Outcomes:

- Explain what binary fission is and the organisms which carry out binary fission.
- Describe the process of binary fission.
- Explain why viruses are not classified as being living organisms.
- Describe the sequence of events by which viruses replicate.
- Explain why viruses are so difficult to treat and develop medicines against.

Explain what binary fission is and the organisms which carry out binary fission.

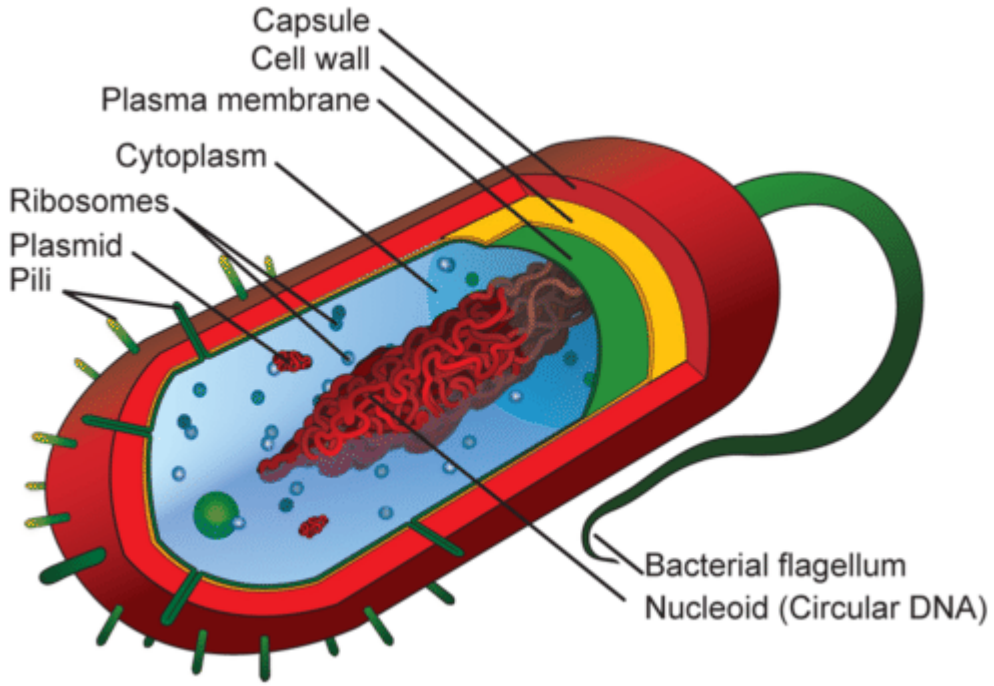
What is Binary fission?

- Binary fission occurs in **prokaryotic cells**

- Where in this cell will DNA replication need to occur?

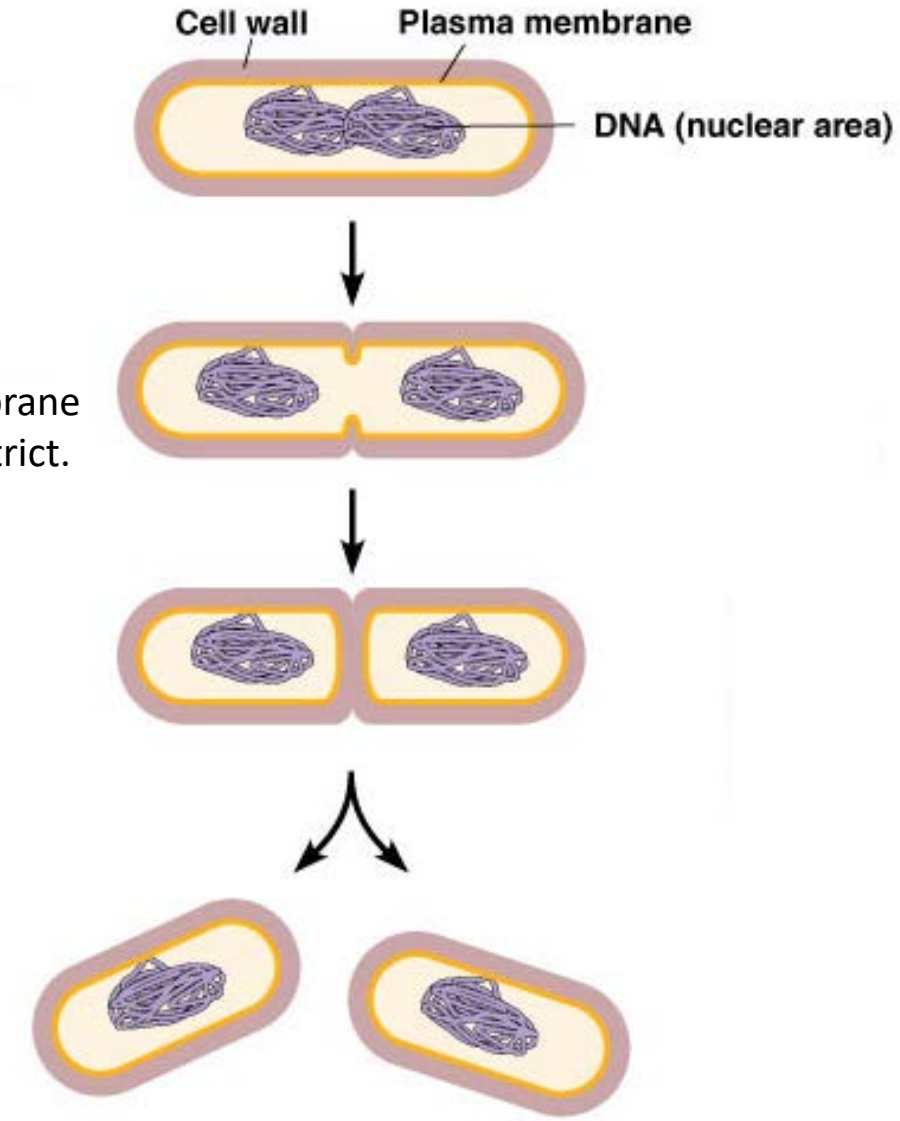
Circular DNA and plasmids

- **Plasmids can be found in variable amounts.**



Describe the process of binary fission.

1. Replication of circular DNA.
2. Cell wall and plasma membrane begin to constrict.
3. Division of cytoplasm.
4. Two new daughter cells with single copy of circular DNA.



Question:

1.A bacterial cell undergoes binary fission every twenty minutes. Starting with a single bacterium how may bacteria will be formed at the end of 3 hours?

3 Hours = 180 minutes
180/20= 9 divisions take place
2^9 = 512 cells.

2. A bacterial cell undergoes binary fission every twenty minutes. Starting with a single bacterium how may bacteria will be formed at the end of 7 hours?
Give your answer in standard form.
7 hours= 420 minutes
420/20= 21 divisions
$2^{21=}$ 2097152
2.1×10^6 bacteria

Viruses are classed as been non-living so do not undergo cell division.

You can be asked to describe the sequence of events by which viruses replicate.

So you will need to make sure you recap this from the immunity topic.

And also…

Explain why viruses are so difficult to treat and develop medicines against which will be summarised on the next slide.

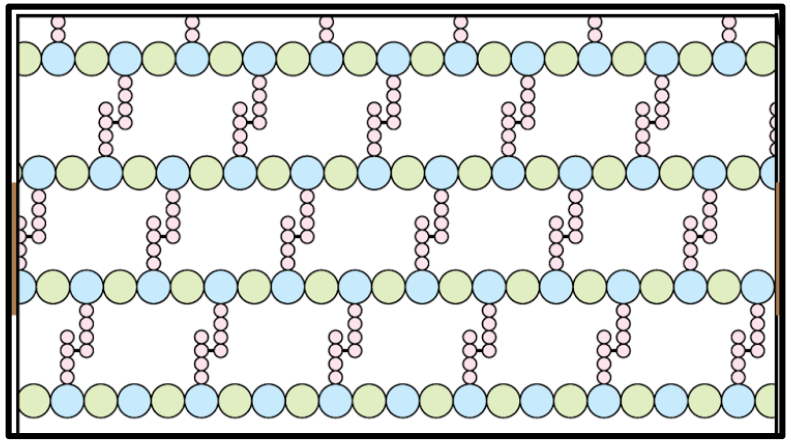
Viruses and antibiotics

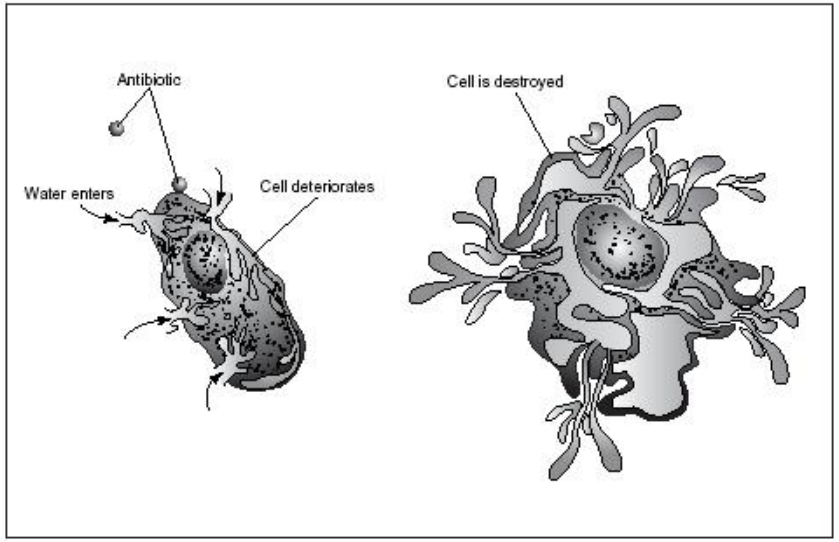
- Antibiotics work by inhibiting enzymes that catalyse the formation of **murein** (peptidoglycan) cross linkages in bacterial cell walls.

- These cell walls prevent bacterial cells undergoing **osmotic** **lysis**

- Viruses **do not have cell walls** – therefore antibiotics are **ineffective**

- Also, once a virus has entered a body cell, antibiotics cannot reach it





Complete exam questions.

Q1.

(a)

1. Binary fission;
2. Replication of (circular) DNA;
3. Division of cytoplasm to produce 2 daughter cells;
4. Each with single copy of (circular) DNA;

1. Ignore reference to 'chromosome'

2. Ignore 'copy'.

4. Ignore references to number of plasmids.

2 max

(b)

1. Both denatured (by high temperature);

2. Denaturation faster at 60 °C due to more (kinetic) energy;

3. Breaks hydrogen / ionic bonds (between amino acids / R groups);

4. Change in shape of the active site / active site no longer complementary **so** fewer enzyme-substrate complexes formed / substrate does not fit;

3. Ignore references to disulphide bonds

*3. Accept (at 60 °C) Change in shape of the active site / active site no longer complementary **so** no enzyme-substrate complexes formed / substrate does not fit;*

4

(c)

1. To digest protein;

2. (So) they can absorb <u>amino acids</u> for growth / reproduction / protein synthesis / synthesis of named cell component;

OR

(So) they can destroy a toxic substance / protein;

1. For 'digest' accept 'break down' here.

2. Accept '(so) they can destroy antibodies / antibiotics / viral antigens / bacterial antigens'

2

(d)

1. Hydrolyse (peptide bonds) to release amino acids;
2. Amino acids can cross (cell) membrane;

OR

Dipeptides cannot cross (cell) membrane;

OR

Maintain concentration gradient of amino acids for absorption;

OR

Ensure (nearly) maximum yield from protein breakdown;

2. Ignore references to crossing gut membranes.

2. Accept 'there are carrier proteins for amino acids'

2. Accept 'no carrier proteins for dipeptides'

2

[10]

Outcomes:

- Explain outcome of mitosis.
- Explain the appearance of cells in each stage of mitosis.

Mitosis

Definition:

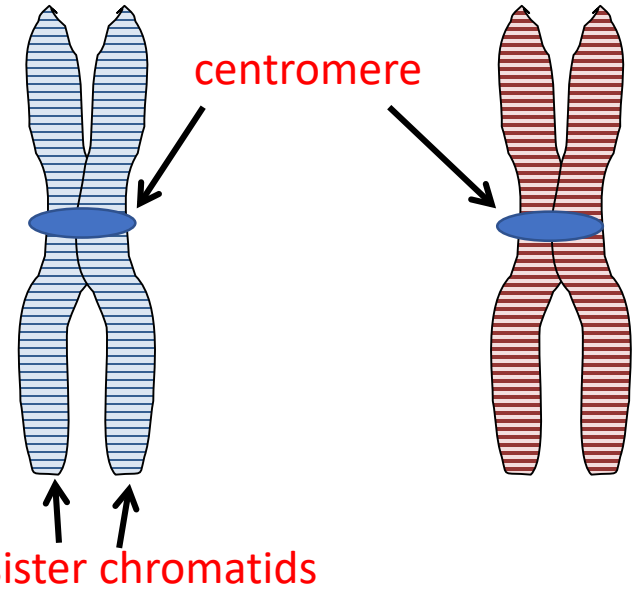
Production of two daughter cells that have the same number of chromosomes as the parent cell and each other.

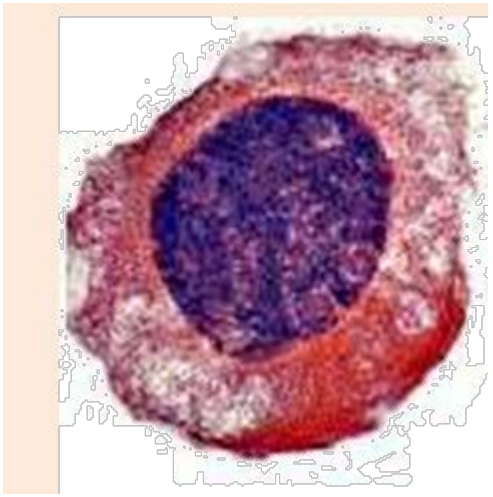
What type of cells undergo mitosis?

