普通生物學甲課程大綱暨教科書參考清單

Chapter 1. Introduction: Themes in the Study of Life

I. The Chemistry of Life

Chapter 2. The chemical context of life

- How elements form the molecules?
  - Protons, neurons, and electrons – atoms – compounds
  - Living organisms have 25 common elements plus trace elements
- The bonding between atoms
  - Electron arrangement
  - Chemical bonding: ionic, covalent, and hydrogen
- The chemical reactions: rearrangement of chemical bonding

Chapter 3. Water and Life

- The importance of water in supporting life
  - The hydrogen bonds: evaporation; boiling temperature
  - The density of water and ice
  - Water is a good solvent
- The pH and the environment
  - pH is important for life
  - Acidification threatens the environment

Chapter 4. Carbon and the Molecular Diversity of Life

- Organic compounds: carbon based molecules
- Bonding around carbon
  - carbon skeleton
  - Functional groups

Chapter 5. The Structure and Function of Large Biological Molecules

- Macromolecules: linkage of simple monomers
- Polysaccharides: fuel and structure
  - Disaccharides
  - Polysaccharides: starch, glycogen, cellulose, and chitin
- Lipids: membrane and energy storage
  - Hydrophobic tail and hydrophilic head

- Saturated and unsaturated

➢ Proteins: various functions
- Peptide bond and side chain
- Protein structure: primary to quaternary

➢ Nucleic acids: the genetic material
- Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA)
- DNA double helix

II. The Cell

Chapter 6. A Tour of the Cell

➢ The Fundamental units of Life- Cell
- Methods of studying cell:
  - Microscopy
    - Light microscope (LM)
    - Electron microscope (EM)
    - Scanning electron microscope (SEM)
    - Transmission electron microscope (TEM)
  - Cell Fractionation
- Compartment of Eukaryotic cells
  - Comparison between prokaryotic and eukaryotic cells
    - Nucleus and ribosomes
    - Endomembrane system
      - ✧ Endoplasmic reticulum
      - ✧ Golgi apparatus
      - ✧ Lysosomes
      - ✧ Vacuoles
    - Mitochondria and chloroplasts
    - Cytoskeleton
      - ✧ Microtubule
      - ✧ Microfilament
      - ✧ Intermediate filament
    - Extramembrane component
      - ✧ Cell walls of plants
      - ✧ Extracellular matrix of animal cells
      - ✧ Cell junctions
- Genetic instruction
  - Nucleus: information central

- Ribosomes: protein factories

■ Endomembrane system and functions
- Endoplasmic reticulum: biosynthetic factory
  - Functions of smooth ER
  - Functions of rough ER
- Golgi apparatus: shipping and receiving center
- Lysosomes: digestive compartments
- Vacuoles: diverse maintenance compartments

■ Energy metabolism of Cells
- Evolutionary origins of mitochondria and chloroplasts
- Mitochondria: chemical energy conversion
- Chloroplasts: capture of light energy
- Peroxisomes: oxidation

■ Cytoskeleton: a network of fibers that organizes structures and activities in the cell
- Roles of the cytoskeleton: support and motility
- Components of the cytoskeleton
  - Microtubules
    - ✧ Centrosomes and centrioles
    - ✧ Flagella
  - Microfilaments (Actin filaments)
  - Intermediate filaments

■ Extracellular components
- Cell walls of plants
- Extracellular matrix (ECM) of animal cells
- Cell junctions
  - Plasmodesmata in plant cells
  - Tight junctions, desmosomes and gap junctions in animal cells

Chapter 7. Membrane Structure and Function

➢ Life at the edge

■ Cell membrane- fluid mosaics of lipids and proteins
- Membrane models: Scientific inquiry
  - Phospholipid bilayer
  - Fluid mosaic model
- The fluidity of membrane
- Evolution of differences in membrane lipid composition
- Membrane proteins and their functions

        - Integral proteins
        - Peripheral proteins
    - The role of membrane carbohydrates in cell-cell recognition
    - Synthesis and sidedness of membranes
- Membrane structure results in selective permeability
    - The permeability of the lipid bilayer
    - Transport proteins
- Passive transport: diffusion of a substance across a membrane with no energy investment
    - Effects of osmosis on water balance
        - Water balance of cells without walls
        - Water balance of cells with walls
    - Facilitated diffusion: passive transport aided by proteins
- Active transport: use energy to move solutes against their gradients
    - The need for energy in active transport
    - How ion pumps maintain membrane potential
    - Cotransport: coupled transport by a membrane protein
- Bulk transport: occur by exocytosis and endocytosis
    - Exocytosis
    - Endocytosis

Chapter 8. An Introduction to Metabolism

- An organism's metabolism transforms matter and energy, subject to the laws of thermodynamics
    - Organization of Metabolic Pathways
    - Energy Forms
    - The Laws of Energy Transformation
- The free-energy change of a reaction
    - Free-Energy Change, ΔG
    - Equilibrium Reaction
    - Metabolism and Free Energy
- ATP powers cellular work
    - ATP Structure
    - How ATP Performs Work
    - ATP Regeneration
- Enzymes speed up metabolic reactions
    - The Activation Energy Barrier
    - How Enzymes Works

- Enzyme Specificity
- Enzyme's Active Site
- Factors Affect Enzyme Activity

➢ Regulation of enzyme activity
- Allosteric Regulation
- Compartmentalization of the Cell

Chapter 9. Cellular Respiration and Fermentation

➢ Oxidizing Organic Fuels Yields Energy
- Catabolic Pathways and ATP Production
- Redox Reactions
- Cellular Respiration

➢ Glycolysis

➢ The Citric Acid Cycle
- Oxidation of Pyruvate to Acetyl CoA
- The Citric Acid Cycle

➢ Oxidative phosphorylation, Chemiosmosis and Electron Transport
- Electron Transport
- Chemiosmosis
- ATP Production

➢ Fermentation and anaerobic respiration
- Fermentation
- Fermentation, Anaerobic and Aerobic Respiration

