1.

(a) • **Maximum 4 points for this part of the question (1 point earned for each bullet below, up to 4)**

(Maximum 3 points, 1 for each bullet)

Describe the use of **plasmid for cloning/sequencing** a human gene

- Cut plasmid with "restriction" enzyme
- Cut/isolate human sequence with the corresponding "restriction" enzyme
- Mix/anneal/ligate
- Introduce recombinant plasmid into bacteria
- Select recombinant bacteria (e.g., antibiotic resistance, fluorescence, reporter gene, etc.)
- Bacterial reproduction used to amplify the sequence
- Describe either degradative (Maxam-Gilbert) or dideoxy (Sanger) method to generate fragments
- Electrophoresis to separate fragments
- Read the sequence (automated method is OK)

(Maximum 3 points, 1 for each bullet)

Explain the contribution of this procedure

- Source of the DNA is immaterial to cloning
- Used to produce transgenic organisms
- Used to make human proteins (e.g., insulin, HGH)
- Understanding gene structure/regulation
- Comparative genomics
- Development of gene therapies
- Making gene library
- Amplifying a particular sequence

• **Maximum 4 points for this part of the question (1 point earned for each bullet below, up to 4)**

(Maximum 3 points, 1 for each bullet)

Describe PCR

- Heat to separate strands
- Add primers
- Cool to anneal
- Add polymerase and/or nucleotides
- Specification of heat stable (Taq) polymerase
- Description of thermocycling process
- Repetition of process

3.A.1 and 3.A.2 FRQ Formatives Rubrics

2.

(a) **Explain** how the reduction and rearrangement are accomplished in meiosis.
(5 points maximum)

REDUCTION
1 point: **(homologous) chromosomes pair, then separate** and move to opposite poles during 1st meiotic division
1 point: **chromatids separate** during 2nd meiotic division

OR

1 point: two rounds of cell (nuclear) division but only one replication of the chromosomes

REARRANGEMENT
1 point: **crossing over** (in proper context)
1 point: **random alignment (independent assortment)** of tetrads
1 point: **elaboration (e.g.: correct mechanism/description or consequences** of one of the above) *

*NOTE: Diagrams that are clearly labeled and are described in the essay portion are acceptable and may receive a point

(b) Several human disorders occur as a result of defects in the meiotic process. **Identify** ONE such chromosomal abnormality; what effects does it have on the phenotype of people with the disorder? **Describe** how this abnormality could result from a defect in meiosis.
(4 points maximum)

CHROMOSOMAL ABNORMALITY
1 point: **Identify** one condition by name or description (e.g.: Down or trisomy 21; Turner or XO; fragile X; cri-du-chat or 5p-; etc.)
1 point: **Phenotype** of the example given above

DESCRIBE
1 point: **Name or identify the meiotic event** (e.g.: nondisjunction, unequal crossing over, inversion, mispairing)
1 point: **Description** of the meiotic event *

(c) Production of offspring by parthenogenesis or cloning bypasses the typical meiotic process. **Describe** either parthenogenesis or cloning and **compare** the genomes of the offspring with those of the parents.
(3 points maximum)

CLONING OR PARTHENOGENESIS
1 point: **Definition**
- **Parthenogenesis**: development of an unfertilized egg into an adult; often the adult is haploid

OR

- **Cloning**: using a somatic cell or cells from a multicellular organism to make one or more genetically identical individuals (or inducing a diploid body cell of an organism to revert to its embryonic state and then develop into a complete adult organism without fertilization)

1 point: **Description** of an example or the process in a plant or animal (parthenogenesis is rare in plants)
1 point: **Comparison** of the genomes of offspring and parents (e.g. identical for cloning)

3.A.1 and 3.A.2 FRQ Formatives Rubrics

3.

NOTE: To receive 10 points, a student must earn at least 1 transcription point and 1 translation point from parts (a), (b), or (c).

Parts (a), (b), and (c) (9 points maximum)

Part (a)

Transcription	**Translation**
• DNA template • complimentary RNA (base-pairing) • RNA produced by RNA polymerase • promoter region/TATA box • transcription factors • DNA unwound (partially, temporarily) • posttranscriptional processing	• mRNA template • codon/anticodon • tRNA carries amino acid • role of ribosome • initiation (fMet, Shine-Delgarno) • elongation (peptide bond formation) • termination description

Part (b)
NOTE: Students must provide specific similarity AND explanation to earn a point.

