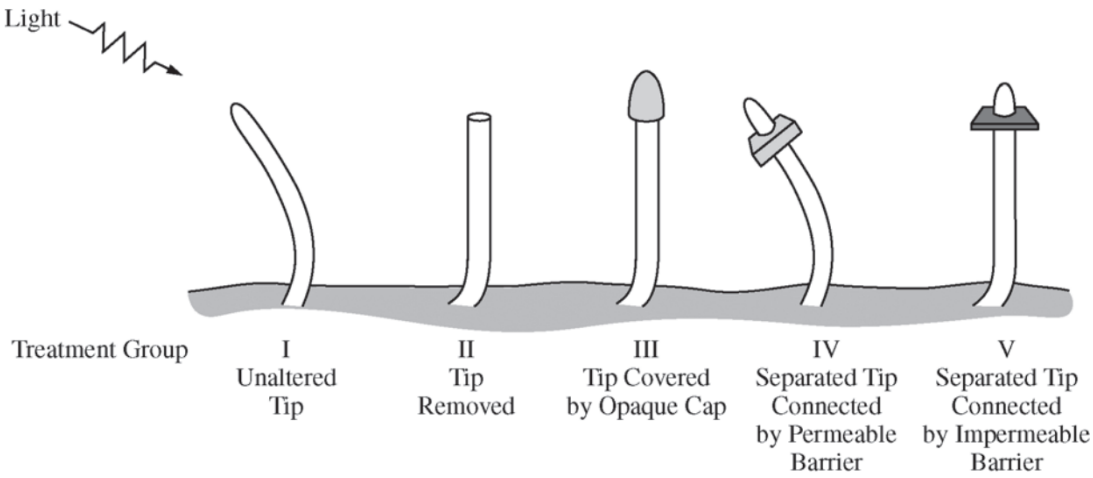
AP BIO Unit 4 Released FRQs

2015 #4

4. Both mitosis and meiosis are forms of cell division that produce daughter cells containing genetic information from the parent cell.

   (a) **Describe** TWO events that are common to both mitosis and meiosis that ensure the resulting daughter cells inherit the appropriate number of chromosomes.

   (b) The genetic composition of daughter cells produced by mitosis differs from that of the daughter cells produced by meiosis. **Describe** TWO features of the cell division processes that lead to these differences.



2015 #4 Answer Key

Question 4

Both mitosis and meiosis are forms of cell division that produce daughter cells containing genetic information from the parent cell.

(a) **Describe** TWO events that are common to both mitosis and meiosis that ensure the resulting daughter cells inherit the appropriate number of chromosomes.

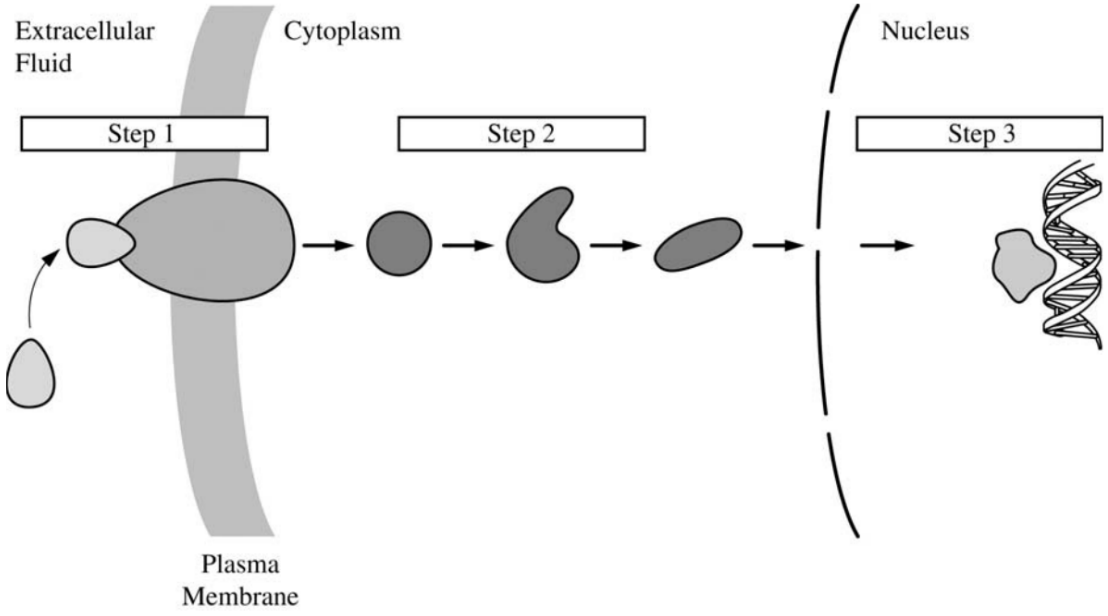
Description (1 point each; 2 points maximum)

