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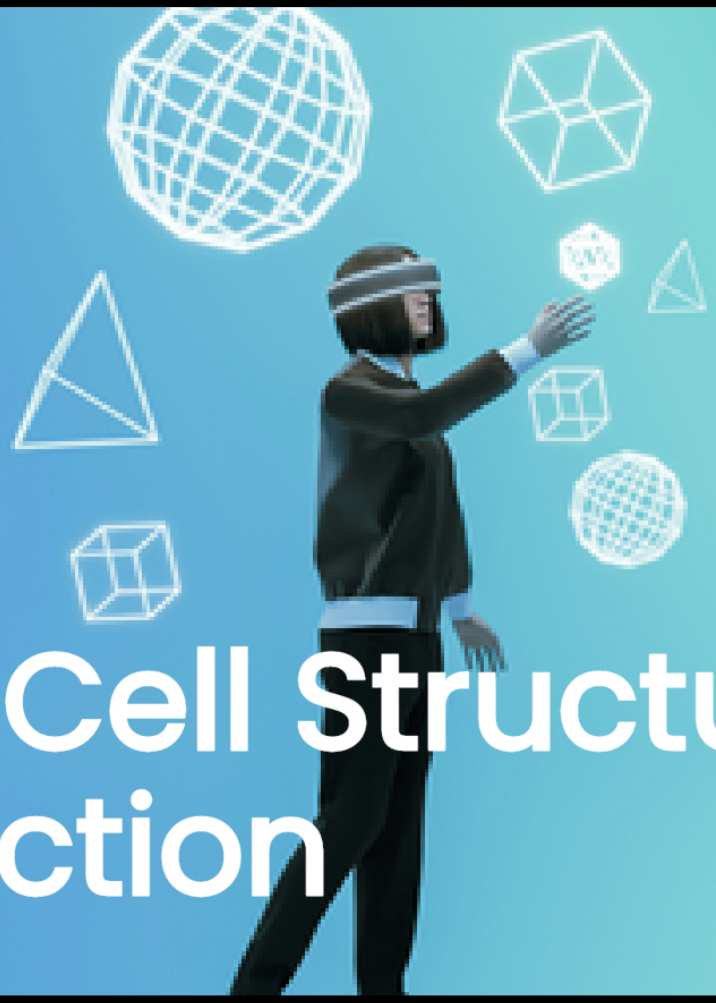

