BIO207 Comprehensive Quiz: Genetics and Cell Biology

LOC & THE UNIOSUN BUZZ TEAM

1 Genetics: Fundamentals and Historical Perspectives

1. Which of the following statements best defines genetics as a scientific discipline?

   (a) The study of how traits are passed from parents to offspring through the transmission of genes
   (b) The analysis of cellular structures and their functions in inheritance
   (c) The science dealing with heredity and variation, seeking laws governing similarities and differences in related individuals
   (d) The investigation of DNA replication and protein synthesis mechanisms

2. William Bateson, who coined the term "genetics" in 1906, defined it as a science that:

   (a) Studies only the molecular structure of genes and chromosomes
   (b) Deals exclusively with human hereditary diseases
   (c) Seeks to discover laws governing similarities and differences in individuals related by descent
   (d) Focuses primarily on genetic engineering applications

3. The transition from philosophical theories of inheritance to experimental genetics began in earnest with:

   (a) Hippocrates' theory of pangenesis in ancient Greece
   (b) Mendel's pea plant experiments in the 1860s
   (c) Darwin's theory of evolution by natural selection
   (d) The discovery of DNA structure in 1953

4. Aristotle's opposition to Hippocrates' pangenesis theory was based on his belief in:

   (a) The influence of "vital heat" in shaping developing organisms
   (b) Preformationism, where organisms develop from miniature forms
   (c) Blending inheritance as the mechanism of trait transmission
   (d) The role of environmental factors exclusively in development

5. Preformationism, prevalent in the 17th century, proposed that:

(a) Organisms develop from undifferentiated materials through gradual differentiation
(b) One parent contributed a fully formed miniature organism that simply grew larger
(c) Traits from both parents blended together in offspring
(d) Acquired characteristics could be inherited by subsequent generations

6. The major flaw in the theory of blending inheritance was its inability to explain:

(a) Why offspring sometimes resemble one parent more than the other
(b) How traits could reappear unchanged after skipping generations
(c) Why some traits are dominant while others are recessive
(d) The mechanism of DNA replication during cell division

7. Jean-Baptiste Lamarck's theory of inheritance of acquired characteristics attempted to explain:

(a) How environmental adaptations could be passed to offspring
(b) Why genetic mutations occur randomly
(c) The molecular basis of genetic recombination
(d) Chromosomal segregation during meiosis

8. Which critical factor contributed most to Gregor Mendel's success where his predecessors failed?

(a) His use of advanced microscopy to observe chromosomes
(b) His application of statistical analysis to inheritance patterns
(c) His discovery of DNA as the genetic material
(d) His focus on human genetic disorders

9. Mendel's choice of pea plants (Pisum sativum) was particularly advantageous because they:

(a) Have a very long generation time allowing detailed observation
(b) Are naturally cross-pollinated only, preventing self-fertilization
(c) Can be easily cross-pollinated despite being normally self-pollinating
(d) Display continuous variation in most traits studied

10. The theory of epigenesis, as elaborated by Caspar Friedrich Wolff, emphasized that:

(a) Organisms develop from pre-existing miniature forms
(b) Development occurs through progressive differentiation from simpler beginnings
(c) All traits are predetermined at conception

(d) Environmental factors have no role in development

11. In Darwin's version of pangenesis, he proposed "cellular gemmules" to explain:

(a) How mutations arise spontaneously in populations
(b) The mechanism of inheritance of acquired characteristics
(c) Why chromosomes segregate during gamete formation
(d) The molecular structure of DNA

12. August Weismann's mouse tail experiment provided crucial evidence against:

(a) Mendelian inheritance patterns
(b) The theory of epigenesis
(c) The inheritance of acquired characteristics
(d) Chromosomal theory of inheritance

13. According to Weismann's germplasm theory, changes in somatic tissues:

(a) Are always transmitted to offspring
(b) Can be transmitted only if they affect reproductive cells
(c) Are never transmitted to offspring
(d) Are transmitted only through mitochondrial DNA

14. The period during which Mendel's work was largely ignored is best explained by:

(a) The scientific community's preoccupation with Darwin's theory
(b) Lack of proper communication channels in the 19th century
(c) Mendel's failure to publish his results in a reputable journal
(d) Incompatibility of his findings with prevailing biological theories

15. Which technological advancement was most crucial for the rediscovery of Mendel's work in 1900?

(a) Development of electron microscopy
(b) Improved statistical methods in biology
(c) Advances in chromosome staining techniques
(d) Invention of the polymerase chain reaction

16. The concept of "true breeding" in genetics refers to organisms that:

(a) Always produce offspring with new combinations of traits
(b) Consistently produce offspring identical to themselves for specific traits
(c) Are heterozygous for all genes being considered
(d) Have undergone recent mutations in their genetic makeup

17. Mendel's experimental design was particularly rigorous because he:

    (a) Studied multiple traits simultaneously in each cross
    (b) Used both qualitative descriptions and quantitative analysis
    (c) Focused exclusively on dominant traits
    (d) Relied on natural pollination without experimental controls

18. In Mendel's monohybrid crosses, the observation that only one parental trait appeared in the F1 generation led to:

    (a) The law of independent assortment
    (b) The principle of dominance
    (c) The chromosome theory of inheritance
    (d) The concept of genetic linkage

19. The reappearance of the recessive trait in the F2 generation in a 3:1 ratio demonstrated:

    (a) That traits blend together in offspring
    (b) That recessive traits are lost during reproduction
    (c) That genetic factors separate during gamete formation
    (d) That environmental factors control inheritance

20. Mendel's law of segregation is fundamentally based on:

    (a) The behavior of chromosomes during meiosis
    (b) The molecular structure of DNA
    (c) The independent assortment of different gene pairs
    (d) The observation of phenotypic ratios in pea plants

