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Level: HL IB in Biology
Subject: Biology
Topic: IB HL Biology
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All International Baccalaureate IB Topic Questions HL Biology

# BIOLOGY

# HL - IB

## Key skills

**Answer 1**

The correct answer is B because:

- Cell 4 shows metaphase: chromosomes align at the equator which is where the mitotic spindle will bind to the centromere.
- Cell 1 shows anaphase: the chromosomes begin to separate into chromatids, which get pulled to the poles of the cell by the contracting mitotic spindle.
- Cell 2 shows telophase: the chromatids are at the poles ready for the nuclear envelope to reform.
- Cell 3 shows late telophase: the uncoiled chromosomes form two nuclei but cytokinesis (division of cytoplasm) has not occurred yet.
- Cell 5 shows a single cell with a nucleus and no distinct chromosomes and therefore it is in interphase.

Note that it would be reasonable to begin with cell 5 and progress on to cell 4, etc., but this is not an available option here.



**Answer 2**

The correct answer is A because a cell plate forms between the two new nuclei during cytokinesis in plant cells but not in animal cells.

B is incorrect because DNA is transcribed and translated in animal cells during interphase when proteins are synthesised.

C is incorrect because the spindle is formed from microtubules in metaphase in animal cells, to allow the sister chromatids to be separated.

D is incorrect because animal daughter cells are formed during cytokinesis by the process of cleavage furrowing.

**Answer 3**

The correct answer is C because tumour cells undergo rapid, uncontrolled cell division and therefore have a shorter interphase, allowing them to progress more quickly to the next round of cell division.

A is incorrect because mutations can occur in any cell, though it is rare that such mutations go on to cause harm.

B is incorrect because new cells, including tumour cells, are created when the cytoplasm divides during cytokinesis.

D is incorrect because tumour cells undergo the same phases of mitosis as normal cells.

**Answer 4**

The correct answer is D because by this point the cells have completed S phase, during which DNA synthesis occurs. Radioactive nucleotides will be incorporated into the DNA during DNA replication.

A and B are incorrect because these indicate mitosis, which is when the replicated chromosomes (sister chromatids) are being separated.

C is incorrect because immediately after mitosis and cytokinesis the cell enters the $G_1$ phase, where the cell grows and organelles are synthesised.

**Answer 5**

The correct answer is B because:

- The nuclear membrane breaks down during prophase, so will still be present just before prohase
- The spindle only starts to form during metaphase
- During S phase of interphase the DNA is replicated; at the end of this process there are 46 chromosomes, each of which is made up of two sister chromatids, resulting in 92 chromatids overall. Read this carefully so that you don't confuse chromatids and chromosomes.

**Answer 6**

The correct answer is D because the order of the mitosis stages are: prophase (the nuclear membrane breaks down), metaphase (chromosomes line up along the equator), anaphase (centromere divide and then chromatids move to opposite poles of the cell) and telophase (chromosomes decondense).

**Answer 7**

The correct answer is A because the mitotic index is the proportion of cells (in a group of cells or a sample of tissue) that are undergoing mitosis. The mitotic index is normally given to 2 decimal places.

| Stage of mitotic cell cycle | Number of cells |
|---|---|
| Interphase | 80 |
| Prophase | 11 |
| Metaphase | 2 |
| Anaphase | 4 |
| Telophase | 3 |

$$\text{Mitotic index} = \frac{\text{number of cells in mitosis}}{\text{total number of cells}}$$



Calculate the cells in mitosis:

$11 + 2 + 4 + 3 = 20$

Calculate total no. of cells:

$20 + 80 = 100$

Calculate mitotic index:

$\frac{20}{100} = 0.2$ [1 mark]

**Answer 8**

The correct answer is B because:

- The chromosomes are distinguishable so the cell has entered mitosis, but it is clear that the cell has not yet entered metaphase as the aligning of the chromosomes at the equator has not yet occurred. It has not entered anaphase as the sister chromatids are not being pulled apart. The cell must therefore be in prophase.
- There are 10 chromosomes here, so 10 is the diploid chromosome number (2n). Don't forget that at this stage the two chromatids together are referred to as a single chromosome.
- The haploid number (n) is half the full number of chromosomes, so the haploid chromosome number is 5.

**Answer 9**

The correct answer is D; a diploid (2n) cell in the zygote gives rise to more diploid (2n) cells in the embryo. The type of cell division that gives rise to identical cells in this way is mitosis.

Fertilisation would cause the chromosome number to double, and can be seen in the life cycle at the point at which the haploid egg and sperm cells (n) fuse to form the diploid zygote (2n). Note that the term 'fusion' given in option C is really just a description of the process of fertilisation given in A, rather than being a biological process in itself.

In meiosis we should see diploid (2n) cells becoming haploid (n); this occurs at the point at which the sporophyte (2n) becomes spores (n).

Note that it doesn't matter if you have never heard of a sporophyte or a gametophyte; as long as you understand the cellular processes of cell division and fertilisation, you know enough to answer this question.

**Answer 10**

The correct answer is B. The individual has an X and a Y chromosome, so they are male, and they have 3 chromosomes instead of 2 in pair 22.

The individual does not have Down syndrome, as this would involve 3 chromosomes in pair 21 (Down syndrome is sometimes known as trisomy 21).

**Answer 11**

The correct answer is D.

Statement I is correct because the mass of DNA in each cell doubles during DNA replication. This occurs during S phase of the cell cycle prior to nuclear division by either mitosis and meiosis.

