**Asexual Reproduction Learning Objectives**

1. **Nucleic Acids**
   1. In nucleic acids, biological information is encoded in sequences of nucleotide monomers. Each nucleotide has structural components: a five-carbon sugar (deoxyribose or ribose), a phosphate and a nitrogen base (adenine, thymine, guanine, cytosine or uracil). DNA and RNA differ in function and differ slightly in structure, and these structural differences account for their differing functions. ***X The molecular structure of specific nucleotides is beyond the scope of the course and the AP Exam.***
   2. Directionality influences structure and function of the polymer.
      1. Nucleic acids have ends, defined by the 3' and 5' carbons of the sugar in the nucleotide, that determine the direction in which complementary nucleotides are added during DNA synthesis and the direction in which transcription occurs (from 5' to 3').
2. **DNA, and in some cases RNA, is the primary source of heritable information.**
   1. Genetic information is transmitted from one generation to the next through DNA or RNA.
3. Genetic information is stored in and passed to subsequent generations through DNA molecules and, in some cases, RNA molecules.
4. Noneukaryotic organisms have circular chromosomes, while eukaryotic organisms have multiple linear chromosomes, although in biology there are exceptions to this rule.
5. Prokaryotes, viruses and eukaryotes can contain plasmids, which are small extra-chromosomal, double-stranded circular DNA molecules.
6. The proof that DNA is the carrier of genetic information involved a number of important historical experiments. These include:
   1. Contributions of Watson, Crick, Wilkins, and Franklin on the structure of DNA
   2. Avery-MacLeod-McCarty experiments
   3. Hershey-Chase experiment
7. DNA replication ensures continuity of hereditary information.
   1. Replication is a semiconservative process; that is, one strand serves as the template for a new, complementary strand.
   2. Replication requires DNA polymerase plus many other essential cellular enzymes, occurs bidirectionally, and differs in the production of the leading and lagging strands.
8. Genetic information in retroviruses is a special case and has an alternate flow of information: from RNA to DNA, made possible by reverse transcriptase, an enzyme that copies the viral RNA genome into DNA. This DNA integrates into the host genome and becomes transcribed and translated for the assembly of new viral progeny.

***X The names of the steps and particular enzymes involved, beyond DNA polymerase, ligase, RNA polymerase, helicase and topoisomerase, are outside the scope of the course for the purposes of the AP Exam.***

* 1. DNA and RNA molecules have structural similarities and differences that define function.

1. Both have three components — sugar, phosphate and a nitrogenous base — which form nucleotide units that are connected by covalent bonds to form a linear molecule with 3' and 5' ends, with the nitrogenous bases perpendicular to the sugar-phosphate backbone.
2. The basic structural differences include:
   1. DNA contains deoxyribose (RNA contains ribose).
   2. RNA contains uracil in lieu of thymine in DNA.
   3. DNA is usually double stranded, RNA is usually single stranded.
   4. The two DNA strands in double-stranded DNA are antiparallel in directionality.
3. Both DNA and RNA exhibit specific nucleotide base pairing that is conserved through evolution: adenine pairs with thymine or uracil (A-T or A-U) and cytosine pairs with guanine (C-G).
   1. Purines (G and A) have a double ring structure.
   2. Pyrimidines (C, T and U) have a single ring structure.
4. **In eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis or meiosis plus fertilization.**
5. The cell cycle is a complex set of stages that is highly regulated with checkpoints, which determine the ultimate fate of the cell.
6. Interphase consists of three phases: growth, synthesis of DNA, preparation for mitosis.
7. The cell cycle is directed by internal controls or checkpoints. Internal and external signals provide stop-and-go signs at the checkpoints.

*For example:*

• Mitosis-promoting factor (MPF)

• Action of platelet-derived growth factor (PDGF)

• Cancer results from disruptions in cell cycle control

1. Cyclins and cyclin-dependent kinases control the cell cycle.

***X Knowledge of specific cyclin-CdK pairs or growth factors is beyond the scope of the course and the AP Exam.***

1. Mitosis alternates with interphase in the cell cycle.
2. When a cell specializes, it often enters into a stage where it no longer divides, but it can reenter the cell cycle when given appropriate cues. Nondividing cells may exit the cell cycle; or hold at a particular stage in the cell cycle.
3. Mitosis passes a complete genome from the parent cell to daughter cells.
4. Mitosis occurs after DNA replication.
5. Mitosis followed by cytokinesis produces two genetically identical daughter cells.
6. Mitosis plays a role in growth, repair, and asexual reproduction
7. Mitosis is a continuous process with observable structural features along the mitotic process. Evidence of student learning is demonstrated by knowing the order of the processes (replication, alignment, separation).

***X Memorization of the names of the phases of mitosis is beyond the scope of the course and the AP Exam.***

1. **Changes in genotype can result in changes in phenotype.**
   1. Errors in DNA replication or DNA repair mechanisms, and external factors, including radiation and reactive chemicals, can cause random changes, e.g., mutations in the DNA.
      1. Whether or not a mutation is detrimental, beneficial or neutral depends on the environmental context. Mutations are the primary source of genetic variation.
   2. Errors in mitosis or meiosis can result in changes in phenotype.
      1. Changes in chromosome number often result in new phenotypes, including sterility caused by triploidy and increased vigor of other polyploids.
      2. Changes in chromosome number often result in human disorders with developmental limitations, including Trisomy 21 (Down syndrome) and XO (Turner syndrome).
   3. Changes in genotype may affect phenotypes that are subject to natural selection. Genetic changes that enhance survival and reproduction can be selected by environmental conditions.

*For example:*

• Antibiotic resistance mutations

• Pesticide resistance mutations

• Sickle cell disorder and heterozygote advantage

* 1. Selection results in evolutionary change.