➢ Controls of the Whole Metabolic Pathways
- Feedback Regulation

Chapter 10. Photosynthesis

➢ The process that feeds the biosphere
- Photosynthesis: convert light energy to the chemical energy of food
  - Chloroplasts: the sites of photosynthesis in plants
  - Tracking atoms through photosynthesis
    - The splitting of water
    - Photosynthesis as a redox process
  - Two stages of photosynthesis: light reaction and Calvin cycle
- The light reactions: convert solar energy to the chemical energy of ATP and NADPH
  - The nature of sunlight
  - Photosynthetic pigments: the light receptors

- Excitation of chlorophyll by light
- A photosystem: a reaction-center complex associated with light-harvesting complexes
  - photosystem II (PSII)
  - photosystem I (PSI)
- Linear electron flow
- Cyclic electron flow
- A comparison of chemiosmosis in chloroplasts and mitochondria

■ The Calvin cycle: use the chemical energy of ATP and NADPH to reduce CO_2 to sugar
- Phase 1: carbon fixation
- Phase 2: reduction
- Phase 3: regeneration of the CO_2 acceptor (RuBP)

■ Alternative mechanisms of carbon fixation
- Photorespiration: an evolutionary relic?
- C4 plants: involve bundle-sheath cells and mesophyll cells
- CAM plants: is similar to the C4 pathway
- The importance of photosynthesis

Chapter 11. Cell Communication

➢ External Signals and Cellular Responses
- ■ Local and Long-Distance Signaling
- ■ Stages of Cell Signaling

➢ Reception
- ■ Cell Surface Receptors
- ■ Intracellular Receptors

➢ Transduction
- ■ Signal Transduction Pathways
- ■ Protein Phosphorylation and Dephosphorylation
- ■ Second Messengers

➢ Response
- ■ Nuclear and Cytoplasmic Responses
- ■ Controls of the Responses

➢ Integrates Multiple Cell-Signaling Pathways
- ■ Apoptotic Pathways and the Signals

Chapter 12. The Cell Cycle

➢ Generation of genetically identical daughter cells

- Genetic Material Organization
- Chromosomes Distribution

- The mitotic phases
  - Cell Cycle Phases
  - The Mitotic Spindle
  - Cytokinesis
- Regulation of Cell Cycle
  - Cytoplasmic Signals
  - Control of Cell Cycle
  - Loss of Cell Cycle Controls and Cancer

III. Genetics

Chapter 13. Meiosis and Sexual Life Cycles

- Sexual Life Cycle Inheritance
- Meiosis and Sexual Reproduction
- Origins of Genetic Variation

Chapter 14. Mendel and the Gene Idea

- Mendel's Principles
- Mendelian Inheritance
- Mendelian Inheritance in Humans
- Non-Mendelian Inheritance

Chapter 15. The Chromosomal Basis of Inheritance

- Chromosome Theory
- Inheritance of X-Linked Genes
- Genetic Recombination and Linkage
- Genetic Disorders

Chapter 16. The Molecular Basis of Inheritance

- DNA is the genetic material
- DNA replication and repair
- Mutations
- Chromosomes

Chapter 17. From Gene to Protein

- Transcription

- Translation
- Gene Expression in Bacteria, Archaea, and Eukarya

Chapter 18. Regulation of Gene Expression

- Prokaryotic Gene Regulation
- Eukaryotic Gene Regulation
- Non-coding RNA
- Cell Differentiation
- Cancer

Chapter 19. Viruses

- The Discovery of Viruses: Scientific Inquiry
- Structure of Viruses
- Replicative Cycles of Viruses
- Evolution of Viruses
- Viral Diseases in Animals and in Plants
- Viroids and Prions

Chapter 20. Biotechnology

- DNA cloning
- DNA technology
- Cloning Organisms
- Applications of DNA Technology

Chapter 21. Genomes and Their Evolution

- Genomics
- Genome Diversity
- Comparative Genomics

IV. Mechanisms of Evolution

Chapter 22. Descent with modification

- Ideas about changes over time
  - Early studies on paleontology
    - Cuvier and Lamarck
    - Darwin and Wallace's concept on natural selection
      - Observations and implication
        - Variation in population

        - ✧ Inheritance
        - ✧ Population growth and environment
        - ✧ Resource limitation
        - ✧ Survival of the fittest
- Evidences of evolution
  - Evolution in action
    - Peppered moths and industrial melanism
    - Medium ground finch
    - Selection in guppies
  - Fossil records and 'missing links'
    - Whales and mammals
    - Birds and dinosaurs
  - Homology and homoplasy
    - Anatomical homology
    - Molecular homology
    - Convergence and divergent evolution
  - Biogeography

Chapter 23. Evolution of populations

- The modern synthesis
  - Microevolution
    - Gene pool
    - Allele frequency in population
    - Variation in gene pool
      - Discrete and quantitative characters
      - Nonheritable traits
      - Geographic variation
      - Cline and ecotypes
    - Hardy-Weinberg theorem
      - Assumptions
      - Sources of variation
        - ✧ Mutation
        - ✧ Sexual recombination
    - Factors influence allele frequencies
      - Mutations
      - Gene flow
      - Nonrandom mating
      - Genetic drift

        - ✧ Bottleneck effect
        - ✧ Founder effect
      - Selection
        - ✧ Nature selection
        - ✧ Sexual selection
    - Preservation of genetic variation
      - Diploidy
      - Balancing selection
      - Neutral variation
    - Molecular evolution
      - Neutral theory
  - Macroevolution
    - Above species

Chapter 24. The origin of species

- Concepts of species
  - Biological species concept
    - Ernst Mayr and Theodosius Dobzhansky
    - What is a species?
    - Reproductive isolation and hybrids
    - Isolation mechanisms
      - Prezygotic barriers
        - ✧ Habitat isolation
        - ✧ Temporal isolation
        - ✧ Behavioral isolation
        - ✧ Mechanical isolation
        - ✧ Gametic mortality
      - Postzygotic barriers
        - ✧ Reduced hybrid viability
        - ✧ Reduced hybrid fertility
        - ✧ Hybrid breakdown
    - Limitation of the biological species concept
  - Other species definition
    - Morphological species concept
      - Phenotypic similarity
    - Ecological species concept
    - Phylogenetic species concept
- Speciation