21. In modern genetic terminology, Mendel's "factors" are equivalent to:

    (a) Chromosomes
    (b) Genes
    (c) Proteins
    (d) Phenotypes

22. The distinction between genotype and phenotype is crucial because:

    (a) Genotype determines phenotype, but phenotype doesn't always reveal genotype
    (b) Phenotype determines genotype through environmental influences
    (c) They are always identical in all organisms
    (d) Only genotype can be inherited by offspring

23. A test cross is specifically designed to:

(a) Determine if two genes are linked on the same chromosome
(b) Identify the genotype of an individual showing a dominant phenotype
(c) Calculate mutation rates in a population
(d) Measure the effect of environmental factors on gene expression

24. In a test cross involving a pea plant with round seeds (dominant phenotype), the appearance of any wrinkled-seed offspring proves:

(a) The round-seed parent is homozygous dominant
(b) The round-seed parent is heterozygous
(c) Round seeds are actually recessive
(d) A mutation has occurred in the offspring

25. Mendel's law of independent assortment applies specifically to:

(a) Alleles of the same gene
(b) Genes located on different chromosomes
(c) Linked genes on the same chromosome
(d) Sex-linked traits only

26. The 9:3:3:1 phenotypic ratio in dihybrid crosses results from:

(a) Complete linkage between the two genes
(b) Incomplete dominance for both traits
(c) Independent assortment of unlinked genes
(d) Sex-linked inheritance patterns

27. In a dihybrid cross (RrYy $\times$ RrYy), the probability of obtaining an offspring with both recessive phenotypes (rryy) is:

(a) 1/16
(b) 3/16
(c) 9/16
(d) 1/4

28. The product rule in probability applied to genetics states that:

(a) The probability of either of two mutually exclusive events occurring is the sum of their individual probabilities
(b) The probability of two independent events occurring together is the product of their individual probabilities
(c) All genetic events are dependent on environmental factors
(d) Probability calculations cannot be applied to biological systems

29. When Mendel analyzed seed color and seed shape separately in his dihybrid cross, each trait showed:

(a) A 1:1 ratio in the F2 generation
(b) A 3:1 ratio in the F2 generation
(c) Complete linkage with no independent assortment
(d) A 9:3:3:1 ratio for each trait individually

30. The fundamental difference between a backcross and a test cross is:

(a) A backcross always involves homozygous recessive individuals
(b) A test cross always uses a homozygous recessive parent
(c) Backcrosses are only used in plant genetics
(d) Test crosses are only applicable to animal breeding

31. The rediscovery of Mendel's work in 1900 by scientists like de Vries and Correns was significant because:

(a) It provided the first evidence for DNA as genetic material
(b) It occurred just as chromosomes were being recognized as carriers of heredity
(c) It immediately led to the development of genetic engineering
(d) It disproved Darwin's theory of natural selection

32. The concept of "genes" as discrete hereditary units was solidified through:

(a) Mendel's mathematical analysis of inheritance patterns
(b) Microscopic observation of chromosome behavior
(c) Biochemical analysis of DNA structure
(d) Population genetics studies of mutation rates

33. In modern terms, Mendel's "pure breeding" lines would be described as:

(a) Heterozygous for the traits being studied
(b) Homozygous for the traits being studied
(c) Haploid for all chromosomes
(d) Polyploid variants of normal plants

34. The historical progression from pangenesis to germplasm theory to Mendelian genetics represents:

(a) A gradual refinement in understanding inheritance mechanisms
(b) Complete paradigm shifts with no continuity between theories
(c) Alternative explanations that are all partially correct
(d) Regional differences in scientific understanding

35. The integration of Mendelian genetics with chromosome theory in the early 20th century:

(a) Created conflicts that took decades to resolve

(b) Provided a physical basis for Mendel's abstract "factors"
(c) Showed that Mendel's laws only applied to plants
(d) Demonstrated that chromosomes were unrelated to inheritance

2 Cell Biology: Structure, Function, and Organization

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1. The cell theory represents one of biology's fundamental principles because it:

   (a) Describes the chemical composition of all living matter
   (b) Identifies the cell as the basic unit of structure and function in organisms
   (c) Explains the mechanism of genetic inheritance
   (d) Details the process of evolution by natural selection

2. Which of the following statements is NOT part of the modern cell theory?

   (a) All living organisms are composed of one or more cells
   (b) The cell is the basic unit of structure and organization in organisms
   (c) All cells arise spontaneously from non-living matter
   (d) Cells contain hereditary information passed during cell division

3. The main source of chemical energy for cellular processes is:

   (a) Glucose stored in the cytoplasm
   (b) ATP produced through cellular respiration
   (c) DNA replication during cell division
   (d) Protein synthesis on ribosomes

4. The primary reason cells are considered the fundamental units of life is that they:

   (a) Are visible under light microscopes
   (b) Can carry out all basic life processes independently
   (c) Contain DNA organized into chromosomes
   (d) Have membrane-bound organelles in eukaryotes

5. Prokaryotic cells differ fundamentally from eukaryotic cells in that they:

   (a) Lack membrane-bound organelles and a defined nucleus
   (b) Are always smaller than eukaryotic cells
   (c) Cannot carry out protein synthesis
   (d) Do not contain genetic material

6. The term "prokaryote" literally means "before nucleus," reflecting that:

   (a) Prokaryotes evolved before eukaryotes in evolutionary history
   (b) Prokaryotic cells have primitive, non-functional nuclei
   (c) Prokaryotes will eventually develop nuclei
   (d) Prokaryotic DNA is not organized into chromosomes

7. In eukaryotic cells, compartmentalization of functions within organelles:

   (a) Slows down cellular processes by creating barriers
   (b) Allows incompatible biochemical processes to occur simultaneously
   (c) Prevents genetic material from interacting with cytoplasm
   (d) Makes cells more susceptible to environmental damage

8. The nuclear envelope is structurally and functionally significant because it:

   (a) Completely isolates DNA from the cytoplasm
   (b) Allows regulated exchange between nucleus and cytoplasm
   (c) Prevents DNA replication from occurring
   (d) Is identical in structure to the cell membrane

