ears. The Rugas realized that the distinctive ears were a unique genetic variation, and started showing off their new breed of cat.

The public loved the new feline breed that the Rugas displayed at various cat shows. After consulting with scientists (who determined the trait was indeed genetic), carefully controlling the breeding of their cats, and earning the acceptance and recognition of the Cat Fanciers’ Association, the Rugas developed the official “American Curl” breed by 1991. American Curls have since become an international hit, and there are now two versions of this breed available: longhair and shorthair.

Within the span of a few years, an entirely new cat breed was thus created by Artificial Selection. As Darwin explained in his book, selection is an incredibly powerful evolutionary force. Imagine what Artificial or Natural Selection can create in a few thousands (or millions) of years!

**Table 1:** Evolutionary Fitness Challenge.

### Survival of the Fittest

In the late 1800s, the catch-phrase of Darwinism, “survival of the fittest,” was as popular as Paris Hilton’s “That’s hot!” and The Donald’s “You’re fired!” have been in recent years. The term fitness, however, has very a different meaning to an evolutionary biologist than it does to the layperson. Evolutionary **fitness** is the reproductive success of an individual. It can be measured as the number of surviving offspring produced in an individual’s lifetime. It is also called the **fecundity** of an individual. As the Geek Chic crowd might be the first to remind us, the most physically fit individuals in a population may not necessarily be the most evolutionarily fit!

To consider Darwin’s use of the term “fitness,” let’s submit some physically-fit action heroes to an Evolutionary Fitness Challenge. In Table 1, evolutionary fitness (number of children sired) is compared among various hunky heroes in Hollywood. Keep in mind that, as a relative measure of fitness, the average American woman has 2 children during her lifetime, according to the U.S. Census Bureau.

To date, athletic Vin Diesel has not passed on his genes to the next generation. On Darwin’s evo-

lutionary playing field, Vin has been left in the dark (or is that *Pitch Black*?). In contrast, Bruce Willis’ genes might *Die Hard*, since he and Demi Moore have collectively passed them on to 3 children. Arnold Schwarzenegger’s bulging biceps and prominent pecs have filled the big screen for almost three decades, from *Pumping Iron* to *T3: Terminator 3 (Rise of the Machines)*. But at almost 60 years old, just how “fit” is this blockbuster barbarian? Clearly, the Governor of California has relatively high fitness (4 kids), but he is not the fittest. Mild-mannered and modestly-muscled Mel Gibson is even more fit -- and more likely to let fly sexist and anti-Semitic rants while drunk -- and has as many kids in real life as he did in the movie *Patriot* (in which he played Captain Benjamin Martin, a widower with 7 children).

Darwin’s realm can be harsh on the male action hero’s ego. But if he talks the talk, shouldn’t Darwin walk the walk? How does the bearded sage and naturalist measure up, in terms of evolutionary fitness? Well, not even promiscuous Mick Jagger, who has 7 kids, meets the fitness of Charles Darwin. With 10 children, Chuck’s fitness makes most others seem weak in comparison. Who’s the girlie-man now, Arnold?

### Three Ways to Keep It Natural

Natural Selection can edit populations in several different ways. But before we discuss the modes of Natural Selection, we need to return to the concept of genetic variation in a population.

The photograph in **Figure x** depicts an interesting biological phenomenon called the **bell curve**, or **normal distribution**. The students in these photos were enrolled in my biology class at the University of Florida, and are standing in the Ben Hill Griffin Stadium (“The Swamp;” Go Gators!). The students are arranged according to height, from shortest to tallest (left-to-right, within each photo). Therefore, one column of students equals a group of students of the same height. When arranged as a whole, it is obvious that most students have a near-average height (in the middle of the bell curve), while only a few students are much shorter or taller than the average (at either edge of the curve). The average height corresponds to the highest column of students in each picture. The average height was 5’4” for females, shown in orange shirts, and 5’10” for males, shown in blue shirts.