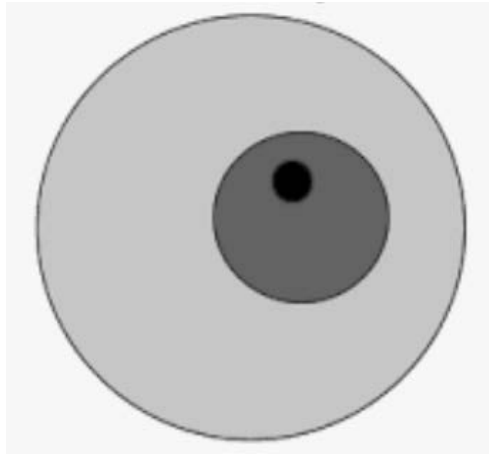
Body cells

Interphase (not a true stage of mitosis!)

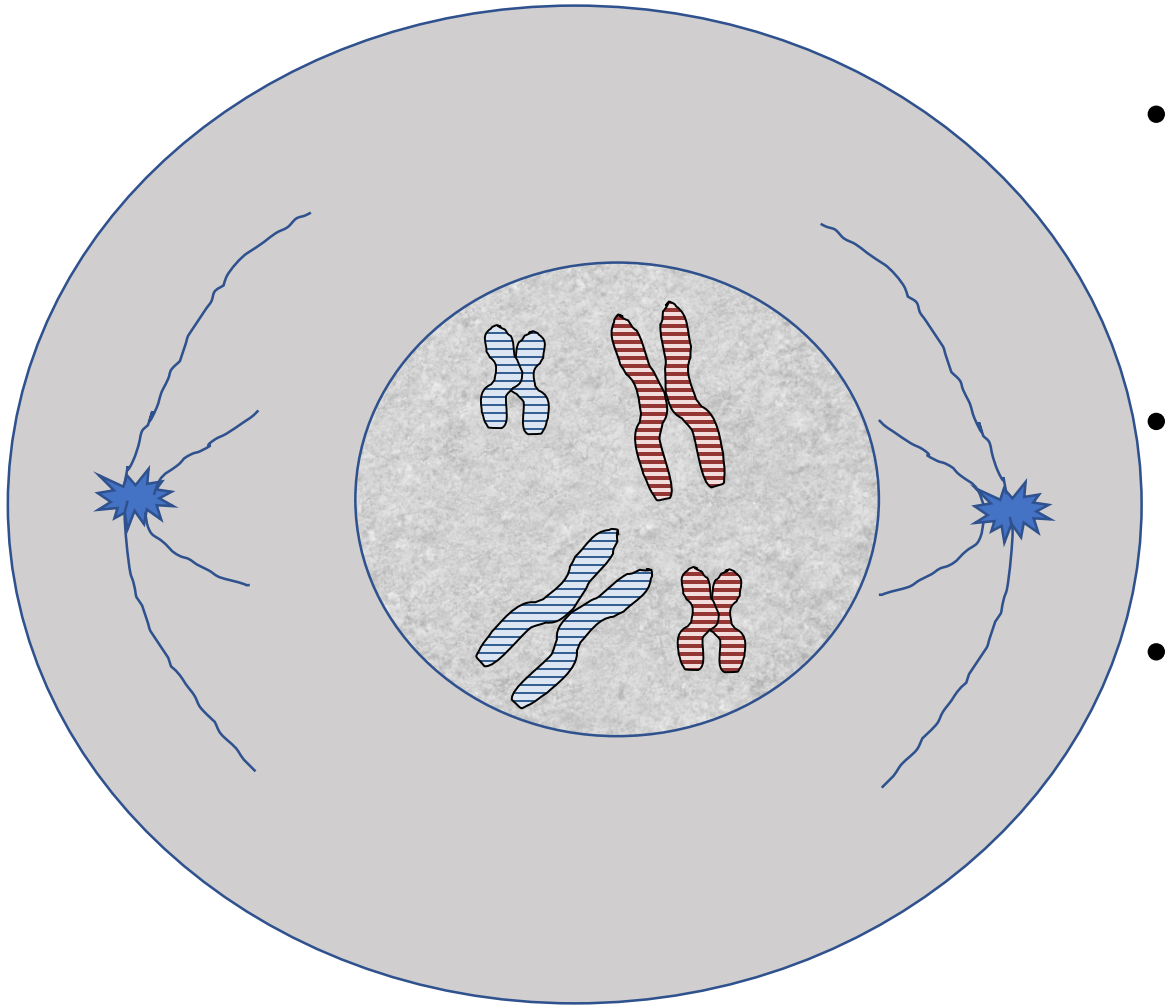
- Chromosomes are dispersed (so not visible)
- Each chromosome replicates.
- Chromosomes made of 2 sister chromatids, joined at centromere.





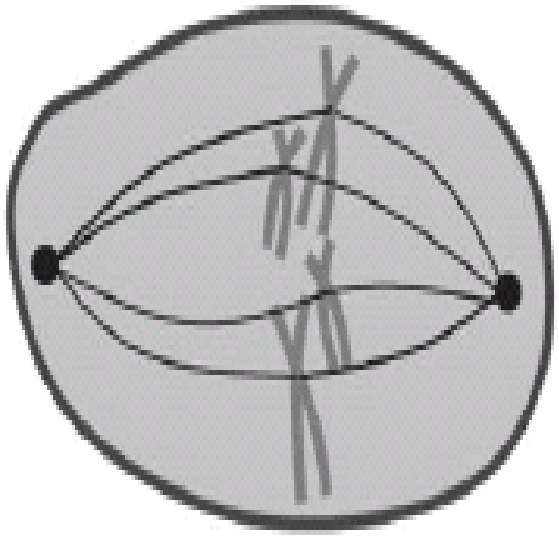


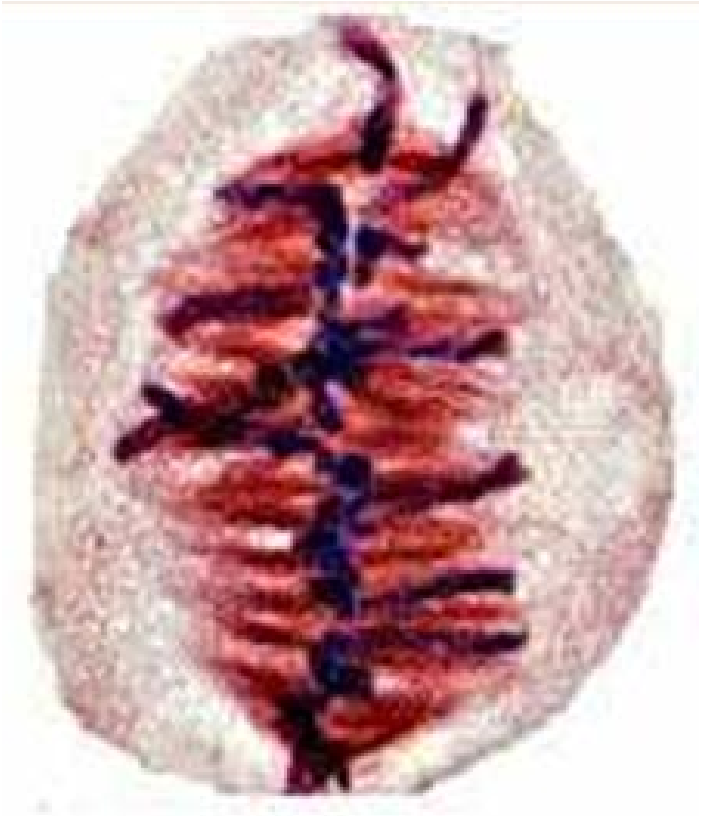
Prophase



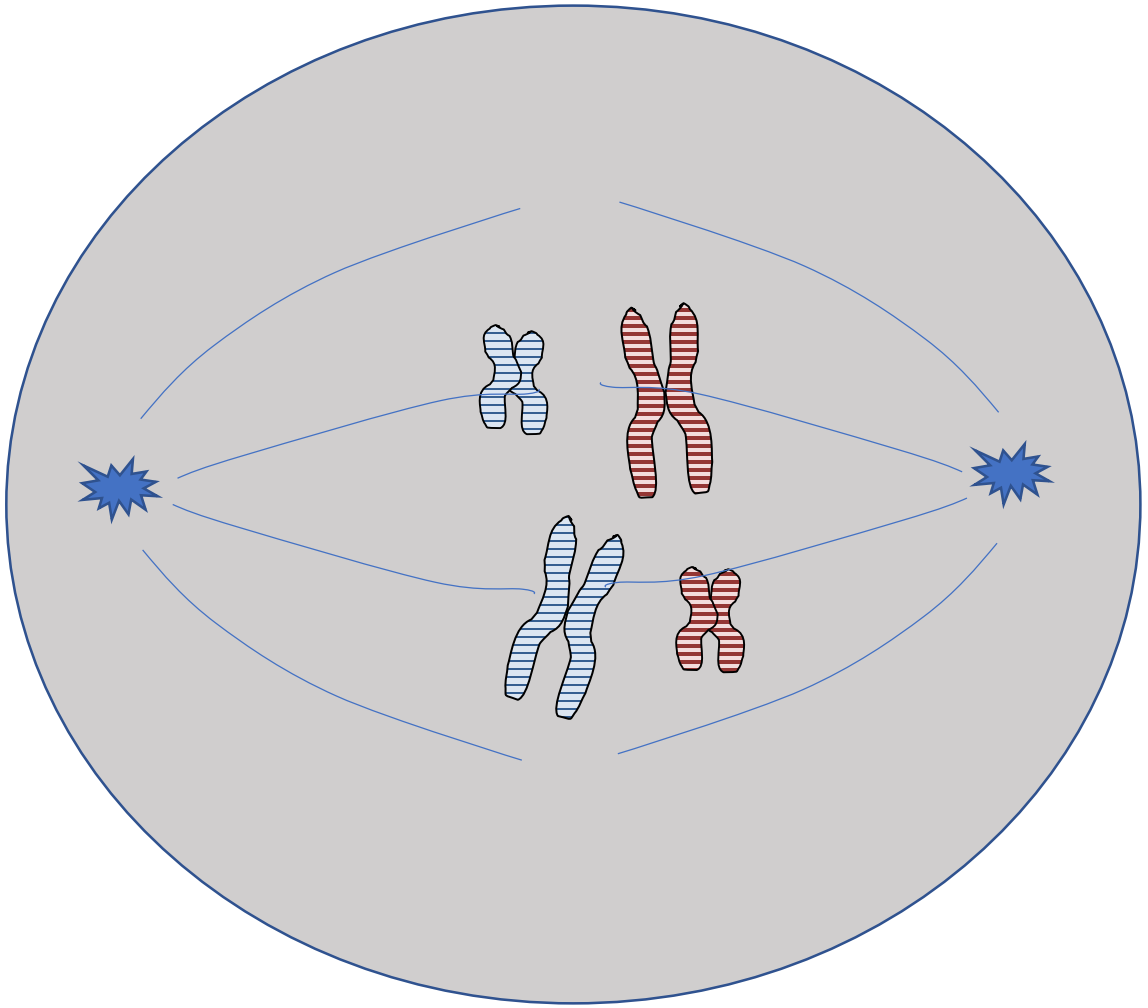
- Chromosomes shorten and thicken to become visible.
- Nuclear envelope breaks down.
- Centrioles move to the poles of the cell and start forming spindle fibres.

