Level 1 — Natural Selection

- Natural selection
- Evolution
- Gene Pool / Genes
- Hardy-Weinberg Equilibrium
- Fitness
- Adaptation
- Darwin
- Mutation

Level 2 — Examples of Natural Selection

- Natural Selection
- Flowering / Climate
- Phenotype
- Genotype
- Sickle-Cell Anemia
- Antibiotic resistance in bacteria

Level 3 — Genetic Drift

- Evolution
- Genetic drift
- Bottleneck
  - N. Elephant Seal
- Founder effect
  - Finches, tortoises
- Gene Flow
- Microevolution

Level 4 — Evidence of Evolution

- Biogeography
- Fossils
- Anatomy
  - Homology
  - Analogy
  - Embryology
  - Vestigial
- Molecular Evidence
- Evolutionary tree

Level 5 — Essential Characteristics are Conserved

- Life
- Genetic code
- Metabolism
- Central dogma
- Genes
- Eukaryotic cells
  - Eukarya
- Prokaryotic cells
  - Bacteria
  - Archaea

Phylogeny 006

- Convergent evolution
- Analogy vs. Homology
- Systematics
- Taxon –
- Cladogram
  - Clade
- Parsimony
- rRNA vs. mt DNA
- Monophyletic

007 Speciation and Extinction

- Speciation
  - Adaptive Radiation
- Extinction
  - Mass Extinction
    - Permian
    - Cretaceous (K/T Boundary)
- Niche

008 – Speciation

- Speciation
- Species = Biological / Morphological / Phylogenetic / Ecological
- Pre-Zygotic Barriers
  - Temporal
  - Habitat
  - Behavior
  - Mechanical
  - Gametic
- Post-Zygotic Barriers
- Allopatric vs. Sympatric Speciation

009 - Populations Continue to Evolve

Natural Selection
- Directional
- Stabilizing
- Disruptive

Sexual Selection
- Intersexual vs. Intrasexual
- Sexual Dimorphism

Hybrid Zones

Galapagos Finches

010 - Abiogenesis

Stromatolite

Miller-Urey Experiment

LUCA

Monomers - Protocell (protobiont)

Ribozymes

011 The Origin of Life

LUCA

Prokaryotic cells → Archaea, Bacteria

Eukaryotic cells

Multicellular life

Horizontal Gene Transfer

DNA

012 Free Energy

Energy

1st Law of Thermodynamics

2nd Law of Thermodynamics

Gibbs Free Energy

Exergonic Reaction
- Cellular Respiration

Endergonic Reaction
- Photosynthesis

ATP

Energy Coupling

013 Free Energy

Respiration

- Redox reaction
- Glycolysis
- Citric acid cycle
- Oxidative phosphorylation
- Chemiosmosis
- $NADH / FADH_2$
- Mitochondria

Photosynthesis

- Light reaction
- Photosystem
- Chlorophyll
- NADPH
- Calvin Cycle
- Chloroplast

Drawings
p. 93
p. 111

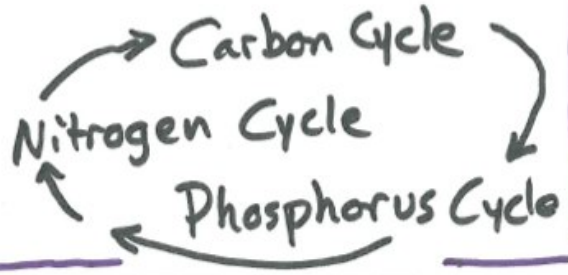
014 Environmental Matter Exchange

Carbohydrates
Mono- Di- Polysaccharides

Lipids
Glycerol, Fatty Acid

Proteins
Amino Acids
Four levels of structure

Nucleic Acids
DNA, RNA, Nucleotides



015 Membranes

- Cell Membrane
- Cell Wall
- Fluid Mosaic
- Proteins
- Phospholipids
- Cholesterol
- Glycoproteins
- Selective Permeability
- Aquaporins

p. 74
Figure 5.1A

016 Transport

- Diffusion
- Osmosis
- Gradient
- Passive Transport
- Active Transport
- Hypo- Iso- Hypertonic
- Facilitated Diffusion
- Exocytosis
- Endocytosis
  - phagocytosis
  - pinocytosis
  - receptor-mediated

