AP® Biology (Operational)
2004 Sample Student Responses

BIOLOGY
SECTION II
Time—1 hour and 30 minutes

Directions: Answer all questions.

Answers must be in essay form. Outline form is not acceptable. Labeled diagrams may be used to supplement discussion, but in no case will a diagram alone suffice. It is important that you read each question completely before you begin to write. Write all your answers on the pages following the questions in this booklet.

1. Meiosis reduces chromosome number and rearranges genetic information.

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

   (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.

   (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.

(a) Reduction is accomplished by two consecutive divisions without replication in between. Following the replication of DNA the chromosomes move to the center and form tetrads in metaphase I. They seperate in Anaphase I, then immediately go into metaphase II where they line up again and split apart during Anaphase II. So essentially the cell does this: 2N → 4N → 2N → 1N. Rearrangement occurs during meiosis when the chromosomes line up in homologous pairs during the metaphases. The chromosomes seperate and each gamete recieves one of each type of chromosome. Crossover while in the tetrad also results in more genetic variability.

(b) Down syndrome results from nondisjunction of the 21st chromosome during meiosis. This means it does not seperate from its homologous partner during anaphase I or II resulting in two in one gamete. The person with downsyndrome has 3 21st chromosomes. People w/ downsydrome have enlarged tongues, heart problems, learning disabilities, and lower IQ's.

IR2

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

© Cloning results from mitotic division, and the genome of the offspring are exactly the same as the parents. Cloning results in no variation in offspring. An example of cloning is the production of plantlets by the Kalenchoe. This plant is known as "The Mother of Thousands" because it produces many clones of the parent plant which are genetically identical. The spider plant is another example of reproduction by cloning, or asexual reproduction.

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(a) During Interphase, the cell makes copies of its DNA in G_2. This is the last phase of Interphase. Once the chromosomes condense to form Chromatin, Meiosis occurs. Starting with Prophase I, the chromosomes duplicate themselves, forming sister chromatid. They are joined together at centromeres. During Prophase I, This an important theme known as crossing over occurs. Double chromosomes cross over to their sister chromatid and exchange genetic information. This is how the majority of rearrangement occurs. Next in Metaphase I, Homologous Chromosomes pair at the center of the cell. During Anaphase I, microfilaments extend to the centromeres and attach to the Kinetochores and pull homologous chromosomes apart. Telophase and cytokinesis occur resulting in 2 diploid new cells. Then begins Prophase II which resembles Prophase I except there is no crossing over. Metaphase II resembles Metaphase I. Anaphase II separates sister chromatids as opposed to homologous chromosomes as in Anaphase I. Telophase II and cytokinesis occur resulting in 4 haploid gametes. The original diploid cell has been reduced to 4 haploid cells.

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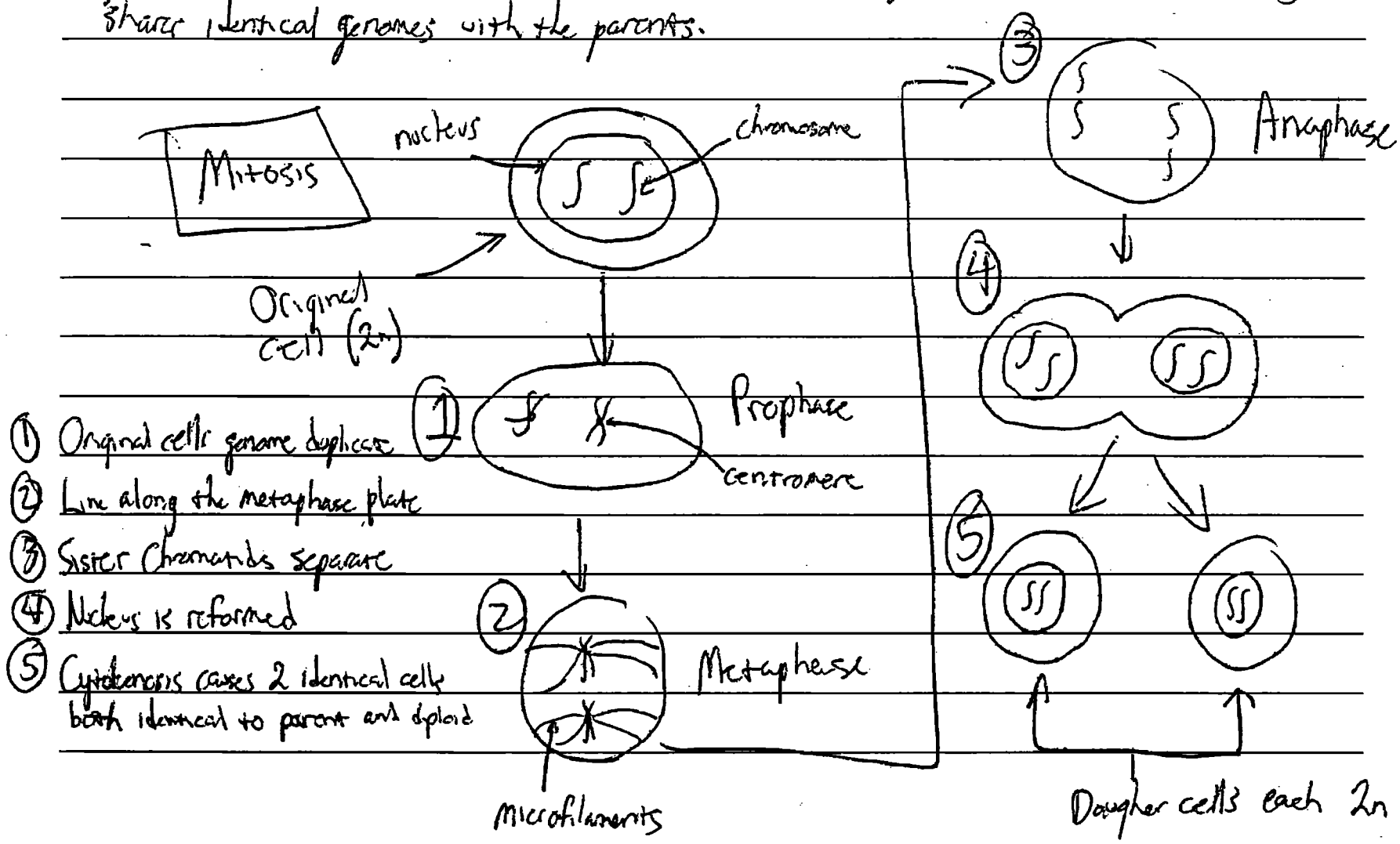
(b) Trisomy 21

