AP Biology Exam Review

Unit 1. The Chemistry of Life

Section 1: Chemistry

Bonds

- Ionic
- Covalent (polar, non-polar)
- Hydrogen

Section 2: Water

Properties

- Excellent solvent
- High heat capacity
- Solid (ice) less dense than liquid (water) – ice floats
- Strong cohesion & surface tension
- Strong adhesion

Water Properties & Cell/Organism/Community/Global Environment

- Climate (coastal vs. inland, global patterns)
- Life in lakes survive in winter
- Cellular reactions, protein folding
- Transpiration, water movement in xylem

Section 3: Macromolecules

Organic Molecules

- Carbon, 4 valence electrons
- Monomers, dimers, polymers
- Functional groups
- Recognize major classes from a structural formula

Carbohydrates

- Function: energy storage, structure
- Structure: monosaccharides, disaccharides, polysaccharides, glycosidic bonds
- Examples: sugars, starch, glycogen, cellulose, chitin

Proteins

- Function: structure, transport, defense, catalysis, genetic “traits”
- Structure: amino acids, peptide bonds, primary, secondary, tertiary, quaternary
- Examples: enzymes, hair, silk, antibodies

Lipids

- Function: energy storage, structure, hormones
- Examples: triglycerides (fats, saturated, unsaturated), phospholipids, steroids (cholesterol, sex hormones)

Nucleic Acids

- Function: information storage
- Structure: nucleotides, A, T, C, G, U
- Examples: DNA, RNA

Section 4: Enzymes

Metabolic Processes

- ATP
- Coupled reactions
- Catabolism (digestion, breakdown, hydrolysis)
- Anabolism (synthesis, dehydration synthesis)

Enzyme Characteristics

- Structure: globular tertiary or quaternary proteins
- Function: metabolic catalysts = lower activation energy
- Lock & key model, induced fit model, substrate, active site, enzyme-substrate complex, products
- Enzyme name usually ends in “ase”, substrate-specific, unchanged during reaction

Factors Affecting Function

- Temperature, pH, salts, [substrate], [enzyme]
- Coenzymes, cofactors
- Activators, allosteric, cooperativity
- Inhibitors: competitive, non-competitive, allosteric
- Negative feedback

UNIT 2. THE CELL

Section 1: Cell & Cell Membrane Structure & Function

Classification

- Prokaryotes (bacteria, Domain Archaea, Domain Bacteria): naked circular DNA, ribosomes, no nucleus or membrane-bound organelles, sometimes cell wall (Domain Bacteria cell walls contain peptidoglycan)
- Eukaryotes (Domain Eukarya): nucleus and membrane-bound organelles
- Animals: lysosomes, centrioles
- Plants: cell wall, chloroplasts, central vacuole

Organelles & Other Structures

- Relationship of structure to function
- Nucleus, ribosomes (no membrane), ER, Golgi, vesicles, mitochondria, chloroplasts, lysosomes, centrioles, vacuoles
- Motility: flagella, cilia
- Cytoskeleton: microtubules, intermediate filaments, microfilaments
- Cell wall (plants, some prokaryotes)
- Cell junctions: desmosomes, tight junctions, gap junctions, plasmodesmata

Cell Membrane Structure

- Phospholipid bilayer: hydrophilic heads, hydrophobic tails, amphipathic, fluid mosaic model
- Proteins
- Integral and transmembrane: channel, transport, electron transport chain
- Peripheral: recognition, receptor, adhesion

Cell Membrane Function – Movement of Materials

- Selectively permeable
- Diffusion, osmosis, facilitated diffusion, active transport
- Hypertonic, hypotonic, isotonic, plasmolysis
- Vesicular transport: exocytosis, endocytosis, phagocytosis, pinocytosis

Section 2: Cellular Respiration

Overview

- Oxidation – reduction reaction (redox, “LEO say GER”)
- Converts “food” (either ingested by heterotrophs or photosynthesized by autotrophs) into energy of ATP
- $C_6H_{12}O_6 + 6O_2 > 6CO_2 + 6H_2O$ + energy (ATP)
- Glycolysis: all organisms, cytosol
- Chemiosmosis: all eukaryotes, mitochondria
- Summary diagram on page 189
- Focus on the end products, where O_2 is used, where CO_2 is produced, why fermentation is less efficient

