AMGEN Biotech Experience

Scientific Discovery for the Classroom

International Baccalaureate Topics Covered in ABE's *Exploring Precision Medicine*

Theme	Molecules	Cells	Organisms	Ecosystems
A. Unity and Diversity Common ancestry has given living organisms many shared features while evolution has resulted in the rich biodiversity of life on Earth.	A1.1 Water A1.2 Nucleic acids	A2.1 Origins of cells [HL] A2.2 Cell structure A2.3 Viruses [HL]	A3.1 Diversity of organisms A3.2 Classification and cladistics [HL]	A4.1 Evolution and speciation A4.2 Conservation of biodiversity
B. Form and Function Adaptations are forms that correspond to function. These adaptations persist from generation to generation because they increase the chances of survival.	B1.1 Carbohydrates and lipids B1.2 Proteins	B2.1 Membranes and membrane transport B2.2 Organelles and compartmentalization B2.3 Cell specialization	B3.1 Gas exchange B3.2 Transport B3.3 Muscle and motility [HL]	B4.1 Adaptation to environment B4.2 Ecological niches
C. Interaction and Interdependence Systems are based on interactions, interdependence and integration of components. Systems result in emergence of new properties at each level of biological organization.	C1.1 Enzymes and metabolism C1.2 Cell respiration C1.3 Photosynthesis	C2.1 Chemical signaling (HL) C2.2 Neural signaling	C3.1 Integration of body systems C3.2 Defense against disease	C4.1 Populations and communities C4.2 Transfers of energy and matter

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D. Continuity and Change Living things have mechanisms for maintaining equilibrium and for bringing about transformation. Environmental change is a driver of evolution by natural selection.	D1.1 DNA replication D1.2 Protein synthesis D1.3 Mutation and gene editing	D2.1 Cell and nuclear division D2.2 Gene expression [HL] D2.3 Water potential	D3.1 Reproduction D3.2 Inheritance D3.3 Homeostasis	D4.1 Natural selection D4.2 Stability and change D4.3 Climate change

NOTE: "HL" in brackets refers to "higher Level" courses for advanced students

SPECIFIC IB LIFE SCIENCES TOPICS BY CHAPTER

Chapter 1: What's the Right Medicine?

- Activity: Genetics vs. Environment
  - IB Topic:
    - D3.2.4–Phenotype as the observable traits of an organism resulting from genotype and environmental factors
- Worksheet: Including Diverse Populations in Medical Trials
  - IB Topic:
    - D4.1.9–Concept of the gene pool
- Worksheet: Reading Questions: Balancing Prevention and Risk
  - IB Topics:
    - D3.2.3–Genotype as the combination of alleles inherited by an organism
    - D3.2.5—Effects of dominant and recessive alleles on phenotype
    - D3.2.18–Loci of human genes and their polypeptide products
    - D3.2.8–Single-nucleotide polymorphisms and multiple alleles in gene pools
    - D4.1.13–Hardy-Weinberg equation and calculations of allele or genotype frequencies
    - D4.1.10–Allele frequencies of geographically isolated populations
    - D1.2.11–Mutations that change protein structure

Chapter 2: Is My Sense of Taste Controlled by My Genes?

- Activity: Rate the Bitterness of These Foods
  - IB Topic:
    - D3.2.4–Phenotype as the observable traits of an organism resulting from genotype and environmental factors
- Activity: Can You Taste It?
  - IB Topic:
    - C2.2.1—Neurons as cells within the nervous system that carry electrical impulses

- Reading: Prepare for the Next Lab and Worksheet: How PCR Works
    - IB Topic:
        - D1.1.4–Polymerase chain reaction and gel electrophoresis as tools for amplifying and separating DNA

Chapter 3: Exploring Our DNA

- Laboratory: Cheek Cell DNA Extraction
    - IB Topic:
        - B2.2.1–Organelles as discrete subunits of cells that are adapted to perform specific functions
- Laboratory: PCR
    - IB Topic:
        - D1.1.4–Polymerase chain reaction and gel electrophoresis as tools for amplifying and separating DNA
- Reading: How DNA is Sequenced
    - IB Topic:
        - A3.1.11—Current and potential future uses of whole genome sequencing

Chapter 4: How Is DNA Sequenced, and What Can We Learn?