Biology: Cell Structure and Function

Date: 2026.3.13

Presenter: UTKARSH THAKUR
2340260
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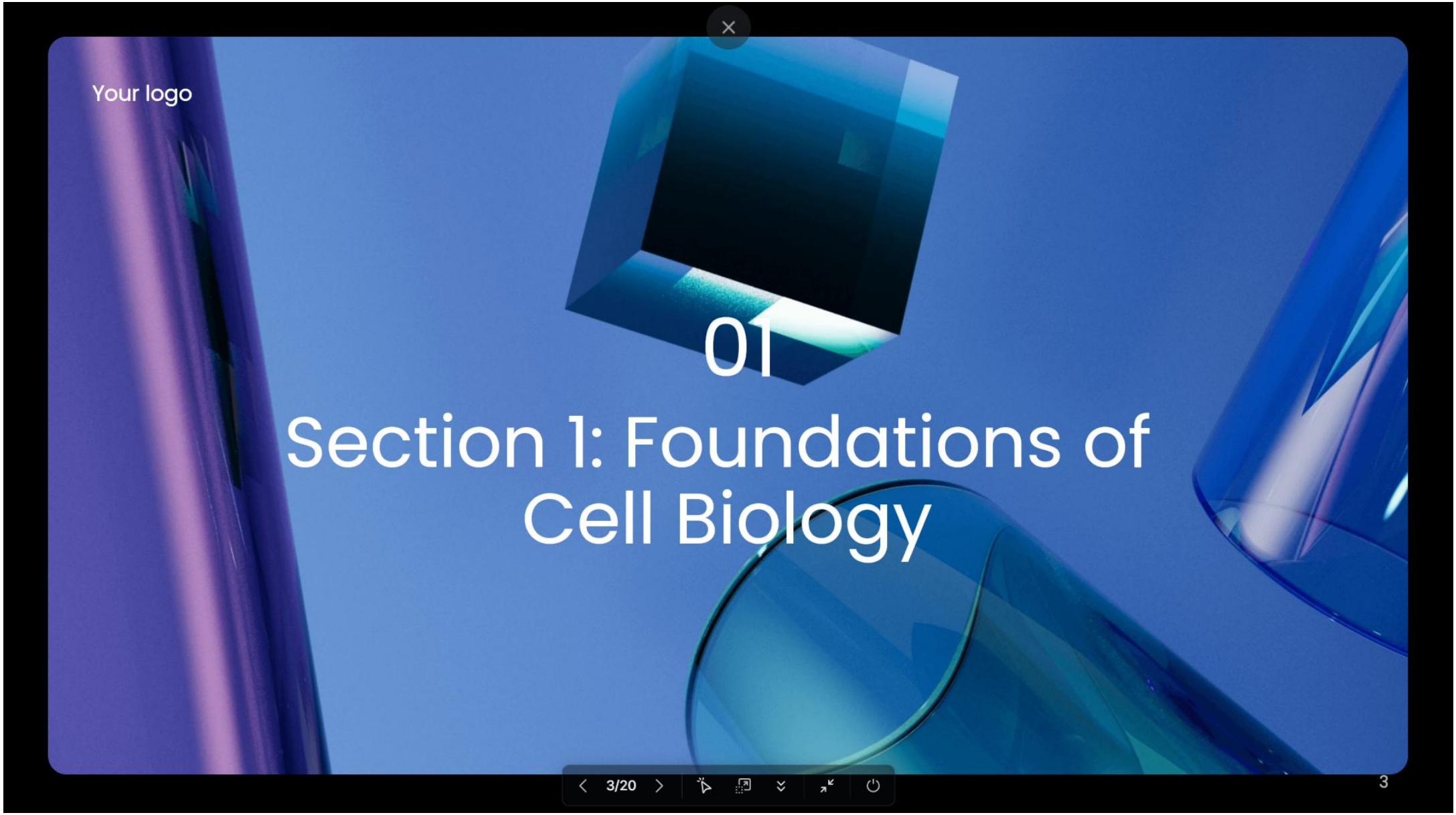
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Section 1: Foundations of Cell Biology
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Introduction to Cells

01
Historical Discovery

Robert Hooke coined the term "cell" in 1665 while examining cork tissue under an early microscope.

02
Universal Cellular Composition

All living organisms are composed of one or more cells, making cells fundamental to life.

03
Minimal Functional Unit

The cell represents the smallest unit of life capable of independent functioning and survival.

04
Cell Theory Principle One

All living things are composed of cells as their basic structural and organizational components.

05
Cell Theory Principle Two

Cells serve as the fundamental units of structure and organization in all living organisms.

06
Cell Theory Principle Three

All cells arise from pre-existing cells through division, establishing cellular continuity and inheritance.

Cell Theory and Historical Context

Early Discovery and Observation

Robert Hooke discovers and names cells from cork tissue observation in sixteen sixty-five.

Microscopy Development Period

Early microscopy reveals cellular structures in various organisms during the sixteen seventies through seventeen hundreds.

Cell Theory Formulation

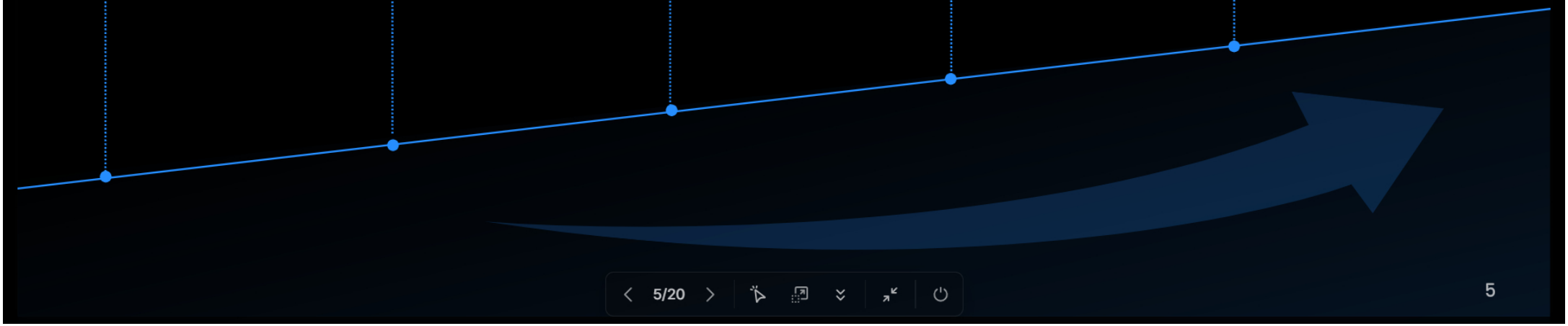
Cell theory is formulated and refined by prominent scientists throughout the eighteen hundreds era.