9. Mitochondria are often called the "powerhouses of the cell" because they:

   (a) Store genetic information for energy production
   (b) Convert chemical energy from food into ATP through cellular respiration
   (c) Synthesize all proteins needed for energy metabolism
   (d) Control the cell cycle and division processes

10. Ribosomes differ from other organelles in that they:

    (a) Are membrane-bound structures
    (b) Are not surrounded by a lipid bilayer
    (c) Contain their own DNA for protein synthesis
    (d) Are only found in eukaryotic cells

11. The endoplasmic reticulum (ER) plays a crucial role in:

    (a) ATP production through oxidative phosphorylation
    (b) Protein synthesis, modification, and transport
    (c) DNA replication and chromosome segregation
    (d) Photosynthesis in plant cells

12. The Golgi apparatus functions primarily in:

    (a) Modifying, sorting, and packaging proteins for secretion

(b) Synthesizing ribosomal RNA for protein production
(c) Breaking down cellular waste and foreign materials
(d) Storing genetic information as chromatin

13. Lysosomes contain digestive enzymes that function optimally at acidic pH because:

(a) Acidic conditions activate the enzymes while protecting the cell
(b) Most cellular components are stable only at low pH
(c) DNA replication requires acidic environments
(d) Protein synthesis occurs more efficiently at low pH

14. Plant cells are distinguished from animal cells primarily by the presence of:

(a) A cell wall, chloroplasts, and a large central vacuole
(b) Mitochondria and endoplasmic reticulum
(c) Multiple nuclei and centrioles
(d) Lysosomes and peroxisomes

15. The cell wall in plant cells provides:

(a) Flexibility for cell movement and shape changes
(b) Structural support and protection against osmotic pressure
(c) Sites for photosynthesis and energy production
(d) Channels for intercellular communication only

16. Chloroplasts are essential for photosynthesis because they:

(a) Store glucose produced during photosynthesis
(b) Contain chlorophyll and the enzymatic machinery for converting light energy
(c) Break down glucose to produce ATP for the cell
(d) Synthesize all proteins needed for light absorption

17. The large central vacuole in plant cells serves multiple functions including:

(a) Protein synthesis and modification
(b) Storage of water, ions, and nutrients; waste disposal; and cell growth
(c) DNA replication and cell division control
(d) Photosynthesis and carbohydrate production

18. The fluid mosaic model of the cell membrane describes it as:

(a) A rigid, static structure with fixed protein positions
(b) A dynamic bilayer with proteins moving within the lipid matrix
(c) A single layer of phospholipids without proteins
(d) A carbohydrate-based structure without lipids

19. Selective permeability of the cell membrane is crucial because it:

    (a) Allows all substances to pass freely in and out
    (b) Maintains homeostasis by controlling substance passage
    (c) Prevents any movement of molecules across the membrane
    (d) Only allows large molecules to enter the cell

20. The cytoskeleton provides structural support through three main components:

    (a) Microfilaments, intermediate filaments, and microtubules
    (b) Cellulose, chitin, and peptidoglycan fibers
    (c) DNA, RNA, and protein complexes
    (d) Phospholipids, cholesterol, and glycolipids

21. Cilia and flagella are specialized cellular structures that:

    (a) Synthesize proteins for export from the cell
    (b) Provide locomotion or move fluids past the cell
    (c) Store genetic information for cellular division
    (d) Break down toxic substances in the cell

22. The endomembrane system includes organelles that:

    (a) Function independently without interaction
    (b) Work together to modify, package, and transport proteins and lipids
    (c) Are only involved in energy production
    (d) Exclusively degrade cellular waste products

23. Peroxisomes contain enzymes that primarily:

    (a) Break down fatty acids and detoxify harmful substances
    (b) Synthesize ATP through oxidative phosphorylation
    (c) Replicate DNA during cell division
    (d) Photosynthesize in the presence of light

24. The nucleolus is the site within the nucleus where:

    (a) DNA replication occurs during the S phase
    (b) Ribosomal RNA is synthesized and ribosomes are assembled
    (c) Chromosomes align during cell division
    (d) mRNA is transcribed from DNA templates

25. Chromatin refers to:

    (a) The complex of DNA and proteins that makes up chromosomes

(b) The fluid portion of the nucleus containing dissolved materials
(c) The membrane surrounding the nucleus
(d) The structures that form during cell division

26. The difference between rough and smooth endoplasmic reticulum is:

(a) Rough ER has ribosomes attached and is involved in protein synthesis
(b) Smooth ER has ribosomes and synthesizes lipids exclusively
(c) Rough ER lacks ribosomes and detoxifies substances
(d) Smooth ER is only found in prokaryotic cells

27. Cellular compartmentalization in eukaryotes provides an evolutionary advantage by:

(a) Allowing larger cell sizes and more complex functions
(b) Making cells more susceptible to viral infection
(c) Slowing down metabolic reactions through separation
(d) Preventing DNA from interacting with cytoplasmic components

28. The theory of endosymbiosis explains the origin of:

(a) The nucleus and nuclear envelope
(b) Mitochondria and chloroplasts from engulfed prokaryotes
(c) The endoplasmic reticulum and Golgi apparatus
(d) Cell walls in plants and fungi

29. Evidence supporting the endosymbiotic theory includes that mitochondria and chloroplasts:

(a) Have single membranes like other organelles
(b) Contain their own DNA and ribosomes similar to prokaryotes
(c) Cannot reproduce independently of the host cell
(d) Are identical in structure to the endoplasmic reticulum

30. Cellular differentiation in multicellular organisms results from:

(a) Different cells containing different genetic information
(b) Selective expression of genes in different cell types
(c) Random mutations occurring in specific tissues
(d) Environmental factors completely determining cell function

31. The extracellular matrix in animal tissues functions to:

(a) Provide structural support and facilitate cell communication
(b) Store genetic information for tissue repair
(c) Synthesize ATP for neighboring cells
(d) Transport oxygen to cells throughout the body