- Geography of speciation
  - Allopatric speciation
    - Interruption of gene flow by geographic barrier
    - Examples of variation in isolated populations
  - Sympatric speciation
    - Autopolyploidy and allopolyploidy in plants
    - Habitat differentiation
    - Sexual selection
- Hybridization
  - Patterns in hybrid zone
    - Space patterns
    - Temporal patterns
  - Reinforcement
    - Barriers and fusions
  - Stability
    - Rapid evolution and adaptive radiation
- Speciation rates
  - Time course of speciation
    - Fossil records
    - Punctuated equilibrium
  - Macroevolution
    - Evolutionary novelties
    - Developmental modification and the molecular basis

Chapter 25. The history of life on earth

- Conditions on early earth
  - Oparin-Haldane model
    - Miller and Urey experiment
    - Studies by Altman and Cech
  - Fossil record chronicles of life on earth
    - Photosynthesis and the oxygen evolution
    - Fossil dating
    - Earth's history in a view of a clock
- Prokaryotes and eukaryotes
  - Endosymbiosis
    - The evolution of eukaryotes
    - Cases of serial endosymbiosis
- Multicellular eukaryotes

- Snowball earth hypothesis
- Cambrian explosion
  - Edicaran biota
  - Microfossil evidence
- Colonization of land
  - Fungi, plants, and animals

➢ Large scale patterns
- Continental drift
  - Break-up of Pangaea
  - Movement of continents
- Mass extinctions
  - The 'big five' events
  - Consequences of mass extinctions

➢ Evolutionary effects of development genes
- Changes in rate and timing
  - Heterochrony
  - Paedomorphosis
- Changes in spatial pattern
  - Ectopic expression of homeotic genes
- Changes in genes
  - Gene number
  - Gene regulation

➢ Evolutionary novelties
- Evolution of complex structure
  - Eyes
- Evolutionary trends
  - patterns, rather than intrinsic drive

V. The Evolutionary History of Biological Diversity

Chapter 26. Phylogeny and the tree of life

➢ Terminology
- Morphological and molecular homologies
- Taxonomy, phylogeny, systematics

➢ Nomenclature and hierarchical classification
- Linnaeus system
  - Binomial nomenclature
  - Naming problems

- Concept of phylogenetic systematics
  - Cladogram and clades
  - Homology and analogy
  - Convergent evolution
  - Molecular evolution
  - Cladistics
    - Shared primitive and derived characters
    - Monophyletic group
    - Nonmonophyletic group
      - Paraphyletic group
      - Polyphyletic group
    - Outgroup and ingroup
- Methodology of phylogenetic analysis
  - General methods
    - Distance methods
    - Most parsimony principle
    - Maximum likelihood method
  - Morphological and molecular characters
    - gene tree and species tree
- Molecular evolution
  - Genome evolution
    - Size and complexity of genomes
    - Gene duplications and gene families
  - Molecular clock
    - Assumptions
    - Neutral theory
    - Difficulties

Chapter 27. Bacteria and Archaea

- General features
  - Structures
    - Shapes of prokaryotic cells
    - Differentiations
    - Cell-surface structures
  - Functional adaptations
    - Motility
    - Reproduction and adaptation
  - Genetic diversity in prokaryotes

        - Rapid reproduction
        - Mutation rates
        - Genetic recombination
            - Conjugation
            - Plasmids
    - Metabolic adaptation
        - Models of nutrition uptake
            - Photoautotrophy
            - Chemoautrophy
            - Photoheterotrophy
            - Chemoheterotrophy
        - Metabolic adaptation to oxygen
        - Nitrogen metabolism
- Classification and evolution
    - Three domain system
        - Bacteria
        - Archaea
        - Eukarya
    - Measuring diversity in nature
        - Culture
        - Direct PCR
    - Mycoplasma
- Roles of prokaryotes in nature
    - General roles
        - Chemical recycling
        - Cyanobacteria and symbiosis
        - Nutritional symbiosis of Buchnera and aphids
        - Pathogenic prokaryotes
    - Utility in biotechnology
        - Molecular cloning
        - Bioremediation

Chapter 28. Protists

- The classification of protists
    - Current understanding according to endosymbiosis theory
- The diversity and features of protists
    - Excavata
        - Diplomonads and parabasalids

- Euglenozoans
  - Euglena
- Kinetoplastids
  - Trypanosoma

■ Chromalveolata
- Alveolates
  - Dinoflagellates
    - ✧ General features
    - ✧ Ecology - toxin
    - ✧ Ecology - symbiosis
    - ✧ Bioluminescence
  - Apicomlexa
    - ✧ Life cycle of Plasmodium
  - Ciliates
    - ✧ Structure of Paramecium
    - ✧ Conjugation and reproduction
- Stramenopiles
  - Heterokonts
    - ✧ Oomycetes
    - ✧ Chrysophytes
    - ✧ Diatoms
  - Brown algae
    - ✧ Life cycle
- Great Irish famine

■ Rhizarians
- General features
- Cercozoans and radiolarians
- Foraminiferans

■ Archaeplastida
- Red algae (Rhodophyta)
  - General features
  - Life cycle
- Green algae
  - General features
  - Life cycle
  - Class Charophyceae
  - Mollusc/algal chloroplast endosymbiosis

■ Unikonta

- Amoebozoans
  - General features
  - Slime molds
    - ✧ Plasmodial slime molds
    - ✧ Cellular slime molds
  - Life cycle
- Opsthokonts
  - Animals, fungi, choanoflagellates

Chapter 29. Plant Diversity I: How Plants Colonized Land

- The evolution and terrestrial adaptations of plants
  - The closed living relative of land plants is green algae, Charophytes
  - Morphologically derived traits of land plants
- nonvascular (early evolving) land plants such as Bryophytes have life cycles dominated by gametophytes
  - Bryophytes include liverworts, mosses and hornworts
  - The diversity of gametophyte and sporophyte in Bryophyte
  - The ecological roles of Mosses
- Seedless vascular plants such as Ferns are dominated by sporophytes and are capable to grow tall by vascular tissues.
  - Key innovative traits of seedless vascular plants: vascular transport, roots, leaves and sporophylls
  - The life cycle of a fern
  - Classification of seedless vascular plants: Lycophyta and Pterophyta
  - The evolutionary and ecological significance of seedless vascular plants