Metaphase



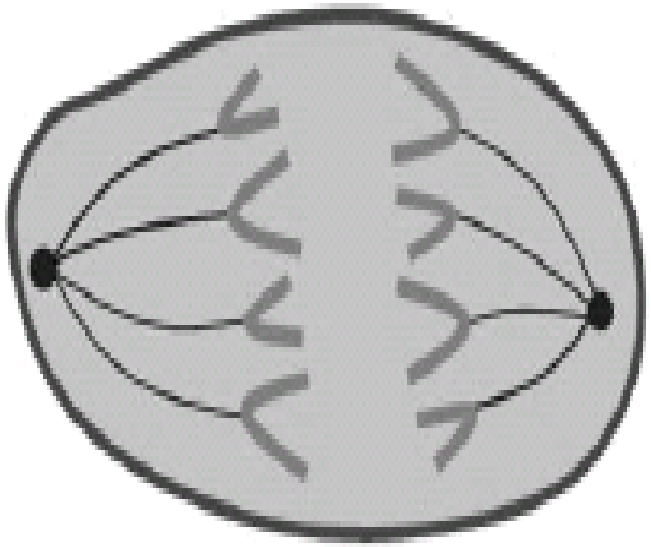


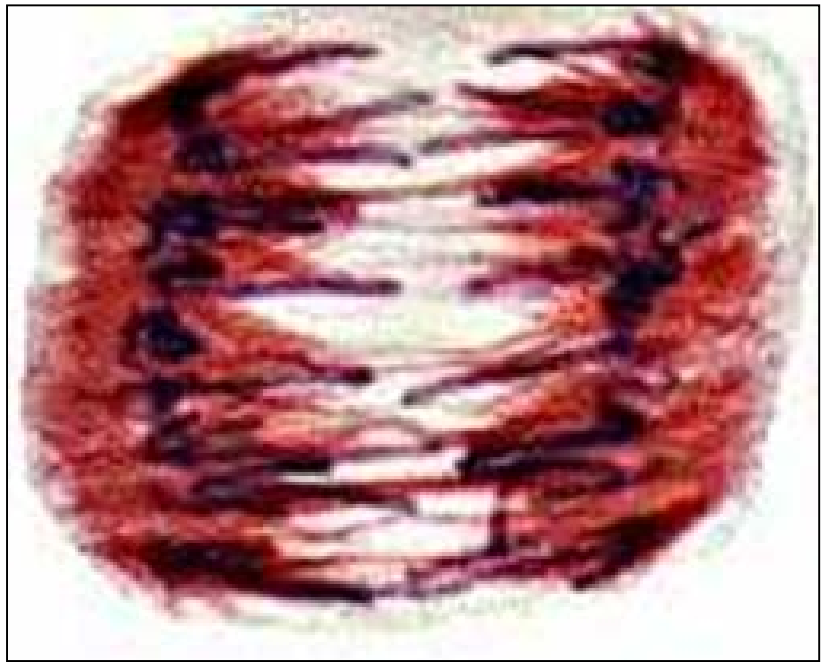
Metaphase



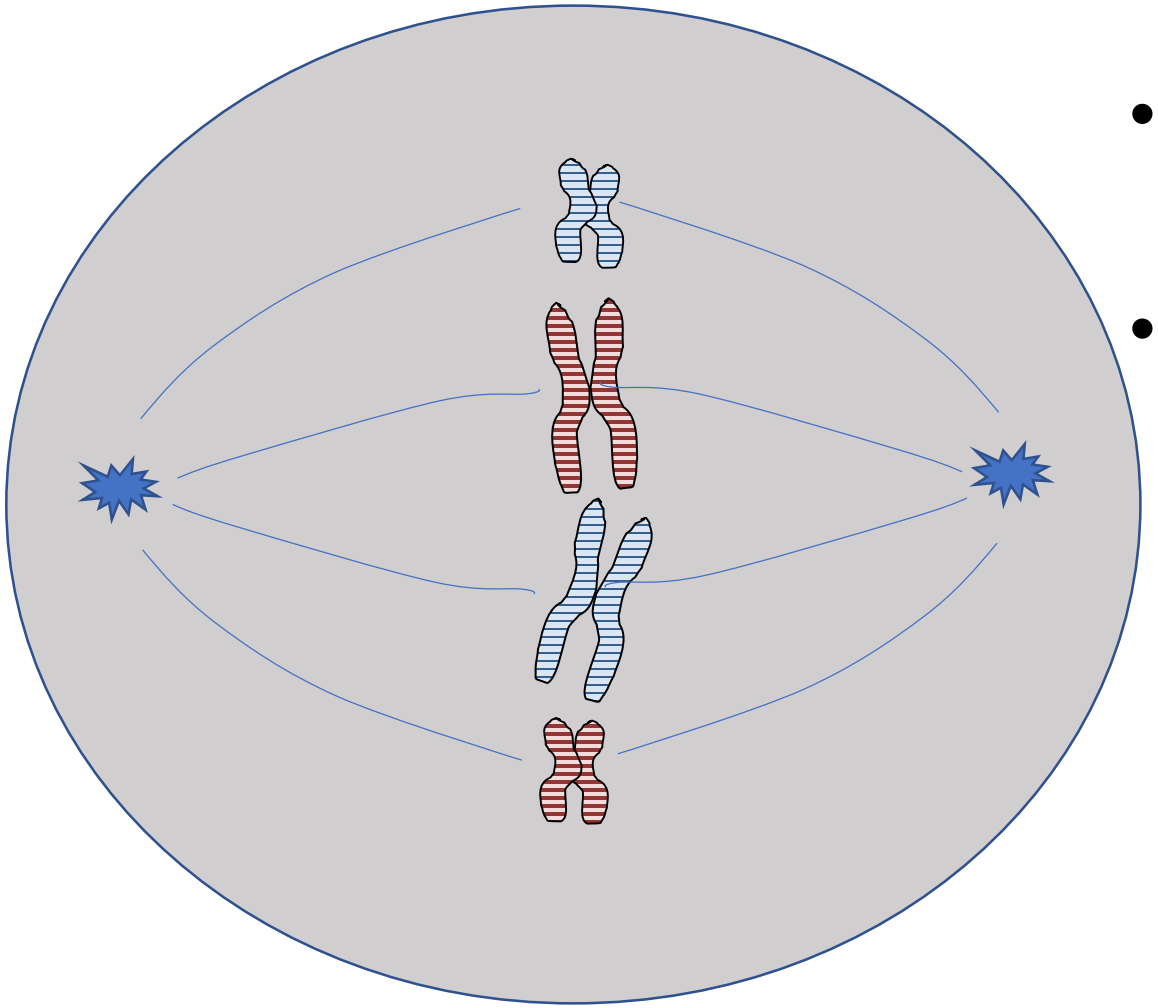
- Spindle fibres attach to centromeres and line up the chromosomes at the equator of cell

Anaphase



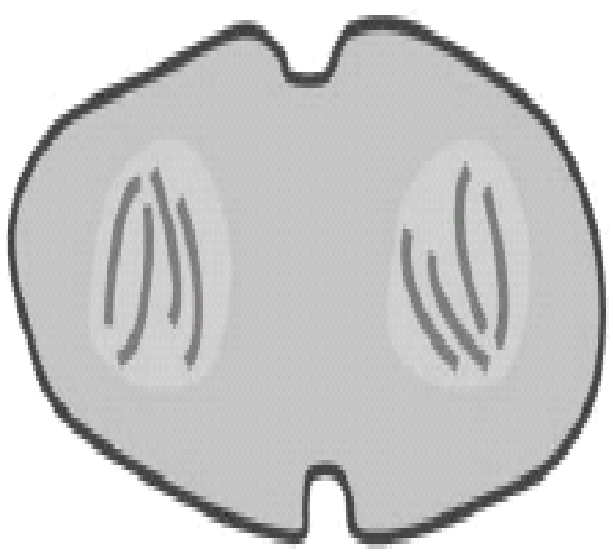


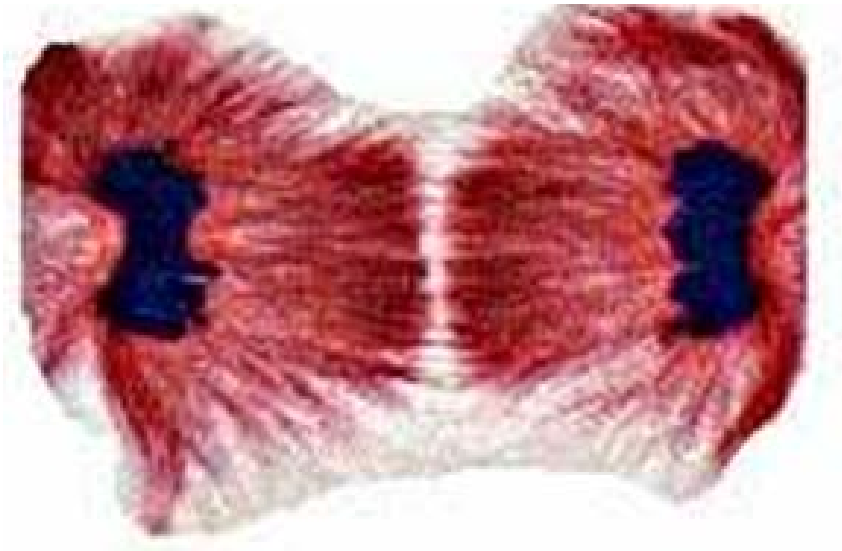
Anaphase



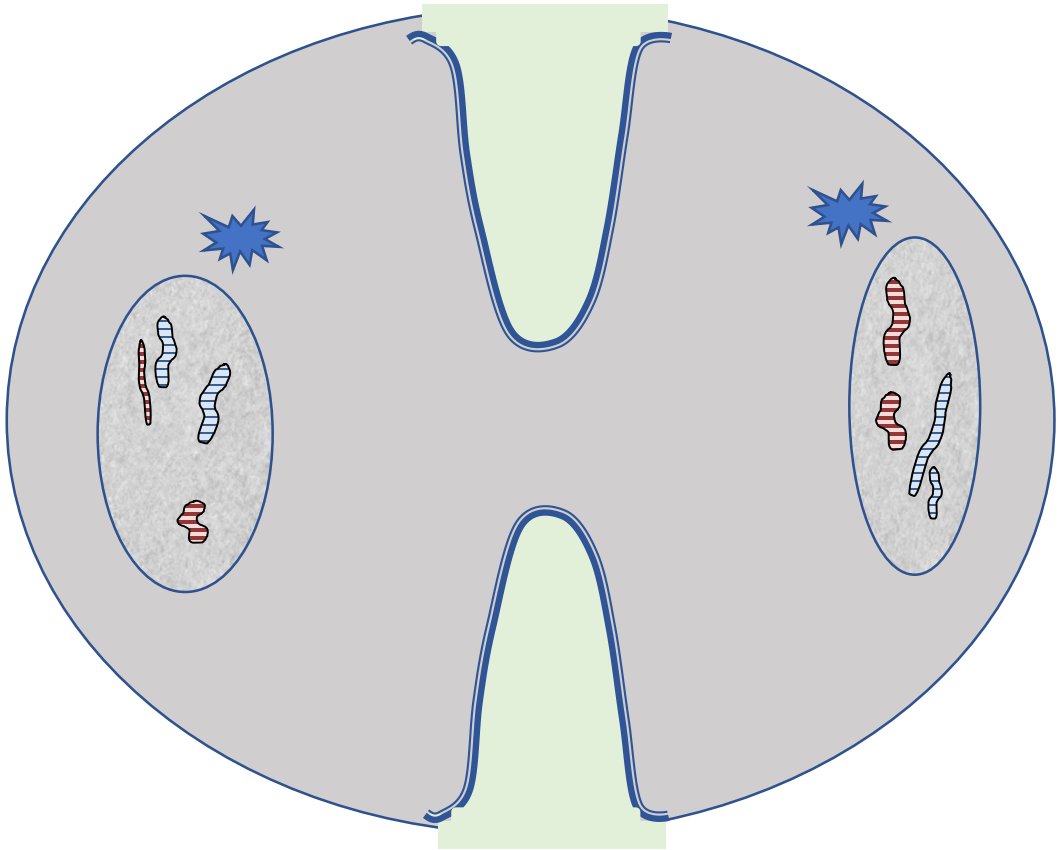
- Spindles contract
- ‘sister’ chromatids separate and are pulled to opposite sides of the cell