32. Plasmodesmata in plant cells and gap junctions in animal cells both:

    (a) Provide rigid structural support between cells
    (b) Allow direct communication and transport between adjacent cells
    (c) Store nutrients for times of scarcity
    (d) Break down cellular waste products

33. The fluidity of cell membranes is regulated by:

    (a) Cholesterol content and fatty acid saturation
    (b) The number of ribosomes attached to the membrane
    (c) DNA sequences within membrane proteins
    (d) The pH of the surrounding environment

34. Active transport across cell membranes differs from passive transport in that it:

    (a) Requires energy input and moves substances against concentration gradients
    (b) Only occurs through protein channels without energy use
    (c) Is limited to small, nonpolar molecules
    (d) Always results in equilibrium concentrations

35. Receptor proteins in cell membranes are crucial for:

    (a) Structural support of the lipid bilayer
    (b) Cell recognition and signal transduction
    (c) ATP synthesis through electron transport
    (d) DNA replication during cell division

3 Cell Division: Mitosis, Meiosis, and Their Regulation

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1. The primary purpose of mitosis in multicellular organisms is:

    (a) Genetic recombination and variation
    (b) Growth, tissue repair, and asexual reproduction
    (c) Production of gametes for sexual reproduction
    (d) Reduction of chromosome number by half

2. The cell cycle is precisely regulated to ensure:

    (a) Cells divide continuously without pause

(b) DNA is properly replicated and chromosomes are accurately segregated
(c) Mutations accumulate rapidly for evolutionary adaptation
(d) All cells differentiate into specialized types

3. Interphase, though not part of mitosis proper, is critical because:

(a) Chromosomes condense and become visible
(b) The cell prepares for division through growth and DNA replication
(c) Nuclear envelope breaks down and spindle forms
(d) Sister chromatids separate to opposite poles

4. DNA replication occurs during which specific phase of interphase?

(a) G1 phase
(b) S phase
(c) G2 phase
(d) M phase

5. Chromatin condensation into visible chromosomes during prophase serves to:

(a) Make DNA more accessible for transcription
(b) Facilitate proper chromosome segregation during division
(c) Protect DNA from damage by UV radiation
(d) Allow DNA replication to occur more efficiently

6. The mitotic spindle, composed of microtubules, functions to:

(a) Replicate DNA during S phase
(b) Separate sister chromatids during anaphase
(c) Synthesize proteins for cell division
(d) Break down the nuclear envelope

7. Kinetochores are protein structures that:

(a) Synthesize spindle microtubules during prophase
(b) Attach chromosomes to spindle fibers at centromeres
(c) Break down nuclear envelope during prometaphase
(d) Form the contractile ring during cytokinesis

8. Metaphase is characterized by:

(a) Chromosomes aligning at the cell's equatorial plane
(b) Sister chromatids separating to opposite poles
(c) Nuclear envelope reforming around chromosomes
(d) Chromosomes condensing and becoming visible

9. The separation of sister chromatids during anaphase is driven by:

(a) Shortening of kinetochore microtubules and movement of polar microtubules
(b) Elongation of chromosomes through DNA unwinding
(c) Contraction of actin filaments in the cytoplasm
(d) Breakdown of spindle fibers into their subunits

10. Telophase essentially reverses many events of prophase, including:

(a) Chromosomes decondensing and nuclear envelopes reforming
(b) Spindle fibers forming and attaching to chromosomes
(c) Sister chromatids separating and moving apart
(d) DNA replicating in preparation for division

11. Cytokinesis in animal cells involves formation of a cleavage furrow through:

(a) Deposition of cellulose to form a cell plate
(b) Contraction of an actin-myosin ring beneath the membrane
(c) Extension of microtubules from the centrosomes
(d) Fusion of vesicles from the Golgi apparatus

12. In plant cells, cytokinesis occurs through:

(a) Formation of a contractile ring of actin and myosin
(b) Vesicle fusion forming a cell plate that becomes the new wall
(c) Pinching of the cell membrane without new wall synthesis
(d) Separation without cytoplasmic division (multinucleate cells)

13. Checkpoints in the cell cycle ensure:

(a) Cells divide as rapidly as possible
(b) Critical processes are completed accurately before progression
(c) All cells differentiate at the same rate
(d) Mutations are introduced at controlled rates

14. The G1 checkpoint (restriction point) is particularly important because:

(a) It determines whether the cell will proceed to S phase or enter G0
(b) It checks if DNA replication has been completed accurately
(c) It ensures chromosomes are properly attached to the spindle
(d) It triggers chromosome condensation for mitosis

15. Cancer cells often bypass normal cell cycle controls by:

(a) Mutating checkpoint genes like p53
(b) Slowing down their rate of division
(c) Differentiating into normal tissue types

(d) Activating programmed cell death pathways

16. Meiosis differs fundamentally from mitosis in its:

(a) Production of genetically identical daughter cells
(b) Reduction of chromosome number and genetic recombination
(c) Occurrence only in somatic (body) cells
(d) Single division producing two daughter cells

17. The evolutionary significance of meiosis includes:

(a) Ensuring genetic stability across generations
(b) Generating genetic variation through recombination and independent assortment
(c) Allowing asexual reproduction in multicellular organisms
(d) Preventing mutations from occurring in gametes

18. Synapsis during prophase I involves:

(a) Separation of sister chromatids to opposite poles
(b) Pairing of homologous chromosomes along their length
(c) Breakdown of the nuclear envelope
(d) Alignment of chromosomes at the metaphase plate

19. Crossing over during pachytene results in:

(a) Genetic recombination between non-sister chromatids
(b) Separation of homologous chromosomes
(c) Doubling of chromosome number
(d) Formation of the spindle apparatus

20. Chiasmata are visible manifestations of:

(a) Sites where crossing over has occurred between homologs
(b) Centromeres where spindle fibers attach
(c) Telomeres at chromosome ends
(d) Locations of ribosomal RNA genes

21. Independent assortment during metaphase I contributes to genetic variation by:

(a) Random alignment of homologous pairs at the equator
(b) Exchange of genetic material between chromosomes
(c) Separation of sister chromatids
(d) Replication of DNA before division