Similarity	**Explanation**	
	Transcription	**Translation**
• base pairing	DNA–RNA, specific base examples	mRNA–tRNA (codon–anticodon), specific base examples
• polymer formed	RNA	polypeptide
• specialized protein	RNA polymerase	initiation factors, etc.
• specific start sites	promoter/TATA	initiation (start) codon

Part (c)
NOTE: Students must provide specific difference AND explanation to earn a point.

Difference	**Explanation**	
	Transcription	**Translation**
• location in cell (eukaryote)	nucleus	cytoplasm, rough ER
• product	RNA	polypeptide
• template	DNA	mRNA
• purpose	transfer information	make proteins
• enzymes	RNA polymerase	peptide bond-forming enzyme (peptidyl transferase)

Part (d) (3 points maximum)

- Folding
- Cleavage
- Chemical modification
- Elaboration—specifics of folding, chaperones, types of bonds, role of Golgi, incorporation into existing molecular arrays, etc.

4.

A molecule of messenger RNA (mRNA) has just been synthesized in the nucleus of a human cell.

(a) What type of modifications may occur to this RNA before it leaves the nucleus?

One point for each of the following explanations/identifications (3 points maximum):

- Difference between introns and exons
- Description of splicing
- 5′ cap added or description of function
- 3′ poly A tail added or description of function

(b) Once in the cytoplasm, how is the mRNA translated to a protein?

One point for each of the following explanations/identifications (6 points maximum):

- Description of the role of tRNA in the transport of amino acids
- Description of the ribosome/rRNA
- Peptide bond formation (or the connecting of amino acids into a polypeptide chain)
- Concept of codon-anticodon binding
- Concept of the role of the genetic code (e.g., mRNA bases determine the sequence of amino acids)
- Description of stages (initiation, elongation, and termination)
- Elaboration point for a detailed explanation—examples of acceptable answers include, but are not limited to, the following:
  - Description of 40S and 60S ribosomal subunits
  - Role of aminoacyl-tRNA synthetase
  - Structure of tRNA
  - Use of GTP as energy source

(c) If the cell is a secretory cell, how is the protein from part (b) eventually targeted, packaged, and secreted to the exterior of the cell?

One point for each of the following explanations/identifications (3 points maximum):

- Role of chaperones in folding a polypeptide into the protein
- Modification of the protein or addition of sugars and/or phosphate
- Concept of the endomembrane system (description of protein moving from ER to Golgi to vesicles)
- Exocytosis through the fusion of the vesicle with the cell membrane

5.

Describe plasmid modification (8 points maximum):

Topic	Description (1 point each)
Plasmid vector	Describes plasmid as small circular DNA
Cut (cleave) DNAs	Use of restriction endonucleases (RE) Plasmid and inserted DNA must have same RE cut ends or be cut by same RE
Sticky ends	Ends of DNA should be sticky, wanting to bond with matching ends Generate ends for attachment using endonucleases
Ligase	For joining of sticky ends
Orientation	Correct orientation of insertion to ensure expression
Gene of interest	DNA cut should be a complete sequence of gene Attach piece with a promoter or insert next to promoter
Reporter gene	Gene used to identify insertion of desired DNA Insert DNA with a gene that produces a new phenotype
Selective marker	Inserted to help identify the DNA insertion (e.g., antibiotic resistance)
AUG in place	Ensure proper start codon
Uptake of plasmid	Calcium chloride and heat shock, electroporation to make competent
Alternative procedures	Blunt cuts; T4 ligase; add terminal transferase to add poly (A) to 3' end

Describe plasmid uptake and how transformation is **determined (6 points maximum)**:

Topic	Description (1 point each)
Transformation	Defined process of transformation of a plasmid
Isolation	Isolate plasmids/agar plate that grows only colonies of resistance gene
Antibiotic	Use of antibiotic resistance/sensitivity genes Detailed description of antibiotic resistance lab procedure
Gel electrophoresis	Isolate plasmid using electrophoresis Detailed description of gel electrophoresis for isolation
Retrieval	Retrieve altered plasmid
Protein	Identification of new protein, possible glowing marker protein Detailed description of retrieval or protein method
Tag	Fluorescent marker, etc. Detailed description of alternate method