017 Compartmentalization

- Plant vs. Animal Cells
- Organelles

Endomembrane System

- Rough ER
- Smooth ER

018 Feedback Loops

Homeostasis

Negative feedback

- Thermoregulation

Positive feedback

- Labor
- Ethylene

Pancreas
Insulin
Glucagon
Diabetes

Level 19 Environmental Response

Behavioral Response
Hibernation
Migration

Physiological Response
Sweating
Shivering

Thermoregulation

Countercurrent Heat Exchange

Cognitive Maps

Level 20

Biosphere
Biome
Ecosystem
Community
Population
Organism

Biotic and Abiotic Factors

- Predator - Prey
- Food Webs
- Biofilms
- Ecology

Level 21

Homeostatic Evolution

Excretory System
Nephron
Filtration, Reabsorption, Secretion, Excretion
Urea, Ammonia, Uric Acid
Respiratory System
Lung / Alveoli
Gill / Lamella
Tiktaalik

Level 22

Homeostatic Disruptions

Osmoconformer
Osmoregulator
Invasive Species
Biodiversity
Endangered Species
Threatened Species

023 Plant/Animal Defense

Plant
Nonspecific
Hypersensitive Response
R-gene
Animal
Nonspecific
Inflammatory Response
Specific
↙ Humoral
Antigen
Antibody
Bcells
↘ Cell-Mediated
Cytotoxic T Cells
Helper T
HIV Infection

024 Timing and Coordination

Germination
Differentiation
Transcription factors
Induction
SRY gene
Apoptosis
RNA interference
Homeotic genes
Mutants
Development

025 Timing and Control

Plants
- Phototropism
  - Auxin
- Photoperiodism
  - Phytochrome

Animals
- Circadian rhythm
- Pineal gland

Bacteria
- Quorum sensing
- Autoinducer

026 Behavior and Natural Selection

- Behavior
  - Innate
  - Learned
- Natural Selection
- Phototropism
- Photoperiodism
- Courtship rituals
- Pollination

Level 27 DNA and RNA

History
- Avery / Griffith
- Hershey-Chase
- Watson-Crick

- Chromosomes
  - Prokaryote
  - Eukaryote
- DNA / RNA Structure
- DNA Replication
- Transcription
- Translation
- Phenotype
- Genetic Engineering

Level 28 Cell Cycle

- Cell Division
- Cell Cycle
  - Interphase
  - M Phase
  - Cytokinesis
- Mitosis
  - Diploid
- Meiosis
  - Haploid
- Fertilization
  - Independent assortment
  - Random fertilization
  - Crossing over

cyclin

Level 29 Genetics

- P, F_1, F_2 generation
- Dominant vs. Recessive
- Phenotype vs. Genotype
- True-breeding
- Monohybrid cross
- Dihybrid cross
- Heterozygous
- Homozygous
- Pedigree
- Law of addition
- Law of multiplication

Level 30 Advanced Genetics

- Incomplete Co-Dominance
- Multiple alleles (ABO)
- Pleiotropy
- Polygenic Inheritance
- Linked genes
  - Autosomes
- Sex linkage
  - Sex chromosomes
- Non-nuclear inheritance
- Gene maps

Level 31 Gene Regulation

- Gene regulation
- Gene expression
- Operon
  - Promoter
  - Repressor
  - Operator
  - Genes
- Lac operon
- Trp operon
- Histone
- Transcription factors
- Enhancers

Level 32

- Signal transmission
- Gene expression
- Endocrine system
- Nervous system
- Glands / Target cells
- Hormones
  - Lipid-soluble
    - testosterone
  - Water-soluble
    - epinephrine

Level 33

Genotypes Phenotypes

- Mutation
  - Base substitution
  - Insertion/Deletion
  - 'Frameshift'
- Sexual recombination
  - Meiosis
- Nondisjunction
  - Down Syndrome
  - Polyploidy
- CCR5-Δ32
- PKU

Level 34

Increasing Variation

- Variation
- Viruses
- Prokaryotes
- Horizontal acquisition
  - Conjugation
  - Transformation
  - Transduction
- Plasmids
- Eukaryotes
  - Independent assortment
  - Crossing over
  - Random fertilization

Level 35

Viral Replication

- Virus
- Capsid-Envelope
- Lytic Cycle
- Lysogenic Cycle
  - Prophage
- Retrovirus
  - Reverse transcriptase
- AIDS
- HIV
- Virulence

Level 36

Cell Communication

- Quorum sensing
- Vibrio fischeri
- Autoinducer
- Luciferase
- Planktonic
- Colonial