22. The reductional division (meiosis I) reduces chromosome number by:

(a) Separating sister chromatids
(b) Separating homologous chromosomes
(c) Replicating DNA only once
(d) Eliminating half the chromosomes randomly

23. Meiosis II resembles mitosis because it involves:

(a) Separation of homologous chromosomes
(b) Separation of sister chromatids
(c) Synapsis and crossing over
(d) Reduction of chromosome number

24. The four haploid cells produced by meiosis in males:

(a) Are unequal in size and only one becomes functional
(b) All develop into functional sperm cells
(c) Fuse to form a diploid zygote
(d) Remain dormant until fertilization occurs

25. Oogenesis in females produces:

(a) Four equal-sized functional egg cells
(b) One large egg and three small polar bodies
(c) Diploid cells that require fertilization to become haploid
(d) Sperm cells that fertilize other eggs

26. The significance of polar bodies in oogenesis is that they:

(a) Develop into additional egg cells if needed
(b) Allow unequal division of cytoplasm to one large cell
(c) Provide nutrients for the developing embryo
(d) Store genetic information for future generations

27. Spermatogenesis and oogenesis differ in that:

(a) Both produce four functional gametes from one precursor cell
(b) Spermatogenesis produces motile cells, oogenesis produces a large immobile cell
(c) Only oogenesis involves reduction of chromosome number
(d) Spermatogenesis occurs only in plants, oogenesis in animals

28. Genetic variation from meiosis arises from two main processes:

(a) DNA replication and checkpoint control
(b) Crossing over and independent assortment
(c) Cytokinesis and cell plate formation

(d) Chromosome condensation and spindle formation

29. Nondisjunction during meiosis can result in:

(a) Increased genetic variation in offspring
(b) Gametes with abnormal chromosome numbers
(c) Prevention of fertilization
(d) Identical twins from one zygote

30. The relationship between mitosis and meiosis in sexual life cycles is:

(a) Meiosis produces gametes, fertilization restores diploidy, mitosis produces multicellular organism
(b) Mitosis produces gametes directly without meiosis
(c) Meiosis occurs in somatic cells, mitosis in germ cells
(d) Both processes occur simultaneously in all cells

31. Polyploidy, common in plants, results from:

(a) Failure of chromosomes to replicate during S phase
(b) Complete nondisjunction during meiosis or mitosis
(c) Excessive crossing over between homologs
(d) Mutation of spindle fiber proteins

32. Programmed cell death (apoptosis) differs from necrosis in that it:

(a) Causes inflammation and damage to surrounding tissues
(b) Is a controlled process that eliminates unwanted cells
(c) Results from external trauma or injury
(d) Always leads to cancer development

33. Stem cells are characterized by their ability to:

(a) Differentiate into specialized cells and self-renew
(b) Only divide a limited number of times before dying
(c) Function as fully specialized tissue cells
(d) Cause cancer when they divide uncontrollably

34. The Hayflick limit refers to:

(a) The maximum number of times most somatic cells can divide
(b) The rate of mutation accumulation during DNA replication
(c) The time required for complete cell cycle progression
(d) The number of chromosomes lost during each cell division

35. Telomeres protect chromosome ends and:

(a) Shorten with each cell division in most somatic cells
(b) Lengthen during each mitotic division
(c) Are identical in length in all cell types
(d) Prevent crossing over during meiosis

36. Cyclins and cyclin-dependent kinases (CDKs) regulate:

(a) DNA replication accuracy during S phase
(b) Progression through the cell cycle at checkpoints
(c) Chromosome condensation during prophase
(d) Cytokinesis and cell separation

4 Advanced Genetic Concepts and Applications

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1. The central dogma of molecular biology describes:

(a) The flow of genetic information: DNA $\rightarrow$ RNA $\rightarrow$ Protein
(b) How chromosomes segregate during cell division
(c) The process of natural selection and evolution
(d) The structure of the DNA double helix

2. DNA replication is semiconservative, meaning:

(a) Each new DNA molecule contains one old and one new strand
(b) DNA is completely degraded and resynthesized
(c) Only one strand of DNA is used as a template
(d) RNA primers are incorporated into the final DNA product

3. Transcription differs from replication in that it:

(a) Produces RNA using DNA as a template
(b) Creates an identical copy of the entire DNA molecule
(c) Occurs only during the S phase of the cell cycle
(d) Requires primers to initiate the process

4. The genetic code is described as degenerate because:

(a) Most amino acids are specified by more than one codon
(b) It contains stop signals for translation termination
(c) It is universal across all living organisms
(d) Codons are always three nucleotides long

5. A silent mutation in DNA:

(a) Changes the amino acid sequence of the protein
(b) Creates a premature stop codon
(c) Alters a codon but codes for the same amino acid
(d) Affects non-coding regions only

6. Frameshift mutations are particularly damaging because they:

(a) Change a single amino acid in the protein
(b) Alter the reading frame of the entire downstream sequence
(c) Only affect non-essential regions of genes
(d) Are automatically repaired by proofreading enzymes

7. Operons, found in prokaryotes, allow:

(a) Coordinated regulation of genes with related functions
(b) Individual gene expression without regulatory sequences
(c) RNA splicing and alternative transcript production
(d) Chromosome condensation during cell division

8. The lac operon in E. coli is an example of:

(a) Constitutive gene expression without regulation
(b) Inducible system activated by lactose presence
(c) Repressible system inhibited by tryptophan
(d) Feedback inhibition of enzyme activity

9. Eukaryotic gene regulation is more complex than prokaryotic due to:

(a) Chromatin structure, transcription factors, and RNA processing
(b) Simpler promoter sequences and fewer regulatory elements
(c) Lack of introns and simpler mRNA processing
(d) Absence of epigenetic modifications

10. Epigenetic modifications like DNA methylation typically:

(a) Increase gene expression by opening chromatin
(b) Decrease gene expression by condensing chromatin
(c) Have no effect on gene expression patterns
(d) Cause permanent mutations in DNA sequence