Telophase





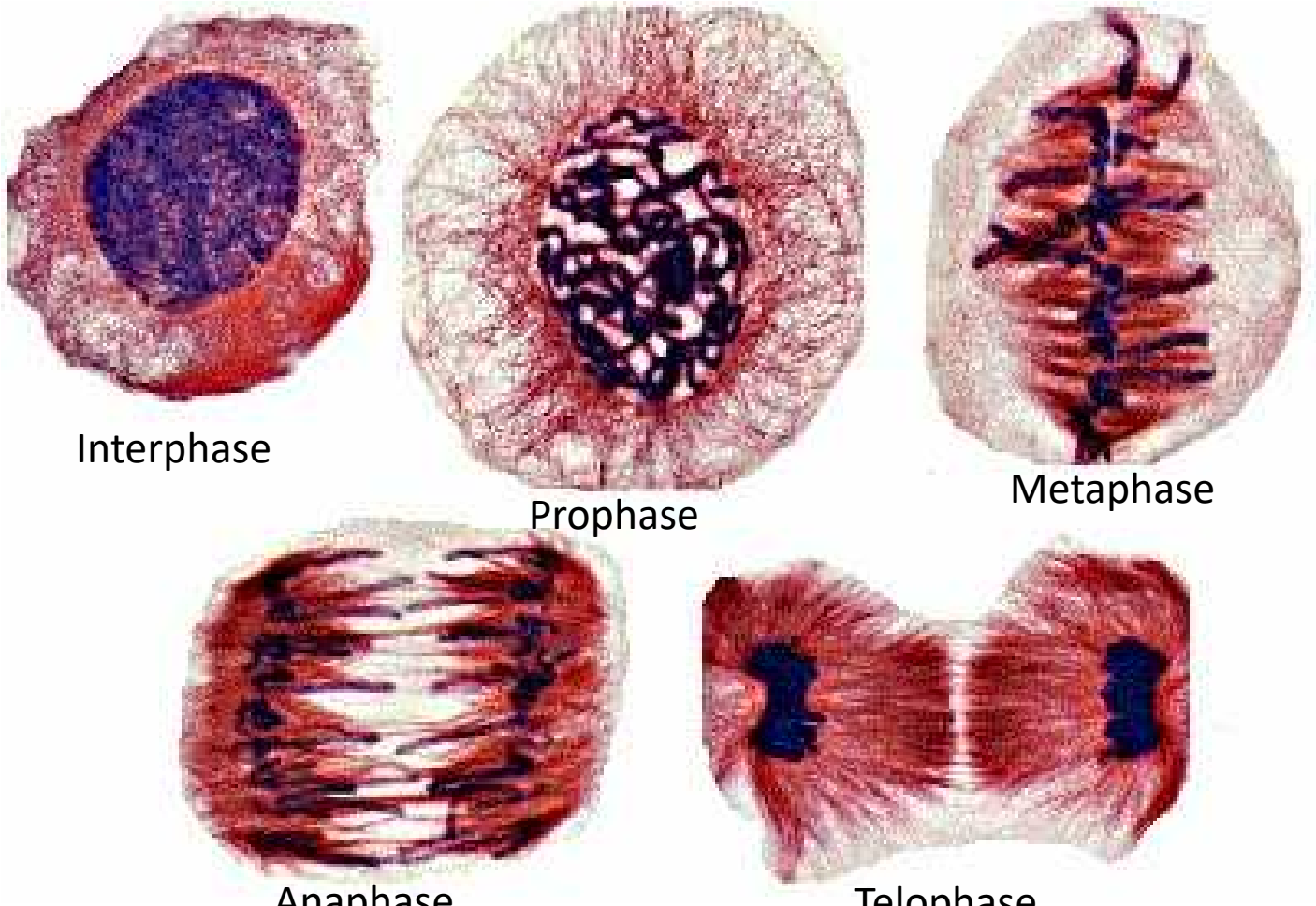
Telophase

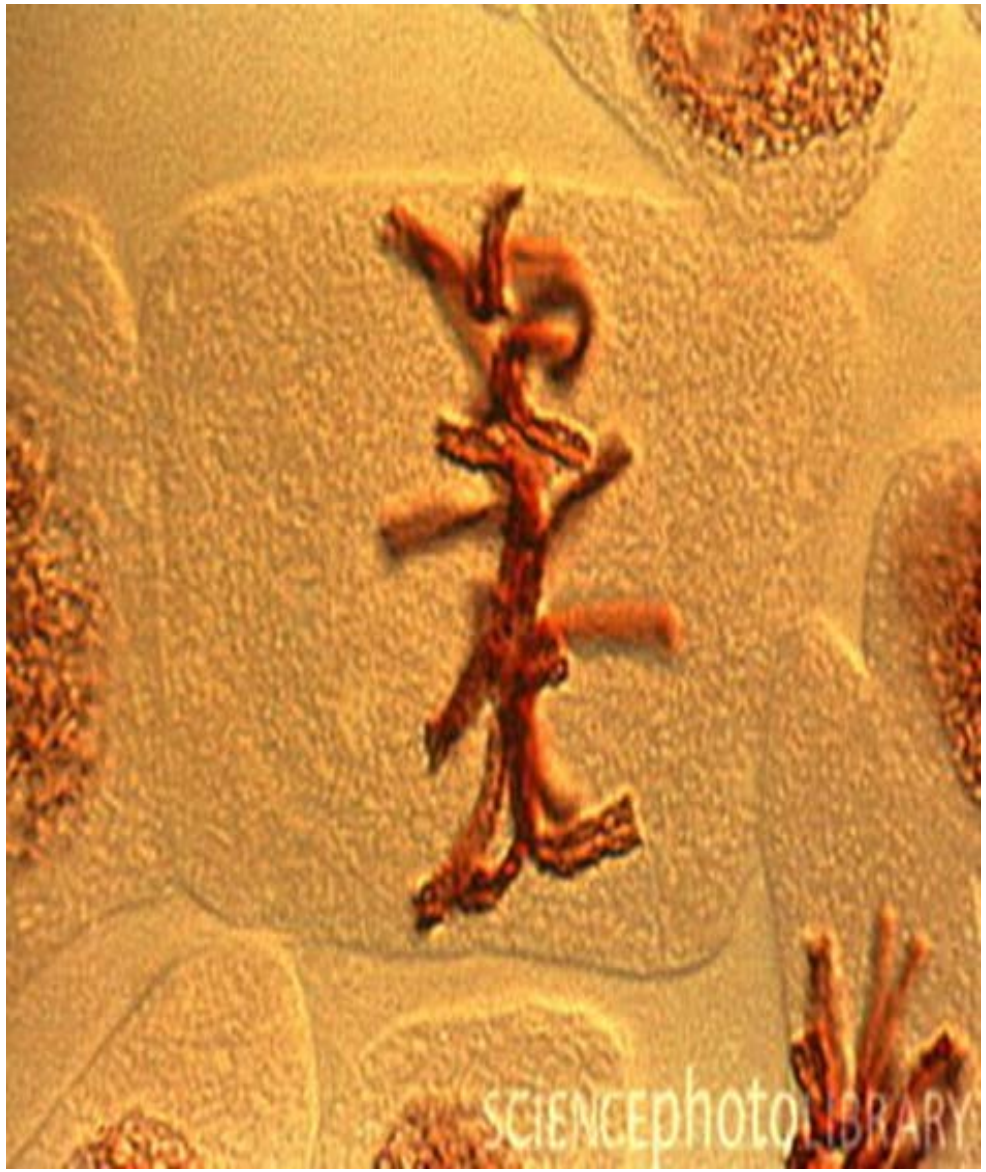


- Spindle breaks down.
- Nuclear envelope reforms.
- Chromosomes disperse.
- Cytokinesis begins.

Mitosis- what is this stage?

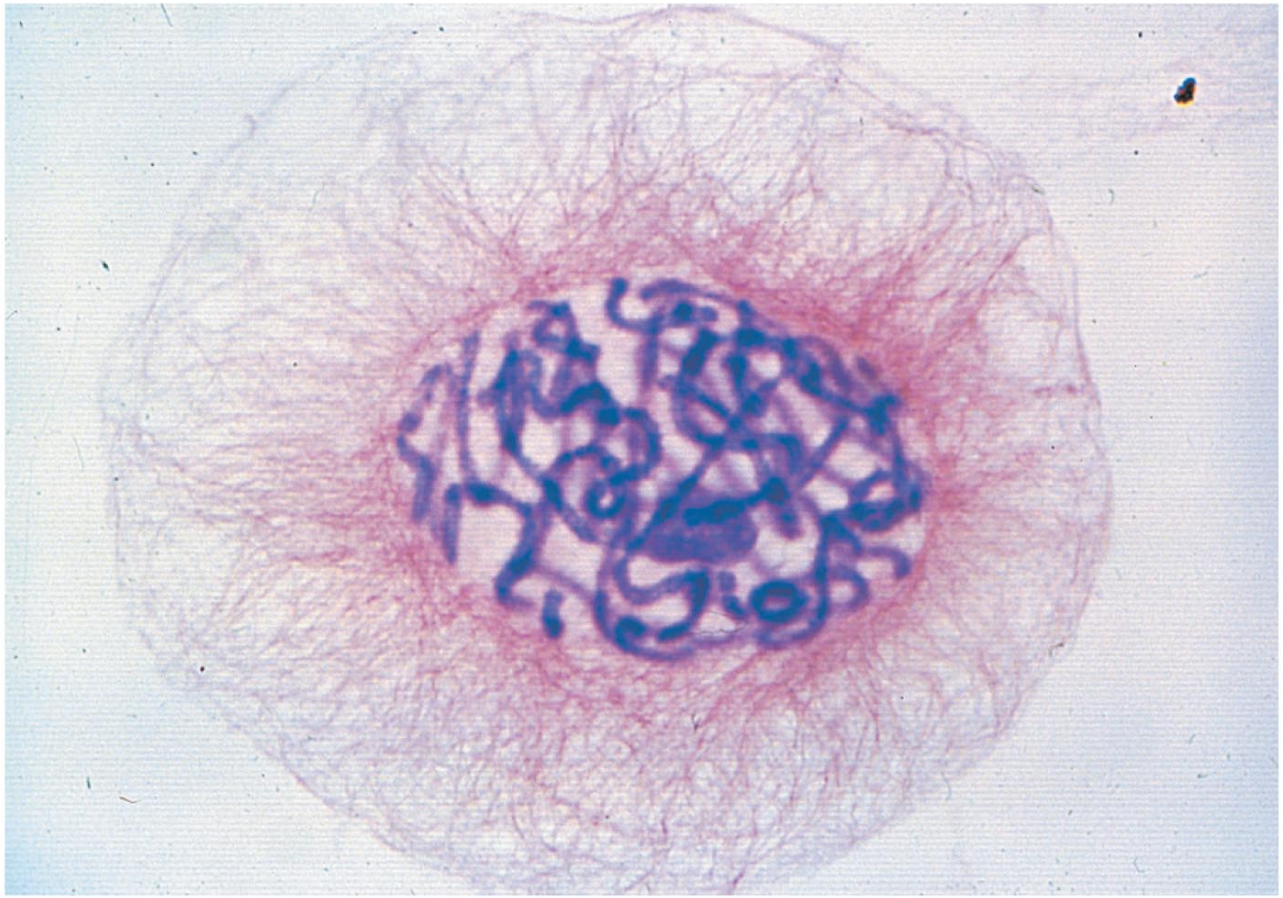
Whiteboards at the ready!





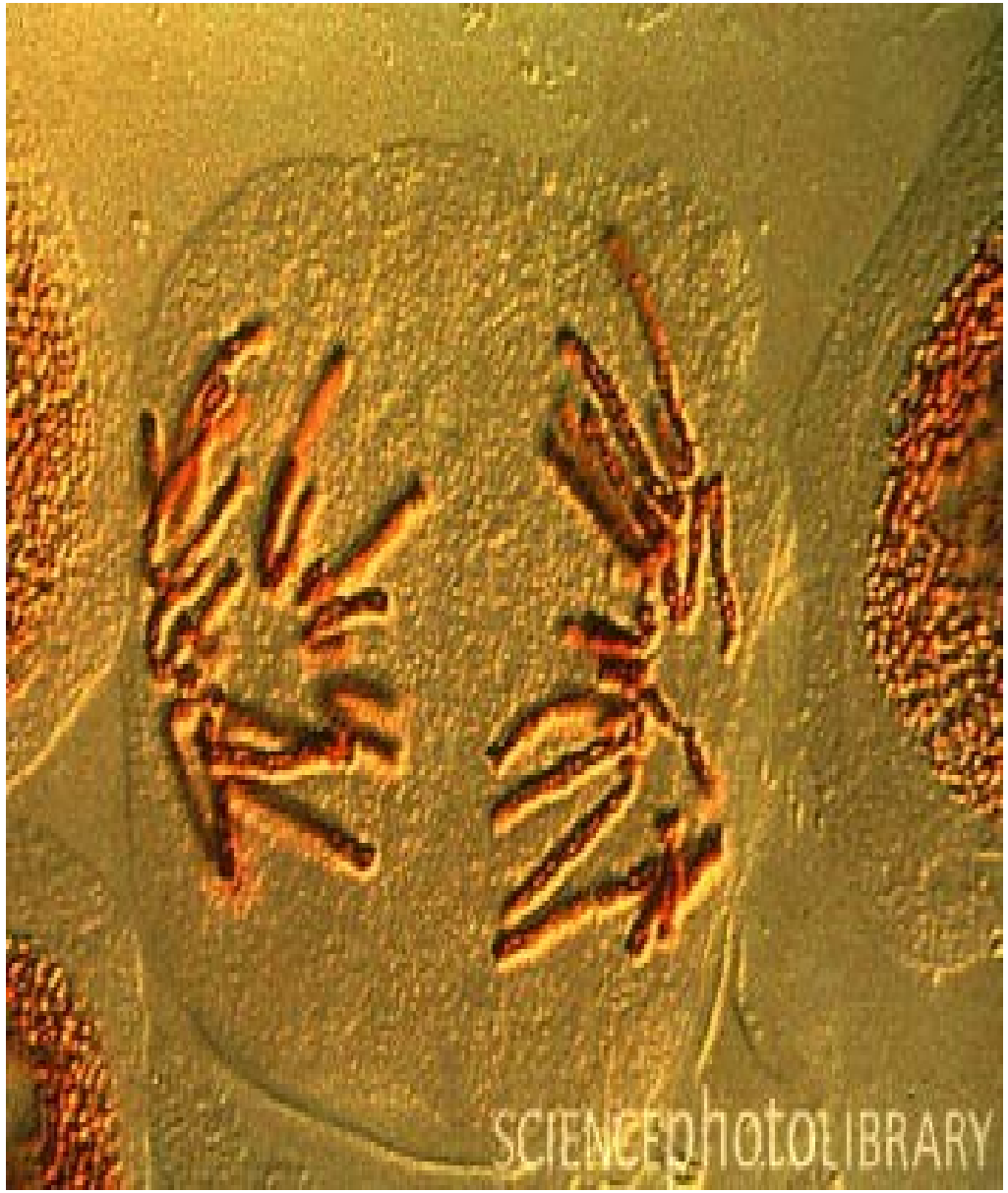
What is this stage?

Metaphase



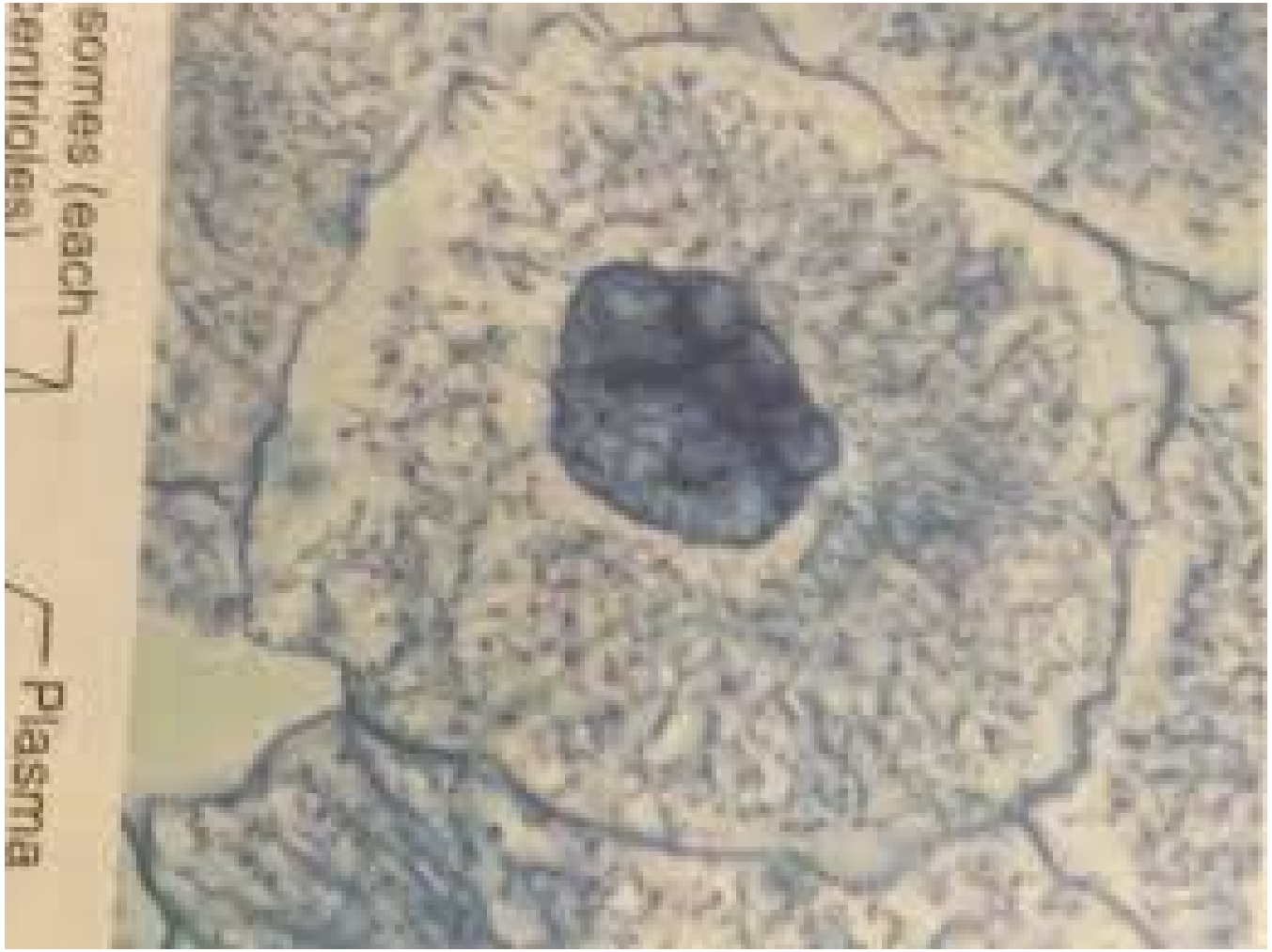
What is this stage?

