**Chapter 9**

**An Evolving Enemy Natural Selection**

**Return of an Ancient Killer**

* Tuberculosis has infected humans for 1000s   
  of years.
  + Evidence of TB has been found in Egyptian mummies.
  + Hippocrates described a TB-like condition.
  + In 1906, TB accounted for 2 out of every 1000 deaths in the U.S.
* TB is caused by bacterium, *Mycobacterium tuberculosis.*
  + 2 billion people carry TB.
  + New infections occur at rate of 1 per second.
  + TB causes roughly 2 million deaths per year.
* Symptoms of TB include:
  + Cough that produces blood
  + Fever
  + Fatigue
  + Period of wasting – patient becomes weaker and thinner
    - Led to calling the disease “consumption”
* Consumptive symptoms occur because of damage to lung tissues.
* Transmission of TB occurs through the air, from infected individuals.
  + A single sneeze can contain 40,000 droplets, all containing infectious bacteria.
  + Most individuals can fight off the infections, except young children, elderly and immune compromised individuals.

**Return of an Ancient Killer - Treatment – and Treatment Failure**

* In the 19th and early 20th century, TB treatment consisted of “sanitariums.”
* The discovery of antibiotics revolutionized TB treatment.
* After 2 weeks of antibiotic treatment the individual is no longer contagious.
* However, treatment with antibiotics needs to continue for 6 to 12 months to completely eliminate the organism.
* Since the 1980s, scientists have noticed an increase in TB that is **resistant** to antibiotics.
* Because of resistance to antibiotics, the number of TB cases worldwide is increasing.
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* Because of resistance to antibiotics, the number of TB cases worldwide is increasing.
* There is a strain of TB that is now resistant to both the original treatment but also resistant to second-line drugs.
  + 1/3 of individuals with this extreme strain die of the disease

**Natural Selection Causes Evolution**

* Darwin discussed two ideas in *Origin*: common descent and **natural selection**
  + Natural selection is considered to be the primary cause of evolution
  + Other factors of evolution include genetic drift and sexual selection

**Natural Selection Causes Evolution - Four Observations and an Inference**

* Natural selection is an inference based on four observations:

1. Individuals within populations vary

2. Some of the variation within individuals can be passed on to their offspring

3. Populations of organisms produce more offspring than will survive

4. Survival and reproduction are not random

* Individuals within populations vary.
  + This is true of human and non-human populations.
  + Variation can include traits other than appearance, such as blooming time in flowers.
* Some of the variation within individuals can be passed on to their offspring.
  + Darwin noticed that animal breeders could get exaggerated traits through selective breeding.
* Populations of organisms produce more offspring than will survive.
  + Even slow-breeding animals can produce large populations quickly.
* Survival and reproduction are not random
  + **Fitness**: Relative survival and reproduction of one variant
  + **Adaptation**: Traits that increase individual fitness in an environment
  + Individuals with adaptations for a particular environment are more likely to survive and reproduce.
* Survival and reproduction are not random.
* Adaptations do not only affect survival.
  + A flower’s reproduction is impacted by traits that affect the number of pollinators it receives.
  + Therefore, color or nectar production might be adaptations.

**Natural Selection Causes Evolution - Darwin’s Inference: Natural Selection Causes Evolution**

* Result of natural selection
  + Favorable inherited variations tend to increase in frequency
  + Unfavorable variations tend to be lost
  + End result is a change in the traits of individuals in a population over generations

**Natural Selection Causes Evolution - Testing Natural Selection**

* **Artificial selection**: Selection imposed by human choice
  + Breeds of pigeons studied by Darwin arose through artificial selection
  + Breeds of dog have been artificially selected by humans
* In laboratory, environmental conditions can be manipulated and effects on population examined
  + Scientists examined alcohol metabolism in fruit flies
  + Variations in ability to metabolize alcohol exist in populations
* Natural selection in wild populations
* Many examples exist:
  + Evolution of resistance of *M. tuberculosis* to antibiotics
  + Many other disease-causing pathogens have also evolved resistance
  + Galapagos finches provide another classic example
  + Blue mussel has evolved the ability to thicken its shell to protect against the invasive Asian crab species.

**Natural Selection Since Darwin - The Modern Synthesis**

* The union of genetics and evolution is called “the **modern synthesis**.”
  + Knowledge of genetics facilitates understanding of the mechanisms of evolution.
  + Alleles are the basis of variation of traits.
  + Half of the alleles carried by a parent are passed to their offspring through their egg or sperm.
  + Mutations can create new alleles and provide the basis for new traits.
  + Natural selection provides a filter that selects for or against new traits.
* Mutation and natural selection

**Natural Selection Since Darwin - A Closer Look: Subtleties of Natural Selection**

* Natural selection cannot cause new traits to arise
  + Not an issue of choice or “will” of organisms
  + Selection can only act on variations that already exist
  + For example, alcohol-rich environment in flies did not cause a gene to arise, instead differential survival caused allele to become more common
* Natural selection does not result in perfection
  + Natural selection does cause organisms to become a better fit to their environment
  + Organisms are not necessarily “better,” just better fit to a particular situation
  + Adaptation that is beneficial in one situation might be a liability in another
  + Adaptations are trade-offs between better fit in one situation versus another
  + Adaptations are constrained by underlying biology
* Natural selection does not cause progression towards a goal
  + Natural selection favors variants with the most appropriate adaptations for current environment
  + Organisms do not choose to change or adapt
  + Natural selection depends on the situation of the population

**Natural Selection Since Darwin - Patterns of Selection**

* Different environmental conditions can lead to different changes in populations
  + Directional selection – change in population traits
  + Stabilizing selection – selection for the average traits
  + Diversifying selection – selection for extremes

**Natural Selection and Human Health - Tuberculosis Fits Darwin’s Observations**

* *Mycobacterium tuberculosis* has evolved resistance to antibiotics because it fulfills the same observations Darwin made
  1. Organisms in the population vary
  2. The variation among organisms can be passed on to offspring
  3. More organisms are produced than survive
  4. An organism’s survival is not random

**Natural Selection and Human Health - Selecting for Drug Resistance**

* Simple antibiotic treatment can result in directional selection in bacteria.

**Natural Selection and Human Health - Stopping Drug Resistance**

* Combination therapy is a powerful tool against drug resistance.

**Natural Selection and Human Health - Can Natural Selection Save Us From Superbugs?**

* If bacteria can evolve resistance to antibiotics, can humans evolve resistance to bacteria?
  + Humans do vary in their immune capacity
  + To evolve resistance to superbugs would require many humans to die
  + Evolution of resistance requires exposure to pathogens, most humans are never exposed
  + Natural selection has also resulted in our brains, giving us another tool to fight disease