1.6 Guided Notes

Cell Division

Name: _____ Pd: ____

Understandings:

- Mitosis is division of the nucleus into two genetically identical daughter nuclei
- Chromosomes condense by supercoiling during mitosis
- Interphase is a very active phase of the cell cycle with many processes occurring in the nucleus and cytoplasm
- Cytokinesis occurs after mitosis and is different in plant and animal cells
- Cyclins are involved in the control of the cell cycle
- Mutagens, oncogenes and metastasis are involved in the development of primary and secondary tumours

Applications:

- The correlation between smoking and incidence of cancers

Skills:

- Identification of phases of mitosis in cells viewed with a microscope or in a micrograph
- Determination of a mitotic index from a micrograph

The cell cycle is an ordered set of _____ which culminates in the division of a cell into _____ daughter cells

- It can be roughly divided into two main phases:

Interphase

The stage in the development of a cell between two successive divisions

This phase of the cell cycle is a continuum of three distinct stages:

- _____ – First intermediate gap stage in which the cell grows and prepares for DNA replication
- _____ – Synthesis stage in which DNA is replicated
- _____ – Second intermediate gap stage in which the cell finishes growing and prepares for cell division

M phase

The period of the cell cycle in which the cell and contents _____ to create two genetically identical daughter cells

This phase is comprised of two distinct stages:

- _____ – Nuclear division, whereby DNA (as condensed chromosomes) is separated into two identical nuclei
- _____ – Cytoplasmic division, whereby cellular contents are segregated and the cell splits into two

The Cell Cycle

Below, create a circle diagram that shows all the stages and substages of the cell cycle. Label each stage.

Interphase is an _____ period in the cell cycle when many metabolic reactions occur
Many events need to occur in interphase to prepare the cell for successful division
These key processes include:

- DNA _____ – DNA is copied during the S phase of interphase
- Organelle _____ – Organelles must be duplicated for twin daughter cells
- Cell _____ – Cytoplasmic volume must increase prior to division
- _____ / _____ – Key proteins and enzymes must be synthesised
- Obtain _____ – Vital cellular materials must be present before division
- _____ (cellular) – ATP production is needed to drive the division process

Chromatin versus Chromosome

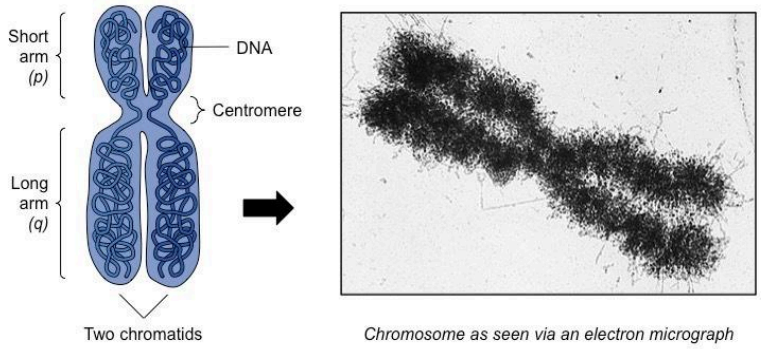
_____ :

- DNA is usually _____ packed within the nucleus as unravelled chromatin
- In this _____ form, the DNA is accessible to transcriptional machinery and so genetic information can be translated
- DNA is organised as chromatin in all non-dividing cells and throughout the process of _____

Chromosome:

- DNA is temporarily packaged into a _____ wound and _____ chromosome prior to division (via supercoiling)
- In this _____ form, the DNA is able to be easily _____ however is inaccessible to transcriptional machinery
- DNA is organised as _____ during the process of mitosis (condense in prophase, decondense in telophase)

Organisation of DNA into a Mitotic Chromosome



Chromosome as seen via an electron micrograph

Chromosome versus Chromatid

A _____ is the _____ form of DNA which is visible during mitosis (via microscopy)

As the DNA is replicated during the _____ of interphase, the chromosome will initially contain two identical DNA strands

These _____ _____ strands are called _____ _____ and are held together by a central region called the _____

When these chromatids separate during mitosis, they become _____ chromosomes, each made of a single DNA strand

Single Chromatid versus Sister Chromatid Chromosome

Below, draw the process of a chromosome being replicated. Then show how they become daughter chromosomes.

_____ is the process of nuclear division, whereby duplicated DNA molecules are arranged into two separate nuclei

Mitosis is preceded by interphase and is divided into four distinct stages: _____ , _____ , _____ , _____