Statement II is incorrect because crossing over occurs between chromatids within homologous pairs of chromosomes. Note that the crossing over takes place between non-sister chromatids, i.e. a chromatid from each member of the pair.

Statement III is incorrect because reduction division occurs during meiosis I. Note that reduction division refers to the halving of the chromosome number when the homologous pairs are separated, not to the separating of sister chromatids.

Statement IV is incorrect because sister chromatids remain together in meiosis I but separate in meiosis II.

**Answer 12**

The correct answer is C.

Recombination involves breaking and re-joining strands of DNA; this can result in new combinations of traits as alleles move from one chromosome to another.

Statement A describes random orientation; while this generates genetic variation, it does not involve the exchange of sections of DNA, so is not genetic recombination.

Statement B is incorrect because mutation occurs when random copying errors arise during DNA replication, and does not involve the breaking and re-joining of chromosomes.

Statement D describes the loss of non-coding DNA from the ends of chromosomes, not the breaking and re-joining of DNA strands.

**Answer 13**

The correct answer is C.

In meiosis I the homologous pairs separate; only in meiosis II do the sister chromatids move to opposite poles.

Whilst it may be tempting to think that chiasmata form in metaphase, when chromosomes align along the equator of the cell, crossing over takes place when the homologous chromosomes pair up during prophase I.

**Answer 14**

The correct answer is B.

Crossing over takes place at the equivalent location on chromatids from homologous pairs of chromosomes; this is because the same base sequences exist at these corresponding points. Breaks occur so that an equal length of DNA is exchanged from one non-sister chromatid to the other. Drawing B shows sections of uneven lengths being exchanged, which would never happen.

A chiasma can form between adjacent chromatids, or between non-adjacent ones, so drawings A, C and D are all possible.

Drawing C shows two crossing over events on the same pair of chromosomes, which is entirely possible.

**Answer 15**

The correct answer is B.

The number of chromosome combinations that can be generated during random orientation is calculated using the formula $2^n$, where $n$ is the haploid chromosome number. Here the diploid number is 14, so the haploid chromosome number is 7; we therefore raise 2 to the power of 7 ($2^7$ = 128).

Option A calculates the number of chromosomes.

Option C uses the diploid number, so this is the incorrect formula.

Option D does not use the correct formula.

Note that this calculation is not specifically mentioned in your specification, but it is a good idea to be familiar with this concept.

**Answer 16**

The correct answer is B; the first nuclear division, or meiosis I, separates the homologous pairs, and so generates haploid cells. Be careful not to confuse this with the separation of the sister chromatids which occurs during meiosis II.

A is incorrect; meiosis is a mechanism of nuclear division that occurs in eukaryotic cells, and specifically the cells of the reproductive organs. Prokaryotic cells do not have a nucleus and so divide by binary fission, while normal body cells divide by mitosis.

C is incorrect; while interphase is part of the cell cycle, it is separate from meiosis, which consists of prophase, metaphase, anaphase, and telophase (all occur twice during meiosis).

D is incorrect; meiosis is very important for the generation of genetic variation in sexual reproduction, but the process of mutation, which generates new alleles, can also take place in cells that divide by mitosis.



**Answer 17**

The correct answer is C because Y is the stage at which the *2n* (diploid) sorus gives rise to *n* (haploid) spores.

Option A is incorrect because W is fertilisation, during which the n gametes fuse to form the *2n* zygote.

Option B and D are incorrect as X and Z are both mitosis. We can see this because growth takes place and the chromosome number does not change. Don't be misled by the production of gametes in stage Z; this is an unusual life cycle in comparison to what you may have come across before.

Note that you are not expected to know anything about the life cycle of ferns, but you should be able to use information about haploid and diploid life cycle stages to determine when meiosis occurs.

**Answer 18**

The correct answer is D.

- DNA replication occurs before nuclear division (stage 1), and the chromosomes change from single strands to sister chromatids joined at the centromere.
- Crossing over takes place during meiosis I (stage 2) while the homologous pairs line up.
- Sister chromatids are separated during meiosis II (stage 3).

While random orientation and separation of homologous pairs are both processes that occur during stage 2, both B and C have other incorrect statements.

- Option B incorrectly identifies stage 1 as mitosis.
- Option C incorrectly describes stage 3 as separation of homologous pairs.

While stages 1 and 3 are correctly described in A, random fertilisation occurs after meiosis and so is incorrect.



**Answer 19**

The correct answer is B.

Statement II is incorrect; *n* represents the number of pairs of chromosomes in a diploid cell, or the haploid chromosome number, not the number of chromosomes in a diploid cell. E.g. in humans there are 23 homologous pairs of chromosomes, and therefore $2^{23}$ possible combinations as a result of random orientation.

**Answer 20**

The correct answer is C. The graph shows that as the distance from the centromere increases, so does the number of crossing over events. As this set of results was gained from male trout, the conclusion can only be applied to male trout.

A is incorrect because we have no statistical analysis to tell us whether the difference in crossing over events at different distances from the centromere is significant.

B is an incorrect reading from the graph; 30 % of crossing over events occurs at a relative distance of 0.8.

D is incorrect because it attempts to apply these results to all fish species; more research would be needed before this conclusion could be reached.

**Answer 21**

The correct answer is A. The graph shows that in the age range of 40-49, there would be 12.5 XY sperm per 10 000 sperm. This then needs to be scaled up to find out the number of XY sperm per 1 000 000.