11. X-chromosome inactivation in female mammals results in:

(a) Both X chromosomes being fully active in all cells
(b) Random silencing of one X chromosome in each cell
(c) Complete elimination of one X chromosome
(d) Only the paternal X chromosome being functional

12. Genomic imprinting involves:

    (a) Differential expression based on parental origin
    (b) Random mutation during DNA replication
    (c) Environmental modification of gene sequences
    (d) Viral integration into host genomes

13. Alternative splicing allows:

    (a) Multiple proteins from a single gene
    (b) DNA replication without errors
    (c) Chromosome pairing during meiosis
    (d) Faster transcription of genes

14. Non-coding RNAs (like miRNA and siRNA) function in:

    (a) Protein synthesis as part of ribosomes
    (b) Gene regulation through RNA interference
    (c) DNA replication as primers
    (d) Chromosome structure as scaffolding

15. The Human Genome Project revealed that:

    (a) Humans have about 100,000 protein-coding genes
    (b) Most human DNA codes for proteins
    (c) Only 1-2% of human DNA codes for proteins
    (d) Human genes have no introns

16. CRISPR-Cas9 technology revolutionized genetics by enabling:

    (a) Rapid DNA sequencing of entire genomes
    (b) Precise editing of specific DNA sequences
    (c) Visualization of chromosomes in living cells
    (d) Measurement of gene expression levels

17. Gene therapy aims to:

    (a) Modify germline cells for inherited changes
    (b) Treat genetic disorders by introducing functional genes
    (c) Create genetically modified organisms for agriculture
    (d) Sequence genomes of endangered species

18. Personalized medicine uses genetic information to:

    (a) Create identical treatments for all patients
    (b) Tailor treatments based on individual genetic profiles
    (c) Replace all traditional medical practices

(d) Focus only on infectious diseases

19. Population genetics studies:

(a) Gene structure and function at molecular level
(b) Genetic variation and changes in populations over time
(c) Cellular processes like mitosis and meiosis
(d) Organelle function within individual cells

20. The Hardy-Weinberg principle describes:

(a) Conditions under which evolution occurs rapidly
(b) A population in genetic equilibrium with no evolution
(c) The process of natural selection in action
(d) How mutations accumulate in populations

21. Genetic drift has the greatest effect:

(a) In large, randomly mating populations
(b) When natural selection is strong
(c) In small, isolated populations
(d) During sexual reproduction with crossing over

22. Founder effect occurs when:

(a) A large population experiences high mutation rates
(b) A small group establishes a new population with different allele frequencies
(c) Natural selection favors intermediate phenotypes
(d) Gene flow between populations is extensive

23. Bottleneck effect results from:

(a) A population expanding rapidly in size
(b) Severe reduction in population size followed by recovery
(c) Continuous gene flow between populations
(d) Strong directional selection for a trait

24. Natural selection acts on:

(a) Genetic mutations directly
(b) Phenotypes that affect survival and reproduction
(c) Allele frequencies in a predictive manner
(d) Chromosome structure during meiosis

25. Directional selection favors:

(a) Both extremes of a phenotypic range
(b) Intermediate phenotypes over extremes
(c) One extreme of a phenotypic distribution
(d) Random phenotypes without pattern

26. Stabilizing selection maintains:

(a) Genetic variation by favoring heterozygotes
(b) The status quo by favoring intermediate phenotypes
(c) Evolutionary change by favoring one extreme
(d) Multiple distinct phenotypes in a population

27. Disruptive selection leads to:

(a) Loss of genetic variation in populations
(b) Maintenance of multiple phenotypic forms
(c) Convergence on a single optimal phenotype
(d) Random changes in allele frequencies

28. Sexual selection often results in:

(a) Traits that improve survival but not mating success
(b) Traits that enhance mating success even if costly
(c) Identical phenotypes in males and females
(d) Reduced genetic variation in populations

29. Speciation requires:

(a) Reproductive isolation between populations
(b) Identical environments for all populations
(c) Complete genetic identity between groups
(d) Unlimited gene flow between populations

30. Allopatric speciation occurs when:

(a) Populations diverge while in the same geographic area
(b) Physical barriers prevent gene flow between populations
(c) Polyploidy creates instant reproductive isolation
(d) Behavioral differences prevent mating

31. Sympatric speciation can occur through:

(a) Geographic isolation of populations
(b) Polyploidy or ecological specialization without physical separation
(c) Gradual climate change affecting all individuals equally
(d) Random mating within a continuous population

32. Phylogenetic trees represent:

    (a) Physical characteristics of living organisms
    (b) Hypothesized evolutionary relationships
    (c) Current geographic distributions of species
    (d) Genetic similarity without evolutionary history

33. Molecular clocks are based on:

    (a) The assumption of constant mutation rates over time
    (b) Physical fossil evidence exclusively
    (c) Behavioral similarities between species
    (d) Environmental changes in specific regions

34. Horizontal gene transfer is common in:

    (a) Multicellular eukaryotes only
    (b) Prokaryotes and sometimes between different species
    (c) Animals during sexual reproduction
    (d) Plants through pollen transfer

35. The endosymbiotic theory is supported by:

    (a) Mitochondria and chloroplasts having their own DNA
    (b) All organelles having identical membranes
    (c) Prokaryotes having membrane-bound nuclei
    (d) Eukaryotes lacking any bacterial characteristics

36. Comparative genomics reveals:

    (a) All organisms have completely unique genes
    (b) Conservation of genes and pathways across diverse species
    (c) No relationship between genome size and complexity
    (d) Each species has optimal genome organization

37. Synthetic biology aims to:

    (a) Study only natural biological systems
    (b) Design and construct new biological parts and systems
    (c) Preserve existing organisms without modification
    (d) Focus exclusively on theoretical models

38. Ethical considerations in genetics include:

    (a) Only technical aspects of gene manipulation
    (b) Privacy of genetic information and genetic discrimination
    (c) How genes physically interact in cells

(d) Mathematical models of inheritance

5 Applied and Integrative Questions

enumi150

1. In a population of pea plants, if the frequency of the recessive allele for wrinkled seeds (r) is 0.4, what is the frequency of heterozygous plants (Rr) assuming Hardy-Weinberg equilibrium?