Modern Technological Advancement

Advanced microscopy and molecular techniques revolutionize cell biology understanding in the modern era.

Contemporary Applications

CRISPR and immunotherapy applications demonstrate practical cell biology significance in present day.



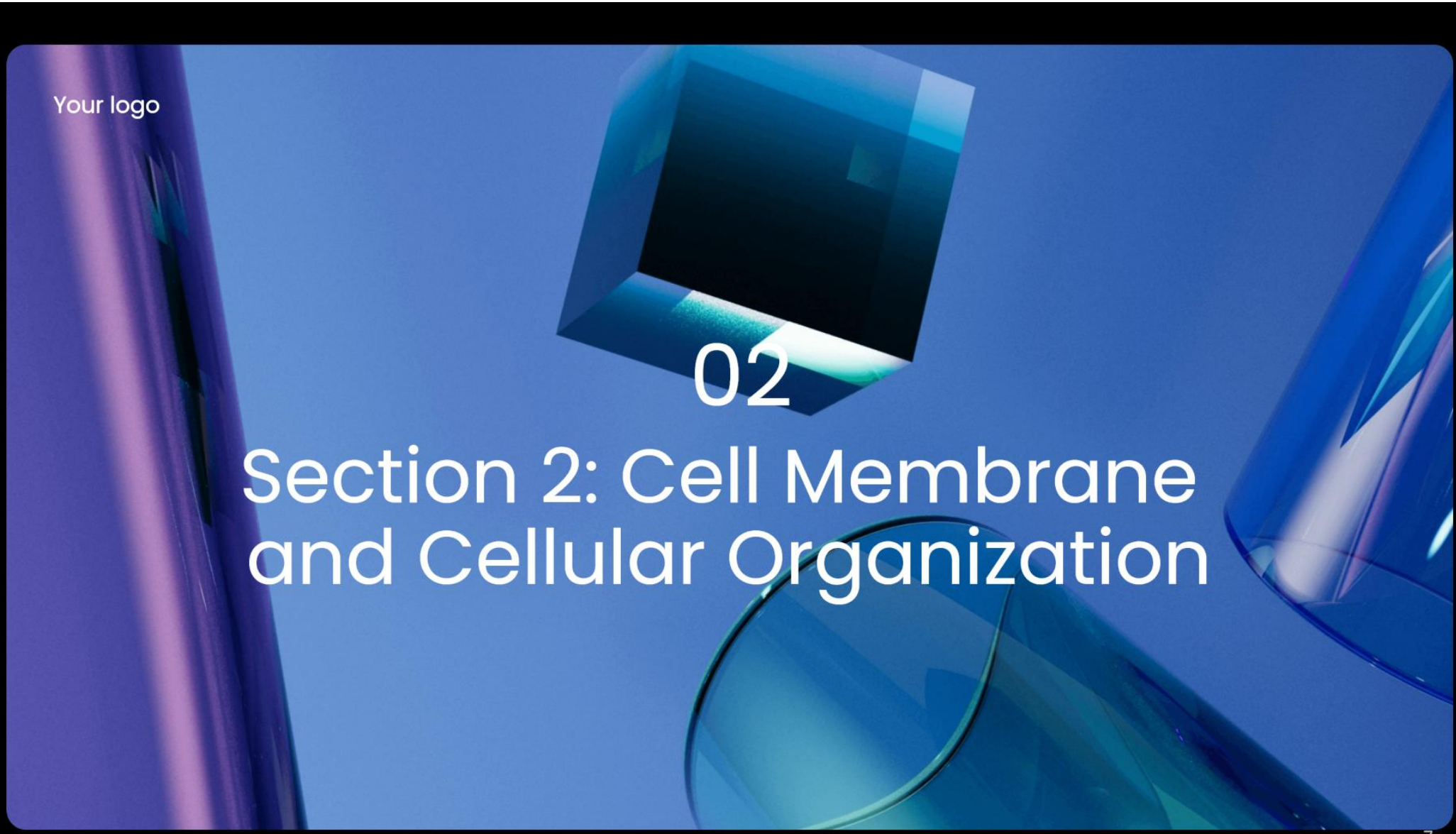
Types of Cells: Prokaryotic vs Eukaryotic

