Introduction to Biology: an overview

biology: science of living organisms and life processes, including the study of structure, function, growth, origin, evolution and distribution of organisms

biology is an umbrella more specific areas of study:

cytology - cells
histology - tissue
zoology - animals
botany - plants
limnology – brackish water
ecology – the relationship between an organism and its environment
pathology - diseases
evolutionary biology – changing of an organism over time
herpetology - reptiles
ornithology - birds
ichthyology - fish
mammology - mammals
vertebrate zoology – animals with backbones
invertebrate zoology – animals without backbones
taxonomy – classification
anatomy - structure of bones
morphology – shape/form
osteology – bones
biochemistry – chemistry of life
genetics – heredity
microbiology – bacteria
entomology – insects
animal husbandry – mating/breeding

Overview of Life's Unity (How to Define Life)

- life is extremely diverse, yet there are some unifying characters all living organisms share

characteristics (unity) of life - all living things have:

organization (unity) of life on earth: a hierarchy (molecules → cells →organs …)

- most important is the DNA molecule
- each level is based on the level below it and provides the basis for the one above it (simple to complex)

emergent properties – inactions between the parts making up the whole

subatomic particles - particles that make up an atom (protons, neutrons, and electrons)

atom - smallest particle of an element that has the properties of that element (H, Al, Fe, O)

molecule - 2 or more joined atoms (H_2 + O = water)
organic molecules = composed mainly of C

organelle - structure within a cell that performs a specific function, cannot survive on its own

cell - smallest unit of life **unicellular** - composed of one living cell
- must contain DNA, be able to perform chemical reactions (gather food for E, expel waste…), surrounded by a membrane for protection

tissue - group of cells that perform a function together (brain tissue, lung tissue)

organ - structure composed of tissues that function together (brain, lung)

organ system - two or more organs working together (nervous system)

organism - all organ systems functioning together to make up a single living individual

multicellular organism – living individual composed of >1 cell

species - group of genetically similar organisms (lion)

population - members of the same species living together (lion pride)

community - populations of different species living together
(lion pride, zebra herd)

ecosystem or **biome** - community plus its non-living environment
(water, soil, temp…)

- **terrestrial** (land) ecosystem = tropical rain forest, grasslands
- **aquatic** (water) ecosystem = lakes, ponds, coral reef

biosphere - earth and its' living (**biotic**) & non-living (**abiotic**) components

- in ecosystems, the same nutrients keep cycling through populations, but E flows because it is eventually converted to heat

- human populations tend to modify existing ecosystems for its own purpose

- biodiversity is being threatened by these changes

biodiversity = # and size of populations in a community
- estimated as high as 80 million species with only about 2 million identified and named
- 24 – 100 species lost daily to human activity

extinction – the death of a species or larger classification category
extinct in the wild – only found in captivity, no longer in nature

metabolism (implying change)
- acquire and use materials (nutrients) to obtain E, this E carries out chemical reactions such as growing/reproducing
- nutrients from the air, water, soil

energy (E) = the ability to do work

How do organisms acquire these nutrients?
producers (**autotrophy** - "self-feeder") – photosynthesis
consumers (**heterotrophy** - "other feeder")
decomposers – breakdown material to be recycled

homeostasis (**homo** = the same; **stasis** = standing)

- maintenance of relatively constant internal body conditions (pH, temp (37^{o}C), water)
- all organisms have a range of tolerance, cells perform chemical reactions in order to maintain internal conditions within these ranges

ability to grow and develop

ability to reproduce - all living things pass on their DNA, the genetic information within all organisms

- asexual → DNA from one parent, identical offspring
  - bacteria, plants, sponges, ….
- sexual → exchange of DNA, two parents, genetic mix

ability to respond to stimuli – with the aid of **receptors**

- light, sound, the presence of prey

capacity to evolve - the genetic info. of one organism stays the same over its lifetime; however, variations between parents and offspring allow for the genetic material of a species to change over time

An Evolutionary View of Diversity

= heritable change in a line of descent over time

What causes change: **mutations** = changes in DNA

three basic concepts of evolution:

1. **genetic variation exists within a population**:
   - differences in the actual genetic code occur in individuals of the same population

2. **inheritance** of those differences occurs when parents pass them to their offspring

3. **natural selection** occurs

- allows for the survival and increased reproduction of the individuals with the most favorable genetic variations over time

physiological processes (improved digestion)
behavior (new way to gather food)
shapes (better at hiding from predators)
sizes (long legs for running)

- **evolve** to enable an individual to be better suited to its environment → this is an **adaptation**