Chapter 30. Plant Diversity II: The evolution of seed plants

- Key adaptive traits for terrestrial seed plants: Seeds and pollen grains
  - Seed plants has reduced gametophytes
  - Seed plants evolved heterospory, ovules, pollens and seeds
  - The evolutionary of the key traits
- The diversity of naked seed plants – gymnosperm
  - The diversity and life cycle of gymnosperms
  - The significance of gymnosperms
- The diversity and reproductive adaptation of angiosperm – flowers and fruits
  - The diversity of flowers and fruits
  - The characteristics and life cycle of the angiosperm
  - The phylogeny and the evolution of angiosperm diversity

- The ecological and developmental significance of flower and fruits, and their interaction with animals.

- Plant diversity in Taiwan and as natural resources for human welfare
  - The flora of Taiwan and their diversity
  - Plant derived natural products - crops, woods, medicine, and ornament
  - Anthropogenic threats to plant diversity – conservation of topical plants

Chapter 31. Fungi

- Body structure of fungi
  - General structure
    - Hyphae and mycelium
    - Septa
    - Cell wall
  - Life cycle
  - Asexual reproduction
- The diversity of fungi
  - Chytrids
    - General features
    - Evolutionary view
    - Ecology
      - Pathogens
  - Zygomycota
    - General features
    - Life cycle
    - Phototropism
    - Microsporidia
  - Glomeromycetes
    - General features
  - Ascomycetes
    - General features
    - Types of ascocarp
    - Life cycle
  - Basidiomycetes
    - General features
    - Life cycle
    - Specialized morphologies
      - Dolipore
      - Clamp connection

- Ecology of fungi
  - Interactions between fungi and other organisms
    - Fungi as decomposers
    - Symbiosis
      - Mycorrhizae and plants
        - Endomycorrhiza
        - Ectomycorrhiza
      - Fungi-animal symbiosis
        - Fungi in guts of ruminant animals
        - Tripartite symbiosis of ants, plants, and fungi
      - Lichens
        - Fungus-algae symbiosis
        - Ecological importances
    - Fungi as predators
    - Fungi as pathogens
      - Ergot of rye
  - Practical uses of fungi
    - Food
    - Medicine

Chapter 32-34. Animal Diversity

- Animal Diversity
  - Overview of Animal Diversity **(Chapter 32)**
    - Definition of animals
      - Modes of nutrition: heterotrophism
      - Tissue organization, cell structure and specialization
      - Reproduction and development
    - Animal body plans
      - Symmetry properties
        - Radial symmetry
        - Bilateral symmetry
      - Tissue layers
        - Ectoderm, mesoderm, endoderm
        - Diploblastic, triploblastic
      - Coelom
      - Protostome vs. deuterostome development
        - Cleavage pattern
        - Fates of blastophore

        - ✧ Modes of coelom formation
    - Phylogenetic relationships between animal phyla
        - ✧ Morphology-based phylogeny vs. molecular phylogeny
        - ✧ Agreements between the two schools
        - ✧ New features of animal molecular phylogeny
        - ✧ Geological record of animal life
- Our Evolutionary History **(Chapter 33-34)**
    - Human evolution (Chapter 34.8)
        - Our species – *Homo sapiens*
        - Our cousins – extinct *Homo* species
            - ✧ Neanderthals
            - ✧ *Homo erectus*
            - ✧ Early *Homo*
        - Human origin
            - ✧ Derived characters of humans
            - ✧ Fossil records
            - ✧ Genetic basis of human origin
    - Mammalian evolution **(Chapter 34.7)**
        - Primates: features
        - Definition of mammals
        - Monostremes, marsupials vs. eutherians
        - Early mammals in fossil record
    - Amniote evolution **(Chapter 34.6)**
        - Amniotes: features, definition and evolution
        - Early evolution of amniotes in fossil record
        - Reptiles: features and evolution
        - Dinosaurs/birds: features and evolution
    - Tetrapod evolution **(Chapter 34.5)**
        - Tetrapods: features, definition and evolution
        - Early evolution of tetrapods in fossil record
        - Amphibians: features and evolution
    - Gnathostome evolution **(Chapter 34.4)**
        - Gnathostomes: features, definition and evolution
        - Early evolution of gnathostomes in fossil record
        - Chondrichthyans: features and evolution
        - Actinopterygians: features and evolution
        - Sarcopterygians: features and evolution
    - Vertebrate evolution **(Chapter 34.2 – 34.3)**

- Origin of vertebrates: craniates
- Vertebrates: features, definition and evolution
- Early craniates and vertebrates in fossil record
- Hagfishes: features
- Lampreys: features

– Chordate evolution **(Chapter 34.1)**
- Chordates: features, definition and evolution
- Cephalochordates
- Urochordates

– Deuterostome evolution **(Chapter 33.5)**
- Echinoderms: features and evolution

– Bilaterian evolution **(Chapter 33.3 – 33.4)**
- Bilaterian origins
- Ecdysozoa
  - ✧ Nematodes: features and evolution
  - ✧ Arthropods: origins, features and evolution
    - ◆ General characters
    - ◆ Chelicerates
    - ◆ Myriapods
    - ◆ Insects
    - ◆ Crustaceans
- Lophotrochozoa
  - ✧ Flatworms: features and evolution
    - ◆ Free-living flatworms
    - ◆ Parasitic flatworms
  - ✧ Rotifers: features and asexual reproduction
  - ✧ Lophophorates: features and evolution
  - ✧ Molluscs: features and evolution
    - ◆ Chitons
    - ◆ Gastropods
    - ◆ Bivalves
    - ◆ Cephalopods
  - ✧ Annelids: features and evolution
    - ◆ Polychaetes
    - ◆ Oligochaetes
    - ◆ Leeches

– Eumetazoan evolution **(Chapter 33.2)**
- Features of Eumetazoa

- Cnidarians: features and evolution
  - ✧ Hydrozoans
  - ✧ Scyphozoans
  - ✧ Cubozoans
  - ✧ Anthozoans
- Origin of animals **(Chapter 33.1)**
  - Cambrian explosion and early evolution of animal phyla
  - Sponge: features
  - Choanoflagellates: the closest relative of our kingdom

VI. Plant Form and Function

Chapter 35. Plant Structure, Growth, and Development

➢ Are Plants Computers?