Glycolysis

- Glucose > pyruvate
- Cytosol
- Yield: net 2 ATP, 2 NADH, 2 pyruvate

Kreb’s Cycle (Citric Acid Cycle)

- 2 pyruvate > 2 acetyl CoA
- Matrix of mitochondria
- Yield: 2 NADH

- 2 acetyl CoA > Electron Transport Chain
- Matrix of mitochondria
- Yield: 2 ATP, 6 NADH, 2 FADH2, 6CO2 (by-product, waste)
- Total yield of energy and electron acceptors = 2 ATP, 8 NADH, 2 FADH2
- Function: produce electron acceptors for ETC

Electron Transport Chain (ETC)

- Chemiosmosis, oxidative phosphorylation
- NADH & FADH2 donate electrons to ETC, cytochrome carrier proteins in mitochondrial membrane, pump H+ ions to intermembrane compartment, H+ flow down concentration gradient through ATP synthase, phosphorylate ADP > ATP
- O2 is the final electron acceptor
- Yield: approximately 36 ATP
- Inner membrane of mitochondria, cristae
- Anaerobic respiration: no O2, lactic acid (animals), alcoholic fermentation (plants, bacteria, yeast)

Section 3: Photosynthesis

Overview

- Light + 6H2O + 6CO2 > C6H12O6 + 6O2
- Chemiosmosis, autotrophs, chloroplasts
- ATP and sugar production
- Interaction between light and dark reactions
- Green plants, pigments, chlorophyll

Light Reactions

- Chloroplasts, thylakoid membrane
- Non-cyclic photophosphorylation
- Photosystem II (P680), photolysis, primary electron acceptor, electron transport chain, ADP > ATP (phosphorylation)
- Cyclic photophosphorylation

Calvin Cycle (Light-Independent or "Dark" Reactions)

- Chloroplast, stroma
- Carbon fixation, Rubisco, CO2 + RuBP > PGA (3C) > glucose (6C)
- C3 metabolism

C4 & CAM Photosynthesis

- Photorespiration, inefficiency of Rubisco in high [O2]
- C4
    - Separate 2 steps of carbon fixation anatomically, in two different cells
    - PEP carboxylase in out ring of mesophyll cells, 4C "storage" compounds (oxaloacetate, malate)

    - Moves carbon by regenerating CO_2 in bundle sheath cells to Rubisco & Calvin Cycle
    - Grasses, corn, rice, sugar cane
- CAM
    - Separate 2 steps of carbon fixation temporally, at two different times
    - Fix carbon at night (when stomates are open), put in "storage" compound (organic acids); during the day, when the stomates are closed, release CO_2 from "storage" compounds to Calvin Cycle
    - Cacti, succulents, pineapple

Section 4: Cell Cycle & Mitosis

Cell Cycle

- Cell spends most of its life in interphase (not dividing)

Mitosis

- Clones, asexual reproduction, growth, repair
- Chromosomes, chromatids, centromere, complementary strands
- Sequence: Interphase, G1, S, G2, G0
- Prophase, metaphase, anaphase, telophase
- Cytokinesis: cleavage furrow (animals), cell plate (plants)
- Cell division triggered by growth (surface-to-volume ratio, density dependent inhibition

UNIT 3. GENETICS

Section 1: Meiosis

Gamete Production

- 1^{st} division of meiosis separates homologous pairs
    - Reduction division, diploid > haploid, 2n > 1n
    - Interphase 1 (DNA replicates), prophase 1 (crossing over), metaphase 1, anaphase 1, telophase 1
    - Crossing over: tetrad, synapsis
    - Independent assortment
- 2^{nd} division of meiosis separates sister chromatids (like mitosis)
    - Haploid > haploid, 1n > 1n
    - No DNA replication prior to meiosis 2
    - Prophase 2, metaphase 2, anaphase 2, telophase 2

Function

Haploid gamete (sex cell, egg, sperm) production
Genetic variation & recombination

Section 2: Heredity

Note: No calculators are allowed, so problems will be "simple"

Mendelian Inheritance

- Locus, gene, allele, homologous pairs, dominant, recessive, phenotype, genotype, homozygous, heterozygous, monohybrid cross, dihybrid cross; P, F1, F2 generations, test cross
- Law of Segregation: random segregation/separation of alleles to separate gametes
- Law of Independent Assortment: chromosomes segregate separately from other non-homologous chromosomes