Prokaryotic Cells

Found in bacteria and archaea; lack membrane-bound nucleus and organelles; smaller cells measuring 0.5–5.0 micrometers with simpler organization and DNA located in nucleoid region.

Eukaryotic Cells

Found in animals, plants, fungi, and protists; possess distinct nucleus with nuclear membrane; contain membrane-bound organelles; larger cells measuring 10–100 micrometers with highly complex, compartmentalized functions.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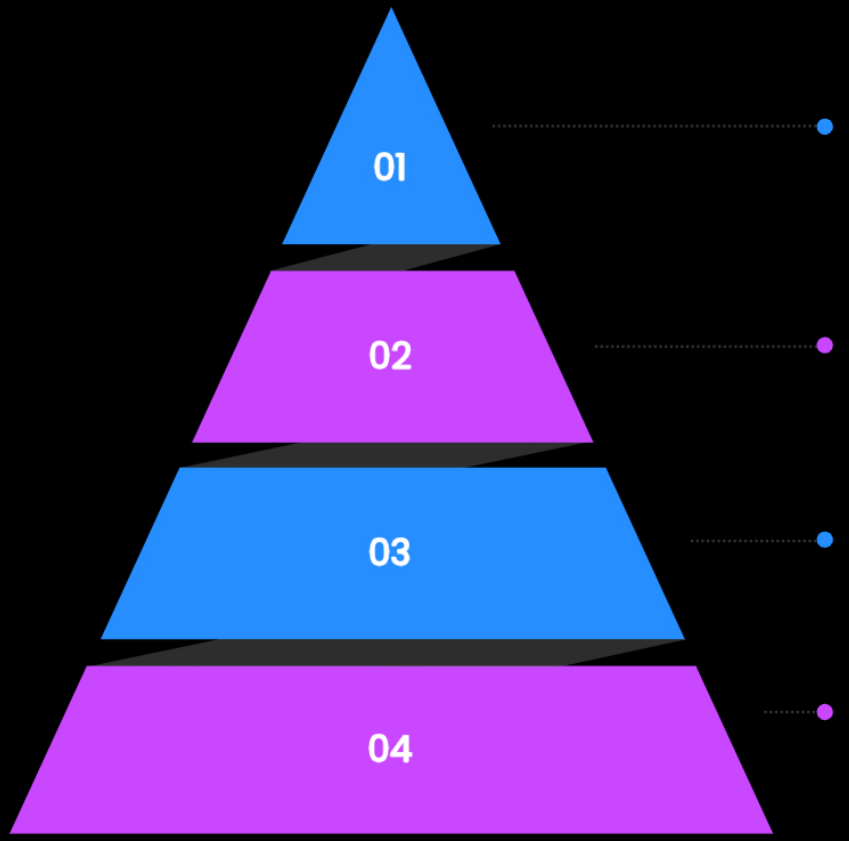
Section 2: Cell Membrane and Cellular Organization

Cell Membrane Structure and Composition



Overall Function

Semi-permeable barrier regulating substance passage between interior and external environment of cells.

Primary Component

Phospholipid bilayer with embedded proteins and cholesterol molecules maintaining structural integrity.

Molecular Arrangement

Hydrophilic heads face outward; hydrophobic tails face inward in organized layers forming barrier.

Structural Model

Fluid mosaic model portrays membrane as dynamic, fluid structure with embedded proteins functioning collectively.

Membrane Proteins and Their Functions

Transport Proteins

Facilitate movement of substances across membrane through channels and carrier-mediated transport mechanisms.