- Spindle elements (microtubules) form/attach to chromosomes
- Chromatin condenses
- Alignment of chromosomes across center of cell prior to chromosome separation
- Separation of chromatids/centromeres to daughter cells
- G2/M checkpoint occurs in both processes
- Replication or synthesis of DNA precedes mitosis/meiosis
- Cytokinesis separates daughter cells after mitosis/meiosis

(b) The genetic composition of daughter cells produced by mitosis differs from that of the daughter cells produced by meiosis. **Describe** TWO features of the cell division processes that lead to these differences.

Feature	**Description (1 point each row; 2 points maximum)**	
	Mitosis	**Meiosis**
Number of divisions/ number of resulting cells	1 division/ 2 cells result	2 divisions/ 4 cells result
Ploidy of daughter cells	• Same as parent cell • Diploid • (2n-->2n or n-->n)	• Half of parent cell • Haploid • (4n-->2n; 2n-->n)
Chromatids separate	Occurs	Not in meiosis I/only in meiosis II
Crossing over	Does not occur	Occurs
Homologous chromosomes separate/independently assort	Does not occur	Occurs

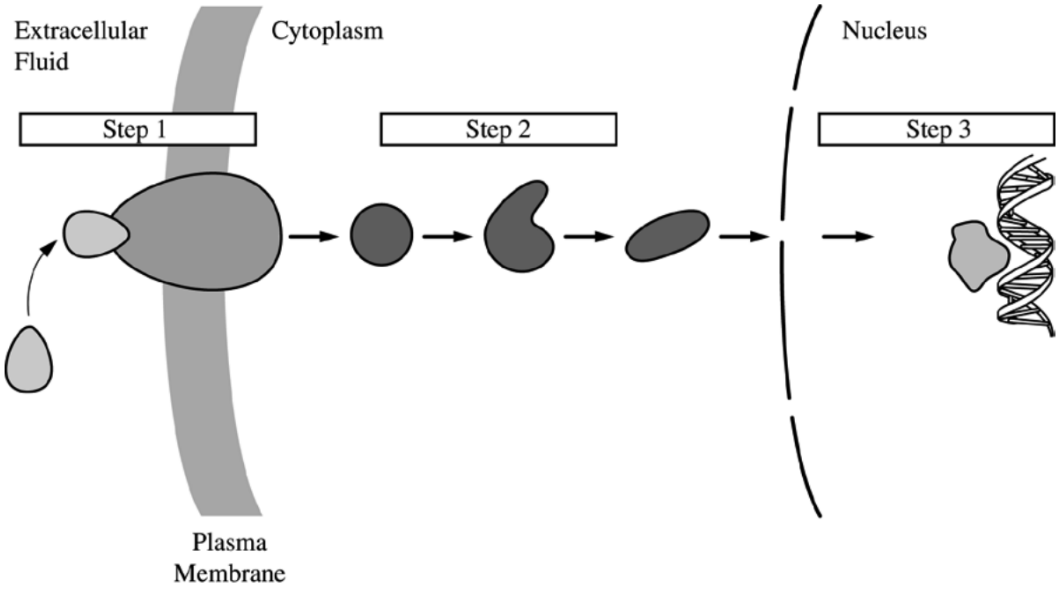
2013 #8



8. The figure above represents a generalized hormone-signaling pathway. Briefly **explain** the role of each numbered step in regulating target gene expression.

2013 #8 Answer Key

Question 8



The figure above represents a generalized hormone-signaling pathway. Briefly **explain** the role of each numbered step in regulating target gene expression. (**3 points maximum**)

- Step 1 = hormone/ligand binding to receptor to initiate/trigger/induce signaling OR signal reception
- Step 2 = an intracellular cascade that transduces/amplifies/transfers the signal from plasma membrane to nucleus (or other cellular effectors)
- Step 3 = transcription/expression of target genes is stimulated/repressed

2011 B #1

1. The cell cycle is fundamental to the reproduction of eukaryotic cells.
   (a) **Describe** the phases of the cell cycle.
   (b) **Explain** the role of THREE of the following in mitosis or cytokinesis.
      - Kinetochores
      - Microtubules
      - Motor proteins
      - Actin filaments
   (c) **Describe** how the cell cycle is regulated and **discuss** ONE consequence of abnormal regulation.