Prophase



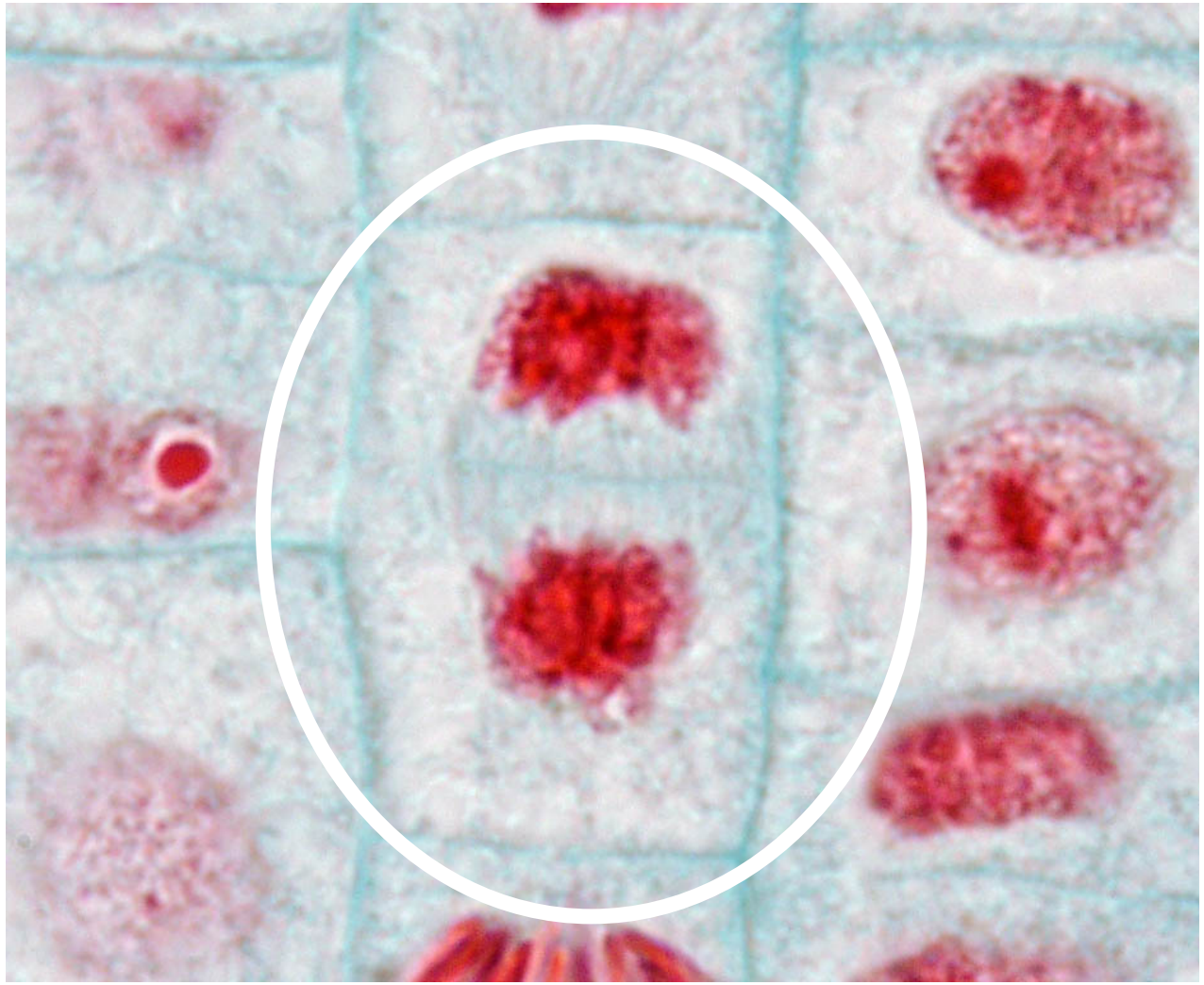
What is this stage?

Anaphase



What is this stage?

Interphase



What is this stage?

Telophase

Now complete the exam questions

Q1.

(a) (i) Prophase; 1

(ii) Chromosomes / chromatids moved apart; **1**

(iii) *A wide range of processes occurs during interphase. This list is by no means exhaustive, but we would expect to see answer such as:*

Increase in volume of cell / volume of cytoplasm / increase in mass / cell bigger; increase in number of organelles;
synthesis of protein / named protein;
DNA replication / increase / chromosomes copied;
ATP synthesis / respiration; **max 2**

(b) Divide real length of bar (in mm) / 10 by 0.02; **1**

(c) 12 / 200 × 24 / single error in otherwise correct method;

1.44 hours (1 hour 26 min); **2**

[7]

Q2.

(a) Centromere;

1

(b) Same size;

Same shape;

Same genes;

In same sequence/locus/loci;

2 max

(c) Chromatids separate;

(Chromatids) pulled to opposite ends of cell;

By spindle fibres;

Become part of new nuclei;

2 max

[5]

Q3.

(a) Sequence: C,A,D,B;

1 mark per correct box to 3 max

3 max

(b)(i) Q;

1

(ii) Cell/nucleus has divided / is dividing (into two);

Accept – mitosis (occurring)

Ignore refs to chromosomes dividing

1

[5]

Q4.

(a) DNA replicated/two DNA strands/molecules;
Coiled/condensed/wound up (to make visible);
Giving/made of (two) chromatids;
Attached at centromere; *Accept linear so eukaryote; with histone; Accept have become shorter and fatter* **2 max**

(b) (i) Stage **A**, anaphase/prophase;
Chromatids/chromosomes moving to poles/chromosomes condensed/
coiled/wound up;

Points not linked but need correct description with stage in this case. Accept prophase because the image could be interpreted as such

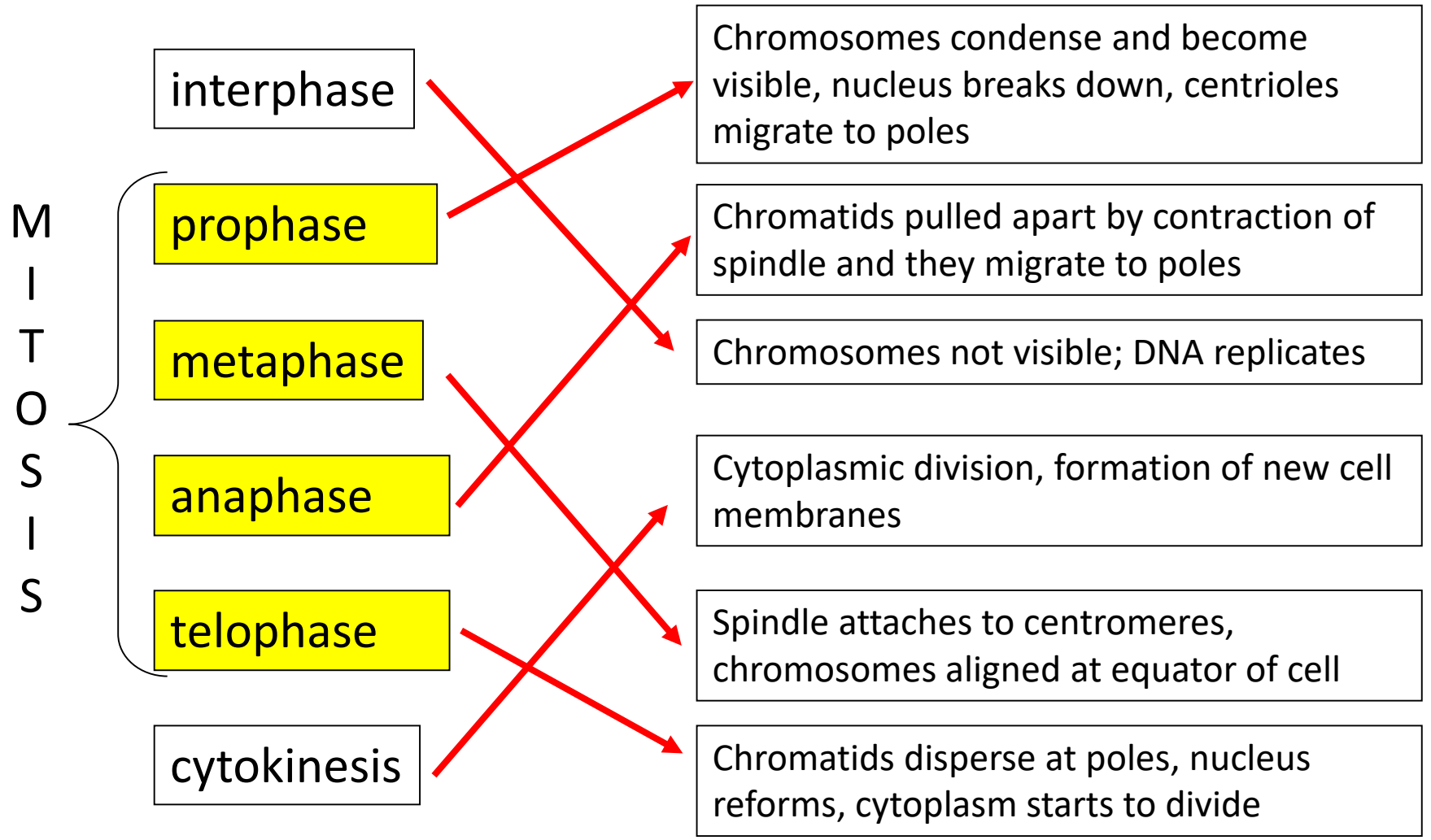
2

(ii) Stage **B**, metaphase;
Chromosomes on equator/attaching to spindle;

Points not linked
Accept equator of cell
Reject centre of cell
Accept chromatids for chromosomes **2**

[6]

Recap – mitosis (page ..)



Outcome:

- Explain the different outcomes of meiosis.
- Complete diagrams showing the chromosome content of cells after the first and second meiotic division, when given the chromosome content of the parent cell.
- Recognise where meiosis and mitosis occurs when given information about an unfamiliar life cycle

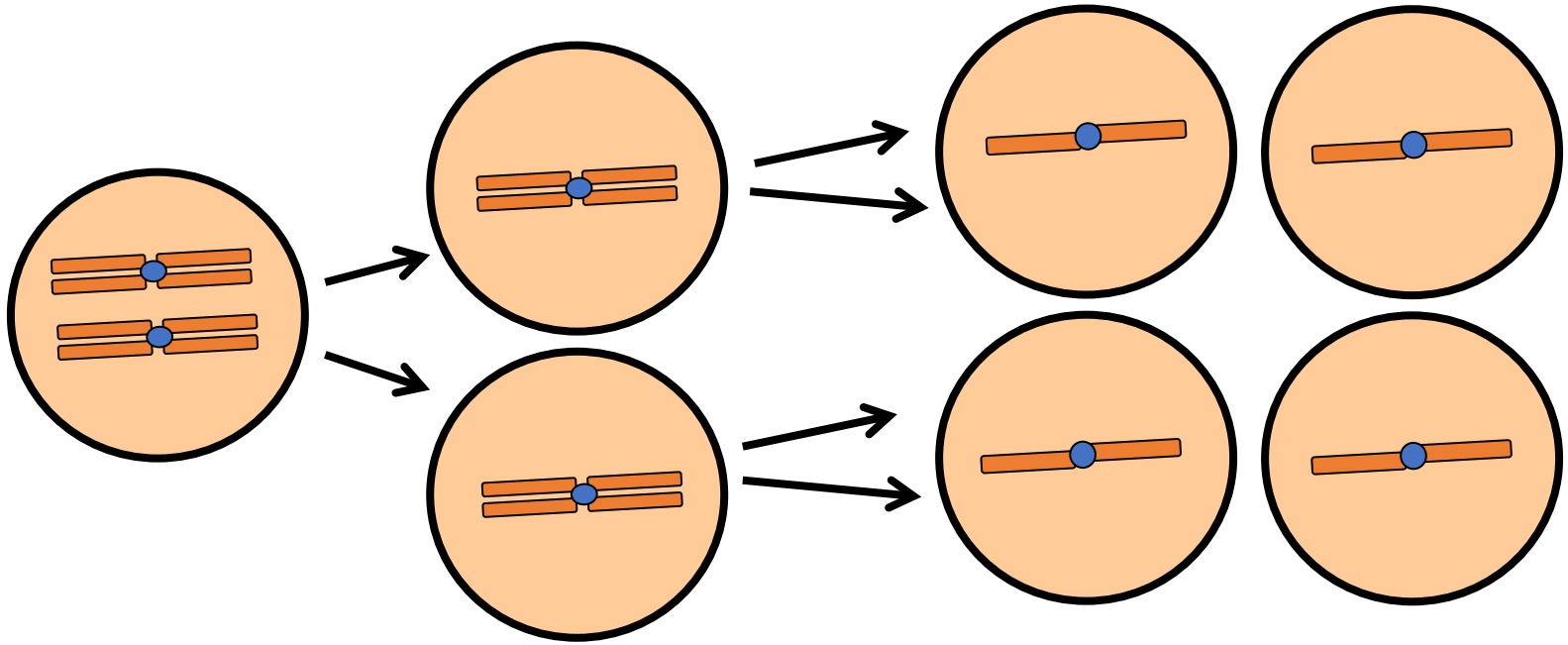
Meiosis

Definition:

Production of four daughter cells that have half the number of chromosomes as the parent cell.

What type of cells undergo mitosis?

Sex cells (gametes)



Stages of meiosis

Meiosis involves the formation of 4 daughter cells. This requires 2 divisions of the cell.