Receptor Proteins

Bind signaling molecules enabling cellular communication and coordinate appropriate physiological responses.

Recognition Proteins

Identify cells as "self" and distinguish between different cell types for immune recognition.

Enzymatic Proteins

Catalyze chemical reactions and regulate metabolic processes within and across membrane structures.

Major Cellular Organelles and Functions

Nucleus: Genetic Control Center

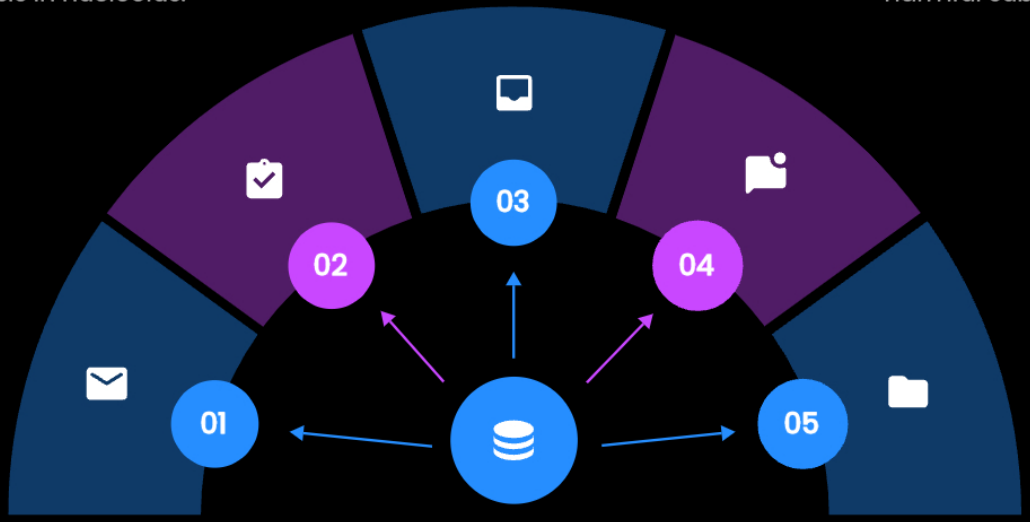
Membrane-bound organelle containing DNA; primary site of transcription, gene expression, and ribosomal RNA synthesis in nucleolus.

Mitochondria: Cellular Energy Producer

Powerhouse of the cell; site of aerobic respiration producing ATP; possesses own DNA suggesting prokaryotic evolutionary origin.

Endoplasmic Reticulum: Synthesis and Processing

Rough ER synthesizes proteins with ribosomal attachment; smooth ER synthesizes lipids and detoxifies harmful substances.



Core Point: Compartmentalized Functions

Eukaryotic cells contain specialized organelles enabling compartmentalized functions and increased metabolic efficiency through functional specialization.

Golgi Apparatus: Protein Modification and Transport

Modifies proteins from rough ER, packages them into vesicles for cellular transport, secretion, and targeted delivery.