**Figure 1:** Students distributed according to height.



**Figure 2:** Students distributed according to height.

This symmetrical, “bell-shaped” pattern is typical of most biological measurements. It shows that in any population, there will be considerable natural-born variation in the traits possessed by individuals. This variation allows for populations to be edited by Natural Selection. Other examples of measurements that conform to a bell curve are body weights, heart rates, running speed, and the amount of weight that can be bench-pressed or squat-thrust.

The range of variation in a trait in a population is also called the range of phenotypes. A **phenotype** is the physical appearance, such as the specific height, of an individual. Phenotypes are coded for by the genetic make-up, or the **genotype**, of that individual. Remember that in order for Natural Selection to work, the phenotypes in a population have to be based on genetics. Otherwise, the advantageous phenotypes are acquired (as in the faulty system of Lamarckian evolution), and would fail to be inherited! For example, if all women in a population in Southern California underwent breast implants to greatly increase their bust line, their female offspring would not inherit their moms’ bogus bosoms. If the phenotype isn’t based on a genotype, it isn’t heritable!

Now that we have that settled, let’s return to the three modes of Natural Selection, as follows:

**1. Stabilizing Selection.** As shown in **Figure x**, Stabilizing Selection narrows down the range of phenotypic variation in a population. This is similar to a reality show where fellow contestants are voted off by the group: the

weakest AND the strongest contestants may be the first to be voted off. Why would you vote off an above-average contestant? Because if you keep a superior contestant ‘on the island’ for very long, sooner or later you will compete against them and you will lose. As a result, the remaining individuals are often the most “mediocre” of the group! The range of variation is thus whittled down to the average.

**2. Directional Selection.** As shown in **Figure x**, Directional Selection shifts the range of phenotypic variation in a population in one direction. If the selective agent in this case is the NBA, the average basketball player will be taller and taller over time. In this mode of selection, today’s Shaq and Yao Ming might become tomorrow’s shortest players!

**3. Diversifying Selection.** As shown in **Figure x**, Diversifying Selection splits the range of phenotypic variation in a population into two (or more) distinct groups. Remember our depiction of the range of heights in students at the University of Florida? Even though the students all belong to the same species, males are taller than females. Both sexes follow the bell curve distribution, but the overall phenotypic variation has been split into two separate groups. When this occurs in a species, the population is called **polymorphic**. A **polymorphic** species is one in which there are two or more distinct groups of phenotypes, with little to no overlap between the groups. When the phenotypes of the two sexes differ within a species, that species is referred to as **sexually dimorphic**. We will discuss this in more detail in the next chapter.

### Natural Selection in Action

How does Darwin’s concept of evolution affect our everyday lives?

For one thing, it has a tremendous impact on human health care. For example, some strains of

bacteria are becoming resistant to antibiotics. This happens because of Natural Selection: in a large population of bacteria, some individuals will have a genetic-based resistance to a certain antibiotic. Those individual bacteria will survive while all other bacteria die in the presence of the antibiotic. The resistant bacteria reproduce and pass along their “advantageous” adaptations to more bacteria. In very little time, a deadly strain of bacteria -- one that is not killed by antibiotics -- evolves and becomes a major threat to human health. This is exactly what has happened in the case of the bacteria that cause tuberculosis and staph infections. What were once easily-treated bacterial diseases are now re-emerging as diseases of major concern.

Similarly, HIV (Human Immunodeficiency Virus, the virus that causes AIDS) is a very dangerous virus because it quickly adapts and becomes resistant to modern medicines. Trying to find a drug that kills HIV is like trying to shoot at a moving target that multiplies and changes shape before your eyes.

In agriculture, similar problems arise due to Natural Selection. Certain weeds and insects have evolved quickly and have become unaffected by the chemicals that farmers spray on their crops to destroy such pests. The “new and improved bugs” are a challenge to eradicate, and their populations can grow out of control.

Of course, not all aspects of Natural Selection are bad. As species evolve, they become better adapted to their environment. The very success of our own species -- due to an increasingly large and complex brain -- may be due to the very principles that Darwin proposed over a hundred years ago in his controversial book.