2011 B #1 Answer Key

The cell cycle is fundamental to the reproduction of eukaryotic cells.

(a) **Describe** the phases of the cell cycle.
(6 points maximum)

Correct order of cycle phases (1 point for entire correct list)
Interphase → Prophase → (Prometaphase) → Metaphase → Anaphase → Telophase → Cytokinesis

OR

$G_1 \rightarrow S \rightarrow G_2 \rightarrow M$

Correct description of at least one important structural or molecular characteristic of each phase (1 point each; 5 points maximum)

- Interphase (including, if specified, G_1, S, G_2 subphases, correctly ordered): Chromatin dispersed in nucleus; nuclear envelope and nucleoli are intact and functional; DNA is replicated here.
- G1, G2: Cell growth.
- S: DNA replication.
- Mitosis: Nuclear division.
- Prophase: Chromosomes begin to condense from chromatin; spindle apparatus assembled.
- (Prometaphase): Nuclear envelope disperses, nucleoli disperse, chromosomes connect to spindle apparatus fibers and begin to show motility.
- Metaphase: Chromosomes reach maximum condensation and align on metaphase plate/plane.
- Anaphase: Two-chromatid chromosomes split into two daughter (one-chromatid) chromosomes; chromosomes move to opposite poles of the spindle apparatus.
- Telophase: Chromosomes disperse back to chromatin form, nuclear envelope reassembles, nucleoli reassemble.
- Cytokinesis: If this occurs, it is normally coordinated with telophase; cell division.

(b) **Explain** the role of THREE of the following in mitosis or cytokinesis.
(*3 points maximum*)

- Kinetochores
- Microtubules
- Motor proteins
- Actin filaments

Correct explanation of function (1 point each; if all four are chosen, only the first three are scored)

- Kinetochores: Located in centromeres of condensed chromosomes; microtubule attachment sites necessary for chromosome positioning and movement.
- Microtubules: Fundamental structural element of the spindle apparatus; framework on which chromosome motility is generated; define axis of division and cytokinesis.
- Motor proteins (correct location and function must be specified): In kinetochores, move chromosomes during mitosis, including anaphase separation; involves kinesins and dyneins.
  OR
  In animal cell cleavage furrow, generate force to pinch cell in two; involves myosins.
- Actin filaments: Assemble under the membrane at the cytokinesis site; interact with myosin motor proteins to generate force to pinch cell in two; also interact with astral microtubules of the spindle to position the spindle apparatus in the cell.

2011 B #1 Answer Key Cont.

(c) **Describe** how the cell cycle is regulated and **discuss** ONE consequence of abnormal regulation. (*3 points maximum*)

Regulation: Correct description of checkpoints, which block cell cycle progress unless specific molecular and/or physical conditions are satisfied (1 point each; 2 points maximum)

- Action of MPF and CDKs in checkpoint regulation
- Contact inhibition of mitosis
- Hormones; growth factor control of cell cycle activity

Correct discussion of the consequences of abnormal cell cycle regulation (1 point maximum)

- Uncontrolled cell proliferation, as in cancer
- Apoptosis
- Non-disjunction/aneuploidy/broken chromosomes from abnormal spindle events

2006 B #1

1. Sexual reproduction requires that half of the chromosomes in a zygote come from one parent and the other half from the second parent.
   (a) Describe the process by which a germ cell's complement of chromosomes is halved in the formation of gametes.
   (b) Choose **one** organism or group of organisms that reproduce **asexually**. Describe the mode of asexual reproduction in that organism and explain the advantages to the organism of asexual reproduction.
   (c) Choose **one** organism or group of organisms that reproduce **sexually**. Describe the mode of sexual reproduction in that organism and explain the advantages to the organism of sexual reproduction.

2006 B #1 Answer Key

Sexual reproduction requires that half of the chromosomes in a zygote come from one parent and the other half from the second parent.

