1. **What is CRISPR-Cas9, and why is it significant?**
   Answer: CRISPR-Cas9 is a gene-editing technology that allows precise modifications in DNA. It is significant for its potential in treating genetic diseases, cancer, and developing pest-resistant crops.

2. **Who were awarded the Nobel Prize in Chemistry in 2020, and for what contribution?**
   Answer: Emmanuelle Charpentier and Jennifer A. Doudna were awarded for developing the CRISPR-Cas9 gene-editing methodology.

3. **Where is DNA located in a eukaryotic cell?**
   Answer: DNA is located in the nucleus, within chromosomes, wrapped around histone proteins to form nucleosomes.

4. **What is the role of histone proteins in chromosome structure?**
   Answer: Histone proteins form octamers around which DNA winds to create nucleosomes, which coil further to form chromosomes.

5. **Who proposed the double helix model of DNA, and what was the key evidence?**
   Answer: James Watson and Francis Crick proposed the double helix model in 1953, based on Rosalind Franklin's X-ray diffraction image, "Photo 51."

6. **Name the nitrogenous bases in DNA and their pairing pattern.**
   Answer: Adenine (A) pairs with Thymine (T), and Guanine (G) pairs with Cytosine (C).

7. **What are the components of a nucleotide in DNA?**
   Answer: A nucleotide consists of a deoxyribose sugar, a phosphate group, and a nitrogenous base (A, T, G, or C).

8. **How long is the DNA in a single human chromosome, and what is the total length in a cell?**
   Answer: A single chromosome's DNA is about 5 cm long; the DNA from 46 chromosomes in a human cell totals about 2 meters.

9. **What is a nucleosome, and how does it contribute to chromosome formation?**
   Answer: A nucleosome is DNA wound around a histone octamer. Multiple nucleosomes coil and pack to form chromosomes.

10. **How many chromosomes do humans have, and how are they categorized?**
    Answer: Humans have 46 chromosomes (23 pairs): 22 pairs of somatic chromosomes (control physical traits) and 1 pair of sex chromosomes (XX or XY).

11. **What is the role of the SRY gene on the Y chromosome?**
    Answer: The SRY gene triggers the development of testes in the embryo, determining male sex.

12. **Describe Turner syndrome and its genetic constitution.**
    Answer: Turner syndrome (44 + X0) occurs in females with only one X chromosome, leading to underdeveloped sexual characteristics.

13. **What is a gene, and what is its function?**
    Answer: A gene is a specific sequence of nucleotides in DNA that codes for proteins, controlling traits and metabolic activities.

14. **Differentiate between transcription and translation in protein synthesis.**
Answer: Transcription occurs in the nucleus, forming mRNA from DNA. Translation occurs in the cytoplasm, where tRNA and rRNA synthesize proteins based on mRNA.

15. **What are the roles of mRNA, tRNA, and rRNA in protein synthesis?**
Answer: mRNA carries genetic instructions, tRNA delivers amino acids, and rRNA (in ribosomes) links amino acids to form proteins.

16. **Define heredity and variation.**
Answer: Heredity is the transmission of traits from parents to offspring. Variation is the expression of traits in offspring that differ from parents.

17. **Who is considered the father of genetics, and why?**
Answer: Gregor Mendel is the father of genetics due to his hybridization experiments on pea plants, establishing the Laws of Inheritance.

18. **What is a monohybrid cross, and what is the phenotypic ratio in the F2 generation?**
Answer: A monohybrid cross involves one pair of contrasting traits (e.g., tall vs. dwarf). The F2 phenotypic ratio is 3:1 (dominant:recessive).

19. **Explain why no intermediate height is observed in Mendel's monohybrid cross for plant height.**
Answer: Due to complete dominance, the tall allele (T) fully masks the dwarf allele (t), preventing an intermediate phenotype.

20. **What is a dihybrid cross, and what does its F2 ratio indicate?**
Answer: A dihybrid cross involves two pairs of traits (e.g., height and seed shape). The F2 ratio (9:3:3:1) indicates independent assortment of genes.

21. **What is incomplete dominance? Provide an example.**
Answer: Incomplete dominance occurs when neither allele is fully dominant, resulting in an intermediate phenotype. Example: Pink flowers from red (RR) and white (WW) four o'clock plants (RW).

22. **How does co-dominance differ from incomplete dominance?**
Answer: In co-dominance, both alleles are expressed simultaneously (e.g., roan coat in cattle). In incomplete dominance, an intermediate phenotype is produced (e.g., pink flowers).

23. **How does multiple allelism function in the ABO blood group system?**
Answer: The ABO blood group is controlled by three alleles (IA, IB, i). IA and IB are co-dominant, producing type AB when together, while i is recessive, resulting in type O.

24. **What is polygenic inheritance, and how does it affect skin color?**
Answer: Polygenic inheritance involves multiple genes controlling one trait. Skin color varies due to multiple genes regulating melanin production.

25. **Describe the process of crossing over and its role in variation.**
Answer: Crossing over occurs during prophase I of meiosis, where homologous chromosomes exchange segments at chiasmata, leading to new allele combinations and genetic variation.

26. **What is a mutation, and how does it contribute to diversity?**
    Answer: A mutation is a sudden, heritable change in DNA. It introduces new traits or variations, contributing to genetic diversity.

27. **Why do ova in females contain only one type of sex chromosome?**
    Answer: Females have two X chromosomes (XX), so during meiosis, each ovum receives one X chromosome.

28. **Application: If a tall pea plant (TT) is crossed with a dwarf plant (tt), what will be the phenotype of the F1 generation?**
    Answer: All offspring in the F1 generation will be tall (Tt) due to the dominance of the tall allele.

29. **Application: In a dihybrid cross between TTRR (tall, round) and ttrr (dwarf, wrinkled) pea plants, what percentage of F2 offspring will be tall and round?**
    Answer: 9/16 (56.25%) of F2 offspring will be tall and round (T_R_).

30. **Application: A person with type AB blood marries a person with type O blood. What are the possible blood types of their children?**
    Answer: The possible blood types are A (IAi) and B (IBi), as the parents' genotypes are IAIB and ii.