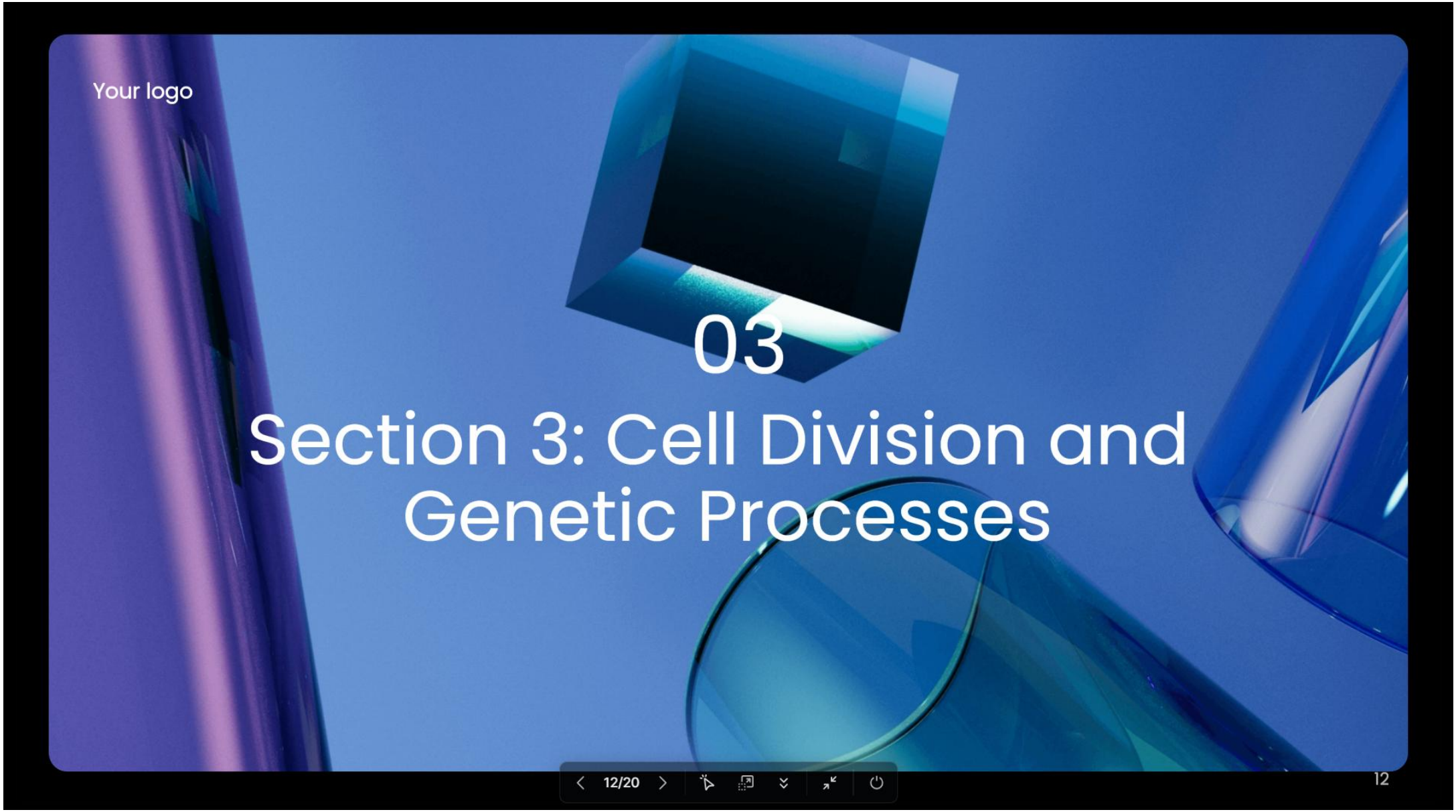
Cellular Support and Specialized Organelles

Cytoskeleton
Network of protein filaments providing structural support, enabling cell movement and facilitating intracellular transport mechanisms throughout cytoplasm.

Lysosomes
Membrane-bound organelles containing hydrolytic enzymes that efficiently digest cellular waste and eliminate foreign materials for cell health.

Chloroplasts
Found exclusively in plant cells; primary sites of photosynthesis converting light energy into chemical energy stored as glucose molecules.

Ribosomes
Sites of protein synthesis existing freely in cytoplasm or attached to rough ER; composed of ribosomal RNA and proteins.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Section 3: Cell Division and Genetic Processes
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Mitosis: Cell Division for Growth

01

Prophase Stage

Chromosomes condense and become visible; nuclear envelope breaks down; spindle fibers form to organize cell division.

02

Metaphase Stage

Condensed chromosomes align precisely at the cell's metaphase plate located at the equatorial plane region.

03

Telophase Stage

Nuclear envelopes reform around separated chromosome groups; spindle fibers disappear; cytokinesis initiates cell division completion.

04

Anaphase Stage

Sister chromatids separate and migrate to opposite poles of the cell during chromosome movement.

05

Division Outcome

Two identical daughter cells are produced for growth and tissue repair in somatic cells.

Meiosis: Sexual Reproduction and Genetic Variation

Step1

Meiosis I: Homologous Chromosome Separation

Homologous chromosomes separate while crossing over generates genetic variation, producing two haploid cells from one diploid parent cell.

Step2

Meiosis II: Sister Chromatid Separation

Sister chromatids separate similarly to mitosis phase II, completing the division process and yielding four distinct haploid daughter cells.