(a) Describe the process by which a germ cell's complement of chromosomes is halved in the formation of the gametes. **(6 points maximum)** One point for each of the following:

- Correct description of meiosis (simply rephrasing the question earns no point)
- Sister chromosomes pair in prophase I
- Spindles move chromosomes pairs to poles in anaphase I
- Two cycles/rounds of division in meiosis
- Sister chromatids separate to poles in anaphase II
- 1 germ cell yields 4 gametes
- DNA replicates in interphase
- No additional replication before meiosis II

(b) Choose **one** organism or group of organism the reproduce **asexually**. Describe the mode of asexual reproduction in that organism and explain the advantages to the organism of asexual reproduction. **(3 points maximum)**

- One point for correct organism or group of organisms that produce asexually
- One point for mode for any of the following (1 point maximum)
  - Plant → cuttings, others possible, e.g., runners
  - Fungi → budding or fission
  - Hydra → budding
  - Bacteria → fission
  - Viruses → uses host machinery
  - Insects/others using parthenogenesis
- One point for advantages for any of the following (1 point maximum)
  - Allows faster reproduction/more efficient
  - Genetic information is identical to parent ("offspring is clone" credited unless already used above)

(c) Choose **one** organism or group of organisms that reproduce **sexually**. Describe the mode of sexual reproduction in that organism and explain the advantages to the organism of sexual reproduction. **(3 points maximum)**

- One point for correct organism or group of organisms that produce sexually
- One point for mode; any of the following acceptable (1 point maximum)
  - Two different parents (male and female)
  - Egg and sperm combine in fertilization
  - Gametes (1n) combine to form zygote (2n), embryo (2n)
  - Fertilization is random
  - Description of fertilization process
- One point for advantages; any of the following acceptable (1 point maximum)
  - Increases genetic diversity/combinations/variations (simply stating "variation" is insufficient, unless linked to genes/genotypes/alleles)
  - Offspring are genetically unique/different from parents
  - Allows individuals/populations to carry recessive lethal

2005 #2

2. The unit of genetic organization in all living organisms is the chromosome.
   (a) **Describe** the structure and function of the parts of a eukaryotic chromosome. You may wish to include a diagram as part of your description.
   (b) **Describe** the adaptive (evolutionary) significance of organizing genes into chromosomes.
   (c) How does the function and structure of the chromosome differ in prokaryotes?

2005 #2 Answer Key

Part A (5 points maximum)		
Component	**Structure: 1 point/component**	**Function: 1 point/component**
Chromatids	2/sister/pair/identical DNA/genetic information	Distribution of one copy to each new cell
Centromere	Noncoding/uncoiled/narrow/constricted region/determines arm ratio	Joins/holds/attaches chromatids together
Nucleosome concept	Histones, DNA wrapped around special proteins	Packaging compacting
Chromatin form (heterochromatin/ euchromatin)	Condensed/supercoiled → Loosely coiled →	Proper distribution in cell division (not during replication) Gene expression during interphase/replication occurs when loosely packed
Kinetochores	Disc-shaped proteins	Spindle attachment/alignment
Genes or DNA	Brief DNA description	Codes for proteins or for RNA
Telomeres	Tips, ends, noncoding repetitive sequences	Protection against degradation/ aging, limits number of cell divisions

NOTE:

- No points for just naming the component.
- No points for stating that chromosomes are made of genes.
- A diagram alone will not suffice but can be used for clarification.

Part B (4 points maximum, 2 points per theme)	**Part C** (4 points maximum)

• allows for **genetic variation**
  ○ through independent assortment (brief description)
  ○ through crossing over (brief description)
  ○ leads to variation in gametes
• allows for **genetic stability**
  ○ efficiency of transfer of genetic information
  ○ prevents loss of genetic information
  ○ offspring get same number of chromosomes
  ○ maintains integrity of chromosomes
  ○ linked genes tend to be inherited together
• allows for **gene regulation**
  ○ increased complex structure
  ○ histone acetylating
  ○ methylation
• allows for **complexity**
  ○ allows for more genes
  ○ evolution of new genes can occur/transposons
  ○ intron/exon allows for alternate splicing
• allows for **diploid/polyploid**
  ○ genetic fitness
  ○ minimizes the effect of harmful alleles/backup copy
  ○ extra set(s) of alleles
  ○ heterozygosity
	• **shape** (circular/nonlinear/loop)
	• **less complex** (no histones/less elaborate structure/folding)
	• **size** (smaller size/less genetic information/fewer genes)
	• **replication method** (single origin of replication/theta replication)
	• transcription/translation may be coupled
	• generally few or no **introns** (noncoding)
	• majority of genome expressed
	• **operons**—gene regulation
	
	No points for plasmids—more common but not unique to prokaryotes/not part of prokaryote chromosome.