**Chapter 10**

**Prospecting for Biological Gold Biodiversity and Classification**

**Biological Classification- How Many Species Exist?**

* **Biodiversity** is the variety within and among living species.
  + Number of species known to science is between 1.4 and 1.8 million
  + Uncertainty due to differences in methods of storing and describing specimens
  + Total number of species – estimates range from 3 – 100 million
* **Systematists** are scientists who specialize in describing and categorizing organisms.
  + They work in the field of **biological classification**.
* Biological collections such as natural history museums and herbaria store samples of the different species.
  + Systematists evaluate these collections to determine overlap in identifying of species.

**Biological Classification - Kingdoms and Domains**

* Modern species are divided into three large groups, or domains.
  + Bacteria, Archaea, and Eukarya
* Within Eukarya, four kingdoms are also recognized
  + Plantae
  + Animalia
  + Fungi
  + Protista
* Recently, some scientists have begun to suggest that organisms should be classified based on evolutionary relationships.
  + Major groups under this system correspond to divergences early in life’s history.
  + Determining evolutionary relationships requires comparing DNA.

**The Diversity of Life - Bacteria and Archaea**

* Life on earth arose at least 3.6 million years ago, according to the fossil record.
  + Most ancient fossilized cells are very similar to modern **bacteria** and **archaea**
  + **Prokaryotes** like bacteria and archaea don’t have a nucleus, lack mitochondria and chloroplasts, and most are **unicellular**
  + Incredibly numerous and diverse
  + Found on every square centimeter of the earth’s surface, even inside deep sea vents, far underground, and in clouds
* **Domain Bacteria**
  + Most bacteria are probably harmless to humans.
    - We are most familiar with the ones that cause disease
    - Many known bacteria obtain nutrients by decomposing dead organisms
  + Competition between bacteria has produced compounds that humans make use of.
    - **Antibiotics** – ~50% of antibiotics are derived from bacterial sources
    - Restriction enzymes – proteins that chop DNA at specific sequences; useful in biotechnology
* **Domain Archaea**
  + Superficially similar to bacteria
    - Differ in structure of cell membranes
    - Archaeans typically found in extreme environments (high temperature, high pressure, high salt concentration)
    - *Taq* polymerase comes from an archaean, *Thermophilus aquaticus*
    - Archaeans are likely to be source of other interesting biomolecules

**The Diversity of Life – Domain Eukarya**

* Evolution of the **Eukaryotes**
  + Protists are the simplest of the eukaryotes
  + Oldest eukaryotic fossils are ~2 billion years old, 1.5 billion years later than the first prokaryotic cells
  + **Endosymbiotic** theory explains the evolution of eukaryotes and their specialized structures.

**The Diversity of Life – Protista**

* Modern protists contain members that resemble animals, plants, and fungi.
  + Most members of the kingdom are not known
  + No agreement among scientists on number of groups below kingdom
    - Number of proposed groups ranges from 8 to 80
  + **Algae** has the ability to manufacture food.
* Bioprospectors have examined the plant-like protists most closely for useful compounds.
  + Natural selection has driven the evolution of defensive compounds in these organisms.
  + Extracts from red algae might be used in anti-viral medication.
  + Carageenan, a stabilizer and thickener, also comes from protists.

**The Diversity of Life – Animalia**

* Animals comprise a wide range of organisms, but all share a common set of characteristics.
  + Multicellular
  + Heterotrophic (must eat to get energy)
  + Mobile during at least one stage of life
* By 530 million years ago, all modern animal groups were present.
  + Most appeared quickly in fossil record
  + Multicellular organisms quickly proliferated
  + Known as **Cambrian explosion**
* Most bioprospecting work focuses on invertebrates.
  + Vertebrates only account for ~4% of animals
  + Invertebrates are far more numerous and diverse
  + Many invertebrates produce compounds found nowhere else in nature