■ Plants have a hierarchical organization consisting of organs, tissues, and cells
- Three Basic Plant Organs: Roots, Stems, and Leaves
- Dermal, Vascular, and Ground Tissues
- Common Types of Plant Cells

■ Meristems generate cells for primary and secondary growth

■ Primary growth lengthens roots and shoots
- Primary Growth of Roots
- Primary Growth of Shoots

■ Secondary growth increases the diameter of stems and roots in woody plants
- The Vascular Cambium and Secondary Vascular Tissue
- The Cork Cambium and the Production of Periderm
- Evolution of Secondary Growth

■ Growth, morphogenesis, and cell differentiation produce the plant body
- Model Organisms: Revolutionizing the Study of Plants
- Growth: Cell Division and Cell
- Expansion
- Morphogenesis and Pattern Formation
- Gene Expression and Control of Cell
- Differentiation
- Shifts in Development: Phase Changes
- Genetic Control of Flowering

Chapter 36. Resource Acquisition and Tranport in Vascular Plants

- Different mechanisms transport substances
  - Symplast and apoplast
  - Short-distance transport
    - Water potential
    - Aquaporin
  - Bulk flow in long-distance transport
- Transport of water and minerals in the xylem
  - Endodermis
    - Casparian strip
  - Bulk flow transport via the xylem
    - Root pressure
    - Transpiration pull
    - Adhesion and cohesion in the ascent of xylem sap
- Transpiration rate regulated by stomata
  - Mechanism of stomata close and opening
    - Potassium ions
    - Abscisic acid
    - Xerophyte and CAM
- Transport of sugars in the phloem
  - Movement from source to sink
    - Phloem sap
  - Pressure flow

Chapter 37. Soil and Plant Nutrition

- Soil contains a living, complex ecosystem
  - Soil texture
  - Topsoil composition
  - Soil conservation and sustainable agriculture
- Plants require essential elements to complete their life cycle
  - Macronutrients and Micronutrients
    - Definition of essential elements
    - Methods for identification of essential elements
  - Symptoms of mineral deficiency
  - Improving plant nutrition by genetic modification
- Plant nutrition often involves relationships with other organisms
  - Soil bacteria and plant nutrition
  - Fungi and plant nutrition

- Epiphytes, parasitic plants, and carnivorous plants

Chapter 38. Angiosperm Reproduction and Biotechnology

- Overview: Flowers of Deceit
- Flowers, double fertilization, and fruits are unique features of the angiosperm life cycle
  - Flower Structure and Function
    - Development of Male Gametophytes in Pollen Grains
    - Development of Female Gametophytes (Embryo Sacs)
    - Pollination
    - Coevolution of Flower and Pollinator
  - Double Fertilization
  - Seed Development, Form, and Function
    - Endosperm Development
    - Embryo Development
    - Structure of the Mature Seed
    - Seed Dormancy: An Adaptation for Tough Times
    - Seed Germination and Seedling Development
  - Fruit Form and Function
- Flowering plants reproduce sexually, asexually, or both Mechanisms of Asexual Reproduction
  - Advantages and Disadvantages of Asexual Versus Sexual Reproduction
  - Mechanisms That Prevent Self-Fertilization
  - Vegetative Propagation and Agriculture
    - Clones from Cuttings
    - Grafting
    - Test-Tube Cloning and Related Techniques
- Humans modify crops by breeding and genetic engineering
  - Plant Breeding
  - Plant Biotechnology and Genetic Engineering
    - Reducing World Hunger and Malnutrition
    - Reducing Fossil Fuel Dependency
  - The Debate over Plant Biotechnology
    - Issues of Human Health
    - Possible Effects on Nontarget Organisms
    - Addressing the Problem of Transgene Escape

Chatper 39. Plant Responses to Internal and External Signals

- Overview: Stimuli and a Stationary Life
- Signal transduction pathways: From signal reception to response
  - Reception
  - Transduction
  - Response and regulation
- Function of plant hormones
  - The discovery of plant hormones
  - A survey of plant hormones
    - Auxin
    - Cytokinins
    - Gibberellins
    - Brassinosteroids
    - Abscisic acid
    - Strigolactones
    - Ethylene
  - Hormone interactions
- Plant light responses
  - Blue-light receptors
  - Phytochromes
  - Circadian rhythms
  - Photoperiodism
- Plant responses to other stimuli
  - Gravity
  - Mechanical stimuli
  - Abiotic stresses
- Plant defenses against herbivores and pathogens
  - Defenses against herbivores
  - Defenses against pathogens

VII. Animal Form and Function

Chatper 40. Basic Principles of Animal Form and Function

- Organization of the animal body
  - Introduction to Animal organization and function
    - Hierarchical organization of the animal body
    - Animal tissues
    - Animal organs and organ systems

- Feedback control mechanism and Homeostasis
- Homeostatic control of body temperature

Chapter 41. Animal Nutrition

- The purpose of the digestive system
- Dietary categories of animal
  - Herbivores
  - Carnivores
  - Omnivores
- Nutritional Requirements
  - energy for cellular processes, building blocks for macromolecules and essential nutrients
  - Essential Nutrients
  - malnutrition
- The main stages of food processing
  - Ingestion
    - intracellular digestion
    - extracellular digestion
      - gastrovascular cavities
      - alimentary canals
  - Digestion
  - Absorption
  - elimination
- Organs of the mammalian digestive system
  - the muscles of the alimentary canals
    - sphincters and peristalsis
  - The Oral Cavity, Pharynx, and Esophagus
    - teeth
    - salivary gland
    - swallowing reflex
  - Digestion in the Stomach
    - Structure and function of the stomach
    - Gastric juice
    - What prevents gastric juice from digesting away the stomach lining?
    - regulation of the secretion of the gastric juice
    - GERD (gastroesophageal reflux disease) and Gastric ulcers
  - Digestion in the Small Intestine
    - Pancreatic Secretions