- Epinephrine
- Glycogen
- CREB

Level 37

Cell Communication
Cell to Cell
- Antigen Presenting Cell

Short Distance
- Local regulator
- Neurotransmitter

Long Distance
- Hormone
- HGH

Receptor
Secondary Message

Level 38

Signal Transduction Pathway
Ligand
Protein modification
Phosphorylation cascade
Transduction
G-Protein
Secondary messenger
cAMP
Protein kinase

Level 39

Changes In Pathways

Tetrodotoxin
Na+ ion channel
Newt/garter snake

Anthrax
Adenylate cyclase

Diabetes
Insulin receptor
GLUT

Level 40

Information Exchange

Signal
- Bee dance

Behavior
- Courtship ritual
- Territory

Monogamy / Polygamy
Agonistic behavior
Dominance hierarchy
Learned vs. Innate Behavior

Level 41 — Nervous system

- Nervous System
  - Central
  - Peripheral
- Neuron
- Action potential
- Myelin sheath
- Voltage-gated channels
- Synapse
  - Neurotransmitters
    - Excitatory / Inhibatory
- Brain
  - Cerebral Cortex

Level 42 — Biological Molecules

- Polymers
  - Monomers
- Proteins
  - Amino acids
  - Four levels of structure
- Lipids
  - Phospholipids
- Carbohydrates
  - Mono- di- poly-saccharides
- Nucleic Acids
  - DNA and RNA
  - Nucleotides

Level 43 — Cellular Organelles

- Nucleus
  - Nucleolus
  - Chromatin
- Smooth ER
- Rough ER
- Golgi apparatus
- Ribosomes
- Lysosomes
- Vacuoles
- Peroxisomes
- Chloroplast
- Mitochondria

Level 44 — Cellular Specialization

- Cells
- Tissues
  - Epithelial
  - Connective
  - Muscle
  - Nervous
- Organs
- Stem cells
  - Totipotent
  - Pluripotent
- Gastrulation
  - Ectoderm
  - Mesoderm
  - Endoderm

gene regulation

Level 45 Organ Systems

- Endocrine system
- Skeletal system
- Circulatory system
- Respiratory system
- Muscular system
- Integumentary system
- Lymphatic system
- Immune system
- Excretory system
- Digestive system
- Reproductive system
- Nervous system

Level 46 Communities

- BBECPO
- Exponential growth
- Logistic growth
- Limiting factors
  - .Density dependent
  - .Density independent
- Carrying Capacity (K)
- Human Population
- Demographic transition

Level 47 Ecosystems

- Ecosystem
- Matter vs. Energy
- Primary Productivity
- Biomass
- Energy Pyramid
- Food Chain
- Producer / Consumer
- Food Web
- Human impacts
- Biotic vs. Abiotic Impacts

Level 48 Enzymes

- Enzyme
- Substrate
- Active Site
- Induced Fit
- Cofactors / Coenzymes
- Competitive inhibition
- Allosteric inhibition
- Activation energy
- Reaction rate

Level 49 Cooperative Interactions

Prisoner's Dilemma
Cooperation
Natural Selection
Cells - Rumen
- Bacteria
- Protozoa
- Archaea
- Fungi
- Viruses

Organelles
- Signal transduction

Organs
- Digestive system

Level 50 Populations

Community
Niche
Symbiosis
Commensalism
Mutualism
Competition
Predation/Parasitism
Ecosystem Feedback
Invasive Species

Level 51 Ecosystem Change

Ecosystem Impacts
Climate Change
Greenhouse ~~Effect~~
Continental Drift
Pangaea
El Niño
Primary Succession
Secondary Succession

Level 52 Cellular Variation

Molecular Variation
Chlorophyll A vs. B
Purple Earth
Phospholipids
Genetic Variation
Heterozygote Advantage
Sickle cell and CF
Gene Duplication
Antifreeze Protein

Level 53 Genotype Expression

Genotype
Phenotype
Himalayan Rabbit
Seasonal Melanin
Flower Color and pH
Lac+ Bacteria
Male pattern baldness
Thalidomide

Level 54 Population Variation and Dynamics

Devil Facial Tumor Disease
Genetic Diversity
Bottleneck / Founder
HIV and Δ32 mutation
Hardy-Weinberg Equilibrium

$p + q = 1$

$p^2 + 2pq + q^2 = 1$

Level 55 Biodiversity

Biodiversity
- Species diversity
- Genetic diversity
- Ecosystem diversity

Keystone Species
- Jaguar
- Sea Otters