- Activity: Finding TAS2R38 Differences
    - IB Topic:
        - A1.2.4–Bases in each nucleic acid that form the basis of a code
        - A1.2.8–Role of complementary base pairing in allowing genetic information to be replicated and expressed
        - A3.1.8–Unity and diversity of genomes within species
- Activity: Reading DNA Chromatograms
    - IB Topic:
        - A3.1.11—Current and potential future uses of whole genome sequencing
- Reading: Exploring the Differences in Our DNA
    - IB Topic:
        - D1.3.2–Consequences of base substitutions
        - D1.3.7–Mutation as a source of genetic variation

Chapter 5: Restriction Enzyme Digestion of TAS2R38 PCR Products

- Activity: Which Restriction Enzyme Should We Use?
    - IB Topic:
        - D1.3.2–Consequences of base substitutions
- Laboratory: Restriction Digest of TAS2R38 PCR Products
    - IB Topic:
        - D1.3.7–Mutation as a source of genetic variation

Chapter 6: Gel Electrophoresis and Genotyping

- Laboratory: Gel Electrophoresis of TAS2R38 Restriction Digest
    - IB Topic:
        - D1.1.4–Polymerase chain reaction and gel electrophoresis as tools for amplifying and separating DNA
- Reading: “Genes Give Africans a Better Sense of Taste”
    - IB Topic:
        - D4.1.5—Differences between individuals in adaptation, survival and reproduction as the basis for natural selection
        - D4.1.11–Changes in allele frequency in the gene pool as a consequence of natural selection between individuals according to differences in their heritable traits
- Activity: Restriction Digestion and SNP Genotyping
    - IB Topic:
        - D1.3.2–Consequences of base substitutions
        - D1.3.7–Mutation as a source of genetic variation

Chapter 7: SNPs and Drug Metabolism

- Activity: Pharmacogenomics of Clopidogrel
    - IB Topic:
        - A3.1.11—Current and potential future uses of whole genome sequencing
        - D1.1.4–Polymerase chain reaction and gel electrophoresis as tools for amplifying and separating DNA
        - D1.2.11–Mutations that change protein structure
        - D1.3.2–Consequences of base substitutions
        - D3.2.3–Genotype as the combination of alleles inherited by an organism
        - D3.2.18–Loci of human genes and their polypeptide products

TOOLS AND SKILLS

From Clegg, C. J., & Davis, A. (2023). Biology for the IB Diploma 3rd Edition. Hodder Education.

Tool 1: Experimental Techniques

- Skill: Measuring Variables
    - Volume
- Skill: Applying Techniques
    - Physical and digital molecular modeling
    - Karyotyping and karyograms

Tool 2: Technology

- Skill: Applying technology to collect data
    - Identify and extract data from databases
- Skill: Applying technology to process data
    - Use spreadsheets to manipulate data (note: this is for an optional data analysis option in Chapter 1)
    - Represent data in graphical form

Tool 3: Mathematics

- Skill: Applying general mathematics
    - Use basic arithmetic and algebraic calculations to solve problems
    - Frequencies (including allele frequencies)
- Skill: Graphing
    - Construct and interpret tables, charts and graphs for raw and processed data, including bar charts, histograms, scatter graphs, line and curve graphs, logarithmic graphs, pie charts and box-and-whisker plots

IB NATURE OF SCIENCE

From International Baccalaureate Organization (2023). Biology guide. Author.

- D1.1.5—Applications of polymerase chain reaction and gel electrophoresis.
    - NOS: Reliability is enhanced by increasing the number of measurements in an experiment or test. In DNA profiling, increasing the number of markers used reduces the probability of a false match. (IB Biology Guide, p. 86)
- D1.3.7—Mutation as a source of genetic variation.
    - NOS: Commercial genetic tests can yield information about potential future health and disease risk. One possible impact is that, without expert interpretation, this information could be problematic. (IB Biology Guide, p. 89)

IB APPROACH TO TEACHING AND LEARNING (ATL)

From International Baccalaureate Organization (2023). Biology guide. Author.

Entire Curriculum Module

- Self-management skills
    - Breaking down major tasks into a sequence of stages
    - Avoiding unnecessary distractions (IB Biology Guide, pp. 15-16)

Chapter 1: What's the Right Medicine?

- Communication skills: Practicing active listening skills (Discussion Questions)

Chapter 2: Is My Sense of Taste Controlled by My Genes?

- Thinking skills: Applying key ideas and facts in new contexts (connecting Precision Medicine to taster trait)

Chapter 4: How Is DNA Sequenced, and What Can We Learn?

- Research skills: Using search engines and libraries effectively (using BLAST)

Chapter 5: Restriction Enzyme Digestion of TAS2R38 PCR Products

- Social skills: Assigning and accepting specific roles during group activities (RE digest lab)

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