### Darwinism end-of-chapter questions

#### Key Words:

adaptations  
adaptive radiation  
Artificial Selection  
bell curve  
Darwinism  
directional selection  
diversifying selection  
evolution  
fecundity  
fitness  
fixed species concept

genotype  
hypothesis  
inheritance of acquired characteristics  
Natural Selection  
normal distribution  
phenotype  
polymorphic  
selective agent  
sexually dimorphic  
stabilizing selection  
theory

#### Review Questions:

- Charles Darwin’s observations of the adaptations of flightless birds, marine iguanas, and giant tortoises were made in
  - Africa.
  - Cuba.
  - the Bahamas.
  - the Hawaiian Islands.
  - the Galapagos Islands.
- The author of the book *On the Origin of Species by Means of Natural Selection* was
  - Anaximander.
  - Darwin.
  - Wallace.
  - Lamarck.
  - Ruga.
- Evolution is defined as
  - a change in a species over time.
  - a change in an individual over time.
  - simple forms changing into more complex forms.
  - one individual changing into another species.
  - one species changing into two new species.
- To say that organisms are constantly evolving means that they are always
  - improving.
  - changing.
  - getting bigger.
  - becoming more like humans.
  - becoming more complex.

5) Imagine that you propose an explanation for a certain phenomenon, such as how young birds migrate over long distances without any prior experience. Then, many different scientists test your explanation and it is always supported. Your explanation would become a scientific

- A) law.
- B) theory.
- C) hypothesis.
- D) prediction.
- E) concept.

6) Which of the following scenarios is **NOT** in accord with Lamarck's ideas of evolution?

- A) Deer will evolve longer necks by stretching to eat leaves from trees.
- B) If you do daily yoga exercises then your offspring will be more flexible.
- C) A bodybuilder's son might grow up to be weaker and thinner than average.
- D) A woman who always shaves her leg hair will have daughters with no leg hair.
- E) Short-tailed puppies will result if the parental dogs have their tails cut short.

7) The idea that the "use or disuse" of body parts in organisms can affect the appearance of their offspring was first published by

- A) Anaximander.
- B) Darwin.
- C) Wallace.
- D) Lamarck.
- E) Ruga.

8) Who developed and proposed the theory of evolution by Natural Selection?

- A) Darwin
- B) Wallace
- C) Lamarck
- D) both Darwin and Wallace
- E) both Darwin and Lamarck

9) Who suggested that giraffes developed their long necks over time by stretching?

- A) Darwin
- B) Lamarck
- C) Wallace
- D) Anaximander
- E) Captain FitzRoy

10) The theory of Natural Selection predicts that

- A) a well-adapted species will not change over time.
- B) every individual in a population will live long enough to breed.
- C) only the biggest and strongest individuals will live long enough to breed.
- D) few populations in nature will be stable over time (most are rapidly growing).
- E) the best-adapted individuals will contribute their traits to the next generation.

11) Which of these conditions was **NOT** part of Darwin's theory of Natural Selection?

- A) within a population, all individuals vary
- B) most populations in nature are stable over time
- C) most offspring in a population die before they breed
- D) advantageous traits are passed from parents to their offspring
- E) the variation among individuals in a population is not inheritable

12) Which of the following is an excellent example of Artificial Selection?

- A) the many different varieties of tomato plants
- B) snakes that can inject venom into their prey
- C) weightlifters putting on muscle mass by using steroids
- D) grey-colored lizards that blend into their rocky surroundings
- E) women undergoing breast implants to increase their bust size

13) If an individual has greater evolutionary fitness than another, it means that he or she

- A) is stronger.
- B) has more offspring.
- C) produces more sperm or eggs.
- D) can survive better.
- E) is faster.

14) Imagine that a population of elephants in Africa develops a longer average trunk over time. This is an example of

- A) directional selection.
- B) stabilizing selection.
- C) disruptive selection.
- D) Artificial Selection.
- E) a polymorphic species.

15) After a finch species from South America made its way to the Galapagos Islands, it evolved into a dozen or so new species. What happened in these "Darwin's Finches"?

- A) the original species became sexually dimorphic
- B) the species became polymorphic
- C) inheritance of acquired characteristics
- D) Artificial Selection
- E) adaptive radiation

Answers: E, B, A, B, B, C, D, D, B, E, E, A, B, A, E