Meiosis 1 – first division takes place

Meiosis 2 – second division takes place

Why?

- Mitosis gives daughter cells with the same chromosome number.

- If we made sperm/eggs by mitosis, when the sperm and egg meet, what would be the number of chromosomes in one cell?

46 + 46 = 92

Meiosis I

- Interphase (pre meiosis)
- Prophase I
- Metaphase I
- Anaphase I
- Telophase I

Meiosis II

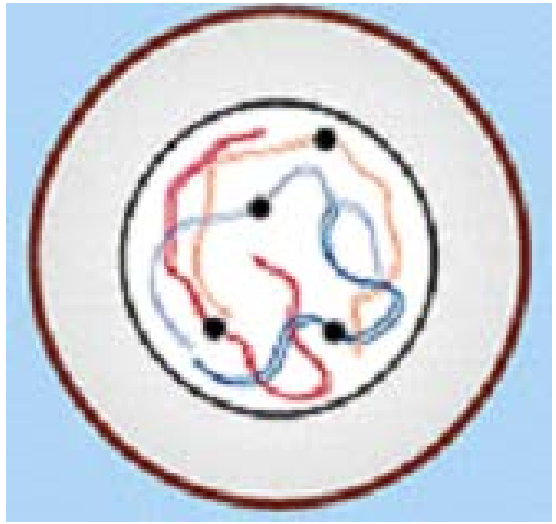
- Prophase II
- Metaphase II
- Anaphase II
- Telophase II

- Followed by cytokinesis

Meiosis I

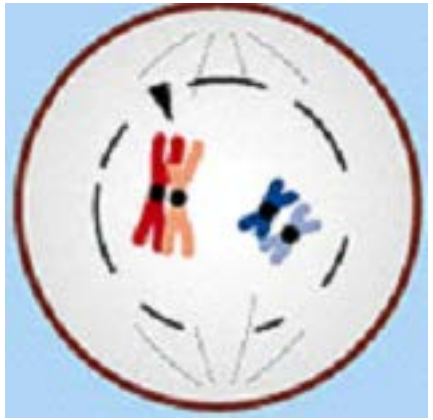
Interphase

- Chromosomes replicate (DNA synthesis)

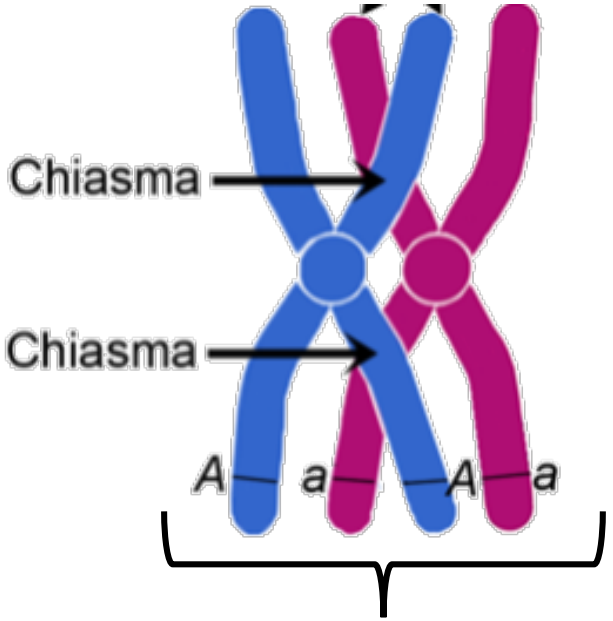


Prophase I

- Chromosomes condense becoming visible
- Nuclear membrane breaks down
- Spindle starts to form



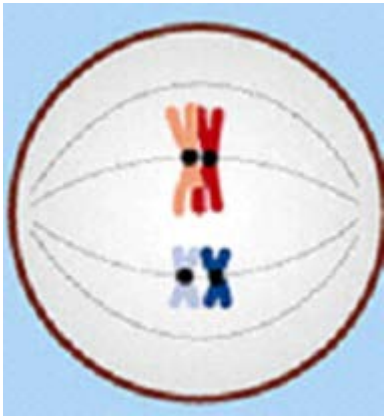
- Homologous pairs of chromosomes form bivalents
- Chiasma form → the point where chromosomes cross over each other



Bivalent

Metaphase I

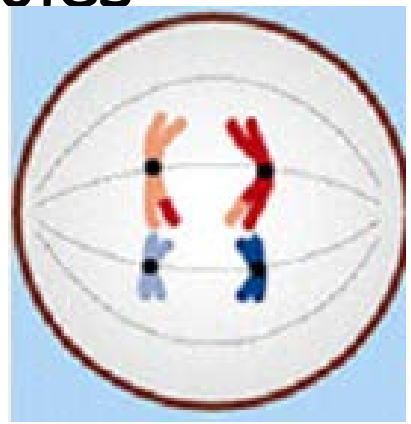
- Spindle attaches to centromeres.
- Bivalents lined up along the equator i
  homologous pairs



Anaphase I

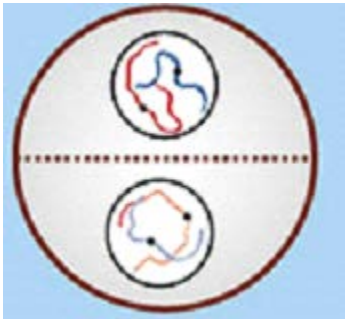
- Bivalents pulled apart by spindle and homologous chromosomes pulled to poles
- Maternal and Paternal

  chromosomes separated randomly.



Telophase I

- Chromosomes reach poles



Often the cell goes straight into meiosis II, but sometimes….:

- Spindle can start to break down
- Nuclear membrane can start to reform
- Cell can start to divide by cytokinesis

Meiosis II

Prophase II

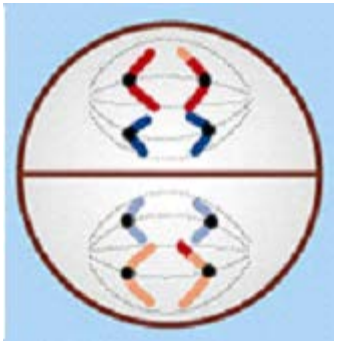
- Spindles form around both sets of chromsomes
- (nuclear membrane breaks down if it had reformed)

Metaphase II

- Spindle fibres line chromosomes up along equator

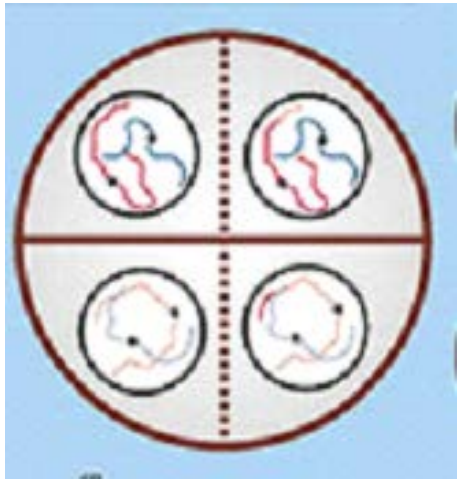
Anaphase II

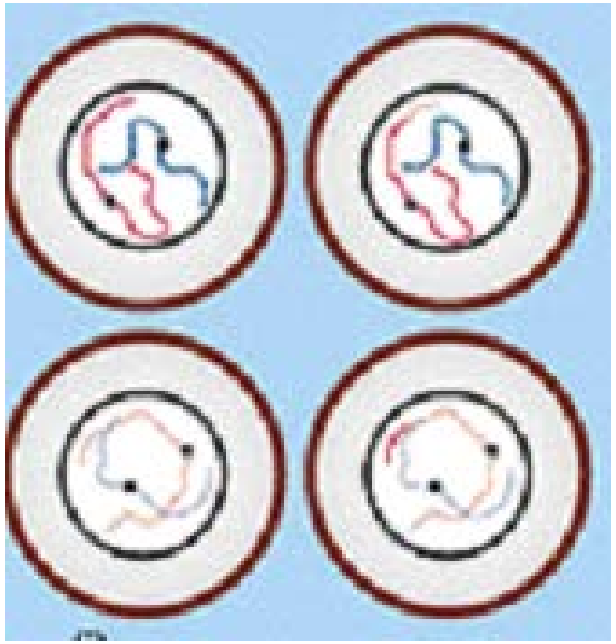
- Spindle fibres contract
- Centromeres divide & chromatids separate and are pulled to the poles



Telophase II

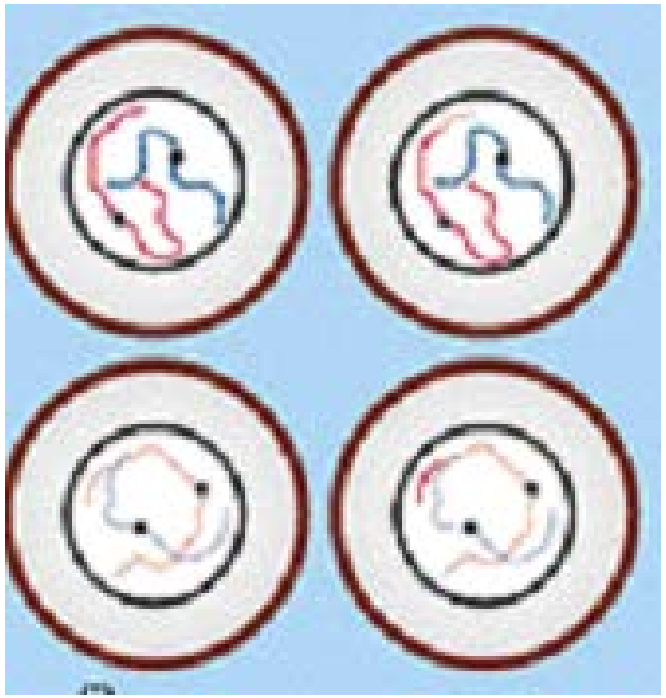
- Chromosomes reach poles & disperse
- Spindle breaks down
- Nuclear membranes reforms
- Cytokinesis begins

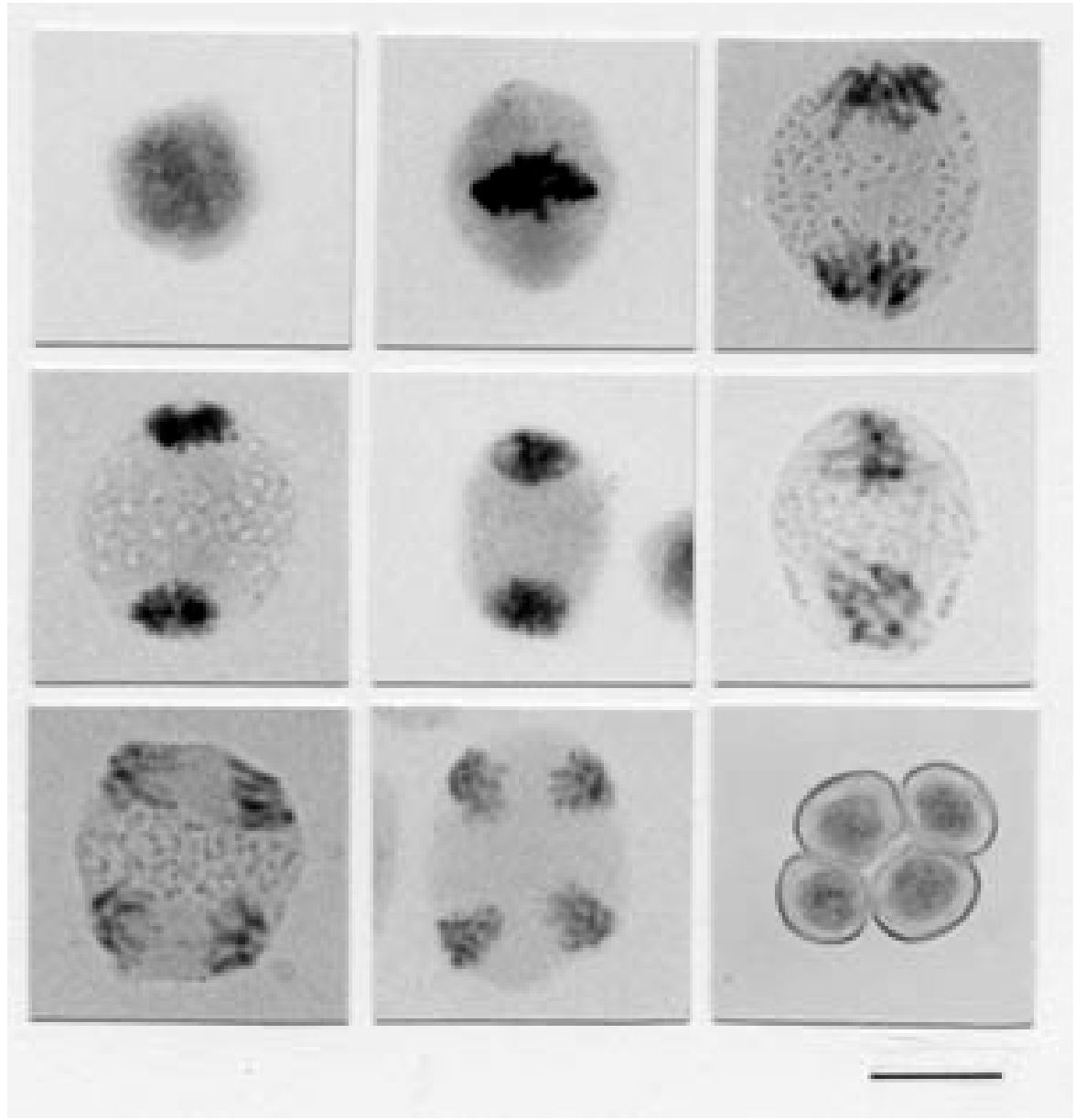




Cytokinesis

- Cytoplasm divides (cytokinesis)
- Membranes form around new cells
- 4 haploid cells produced