Non-Mendelian Inheritance

- Incomplete dominance, codominance, multiple alleles, epistasis, pleiotropy, polygenic inheritance, linkage, sex-linked, X-inactivation, non-disjunction, deletion, duplication, translocation, inversion

Section 3: Molecular Genetics

DNA Replication

- Semiconservative replication, template strand, DNA polymerase, leading strand, lagging strand, Okazaki fragments, helicase, replication fork, single stranded binding proteins, DNA ligase, RNA primase, RNA primer, 3' vs. 5' end
- Mutations: deletion, substitution, insertion, frame shift

Protein Synthesis

- One-gene-one-enzyme hypothesis, one-gene-one-polypeptide hypothesis
- Transcription: mRNA, RNA polymerase
- RNA processing: introns, exons, 5'cap, poly-A tail
- Translation: mRNA, codon, tRNA, anticodon, ribosome, small ribosomal subunit, large ribosomal subunit, P site, A site, wobble, stop codon, start codon (Met), initiation, elongation, termination

DNA Organization

- Chromatin, histone proteins, nucleosomes, euchromatin, heterochromatin, transposons

Viruses

- Bacteriophages, capsid, envelope, lytic cycle, lysogenic cycle, retroviruses, reverse transcriptase

Bacteria

- Plasmids, conjugation, transduction, transformation

Operons

- Regulation of gene expression

- Regulatory gene, repressor protein, promoter, operator, structural gene
- Inducible enzyme: lac operon, normally "off', when lactose is present binds to repressor, causes repressor to disengage from the DNA, allows DNA to actively code for protein/enzyme that will break down lactose
- Repressible enzyme: trp operon, normally "on", when Tryptophan (corepressor) is present in high enough quantities, binds to repressor that in turn binds to DNA, prevents protein/enzyme product from being made

Section 4: Biotechnology

Recombinant DNA

- Restriction enzymes, sticky ends, ligase, plasmids (vector), transformation, antibiotic selection, genetically modified organisms

Other Technologies

- Gel electrophoresis, RFLPs (restriction fragment length polymorphisms), PCR (polymerase chain reaction), DNA library, cDNA library, reverse transcriptase, probes, DNA sequencing, Human Genome Project, Southern blotting

UNIT 4. MECHANISMS OF EVOLUTION

Section 1: Darwinian Evolution

Evidence

- Paleontology, biogeography, embryology, comparative anatomy, homologous structures, analogous structures, vestigial structures, molecular biology, artificial selection

Natural Selection

- Over-production of offspring, inherited variation, competition, adaptations, fitness, reproductive success of advantageous traits
- Stabilizing selection (human birth weight, extremes selected against - too small won't survive, too big difficult birth), directional selection (pesticide resistance, peppered moth), disruptive selective (opposite of stabilizing), sexual selection (male competition, female choice)
- Variation: mutation, sexual reproduction (crossing over, independent assortment, random fertilization), diploidy, heterozygosity, pool of recessive alleles, out-breeding

Section 2: The Evolution of Populations & Speciation

Hardy-Weinberg Equilibrium

Conditions for genetic equilibrium (no change in gene pool/allele composition)

- Infinitely large population

- No natural selection
- No mutations
- No gene flow (no migration)
- Completely random mating
    - Frequency of alleles: $p + q = 1$
    - Frequency of genotypes or individuals: $p^2 + 2pq + q^2 = 1$

Causes of non-equilibrium (i.e., evolution)

- Genetic drift: founder effect, bottleneck
- Natural selection, gene flow, mutation, non-random mating, sexual selection

Speciation

- Adaptive radiation
- Allopatric: geographic isolation
- Sympatric: reproductive isolation
    - Prezygotic isolation
        - Habitat isolation
        - Temporal isolation
        - Behavioral isolation
        - Mechanical isolation
        - Gametic isolation
    - Postzygotic isolation
        - Reduced hybrid viability
        - Reduced hybrid fertility
        - Hybrid breakdown

Patterns of Evolution

- Divergent evolution, adaptive radiation
- Convergent evolution, analogous structures
- Parallel evolution
- Coevolution
- Macroevolution: gradualism vs. punctuated equilibrium