   (a) 0.16
   (b) 0.24
   (c) 0.48
   (d) 0.36

2. A woman with type A blood (genotype IAi) marries a man with type B blood (genotype IBi). What is the probability their child will have type O blood?

   (a) 0%
   (b) 25%
   (c) 50%
   (d) 100%

3. In humans, brown eyes (B) are dominant over blue eyes (b). If two heterozygous brown-eyed parents have four children, what is the probability that exactly three will have brown eyes?

   (a) 0.25
   (b) 0.316
   (c) 0.422
   (d) 0.75

4. A cell with 2n=46 chromosomes undergoes meiosis. How many chromosomes will each gamete have?

   (a) 23
   (b) 46
   (c) 92
   (d) Variable number

5. In a dihybrid cross between two heterozygous plants (RrYy × RrYy), what proportion will be homozygous for at least one trait?

   (a) 1/16
   (b) 4/16

(c) 9/16
(d) 12/16

6. A man with hemophilia (X-linked recessive) marries a woman who is a carrier. What is the probability their son will have hemophilia?

(a) 0%
(b) 25%
(c) 50%
(d) 100%

7. During which phase of meiosis does crossing over occur?

(a) Prophase I
(b) Metaphase I
(c) Anaphase I
(d) Telophase I

8. If a cell has 8 chromosomes at the beginning of mitosis, how many chromosomes will each daughter cell have?

(a) 4
(b) 8
(c) 16
(d) 32

9. In the lac operon, when glucose is present but lactose is absent:

(a) The operon is fully induced
(b) The operon is partially induced
(c) The operon is repressed
(d) cAMP levels are high

10. Which cellular structure is primarily responsible for protein synthesis?

(a) Mitochondria
(b) Ribosomes
(c) Golgi apparatus
(d) Lysosomes

11. The fluid mosaic model best describes the structure of:

(a) DNA double helix
(b) Cell membrane
(c) Chromosomes
(d) Ribosomes

12. During oxidative phosphorylation, ATP is produced in the:

    (a) Cytoplasm
    (b) Mitochondrial matrix
    (c) Inner mitochondrial membrane
    (d) Nucleus

13. Photosynthesis converts light energy into chemical energy stored in:

    (a) ATP only
    (b) Glucose only
    (c) ATP and NADPH
    (d) Proteins and lipids

14. In cellular respiration, most ATP is produced during:

    (a) Glycolysis
    (b) Krebs cycle
    (c) Electron transport chain
    (d) Fermentation

15. DNA polymerase requires a primer because it:

    (a) Cannot initiate synthesis on single-stranded DNA
    (b) Is too large to bind to DNA directly
    (c) Only works on RNA templates
    (d) Needs a specific sequence to start replication

16. Introns are removed from pre-mRNA through:

    (a) Transcription
    (b) Translation
    (c) Splicing
    (d) Replication

17. The genetic code is read in groups of three nucleotides called:

    (a) Exons
    (b) Introns
    (c) Codons
    (d) Anticodons

18. tRNA molecules function in translation by:

    (a) Carrying amino acids to the ribosome
    (b) Forming the structure of the ribosome
    (c) Carrying the genetic code from nucleus to cytoplasm

(d) Regulating gene expression

19. Restriction enzymes are used in genetic engineering to:

(a) Copy DNA sequences
(b) Cut DNA at specific sequences
(c) Translate RNA into protein
(d) Repair damaged DNA

20. Polymerase chain reaction (PCR) amplifies:

(a) Proteins
(b) RNA
(c) Specific DNA sequences
(d) Whole chromosomes

21. Gel electrophoresis separates DNA fragments based on:

(a) Charge only
(b) Size only
(c) Both size and charge sequence

22. DNA sequencing methods like Sanger sequencing use:

(a) Dideoxynucleotides to terminate chain elongation
(b) Restriction enzymes to cut DNA
(c) RNA polymerase to transcribe DNA
(d) Ligase to join DNA fragments

23. CRISPR-Cas9 uses guide RNA to:

(a) Direct Cas9 to specific DNA sequences
(b) Repair damaged DNA automatically
(c) Translate proteins more efficiently
(d) Replicate DNA during cell division

24. Stem cells are valuable for research because they can:

(a) Only form one specific cell type
(b) Differentiate into various cell types
(c) Never divide or proliferate
(d) Only be obtained from embryos

25. Cancer develops when:

(a) Cells stop dividing completely
(b) Cell division is uncontrolled

(c) All cells differentiate normally
(d) Apoptosis occurs too frequently

26. Oncogenes are:

(a) Genes that normally inhibit cell division
(b) Mutated genes that promote uncontrolled growth
(c) Viral genes that have no effect on cells
(d) Genes that repair DNA damage

27. Tumor suppressor genes like p53:

(a) Promote cell division
(b) Normally inhibit cell cycle progression
(c) Cause cancer when functioning normally
(d) Are only found in cancer cells

28. Apoptosis is important for:

(a) Promoting cancer development
(b) Eliminating damaged or unnecessary cells
(c) Increasing cell numbers rapidly
(d) Causing inflammation in tissues

29. Telomerase is active in:

(a) Most somatic cells
(b) Cancer cells and stem cells
(c) Only prokaryotic cells
(d) Cells that have stopped dividing

30. Cell signaling pathways allow cells to:

(a) Replicate DNA without control
(b) Communicate and respond to their environment
(c) Isolate themselves completely
(d) Only function independently

31. Hormones are chemical messengers that:

(a) Only act on adjacent cells
(b) Travel through the bloodstream to target cells
(c) Are always proteins
(d) Directly enter cells without receptors