- Secretions of the Small Intestine
- Bile Production by the Liver

- Absorption in the Small Intestine
  - absorption surface of the small intestine
  - capillaries and hepatic portal vein
  - Na^+-glucose co-transporter
  - the absorption and transport of the lipids
  - Lipoprotein
- Absorption in the Large Intestine
  - aquaporin

- The digestive systems of vertebrate
  - Adaptations of the digestive systems
  - the digestion and absorption of cellulose
- Feedback circuits regulate digestion
  - Hormonal Regulation of Digestion
  - Glucose Homeostasis
  - Regulation of Appetite and Consumption
  - *ob* gene, *db* gene and leptin

Chapter 42. Circulation and Gas Exchange

- Homeostasis of internal environment
  - Transport of materials: The circulatory system
    - Internal transport of materials
      - Gastrovascular cavity
      - Open and closed circulatory systems
      - Vertebrate circulatory systems
        - ✧ Single circulation
        - ✧ Double circulation
    - The mammalian heart
      - Cardiac structure
      - Pacemaker and conducting system of the heart
      - Electrocardiogram
      - Cardiac cycle
    - The structure and function of blood vessels
      - Arteries, veins and capillaries
      - Pressure, blood flow and resistance
      - Blood velocity
      - Site for exchange of materials : capillaries

        - ✧ The distribution of fluid across the walls of capillaries
        - ✧ Fluid return via lymphatic vessels
    - Regulation of blood pressure
        - Measurement of arterial blood pressure
        - Autonomic nervous system and hormones
            - ✧ Arterial baroreceptor reflex
    - Blood composition and function
        - Plasma and blood cells
        - Blood clotting
    - Cardiovascular diseases
        - Atherosclerosis
        - Stroke and heart attack
        - Hypertension
- Gas exchange: The respiratory system
    - The process of gas exchange
    - Gas exchange surfaces in animals
        - Body surface in earthworms
        - Gills in fish
            - ✧ Counter-current gas exchange
        - Tracheae in insects
        - Lungs in land vertebrates
    - The diffusion of gas
        - Fick’s law of diffusion
        - Dalton’s la
        - Henry’s la
    - The efficient lungs in birds
        - Avian lungs and air sacs
        - Air flows in one direction
        - cross-current gas exchange
    - Mammalian respiratory system
        - The structure and function of airways
        - Site of gas exchange: The alveoli
    - Breathing
        - Boyle’s law
        - inhalation
        - exhalation
        - Spirometer and lung volumes and capacities
        - Control of breathing

        - ✧ Breathing control centers in brainstem
        - ✧ Central and peripheral chemoreceptors
    - Gas exchange and transport
        - Gas exchange
            - ✧ Gas exchange in alveoli
            - ✧ Gas exchange in other tissues
        - Oxygen Transport
            - ✧ Hemoglobin-oxygen dissociation curve
            - ✧ Bohr effect
        - Carbon dioxide transport
    - Respiration in special environments
        - High altitudes
            - ✧ Thin air at high altitude
            - ✧ Adaptation to high altitude
        - Ocean depths
            - ✧ The problem of high partial pressure of gas
            - ✧ Decompression sickness
            - ✧ Adaptation of diving mammals

Chapter 43. The Immune System

- Innate immunity: non-specific protection against pathogens
    - External physical barriers: skin, pH, mucus, ….
    - Phagocytes and natural killer cells
    - Defensive proteins: interferons and complement system
    - Inflammatory responses: disinfect, clean, and limited the spread of pathogens
- The lymphatic system: to fight infections
- Adaptive immunity: specific response to pathogens
    - Active and passive immunities
    - B and T cells for humoral and cell-mediated immune responses, respectively.
    - Antigens: molecules that induce adaptive immune responses
    - Clonal selection of B cells: primary and secondary responses
    - Antibody functions: neutralization, agglutination, precipitation, and complement system activation
    - Helper T cell: recognizes the antigen from the antigen-presenting cell then activates the cyotoxic T cell and B cell; different interleukins involved
    - Cytotoxic T cell: kill “infected” cells

- HIV positive and AIDS: when blood Th cells drop from 600 to 200 per microliter

- Immune malfunction
  - Autoimmune diseases: immune system attack the body's molecules
  - Weakened immune system: genetic or stress
  - Allergy: hypersensitive response to harmless environmental factors

Chapter 44. Osmoregulation and Excretion

- The balances between uptake and loss of water and solutes
  - Osmosis and Osmolarity
  - Osmoconformer and osmoregulator
  - Euryhaline and stenohaline animals
  - Marine Animals
    - Chloride cells actively transport chloride ions out
    - Trimethylamine oxide (TMAO), salts and Urea
  - Freshwater Animals
    - Replenishing salts by uptake across the gills and by eating
    - The functions of the steroid hormone cortisol
  - Anhydrobiosis
  - Land Animals
    - Water gain derived from metabolism
    - Water gain ingested in food
    - Water gain ingested in liquid
  - Transport epithelia
- Animal's nitrogenous wastes
  - Ammonia
    - a small and very toxic molecule
    - can be tolerated at only very low concentrations
  - Urea
    - Urea's low toxicity reduces the amount of water needed for nitrogen excretion
  - uric acid
    - uric acid is relatively nontoxic, and insoluble in water
    - gout
- Diverse excretory systems
  - Excretory Processes
    - Filtration
    - Reabsorption

- secretion
- Excretory Systems
  - Protonephridia
  - Metanephridia
  - Malpighian tubules
  - Kidneys