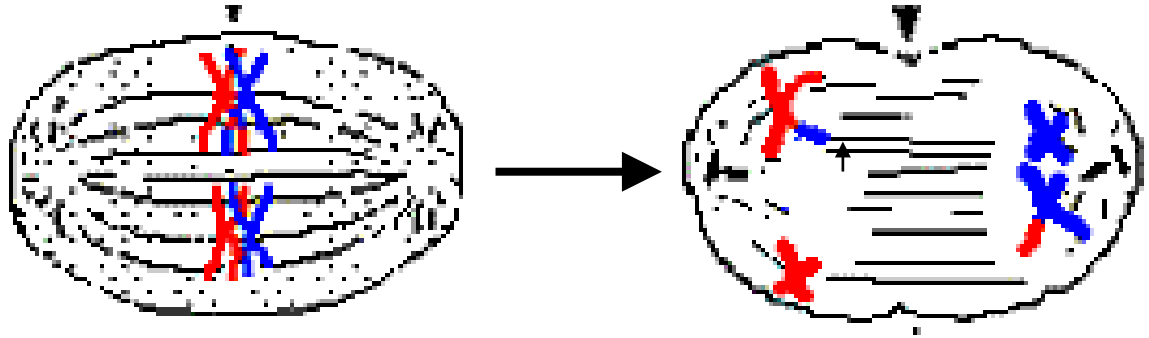


Differences between the two

Meiosis occurs in 2 divisions (I and II) that *superficially* resemble mitosis:

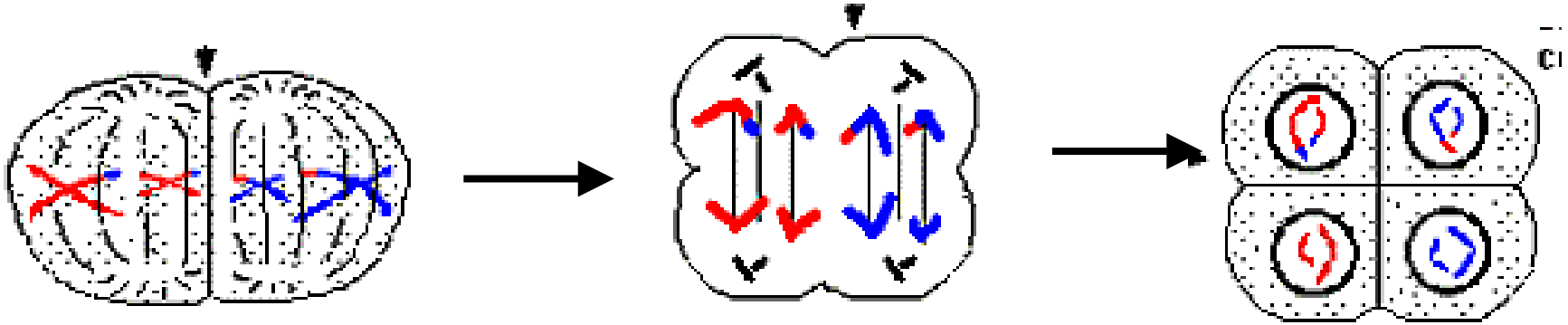
Meiosis I

- Homologous **pairs** of chromosomes are separated



- **Meiosis II**

- Pairs of chromatids are separated



Outcome:

- Explain how meiosis results in variation.
- Explain how random fertilisation of haploid gametes further increases genetic variation within a species.
- Explain what a non-disjunction event is and how it occurs.
- Compare and contrast gene and chromosomal mutations.

Significance of meiosis

- Diploid cells are formed on fertilisation
- Increases variation in 2 ways:

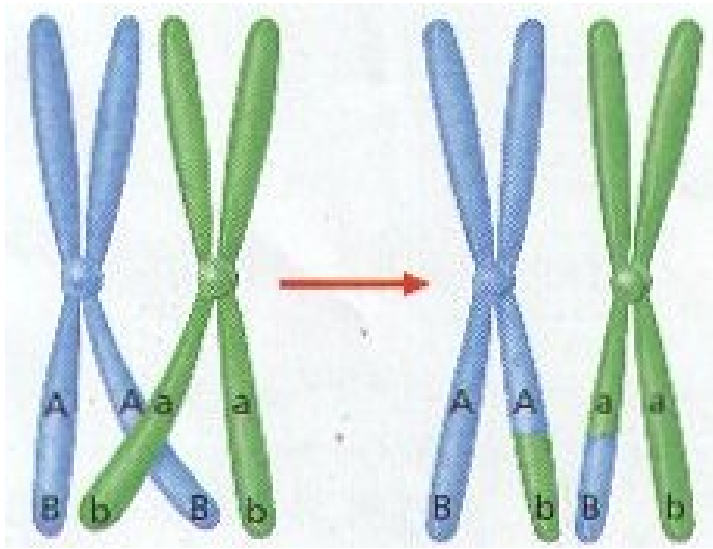
  - Crossing over in prophase I

  - independent segregation of maternal & paternal chromosomes in anaphase I

RANDOM COMBINATIONS

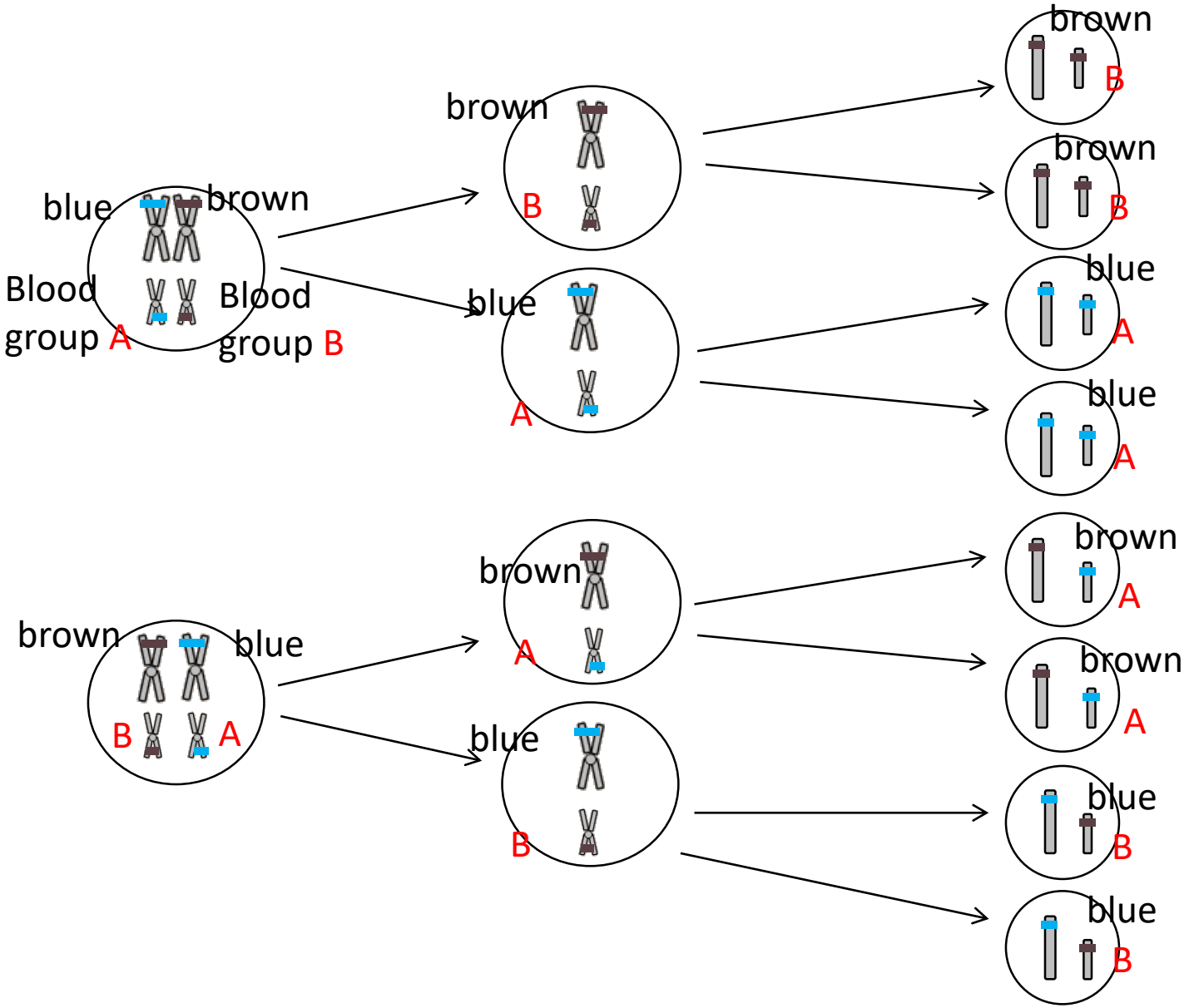
- 4 daughter cells have completely different combinations of **chromosomes**
- This is because of **random assortment (segregation)** of chromosomes in meiosis I, and of the chromatids in meiosis II

Crossing over



- During meiosis 1, the chromatids of each pair of homologous chromosomes become twisted around each other.
- During this twisting tensions are created and parts of the chromosome break off.
- These broken portions join with the chromatids of its homologous partner.
- It is the equivalent portions of the chromosomes that are exchanged.
- New genetic combinations of alleles are produced.

Independent segregation/ assortment



Independent assortment is important because it gives rise to new combinations of alleles.

Non- disjunction events

- Sometimes individual homologous pairs of chromosomes fail to sperate during meiosis. This is known as non-disjunction and usually results in the gamete having either one more or fewer chromosomes. When fertilised with a gamete with a normal complete chromosome number this will make the offspring have more or fewer chromosomes than normal. This will be the same in all their body cells. An example of non-disjunction is down syndrome.

- A non-disjunction event is an example of a ‘chromosome mutation’. A chromosome mutation changes the structure or number of whole chromosomes. This is different to a gene mutation which is a change in the base sequence of a gene.

Q1.

(a) (i) 8 ‘chromatids’ each side;
spindle drawn;

2

(ii) 4 chromosomes;
1 from each homologous pair;

2

(b) produces haploid cells / chromosome number halved;
fertilisation maintains the diploid / chromosome number (in next generation);

2

[6]

Q2.

(a) replication / duplication / doubling of chromosomes / replication of DNA / transcription of DNA;

1

(b) (i) cell to show correct number of chromosomes; correct shape and position of centromere;

2

(ii) as (i) except everything halved – *Ignore crossing over*; (if mitosis and meiosis reversed, allow 1 if otherwise correct)

2

(c) to replace cells;

1

[6]

Q3.

(a) (i) Centromere;

Accept: if phonetically correct

Reject: centriole

1

(ii) 1. Holds chromatids together;

2. Attaches (chromatids) to spindle;

3. (Allows) chromatids to be separated / move to (opposite) poles / (centromere) divides / splits at metaphase / anaphase;

*3. **Q** Neutral: chromosomes or chromatids split / halved / divided*

3. Reject: reference to homologous chromosomes being separated

Accept 'chromosomes' instead of 'chromatids'

*Ignore incorrect names for **X***

2 max

(iii) (Homologous chromosomes) carry different alleles;

Accept alternative descriptions for 'alleles' eg different forms of a gene / different base sequences

Neutral: reference to maternal and paternal chromosomes

1

(b) (i) (In **Figure 2**)

1. Chromatids have separated (during anaphase);

*1. **Q** Neutral: split / halved / divided*

1. Reject: reference to homologous chromosomes being separated

or

2. Chromatids have not replicated;

1. & 2. Accept 'chromosomes' instead of 'chromatids'

or

3. Chromosomes formed from only one chromatid;

*Accept converse arguments for **Figure 1***

Ignore references to the cell not dividing as in the question stem

Ignore: named phases

1 max

(ii) 1. Three chromosomes;

Ignore shading

2. One from each homologous pair;

Only one mark for three chromosomes shown as pairs of chromatids

2

(iii) Crossing over / alleles exchanged between chromosomes or chromatids / chiasmata formation / genetic recombination;

Accept: description of crossing over eg sections of chromatids break and rejoin

Neutral: random fertilisation

Reject: reference to sister chromatids

Q *Neutral: genes exchanged*

Neutral: mutation

1

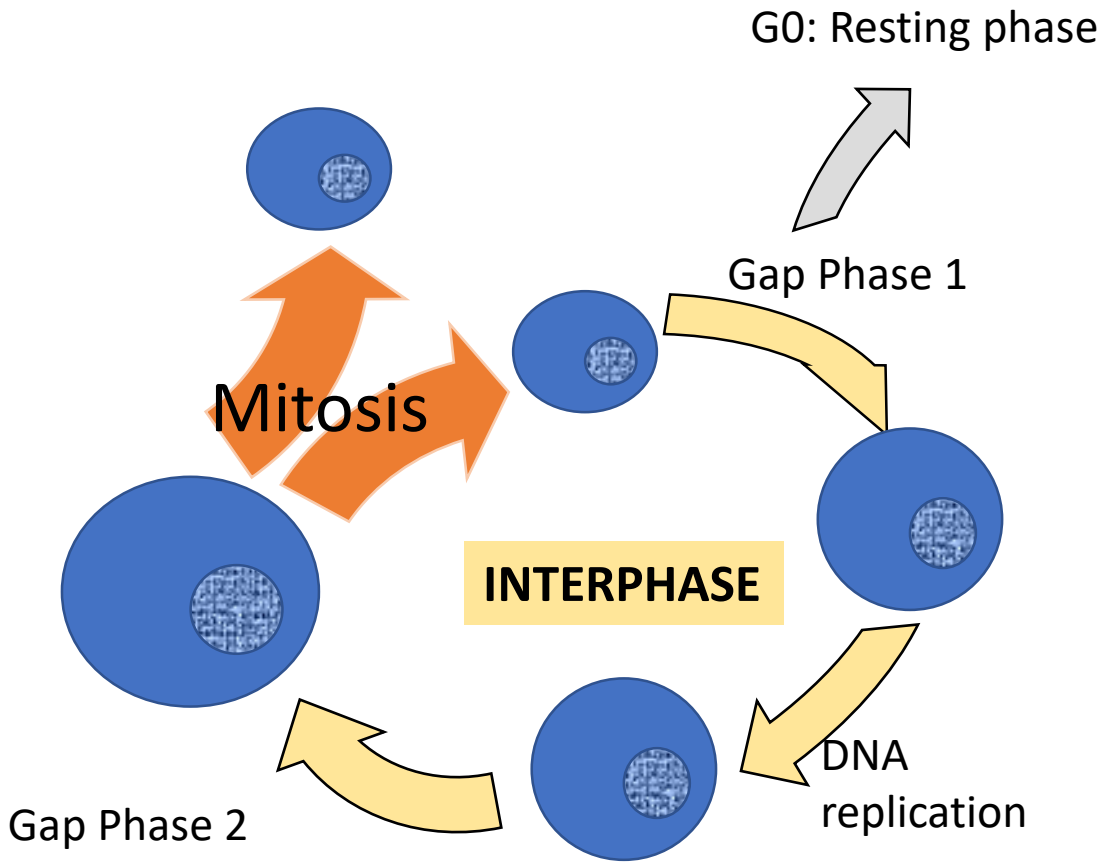
[8]

