1. What is the average cell cycle span for a mammalian cell?

Solution:

The average cell cycle span of a mammalian cell is about 24 hours.

2. Distinguish cytokinesis from karyokinesis.

Solution:

<table>
<thead>
<tr>
<th>Cytokinesis</th>
<th>Karyokinesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>The process of division of cytoplasm is Cytokinesis.</td>
<td>The process of division of the nucleus is Karyokinesis.</td>
</tr>
<tr>
<td>It takes place post-nuclear division in both mitotic and meiotic cell division.</td>
<td>It is the first stage in both mitotic and meiotic cell division.</td>
</tr>
<tr>
<td>It is a single step process.</td>
<td>It takes place in 4 stages such as prophase, anaphase, metaphase, and telophase.</td>
</tr>
</tbody>
</table>

3. Describe the events taking place during interphase.

Solution:

The interphase is the phase in which the major changes take place, and cell stays the longest in this phase. Some of the changes in the cell during interphase include the formation of copies of cell organelles, the formation of chromosomes, checkpoints to detect errors in chromosome replication.
The interphase takes place in 3 main stages:

1) **G1 phase (Gap 1)** - In this phase, the cell enters the cycle after a period of rest in 
   \(G_0\) phase or after the mitotic division of the cell. \(G_1\) phase is marked by some of the 
   significant changes in the cell, which includes duplication of cell organelles. It is 
   also known as the growth phase since the content in the cell grow and prepares for 
   the DNA replication.

2) **S phase (Synthesis)** – It is the stage at which DNA replication takes place, and the 
   quantity of DNA increases, i.e., if the amount is 2x, it increases to 4x, however, the 
   chromosome number remains the same, in humans, it is 46. The centriole in the 
   cytoplasm doubles.

3) **G2 phase (Gap 2)** – The various proteins are synthesized to assist in the cell growth 
   and cell division. The DNA condenses to initiates the process of mitosis. It is 
   shorter in duration.

Here,
I refer to Interphase
G1 refers to G1 or Gap 1 phase
S refers to the Synthesis phase
G2 refers to G2 or Gap2 phase
M refers to Mitosis phase
G0 refers to Exit or Quiescent phase.

G1, S and G2 phases represent the Interphase of a cell cycle.

4. **What is Go (quiescent phase) of cell cycle?**
Solution:

The cells that do not undergo cell division enter Go phase, also known as the quiescent phase, wherein the cell is metabolically active but remains in that stage until the cell division is required.

5. Why is mitosis called equational division?

Solution:

The mitotic division is called the equational division since the number of chromosomes is the same in both parent and daughter cells.

6. Name the stage of cell cycle at which one of the following events occur:
   (i) Chromosomes are moved to spindle equator.
   (ii) Centromere splits and chromatids separate.
   (iii) Pairing between homologous chromosomes takes place.
   (iv) Crossing over between homologous chromosomes takes place.

Solution:

   i)  Metaphase
   ii) Anaphase
   iii) Zygotene stage of Prophase I in Meiosis
   iv) Pachytene stage of Prophase I in Meiosis.

7. Describe the following:
   (a) synapsis (b) bivalent (c) chiasmata
   Draw a diagram to illustrate your answer.

Solution:

   a) Synapsis

   Synapsis is the pairing of chromosomes which takes place in the Zygotene phase of Prophase I of Meiosis. The paired chromosomes are known as
homologous chromosomes. Synapsis of the chromosomes lead to the formation of synaptonemal complex.

b) **Bivalent**
   Bivalent or tetrad refers to the complex formed due to pairs of homologous chromosomes that have synapsed. Tetrad means four chromatids. It occurs in the Zygote phase of Prophase I in Meiosis.

c) **Chiasmata**
   It is the site of crossing over of the two non-sister chromatids of homologous chromosomes. It takes place during the Diplotene stage of Prophase I in Meiosis. It is an important event where the recombination of the two parental genes takes place, leading to variation in the progeny.
8. How does cytokinesis in plant cells differ from that in animal cells?

Solution:

<table>
<thead>
<tr>
<th>Cytokinesis in plant cells</th>
<th>Cytokinesis in animal cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cytokinesis in plant cells takes place through the formation of a cell plate at the centre of the cell.</td>
<td>Cytokinesis in animal cells takes place through the formation of a furrow in the plasma membrane.</td>
</tr>
<tr>
<td>It starts to form at the centre of the cell and extend toward the lateral wall of the existing cell, further forming the cell wall of new cells.</td>
<td>It starts forming furrow from the plasma membrane and deepens further into the cytoplasm to form new cells.</td>
</tr>
</tbody>
</table>

9. Find examples where the four daughter cells from meiosis are equal in size and where they are found unequal in size.

Solution:

In the process of gamete formation, i.e. spermatogenesis and oogenesis, there is the formation of four daughter cells.

a) Meiotic division forming four daughter cells of equal size.
   - Spermatogenesis in human beings results in the formation of four sperms, which are equal in size.

b) Meiotic division forming four daughter cells of unequal size
   - Oogenesis in human beings results in the formation of one large mature egg cell and three small polar bodies.
10. **Distinguish anaphase of mitosis from anaphase I of meiosis.**