**The Diversity of Life – Fungi**

* Fungi characteristics
  + Immobile
  + Many reproduce by releasing **spores**
  + Heterotrophic
    - Feed by means of hyphae
    - The hyphae of fungi can extend over a very large area
  + DNA analysis by **mycologists** indicates fungi is more closely related to animals than to plants
* Commercially important fungal forms
  + Yeast is a single celled type of fungi that is used in bread, wine, and beer making.
  + Mold is quickly reproducing and fast growing to produce flavorful cheeses
* Fungi produce a number of important drugs
  + Antibiotics
  + Cyclosporin
  + Statins

**The Diversity of Life – Plantae**

* Characteristics of Plantae
  + Multicellular
  + Eukaryotic
  + Autotrophic (manufacture own food) via photosynthesis
* Plants have been present on land for ~400 million years.
  + First plants were low to ground, lacked **vascular tissue**
  + Evolution of vascular tissue for water and nutrient transport
    - Allowed growth to tree size
    - Allowed growth in drier areas
  + Most modern plants in group only ~140 million   
    years old
    - **Flowering plants**
* Over 90% of modern plants are flowering plants   
  and many specializations
  + Rapid increase of flower plant species is called **adaptive radiation**.
  + Flowering plants employ double fertilization method or reproduction
  + Also often involve animals in reproductive process (pollination)
  + Also synthesize many **secondary compounds** that deter predators
* Kingdom Plantae is the source of many drugs and compounds.
  + Source of most naturally derived drugs
  + Aspirin, Digitalis, Morphine, and Caffeine
* Pharmaceutical manufacturers reproduce hundreds of compounds first found in plants

**The Diversity of Life – Viruses**

* A virus consists of a strand of DNA or RNA.
  + Considered non-living because they are unable to grow or reproduce without assistance from other organisms
  + Viruses hijack transcription machinery of cells to reproduce
  + Once hijacked cell cannot perform own functions
  + HIV, SARS, smallpox, polio, influenza are all caused by viruses

**Learning About Species – Fishing For Useful Species**

* The National Cancer Institute has employed a brute-force approach to looking for anti-cancer compounds.
  + Receive specimens from around the world, extract materials and screen against cancer cell lines
  + One major compound, Taxol, has been identified using this technique

**Learning About Species – Understanding Ecology**

* Understanding an organism’s **ecology**—how it lives in its environment—can be helpful in evaluating potentially beneficial compounds.
  + Survival in extreme environments
  + High levels of competition with bacteria and fungi
  + Susceptibility to predation
  + Ability to live on or in other organisms
  + Survival in high population densities

**Learning About Species – Reconstructing Evolutionary History**

* A classification system reflecting evolutionary relationships is more useful to scientists.
  + An organism’s chemical traits will probably be similar to those of its closest relative
  + If looking for new compounds, could begin by screening close relatives of organisms already known to produce compounds
* The challenge in making an evolutionary classification is that organisms do not always resemble their closest living relatives.
* Reconstructing evolutionary history not always as easy as the sparrow example.
* Can be confounded by loss of traits, and convergence
* DNA provides a means of testing evolutionary hypotheses

**Learning About Species – Testing Evolutionary Classifications**

* Scientists can test evolutionary hypotheses with data from fossils and from living organisms.
  + Fossils provide information about the genealogy of different living groups
  + Comparison of DNA from living organisms can also validate or refute proposed classifications
  + DNA supports vulture classification, but does not support sparrow classification
  + DNA can give clues to near relatives, but lab process can take time

**Learning About Species – Learning From the Shamans**

* Often local people in biologically diverse areas make extensive use of naturally occurring products.
  + Shamans often have much knowledge of locally useful compounds.
  + **Biopiracy** is when local knowledge is used without benefiting local people.
  + UN Convention on Biodiversity is supposed to address this.
  + Our biodiversity represents an enormous potential, but only if we recognize its value.