Step3

Genetic Variation: Crossing Over and Independent Assortment

Crossing over and independent assortment mechanisms create genetically non-identical daughter cells, ensuring diversity in offspring populations.

Step4

Chromosome Reduction: Maintaining Genetic Consistency

Produces four non-identical daughter cells containing half the chromosome number of the parent cell for accurate genetic transmission.

Step5

Significance: Essential Biological Function

Meiosis enables sexual reproduction and maintains consistent chromosome numbers across successive generations in all organisms.

Cellular Transport Mechanisms

01 FIRST

Diffusion Process

Molecules move from high to low concentration gradient passively without requiring cellular energy expenditure throughout the process.

02 SECOND

Osmosis Mechanism

Water moves across semi-permeable membranes maintaining cellular hydration balance and regulating internal osmotic pressure effectively.

03 THIRD

Vesicular Transport Method

Endocytosis and exocytosis enable large molecule movement, maintaining membrane composition and delivering materials throughout cellular structures.

04 FOURTH

Active Transport System

Movement against concentration gradient requires ATP energy; sodium-potassium pump maintains essential ionic gradients across membranes.


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Section 4: Significance and Modern Applications
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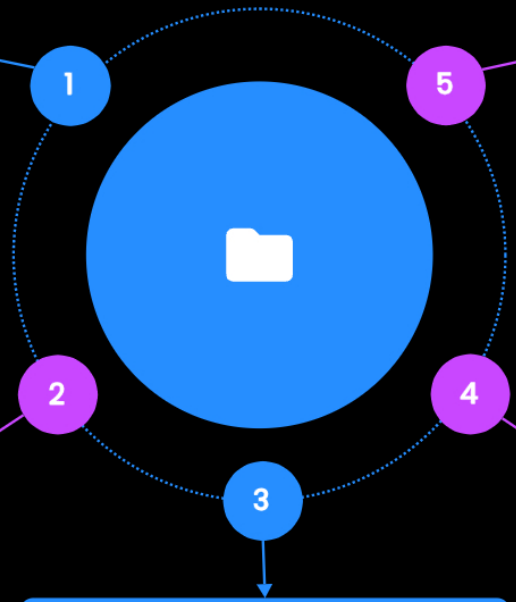
Fundamental Biological Processes Enabled by Cell Understanding



Core Significance

Understanding cell structure and function is fundamental to comprehending organism development, homeostasis maintenance, environmental response mechanisms, and reproductive processes.

Organism Development

Cell division and differentiation enable growth from single cells to complex multicellular organisms through coordinated developmental processes.

Homeostasis Maintenance

Cellular transport and regulatory mechanisms maintain stable internal environments despite fluctuating external conditions and environmental pressures.