**Solution:**

<table>
<thead>
<tr>
<th>Anaphase of Mitosis</th>
<th>Anaphase I of Meiosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is the 3rd stage of cell division in somatic cells.</td>
<td>It is the 3rd stage of cell division in Meiosis I of gametic cells.</td>
</tr>
<tr>
<td>In this stage, the centromere splits and sister chromatids separate and move towards opposite poles with the centromere heading in the direction of the poles.</td>
<td>In this stage, the centromere doesn’t split, and sister chromatids remain attached and move in towards the opposite poles.</td>
</tr>
<tr>
<td>The chromosomes are genetically identical.</td>
<td>The chromosomes are genetically unidentical.</td>
</tr>
</tbody>
</table>

11. **List the main differences between mitosis and meiosis.**

**Solution:**

<table>
<thead>
<tr>
<th>Mitosis</th>
<th>Meiosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is the cell division which takes place in the cells involved in cell repair and growth.</td>
<td>It is the cell division that takes place in the cells involved in gamete formation.</td>
</tr>
<tr>
<td>The daughter cells formed are identical to the parent cells since crossing over of non-sister chromatids does not take place.</td>
<td>The daughter cells are non-identical to the parent cells since crossing over of non-sister chromatids takes place, causing variation.</td>
</tr>
<tr>
<td>At the end of mitosis, two daughter cells are formed.</td>
<td>At the end of meiosis, four daughter cells are formed since meiosis takes place in two successive divisions such as Meiosis I and II.</td>
</tr>
<tr>
<td>Prophase is short and does not comprise of any stages.</td>
<td>Prophase I is long and comprise of 5 stages such as Leptotene, Zygotene, Pachytene, Diplotene and Diakinesis.</td>
</tr>
<tr>
<td>Mitosis is also known as equational division since the chromosome number is the same as in parent and daughter cells.</td>
<td>Meiosis is also known as reductional division since the chromosome number in daughter cells is reduced to half the number present in the parent cell.</td>
</tr>
</tbody>
</table>

12. **What is the significance of meiosis?**
Meiosis is the cell division that takes place during gamete formation. The specific chromosomes or genes are preserved through generations. It is also called a reductional division since the number of chromosome in the parent cell is reduced to half the number of chromosomes in the daughter cell.

One of the significant events that take place in Meiosis is the crossing over of the non-sister chromatids, which result in the variations in the further generations. Variations are important aspects of evolution.

13. Discuss with your teacher about
   (i) haploid insects and lower plants where cell-division occurs, and
   (ii) some haploid cells in higher plants where cell-division does not occur.

Solution:

   i) Haploid insects include ants, bees, wasps, and in lower plants such as Chlorella, Spirogyra and Chlamydomonas, the meiosis of zygote takes place post-fertilization, which results in haploid organisms. This kind of cell cycle is called haplontic cell cycle.

   ii) In higher plants, where flowers are the reproductive part of sexually reproducing plants, the antipodal cells and synergids which are haploid do not undergo cell division.

14. Can there be mitosis without DNA replication in ‘S’ phase?

Solution:

Mitosis is the process of cell division, which requires the replication of DNA, to form new cells. The replication of DNA takes place in the ‘S’ or Synthesis phase of the cell cycle, and it is required for equal distribution of DNA in the newly formed cells.

15. Can there be DNA replication without cell division?
Solution:

Yes, DNA replication can take place without cell division, resulting in accumulation of excess of DNA within the cell and hence increase the cell density. In cell organelles such as mitochondria and chloroplasts, the DNA replication takes place to replace the worn out or damaged cell organelles.

16. Analyse the events during every stage of cell cycle and notice how the following two parameters change
   (i) number of chromosomes (N) per cell
   (ii) amount of DNA content (C) per cell

Solution:

The stages of the cell cycle are Interphase, which consists of G1, S and G2 phase, which is followed by the M phase. M phase or Mitotic phase has Prophase, Metaphase, Anaphase and Telophase (Somatic cell division).

Gamete formation is due to Meiotic division. Meiosis takes place in two successive stages: Meiosis I and Meiosis II. In human beings, the chromosome number is 2N or 46 (23 pairs).

Hence,

i) The number of chromosomes (2N) per cell remains the same in the interphase, whereas in the Anaphase of Mitosis, the chromosome number increases to 4N, and at the end of cell division, the chromosome number is 2N, due to the formation of two daughter cells.

   In meiotic division, the chromosome number reduces to half, i.e., (N) at the end of Meiosis I. In the Anaphase II of Meiosis II, the chromosome number doubles (2N) and at the end of Meiosis II, the chromosome number reduces to (N), due to formation of four daughter cells.

ii) The amount of DNA content (C) per cell remains the same in the G1 phase, however, in the S phase, the amount of DNA content doubles and it remains unchanged in the G2 phase. In the anaphase of Mitotic division, the DNA is equally distributed in the daughter cell. Hence the amount of DNA remains the same, whereas, in Anaphase II of meiotic division, the DNA content is reduced to half the amount per cell compared to the parent cell.