Origin of Life

- Methane, ammonia, water vapor, hydrogen
- Early earth and atmosphere: low or no O2
- Complex molecules in primordial seas, monomers, polymers
- Organic molecules and early cells formed
- Heterotrophic prokaryotes
- Autotrophic prokaryotes: O2 and ozone layer formed
- Eukaryotes formed, endosymbiotic theory
    - Mitochondria and chloroplasts have own DNA, reproduce independently (~binary fission), and have ribosomes similar to bacteria and cyanobacteria

UNIT 5. BIOLOGICAL DIVERSITY

Section 1: Three Domain Survey

Domain Bacteria

- Prokaryotes: bacteria, spirochetes, cyanobacteria (autotrophs)
- Formerly included in Kingdom Monera

Domain Archaea

- Extremophiles: thermophiles, halophiles, methanogens
- Formerly included in Kingdom Monera

Domain Eukarya

Protists: more simple than fungi, plants or animals
Algae, euglenozoans, dinoflagellates, amoebozoans, ciliates, diatoms

Fungi: chitin cell wall, hypha body plan, heterotrophic by absorption

Plants: cellulose cell wall, photosynthetic
Bryophytes (mosses): seedless non-vascular, gametophyte dominant
Ferns: seedless vascular, sporophyte dominant, free-living gametophyte
Gymnosperms (conifers): pollen, naked seeds, vascular, sporophyte dominant, reduced dependent gametophyte
Angiosperms (flowering): pollen, flowers, fruit, seeds, sporophyte dominant, reduced dependent gametophyte, monocot vs. dicot

Animals

Asymmetrical

- Phylum Porifera
- Sponges: no true tissues

Radials

- Phylum Cnidaria
- Jellyfish, hydra, and corals: gastrovascular cavity

Bilaterals

Protostome development (mouth 1st)

- Flatworms (phylum Platyhelminthes, planaria): acoelomates
- Round worms (phylum Nematoda): pseudocoelomates
- Segmented worms (phylum Annelida, earthworm): coelomates
- Phylum Mollusca, snail, slug, and octopus: coelomates
- Phylum Arthropoda, insects, spiders, and crustaceans: coelomates

Deuterostome development (mouth 2nd)

- Invertebrates (Phylum Echinodermata, sea stars and sea urchins): coelomates
- Vertebrates: coelomates

Phylum Chordata

Dorsal & hollow nerve cord, pharyngeal gill slits, post-anal tail, notochord
Fish, amphibians, reptiles, birds, mammals

Section 2: Five Kingdom Survey

No longer used
Monera: prokaryotes, no longer considered accurate
Protists: eukaryotes, will be changed in the future
Fungi: eukaryotes
Plants: eukaryotes
Animals: eukaryotes

UNIT 6. PLANT FORM & FUNCTION

Section 1: Plant Structure & Function

Plant Tissues

- Ground tissues: parenchyma, collenchyma, sclerenchyma
- Dermal tissues: epidermis, cuticle
- Vascular tissues
    - Xylem
        - Tracheids, vessel elements, cells interconnected through pits
        - Dead at functional maturity
    - Phloem
        - Sieve tubes interconnected through pores/sieve plates, companion cells connected to sieve tubes through plasmodesmata giving physiological support
        - Conduction of sugars, bulk flow, source-to-sink flow
        - Alive at functional maturity; loss of nuclei, ribosomes & central vacuole

Plant Growth

- Meristem growth
- Primary growth: vertical
    - Apical shoot
    - Apical root: root cap, zone of cell division, zone of elongation, zone of maturation/differentiation
- Secondary growth: girth
    - Lateral meristems: vascular cambium (secondary xylem & secondary phloem), cork cambium (periderm & bark)

Plant Structures

- Root
    - Epidermis, root hairs
    - Cortex
    - Endodermis, Casparian strip
    - Stele (vascular cylinder), xylem, phloem

- Leaf
    - Cuticle
    - Upper palisade mesophyll (photosynthesis)
    - Lower spongy mesophyll (gas exchange), stomates, guard cells
    - Vascular bundle (vein), xylem, phloem

Plant hormones

- Auxin: promotes plant growth, cell elongation; apical dominance
- Gibberellins: cell growth, fruit development; bigger grapes
- Cytokinins: promote cell growth (cytokinesis); apical dominance
- Ethylene: promotes fruit ripening
- Abscisic acid (ABA): maintains seed and bud dormancy