- if the environment changes, the adaptation may no longer be beneficial over a long period of time; this may change the genetic make-up of a population as new adaptations arise

difference between acclimation and adaptation:

acclimation = a temporary adjustment to an environmental condition
= when you reduce the temp. in a fish tank; the fish responds by changing their breathing rates - they are adjusting to a new environment

adaptation = an inherited genetic trait passed on from parent to offspring
- the result of evolution over a tremendous amount of time is a vast variety of species each with its own set of requirements for living:
= interrelationships between predators, prey, parasites
= temperature, nutrient & water requirements

biodiversity - the diversity of species and the complex interrelationships that surround each of them

artificial selection – one form of a trait is favored over another in an artificial environment under contrived, manipulated conditions.
(dogs, cats, cows, corn)

If So Much Unity, Why So Many Species: Living Things Classified

taxonomy (*tasso* - arrange, classify; nomas – usage, law)
- the discipline of identifying and classifying organisms according to certain rules
- each species is given a **binomial** (*bis* = two; *nomen* = name)
  Bison bison (Genus species) or Bison bison

Carolus **Linnaeus** = Father of Taxonomy 1735
- developed the binomial system of naming organisms

Categorizing the Diversity of Life
- a hierarchy usually categorized by:
  cell number → unicellular vs. multicellular
  cell type → prokaryotic vs. eukaryotic
  how E is acquired → producer vs. consumer

Cell types:

1) **Prokaryotic** "no nucleus":
   Domain:
   Bacteria "true-bacteria" – decomposers of the world
   = distributed in various environments
   Archaea - live in extreme environments
   = hot springs, high salinity, low pH, etc.

   - unicellular organisms which are structurally similar, metabolically complex
   - can be autotrophic or heterotrophic or decomposers

2) **Eukaryotic** "true nucleus":
   Domain:
   Eukarya
   - mostly multicellular organisms
   - some unicellular organisms

   Kingdoms
   Protista – auto/heterotrophic or decomposers;
   uni/multicellular (euglena, amoeba, kelp)
   - protists are currently being split up

Fungi - multicellular; heterotrophic or decomposers (molds, mushrooms)

Plantia - multicellular; autotrophic (photosynthesis → oaks, roses, grasses

Animalia - multicellular; ingest their food
herbivores = plant eater (zebra, deer)
carnivores = meat eaters (lions, wolves)
parasites = host eater (tapeworm)
decomposers = eat dead things (vultures)
insectivores = insect eaters (bats, spiders)
omnivores = plant and meat eater (humans)

- broken down further into: **Phylum**, **Class**, **Order**, **Family**, ***Genus species*** (or **Genus species**)

The Nature of Biological Inquiry: The Process of Science

biology – the scientific study of life

science: an organized body of knowledge that attempts to explain natural phenomenon with a collection of facts and theories, a process of discovery, it is self-correcting and solves problems, searches for patterns with observable data, information processing.

inductive reasoning – using isolated facts and creative thinking to come up with a possible explanation for your observations; creating a hypothesis

deductive reasoning – once the hypothesis is stated, it is a general statement that infers a specific conclusion; information based on previous work

Scientific Method - method of asking questions and testing those questions

observation: using your senses

- gather supporting information (Internet, journals)
  = previous data

hypothesis: generate an explanation for your observation, must be testable

experiment: a test for data collection and results to support or reject your hypothesis

variables - within an experiment, one variable/ factor must change
  independent var. – what is changed
  dependent var. – response to change

control – a standard used for comparison against one or more experimental groups (the baseline)

replication - repeats the experiment to obtain consistent results
- gives "power" to the experiment, able to average results

conclusions: explanation of your results in order to inform other people (graphs, publication)

theory: general explanation of a natural phenomenon, after much testing; concepts that join together well-supported and related hypotheses

- fundamental principles of biology such as:

  cell theory - all living things are composed of cells

  biogenesis (**bio** = life; **genesis** = first) – life comes from life

  evolution – all living things have a common ancestor and are adapted to a particular way of life

  gene – organisms contain coded information that dictates their form, function, and behavior

all science is based on a small number of **assumptions** thoroughly tested and found to be valid:

1. all events can be traced to **natural causes** that can be understood (i.e. supernatural powers are not part of science)

2. **laws** derived from nature are uniform in space and time and do not change: light, gravity, interactions between atoms, etc.

3. **objectivity**: science requires all people remain objective during scientific pursuits

Read through experiments at the end of the chapter to understand the scientist process including terms.