Outcome:

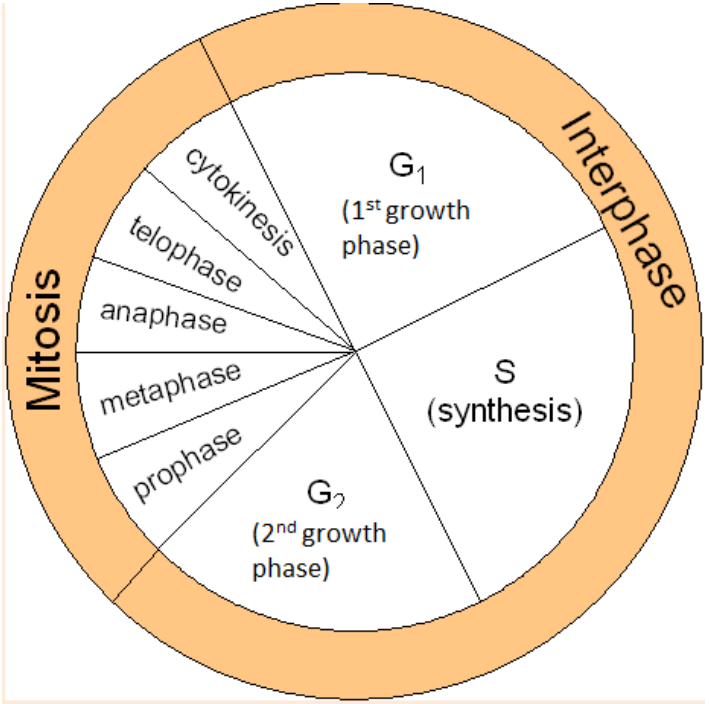
- Explain what the cell cycle is and why it does not occur in some cells from multicellular organisms.
- Describe the stages of the cell cycle.
- Recognise the stages of the cell cycle: interphase, prophase, metaphase, anaphase and telophase (including cytokinesis).

The cell cycle

- The cell cycle is an ordered set of events, leading to cell growth and division.



The cell cycle



Interphase occupies most of the cell cycle.

1. G1 phase: synthesis of proteins
2. S phase: DNA is replicated.
3. G2 phase: organelles grow and divide, ATP stores increased.

Nuclear division

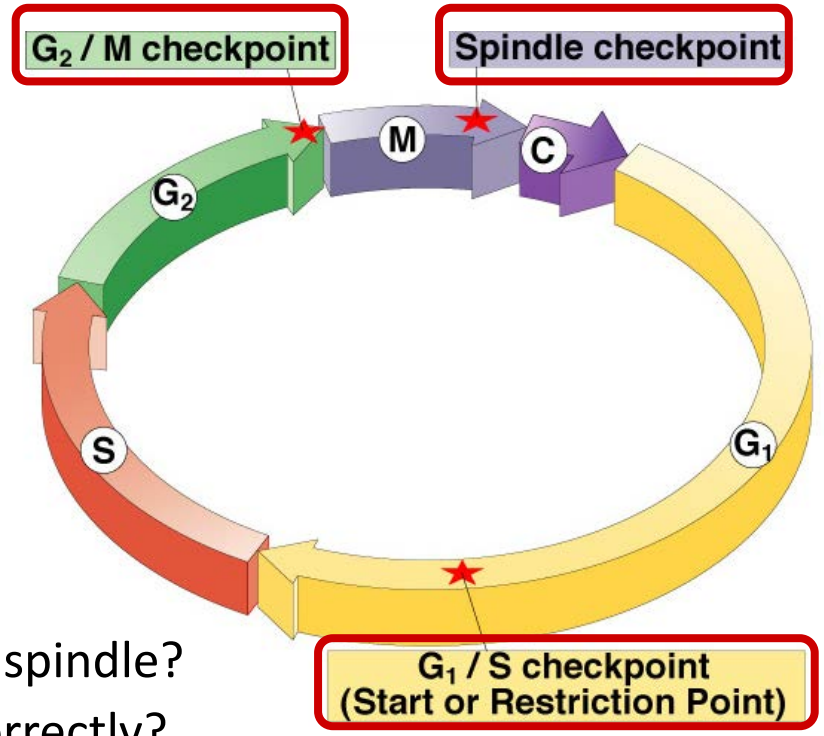
- Mitosis (PMAT)

Cell division

- Cytokinesis

Checkpoint control system

- 3 major checkpoints:
  - G_1/S
    - can DNA synthesis begin?
  - G_2/M
    - has DNA synthesis been completed correctly?
    - commitment to mitosis
  - spindle checkpoint
    - are all chromosomes attached to spindle?
    - can sister chromatids separate correctly?



cell cycle controlled by STOP & GO chemical signals at critical points

Exam questions

The number of cells at each stage of mitosis was counted. The results are shown in the table.

One complete cell cycle takes 24 hours. The number of cells at each stage is proportional to the time spent at that stage. Calculate the length of time spent in metaphase. Show your working.

Stage of mitosis	Number of cells
Interphase	123
Prophase	32
Metaphase	12
Anaphase	6
Telophase	27

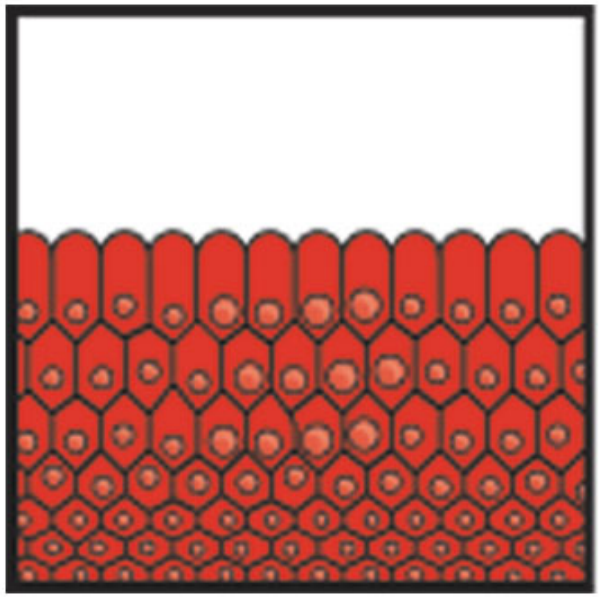
$$\left(\frac{\text{Number of cells in that stage}}{\text{Total Number of Cells}}\right) \times \text{nº of hours}$$

123+32+12+6+27 = 200 cells
12/200= 0.06
0.06 x 24 = 1.44 hours

Answer ..... Hours **(2)**

Cancer

- Cancer is essentially the incorrect replication of DNA. It is the result of damage to the genes that control cell mitosis and the cell cycle.
- Results in uncontrolled cell growth, developing a tumour.



Cancer treatment

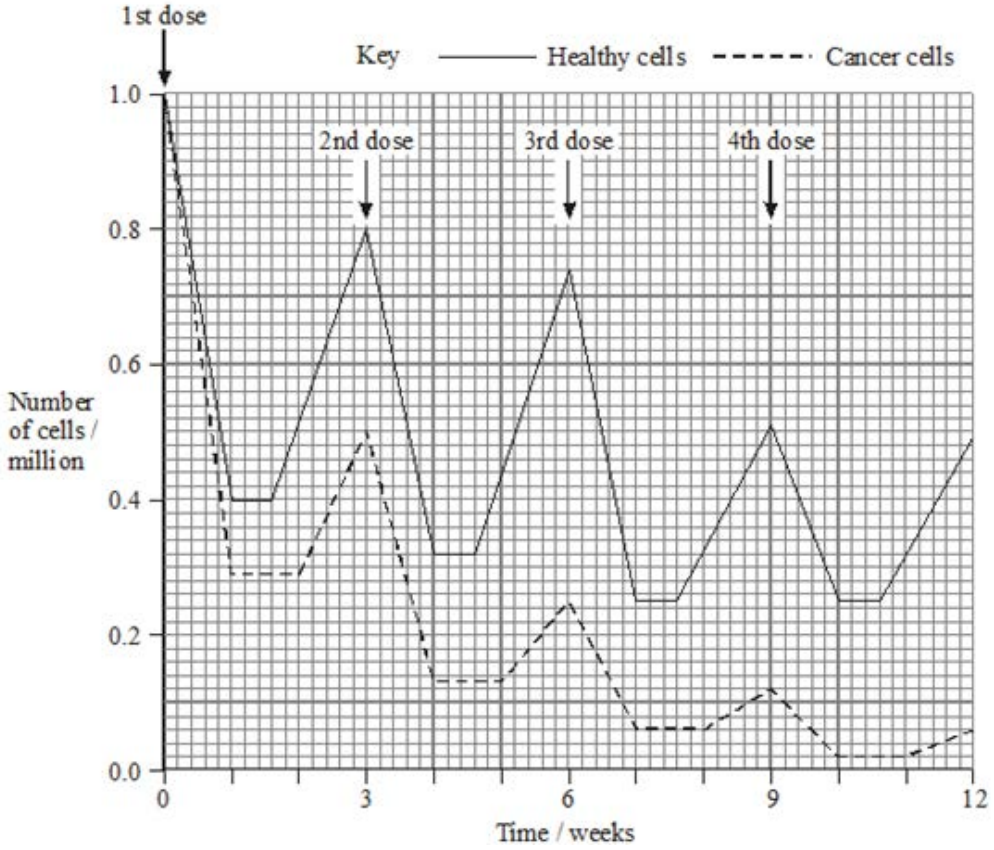
Cancer is often treated by blocking some part of the cell cycle.

- Preventing DNA replication
- Inhibiting the metaphase by interfering with spindle formation

Problems:

- Drugs are most effective against rapidly dividing cells, but they also disrupt the cell cycle of healthy cells.

- Hair producing cells divide rapidly, explaining hair loss.



It would be possible to kill more cancer cells by administering the drug more frequently or giving a larger dose. Suggest why

The drug was not given more frequently

If frequency was increased healthy cells would not have time to increase numbers to near normal between treatments;
Healthy cell count would become too low and patient may die.

The dose of the drug was not increased

Increased dose would kill too many healthy cells each treatment,
Healthy cell count would be too low and patient may die.

Q1.

(a) (i) Cells are in interphase;

Accept G phase / S phase.

1

(ii) Cells undergoing mitosis / in telophase / cytokinesis;

Accept all named stages but reject prophase, metaphase or anaphase on their own.

1

(b) 1. 3 hours;

2. Time between beginnings / endings DNA replication / Increases / levelling outs of DNA concentration / for shape (of curve for replication) to be repeated;

3. (DNA) replication takes place once per cell cycle;

Allow close approximation where candidate attempts to be more accurate.

Principle
What is shown on the graph

3

[5]

Q2.

(a) (i) Spindle formed / chromosome / centromere / chromatids attaches to spindle;

Chromosomes / chromatids line up / move to middle / equator (of cell);

Do not award second mark for answers referring to chromosomes 'pairing up'.

Ignore reference to homologous chromosomes unless context suggests pairing which negates second mark.

Neutral: Details on nuclear membrane.

Accept: Diagram for second marking point.

2

(ii) Chromosome / centromere splits / chromatids / 'chromosomes' separate / pulled apart;

To (opposite) sides / poles / centrioles (of cell);

Reject: Homologous chromosomes separate for first marking point.

Accept: Diagram for second marking point.

Chromatids / 'chromosomes' move to poles / sides / centrioles = 2 marks.

2

(b) (i) Form / replace cells quickly / rapidly / divide / multiply / replicate rapidly;

Neutral: Repair cells.

Answers must convey idea of 'speed'.

1

(Ii) Correct answer = 774 minutes / 12 hours 54mins = 2 marks;;

Incorrect answer but indicates 3 cell cycles involved = one mark;

2

(c) Prevents / slows DNA replication / doubling / prevents / slows mitosis;

New strand not formed / nucleotides (of new strand) not joined together / sugar-phosphate bonds not formed;

First marking point must be in context of DNA replication not cell replication.

Do not negate first marking point if role of DNA polymerase is described incorrectly e.g. Reject: 'joins bases / strands together'.

Role of DNA polymerase must be correct for last marking point.

2

[9]

Q3.

(a)

Nucleus	Number of chromosomes	Mass of DNA / arbitrary units
At telophase of mitosis	26;	30;
From a sperm cell	13;	15;

4

(b) Cancer cells often have faulty / damaged DNA;
Protein / p53 faulty / not made;
Cell (with faulty / DNA) divides / completes cell cycle;
Uncontrolled division produces cancer;
p53 refers to the protein so do not accept reference to p53 mutating.

3

(c) (i) Interphase / S phase / synthesis phase;

1

(ii) Anaphase / **A**;

1

[9]

Q4.

(a) (i) (D) B E A C;

1

(ii) <u>metaphase</u>;

1

(b) interphase / S phase;

1

(c) (i) 0.06 × 100;
6(%);

(correct answer 2 marks)

2

(ii) more(cancer cells) killed, cancer cells divide more (often)
(so are more likely to be killed, more susceptible);

1

(iii) longer time to recover;
reduced rate of mitosis / divide more slowly /
increased doubling time;

2

[8]