- The nephron is the functional unit of the kidney
  - The structure of the kidney
  - From Blood Filtrate to Urine
    - Filtration: the renal corpuscle
    - Reabsorption: the proximal tubule
    - Creating an osmotic gradient: the loop of Henle
    - Regulating water and electrolyte balance: the distal tubule and collecting duct
  - The mammalian kidney's ability to conserve water is a key terrestrial adaptation
  - Diverse adaptations of the vertebrate kidney
- Urine Formation Is under Hormonal Control
  - Antidiuretic Hormone
    - ADH triggers the insertion of aquaporins into the apical membrane
    - ADH increases permeability to urea, which increases the osmolarity of the surrounding fluid
    - diabetes insipidus
  - The Renin-Angiotensin-Aldosterone System
  - Homeostatic Regulation of the Kidney

Chapter 45. Hormones and the Endocrine System

- Chemical signals in animals
  - Chemical signals
    - Paracrines
      - Nitric oxide; NO
      - prostaglandins
    - Autocrines
    - Neurotransmission
    - Endocrine-hormones
      - Neurosecretory
    - Pheromones
  - Hormones

- Signal molecules and receptors
- Chemical hormone classes
  - Lipid soluble hormones: steroids, thyroxin
  - Water soluble hormones: proteins, peptides, amines
- Hormone actions and responses of target cells
  - Lipid soluble hormones: intracellular hormone-receptor complex and regulation of gene expression
  - Water soluble hormones: activation of surface receptor and intracellular second messengers
    - cAMP-dependent pathway
    - Ca^{2+}-IP_3 signaling pathway

■ Invertebrate endocrine system
- Hormone regulation of molting in Crustacea
  - Ecdysone
  - Molting-inhibiting hormone
- Hormone regulation of metamorphosis in insects
  - prothoracicotropic hormone
  - Ecdysone
  - Juvenile hormone

■ Vertebrate endocrine system
- Hypothalamus-anterior pituitary gland
  - Thyroid-stimulating hormone; TSH
  - Adrenocorticotropic hormone; ACTH
  - Follicle-stimulating hormone; FSH
  - Luteinizing hormone; LH
  - Prolactin
  - Growth hormone
- Thyroid gland and thyroid hormone
  - Thyroid gland
  - Thyroid hormone
  - Negative feedback regulation of thyroid hormone secretion
- Adrenal gland and stress
  - Adrenal cortex
    - glucocorticoids
  - Adrenal medulla
    - Epinephrine
- Posterior pituitary gland
  - Antidiuretic hormone; ADH

        - Oxytocin
    - Others
        - Parathyroid hormone and calcium homeostasis
        - insulin, glucagon and glucose homeostasis

Chapter 46. Animal Reproduction

- Overview
    - Pairing Up for Sexual Reproduction
- Modes of Reproduction
    - Asexual Reproduction
    - Sexual Reproduction
        - In vitro and in vivo fertilization
        - Reproductive system
        - Reproductive Cycle
        - Production and transport of gametes
- Mammalian Reproduction
    - Mammalian sex hormonal regulation
        - Female sex hormonal regulation
        - Male sex hormonal regulation
        - Human Sexual Response
    - Reproduction of placental mammals
        - Conception, Embryonic Development, and Birth
        - Maternal immune tolerance of the embryo and fetus
- Modern Reproductive Technologies

Chapter 47. Animal Development

- Overview
    - A Body-Building Plan
- Initiation of development
    - Fertilization
    - Cleavage
- Morphogenesis
    - Gastrulation
    - Developmental Adaptations of Amniotes
    - Organogenesis
    - Mechanisms of morphogenesis

Chapter 48. Neurons and Synapses and Signaling

- Neuron organization and structure
  - Introduction to Information Processing
  - Neuron Structure and Function
- Ion pumps and ion channels establish the resting potential of a neuron
  - Formation of the Resting Potential
    - Sodium-potassium pump
    - Leaky potassium channel
  - Modeling the Resting Potential
    - Polarization
    - Concentration gradient
    - Electric gradient
    - Nernst equilibrium potential
- Action potentials are the signals conducted by axons
  - Hyperpolarization and Depolarization
  - Graded Potentials and Action Potentials
  - Generation of Action Potentials
    - Threshold
    - All-or-none
  - Conduction of Action Potentials
    - Myelin sheath
    - Saltatory conduction
- Neurons communicate with other cells at synapses
  - Generation of Postsynaptic Potentials
    - Ligand-gated ion channel
    - EPSP
    - IPSP
  - Summation of Postsynaptic Potentials
    - Spatial summation
    - Temporal summation
  - Modulated Signaling at Synapses
    - Presynaptic
    - Postsynaptic
  - Neurotransmitters
    - Excitatory
    - Inhibitory

Chapter 49. Nervous systems

- Nervous systems consist of circuits of neurons and supporting cells

- Organization of the Vertebrate Nervous System
- Glia
- The Peripheral Nervous System

➢ The vertebrate brain is regionally specialized
- Arousal and Sleep
- Biological Clock Regulation
- Emotions

➢ The cerebral cortex controls voluntary movement and cognitive functions
- Language and Speech
- Lateralization of Cortical Function
- Information Processing
- Frontal Lobe Function
- Evolution of Cognition in Vertebrates

➢ Changes in synaptic connections underlie memory and learning
- Neural Plasticity
- Memory and Learning
- Long-Term Potentiation
- Stem Cells in the Brain

➢ Many nervous system disorders can be explained in molecular terms
- Schizophrenia
- Depression
- Drug Addiction and the Brain's Reward System
- Alzheimer's Disease
- Parkinson's Disease

Chapter 50. Sensory and Motor Mechanisms

➢ Animal sensory system
- Sensory receptors and sensory pathways
  - Sensory pathways
    - Transduction of sensory receptors
    - Transmission of sensory neuron
    - Sensation at specific brain area
  - Types of sensory receptors
    - Mechanoreceptors
    - Chemoreceptors
    - Thermoreceptors
    - Electromagnetic receptors
    - Nociceptors

- Cutaneous sensations
  - cutaneous sensory receptors
  - receptive field and sensory acuity
  - Somatosensory cortex
- Chemical sense
  - Taste
  - Smell
- Equilibrium and hearing
- Vision
  - Invertebrate visual system
  - Vertebrate visual system
    - Vertebrate complex eye
    - Retina structure
    - Photoreceteers