During Anaphase sister chromatids are not separated properly. Instead of an equal division of chromosomes, their is an unbalance where one cell has an extra chromosome while the other cell lacks that chromosome. If the gamete with the extra chromosome should fuse with another gamete, the result would be an individual with the chromosomal abnormality known as Down Syndrome. The often results with the individual having pale skin, high forehead, large eyes, mental retardation, and sometimes sterility.

© Cloning is when an identical copy of a cell is reproduced. This occurs during asexual reproduction which uses Mitosis instead of Meiosis. Mitosis is analogous to Meiosis II. However instead of ending with 4 haploid gametes, the endgame of Mitosis is two daughter cells, each diploid, and each containing the same genetic information as the other and as the original. Therefore the offspring share identical genomes with the parents.



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(a) Meiosis is the process of getting four haploid cells from one diploid cell. There are 5 phases of meiosis. Interphase, Prophase, Metaphase, Anaphase & Telophase. After those 5 phases happen, they happen again. That's how the number of gametes being made are reduced. During the first IPMAT of meiosis, two daughter cells are made from the parent cells. During IPMAT II, two more cells are made totalling four gametes. Interphase is when the DNA gets replicated, Prophase is when the chromosome start to move toward the center of the cell. Metaphase is when the chromosomes (homologous chromosomes) line up in the center. Homologous means they are the same chromosome (same size, contain same genes, etc.) During Anaphase, the spindle fibers pull the homologous pairs of chromosomes apart

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to the ends of the cell. Telophase is when the cleavage furrow forms and the cell divides. When the cytoplasm divides, it's called cytokinesis. During Interphase II, the same things happen: enzymes get made, DNA does not get replicated, chemicals get made, etc. During ~~[illegible]~~ prophase II, metaphase II, and anaphase II, the same things basically happen. But synapsis can occur, which is also called crossing over. It's when a piece of a chromosome from one homologous pair switches with another piece from the other chromosome. This doesn't happen as rarely as you'd think. This is the cause of much mutations and variations in genotype + phenotype. It happens during prophase II. After the second "IPMAT" happens, there are a total of four cells from one. (b) Downs-syndrome is an example of one chromosomal disorder. This is when an individual has an extra ~~[illegible]~~ 21st chromosome. Instead of two chromosomes, it has three. The phenotypic qualities of an individual with downs-syndrome includes: droopy eyes, underbites, obesity, difficulty speaking, etc. There are also behavioral problems included in one who has this disorder. They tend to be slower in school, have more difficulty with everyday tasks, They also have an early death rate. This can be caused by a defect in

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

the splitting of the chromosomes during Anaphase or Metaphase of meiosis. An extra chromosome could have mistakenly been copied and grouped in one of the daughter cells.

(c) With cloning, exact duplicates are made from others. The same DNA is in two different organisms. the same exact nucleotide sequences are present in each. The genomes of the offspring would have 1/2 the DNA of the male parent and 1/2 the DNA of the female parent. The offspring's clone would have the same exact DNA as the offspring. In this case, parents and offspring wouldn't share the same exact DNA -- only half.