32. Second messengers like cAMP:

(a) Carry signals across the cell membrane
(b) Amplify signals within the cell
(c) Are the initial extracellular signals
(d) Only function in nerve cells

33. The immune system uses genetic recombination to:

(a) Generate antibody diversity
(b) Replicate DNA more accurately
(c) Produce identical immune cells
(d) Repair damaged tissues

34. Vaccines work by:

(a) Treating active infections
(b) Stimulating immune memory without disease
(c) Killing pathogens directly
(d) Replacing defective genes

35. Antibiotic resistance evolves through:

(a) Lamarckian inheritance of acquired resistance
(b) Natural selection of resistant bacteria
(c) All bacteria becoming resistant simultaneously
(d) Human immunity to antibiotics

36. Genetic engineering of crops has led to:

(a) Decreased crop yields worldwide
(b) Plants with herbicide or pest resistance
(c) Complete elimination of pesticide use
(d) No controversies or concerns

37. Gene drives are designed to:

(a) Slow the spread of genes in populations
(b) Rapidly spread specific genes through populations
(c) Prevent any genetic changes in organisms
(d) Only work in laboratory conditions

38. Cloning produces organisms that are:

(a) Genetically identical to the donor
(b) Completely different genetically
(c) Hybrids of two different species
(d) Always sterile and unable to reproduce

39. In vitro fertilization (IVF) involves:

    (a) Fertilization inside the mother's body
    (b) Fertilization outside the body followed by implantation
    (c) Genetic modification of embryos
    (d) Cloning of existing individuals

40. Preimplantation genetic diagnosis (PGD) allows:

    (a) Treatment of genetic diseases after birth
    (b) Selection of embryos without specific genetic disorders
    (c) Modification of genes in adult individuals
    (d) Creation of genetically identical humans

41. Gene expression profiling can:

    (a) Determine which genes are active in a cell or tissue
    (b) Change DNA sequences permanently
    (c) Only be done on bacterial cells
    (d) Predict exact physical traits from DNA alone

42. Epigenetic changes can be influenced by:

    (a) Only genetic factors
    (b) Environmental factors like diet and stress
    (c) DNA sequence mutations only
    (d) Random chance with no patterns

43. Mitochondrial DNA is inherited:

    (a) Only from the father
    (b) Only from the mother
    (c) From both parents equally
    (d) Randomly from either parent

44. Y chromosome analysis is useful for:

    (a) Tracing maternal lineages
    (b) Tracing paternal lineages
    (c) Studying mitochondrial diseases
    (d) Analyzing autosomal traits

45. Genetic ancestry testing compares:

    (a) Only mitochondrial DNA
    (b) Only Y chromosome DNA DNA markers
    (c) Protein sequences exclusively

46. The microbiome refers to:

    (a) All genes in a single organism
    (b) Communities of microorganisms in an environment
    (c) Only pathogenic bacteria
    (d) Viruses that infect humans

47. Synthetic biology aims to create:

    (a) Only natural biological systems
    (b) New biological parts and systems
    (c) Exact copies of existing organisms
    (d) Only computer models of biology

48. Bioethics in genetics considers:

    (a) Only technical feasibility
    (b) Social, legal, and ethical implications
    (c) Only economic factors
    (d) Scientific theories without practical concerns

49. Genetic privacy concerns:

    (a) Who has access to genetic information
    (b) The cost of genetic testing only
    (c) Technical accuracy of tests
    (d) Only research applications

50. Eugenics refers to:

    (a) Improving human genetics through selective breeding
    (b) Treating genetic diseases medically
    (c) Studying natural genetic variation
    (d) Cloning endangered species

51. Genetic discrimination involves:

    (a) Treating people differently based on genetic information
    (b) Equal access to genetic testing
    (c) Voluntary genetic testing only
    (d) Research on animal genetics only

52. Gene patents have raised concerns about:

    (a) Owning rights to naturally occurring sequences
    (b) Too little protection for discoveries

(c) Only plant and animal genetics
(d) No ethical issues whatsoever

53. Environmental DNA (eDNA) analysis detects:

(a) Only human DNA in environments
(b) Organisms through DNA shed into environments
(c) Only bacterial contamination
(d) DNA that has been genetically modified

54. Conservation genetics helps:

(a) Increase genetic uniformity in populations
(b) Preserve genetic diversity in endangered species
(c) Breed genetically identical individuals
(d) Eliminate all genetic variation

55. De-extinction attempts to:

(a) Bring extinct species back using genetic technology
(b) Prevent any species from going extinct
(c) Create completely new species
(d) Study only living organisms

56. Genetic load refers to:

(a) The weight of DNA in a cell
(b) Accumulation of harmful mutations in a population
(c) Only beneficial mutations
(d) The number of genes in a genome

57. Genetic rescue involves:

(a) Introducing genetic variation to inbred populations
(b) Removing all genetic variation
(c) Creating genetically identical populations
(d) Only laboratory research

58. The relationship between genotype and phenotype is influenced by:

(a) Only the DNA sequence
(b) Environmental factors and gene interactions
(c) Random chance exclusively
(d) Only maternal effects

59. Quantitative traits show continuous variation because:

(a) They are controlled by single genes
(b) They are influenced by multiple genes and environment
(c) They follow Mendelian inheritance patterns
(d) They are always dominant or recessive

60. Heritability measures:

(a) How much of trait variation is due to genetic differences
(b) How much of trait variation is due to environment
(c) The exact genes controlling a trait
(d) Whether a trait is dominant or recessive

61. Gene-environment interactions mean:

(a) Genes and environment work independently
(b) Genetic effects depend on environmental context
(c) Environment completely determines traits
(d) Genes completely determine traits

62. The future of genetics will likely involve:

(a) Less integration with other sciences
(b) More personalized medicine and gene therapies
(c) Complete understanding of all genetic mechanisms
(d) No new discoveries or applications

Answer Key

1. C
2. C
3. B
4. A
5. B
6. B
7. A
8. B
9. C
10. B
11. B
12. C
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