➢ Animal Motor System
- Muscle composition
  - Muscle – muscle fiber (cell) – myofibril – sarcomere
  - Filament sliding: consume ATP for thick filament (myosine) to slide against the thin filament (actin)
  - Motor neuron: induce muscle cell Ca2+ elevation to trigger muscle contraction
- Locomotion
  - Skeletons: hydrostatic skeleton, exoskeleton, and endoskeleton
  - Vertebrate skeleton: our body
  - Different types of locomotions: like swimming, hopping, running ….
  - Bone and joints
  - Skeleton and muscle: linked with each other for movement

Chapter 51. Animal Behavior

➢ Sensory Inputs and Behaviors
- Fixed Action Patterns
- Migration and Behavioral Rhythms
- Animal Signals and Communication
  - Forms of Animal Communication
  - Pheromones

➢ Learning and Behaviors
- Experience and Behavior
- Learning

        - Imprinting
        - Spatial Learning and Cognitive Maps
        - Associative Learning
        - Cognition and Problem Solving
- Food and Sex
    - Foraging Behavior
    - Mating Behavior and Mate Choice
        - Mating Systems and Sexual Dimorphism
        - Mating Systems and Parental Care
        - Sexual Selection and Mate Choice
- Evolution of Behaviors
    - Genetic Basis of Behavior
    - Genetic Variation and the Evolution of Behavior
    - Altruism
    - Inclusive Fitness
        - Hamilton's Rule and Kin Selection
    - Evolution and Human Culture

VIII. Ecology

Chapter 52. An Introduction to Ecology and the Biosphere

- The Scope of Ecological Research
    - Evolution and Ecology
    - Ecology and Biological Hierarchy
- Earth's Climate
    - Global Climate Patterns
        - Seasonality
        - Atmosphere circulation
        - Oceans circulation
            - El Nino
        - Regional and Local Effects
            - Bodies of Water
            - Mountains and Rain Shadows
    - Elevation
    - Microclimate
    - Global Climate Change
- Terrestrial Biomes
    - Climate and Terrestrial Biomes

- General Features of Terrestrial Biomes
- Disturbance and Terrestrial Biomes

➢ Aquatic Biomes
- Light and Nutrients
- Zonation in Aquatic Biomes

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Chapter 53. Population Ecology

➢ Distribution and Range
- Population and Spatial Scale
- Speciation and Dispersal Ability
- Behavior and Habitat Selection
- Abiotic Factors
- Biotic Factors
- Patterns of Dispersion

➢ Abundance and Sampling
- Quadrat Methods
- Mark-recapture Methods
- Birth, Death, Immigration, and Emigration

➢ Demographics and Population Dynamics
- Survival and Reproductive Rates
- Age Structure and Life Table

➢ Life History
- Life Table and Life History
- Life History Diversity
- Life History Trade-offs

➢ Exponential Model
- Per Capita Rate of Increase
- Exponential Growth

➢ Logistic Model
- Carrying Capacity
- Density-dependent Growth and Real Populations
- Mechanisms of Density-Dependent Population Regulation

➢ Human Population
- The Global Human Population
- Global Carrying Capacity
- Ecological Footprints

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Chapter 54. Community Ecology

- Causes of Species Richness
  - Ecosystem Productivity
  - Habitat Heterogeneity
- Community Interactions
  - Competition
  - Exploitation
    - Predation
    - Herbivory
    - Pathogens and Parasites
  - Mutualism and Facilitation
  - Symbiosis
  - Coevolution
- Niche Concept
  - Competitive Exclusion
  - Resource Partitioning
  - Character Displacement
- Species Diversity and Trophic Structure
  - Trophic Structure
  - Keystone Species and Ecosystem Engineer
  - Bottom-Up and Top-Down Controls
  - Diversity and Community Stability
- Effects of Biogeographic factors
  - Latitudinal Gradients
  - Area Effects
  - Island Equilibrium Model
- Ecological Succession
  - Effects of Disturbance
  - Human Disturbance
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Chapter 55. Ecosystems and Restoration Ecology

- Physical Laws Govern
  - Conservation of Energy
  - Conservation of Mass
  - Energy, Mass, and Trophic Levels
- Primary Productivity

- Ecosystem Energy Budgets
- Primary Production in Aquatic Ecosystems
- Primary Production in Terrestrial Ecosystems

➢ Energy Transfer Efficiency
- Production Efficiency
- Ecological Pyramids

➢ Nutrients and Water Cycles
- Biogeochemical Cycles
- Decomposition and Nutrient Cycling Rates
- Experimental Forest

➢ Human Activity and Ecosystem Stress
- Pollution
- Acid Precipitation
- Ozone Hole
- Habitat Destruction

➢ Restoration Ecology
- Bioremediation
- Biological Augmentation
- Restoration Projects Worldwide

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Chapter 56. Conservation Biology and Global Change

➢ Earth's biodiversity
- Three Levels of Biodiversity
- Biodiversity Hot spots and Endemism
- Extinction and Biodiversity Crisis
- Small Populations
  - Loss of Genetic Variability
  - Catastrophic Disturbances
  - Demographic Factors
  - Captive Breeding
- Biodiversity and Human Welfare

➢ Population conservation
- Small-Population Approach
- Declining-Population Approach
- Weighing Conflicting Demands

➢ Landscape and regional conservation
- Landscape Structure and Biodiversity

- Establishing Protected Areas
- Megareserves

- Factors responsible for Extinction
  - Habitat destruction
    - Degradation
      - Nutrient Enrichment
      - Toxins in the Environment
      - Greenhouse Gases and Global Warming
    - Habitat Loss and Fragmentation
      - Habitat Area and Edge
      - Disturbance and Stress
      - Isolation and Distance
  - Overexploitation
  - Introduced species
  - Pollution and Biological Magnification
  - Disruption of ecological interactions
- Sustainable development
  - Sustainable Biosphere Initiative
  - The Future of the Biosphere
- Case Studies in Taiwan

Textbooks used for the General Biology courses in NTU

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