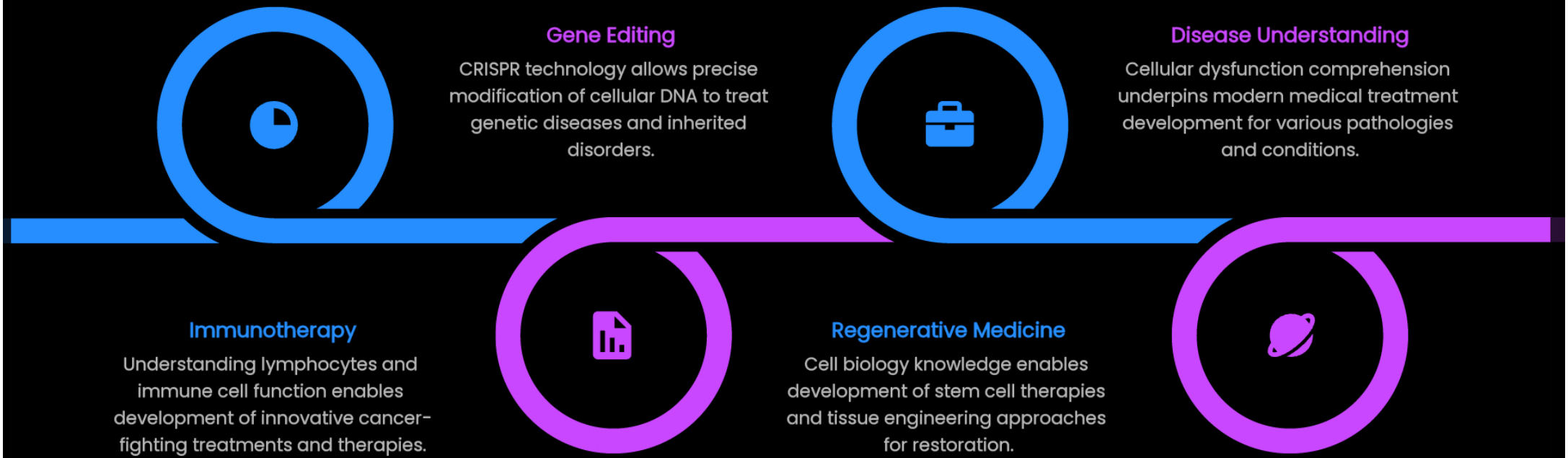
Environmental Response

Receptor proteins and signaling pathways enable cells to detect environmental stimuli and initiate appropriate physiological responses.

Reproduction and Genetic Diversity

Mitosis enables asexual reproduction and tissue repair; meiosis enables sexual reproduction with increased genetic diversity.

Medical and Biotechnology Applications



Gene Editing

CRISPR technology allows precise modification of cellular DNA to treat genetic diseases and inherited disorders.

Disease Understanding

Cellular dysfunction comprehension underpins modern medical treatment development for various pathologies and conditions.

Immunotherapy

Understanding lymphocytes and immune cell function enables development of innovative cancer-fighting treatments and therapies.

Regenerative Medicine

Cell biology knowledge enables development of stem cell therapies and tissue engineering approaches for restoration.

Current Research and Future Directions

01 Advanced Microscopy Techniques

Electron microscopy and fluorescence imaging reveal subcellular structures at unprecedented resolution, enabling detailed visualization of cellular components and their spatial organization.

02 Molecular Cell Biology

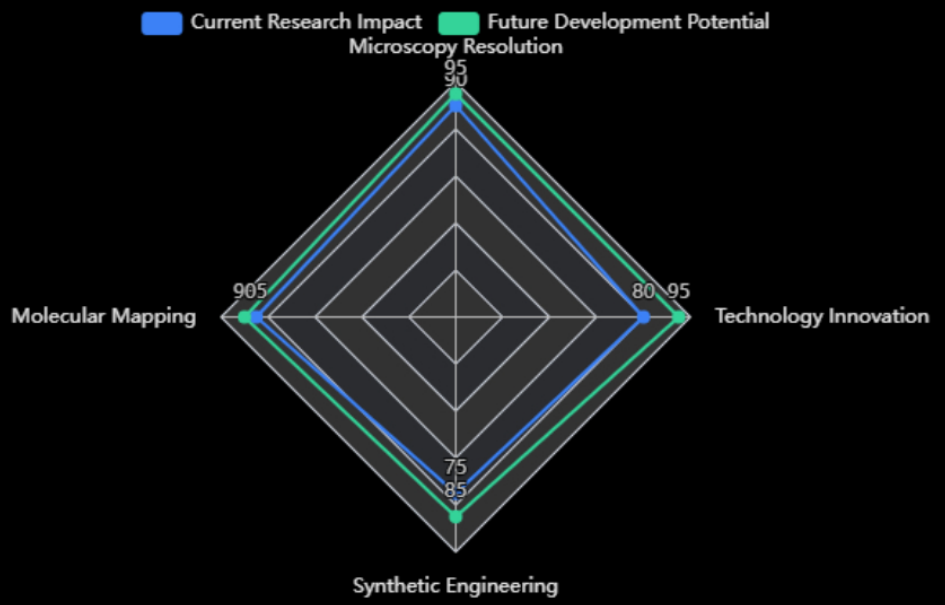
Genomic sequencing and proteomics comprehensively map cellular molecular interactions and regulatory networks, decoding complex biological information flows.

03 Synthetic Biology Applications

Engineering cells with modified structures and functions creates therapeutic and industrial applications, advancing biotechnology and regenerative medicine.

04 Emerging Technologies

Single-cell analysis, organoid development, and artificial cell membrane research continuously push biological boundaries, revealing new cellular mechanisms.



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