Section 2: Plant Reproduction

Alternation of Generations

- Multicellular sporophyte (2n) > meiosis > spores (1n) > mitosis > multicellular gametophyte (1n) > mitosis > gametes (1n) > fertilization > multicellular sporophyte (2n)

Flowers & Seeds

- Sepals, petals, anthers (pollen), pistil/carpel (egg)
- Double fertilization
    - Zygote (2n): new plant, developing embryo
    - Endosperm (3n): nutrition for new plant
- Seed
- Embryo, seed coat, endosperm, cotyledons (seed leaves), hypocotyl (embryonic stem), radicle (embryonic root)

Section 3: Plant Response

Phototropism

- Response to light
- Auxin concentrates on shady side of plant, differential growth

Gravitropism

- Response to gravity

Thigmotropism

- Response to touch

Photoperiodism

- Response to relative length of daylight and darkness, circadian rhythm
- Phytochrome protein
- Night length resets circadian-rhythm clock

- Long-day plants flower in longer days/shorter nights
- Short-day plants flower in shorter days/longer nights
- Day-neutral plants are not triggered by daylight changes

UNIT 7. ANIMAL FORM & FUNCTION

Section 1. Animal Structure & Function

Review tissues, organs, and the general functions of each system. Relate each to the problem that it solves for the organism, and how it differs in different environments (structure is related to function!).

Homeostasis

Digestive System

- **Mouth**
  - Salivary amylase (starch yes, cellulose no), physical breakdown
- Pharynx, epiglottis, esophagus, peristalsis
- Stomach
  - Gastric juices, HCl, pepsin, mucous
  - Storage, disinfection, physical & chemical breakdown, controlled release
- Small intestine
  - Digestion and absorption (villi and microvilli)
  - Duodenum: proteases, maltase, lactase, phosphatases
- Pancreas: Trypsin, chymotrypsin, lipase, amylase
- Liver, gall bladder
  - Bile (emulsify fats)
- Large intestine
  - Water absorption
  - E. coli symbiotic bacteria

Respiratory System

- Gill function: countercurrent exchange
- Lung function: nose, pharynx, larynx, trachea, bronchi, bronchioles, alveoli, diaphragm
  - CO_2 & O_2 diffusion across moist membranes, red blood cells
    - O_2 transported by hemoglobin (iron)
    - CO_2 transported as dissolved bicarbonate
- Regulation: blood pH

Circulatory System

- Open circulatory system (hemolymph)
- Closed circulatory system (blood), 2-, 3-, 4-chambered hearts, arteries, veins, capillaries

- Heart function
    - Atria, ventricles, valves, pulmonary circuit, systemic circuit, SA node, AV node, systole, diastole
- Heart structure & double circulation (diagram page 823)
- Blood: RBCs, WBCs, platelets, plasma

Excretory System

- N waste: ammonia, urea, uric acid
- Nephron structure & function (diagrams pages 884 & 888)
    - Glomerulus, Bowman's capsule, proximal tubule, loop of Henle, distal tubule, collecting duct, ureter, bladder, urethra
    - Filtration, secretion and reabsorption
- Osmoregulation: ADH (antidiuretic hormone), aldosterone

Nervous System

- Structure
    - Central Nervous System (CNS): brain, spinal cord
    - Peripheral Nervous System (PNS): sensory & motor neurons
        - Somatic: skeletal muscle
        - Autonomic
            - Sympathetic: stimulates activities
            - Parasympathetic: calming/slowing down effect
    - Reflex arc
- Neuron Structure & Function
    - Cell body, dendrites, axon, synapse, myelin sheath, Schwann cells
    - Polarized resting potential, action potential, depolarization, repolarization, hyperpolarization, refractory period
        - K+, Na+, voltage-gated channels, Na-K pumps
        - Synapse: Ca2+ gates, neurotransmitters, ion-gated channels
            - Neuromuscular: acetylcholine, cholinesterase
            - CNS: epinephrine, dopamine, serotonin
- Sensory organ structures: eye & ear (diagrams pages 1021 & 1027)

Muscle System

- Skeletal, smooth, cardiac
- Muscle Structure & Function
    - Sarcomere, sarcoplasm, sarcoplasmic reticulum, thin filaments (actin, troponin, tropomyosin), thick filaments (myosin)
    - Sliding-filament model
        - ATP-myosin binding, Ca2+ release, Ca2+-troponin binding, myosin-actin binding, actin filaments slide

Immune System

- Non-specific barriers

    - Skin, anti-microbial proteins, gastric juices, symbiotic bacteria
- Non-specific patrol
    - Phagocytes, complement proteins, inflammatory response (histamine, vasodilation, phagocytes)
- Specific immunity (diagram page 867)
    - Lymphocytes, antigens, MHC (major histocompatibility complex), self vs. non-self
    - B cells
        - Antibodies (immunoglobins), plasma cells, memory cells
        - Humoral response, attack circulating invaders, bone marrow maturation
    - T cells
        - Cytotoxic T cells (killer T cells), helper T cells
        - Cell-mediated response, attack infected or cancer cells
    - Supplements
        - Antibiotics, vaccines, passive immunity

Endocrine System (table page 919)

- Homeostasis
    - Blood sugar regulation, blood calcium regulation
    - Negative feedback, positive feedback
- Neurosecretory cells
    - Hypothalamus, posterior pituitary (storage of ADH, oxytocin), anterior pituitary (release of TSH, ACTH, FSH, LH)
- Ductless glands
    - Pancreas: insulin, glucagons
    - Adrenal: epinephrine, aldosterone
    - Gonads: ovaries (estrogen, progesterone), testes (testosterone)
- Hormones
    - Steroid: transcription factors, directly interact with DNA
    - Protein: second messengers necessary

Section 2: Animal Reproduction & Development

Anatomy

- Female
    - Ovary, oviduct (fallopian tube), uterus, vagina, egg, corpus luteum
    - Oogenesis
- Male
    - Testes (sperm production), epididymis (sperm maturation), vas deferens (sperm delivery), seminal vesicles (secretions), prostate gland (secretions), penis, sperm
    - Spermatogenesis

Regulation

- Female hormones: GnRH (hypothalamus), FSH (pituitary), estrogen (ovary), LH (pituitary), progesterone (corpus luteum)
- Ovulation

Development
- Fertilization, cleavage, morula, blastula, gastrula, gastrulation, differentiation, organogenesis, grey crescent, animal pole, vegetal pole, blastopore
- Ectoderm, mesoderm, endoderm, archenteron, blastopore (see table 43.1)
- Regulation: egg cytoplasm, embryonic induction, homeotic genes

Section 3: Animal Behavior

Types of Animal Behavior
- Instinct, FAP (sign stimulus), imprinting (critical period), learning, classical conditioning, operant conditioning (trial and error), habituation
- Movement: kinesis (undirected change in speed), taxis (directional movement), migration
- Foraging: herds, flocks, schools, and packs
- Social: agonistic, dominance/hierarchy, territoriality, altruistic (kin selection), cooperation, colonial

Communication
- Chemical (pheromones), visual (displays), auditory, tactile

UNIT 8. ECOLOGY

Section 1: Population Ecology

Population Growth & Distribution
- Size, density, dispersal (clumped, uniform, random), age structure, survivorship curves, reproductive tables
- Limiting factors: density-dependent, density-independent
- Growth: exponential, logistic, carrying capacity (K), r-selected, K-selected, population cycles

Section 2: Community Ecology

Population Interactions
- Interspecific competition: (-, -), niche (competitive exclusion), resource partitioning, keystone species, and dominant species
- Predation: (+, -), predator, parasite, and herbivore
- Symbiosis: mutualism (+, +), commensalism (+, 0), parasitism (+, -_
- Coevolution: predator-prey adaptations, cryptic coloration, warning coloration, mimicry, Batesian mimicry (fooling) vs. Mullerian mimicry (warning), convergent evolution

Succession

- Primary succession, pioneer species, secondary succession

Section 3: Ecosystems

Biomes

- Tropical rain forest, savanna, temperate grassland, temperate deciduous forest, desert, taiga (boreal forest), tundra, freshwater, marine

Trophic Levels

- Primary producers, primary consumers, secondary consumers, tertiary consumers, decomposers, food chain, food web, ecological pyramids (energy, biomass, numbers), energy flow, nutrient cycling, eutrophication

Nutrient Cycles

- Carbon, water, nitrogen, phosphorus

Human Impacts

- Global climate change, ozone depletion, acid rain, deforestation, loss of habitat, loss of biodiversity, fragmented habitat, biomagnification, introduced species, over-exploitation, desertification