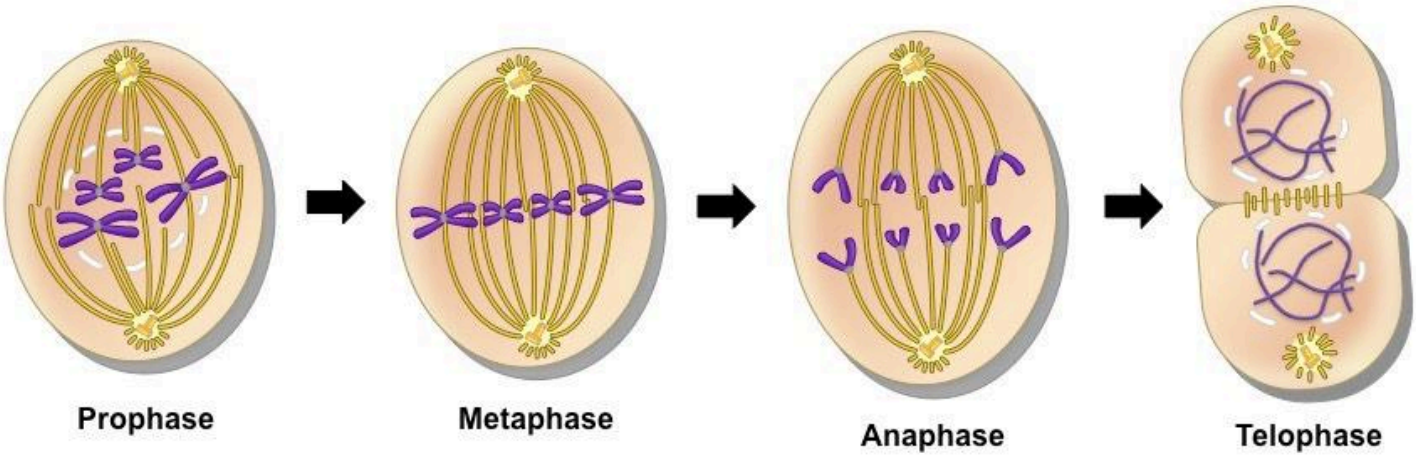
- The division of the cell in two (cytokinesis) occurs concurrently with the final stage of mitosis (telophase)

Before Mitosis

Interphase:

- DNA is present as _____ chromatin (not visible under microscope)
- DNA is contained within a clearly defined _____
- _____ and other organelles have been _____
- Cell is _____ in preparation for division

Stages of Mitosis



Prophase:

- DNA _____ and chromosomes _____ (becoming visible under microscope)
- Chromosomes are comprised of genetically _____ sister chromatids (joined at a _____)
- Paired centrosomes move to the opposite _____ of the cell and form microtubule spindle _____
- The nuclear membrane _____ down and the nucleus _____

Metaphase:

- Microtubule spindle fibres from both centrosomes _____ to the centromere of each chromosome
- Microtubule depolymerization causes spindle fibres to _____ in length and contract
- This causes chromosomes to align along the _____ of the cell (equatorial plane or metaphase plate)

Anaphase:

- Continued _____ of the spindle fibres causes genetically identical sister chromatids to _____
- Once the chromatids separate, they are each considered an _____ chromosome in their own right
- The genetically identical chromosomes move to the _____ poles of the cell

Telophase:

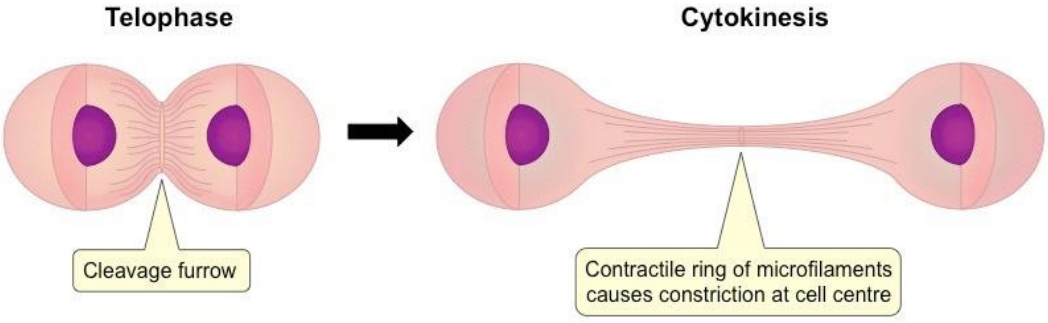
- Once the two chromosome sets arrive at the poles, spindle fibres _____
- Chromosomes _____ (no longer visible under light microscope)
- Nuclear membranes _____ around each chromosome set
- Cytokinesis occurs _____ , splitting the cell into two

Cytokinesis is the process of cytoplasmic division, whereby the cell _____ into two _____ daughter cells

Cytokinesis occurs concurrently with the final stage of mitosis (telophase) and is _____ in plant and animal cells

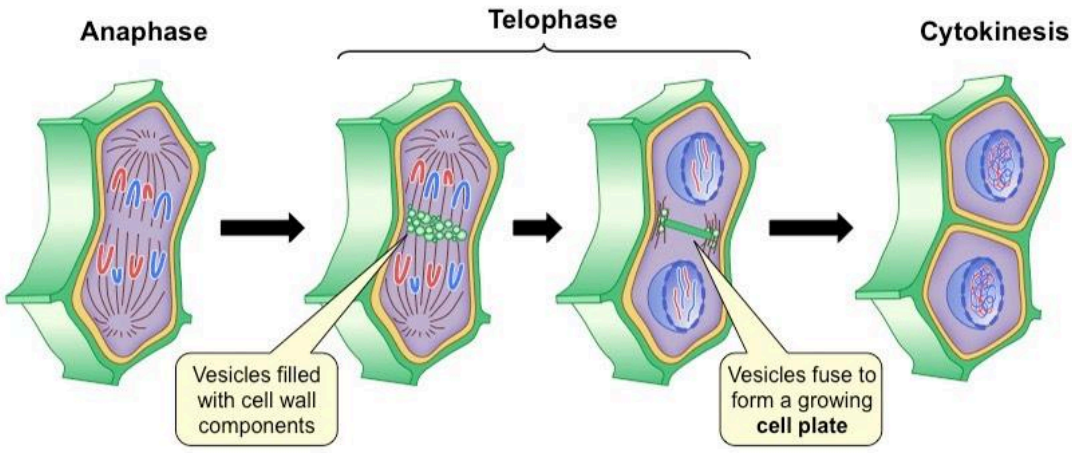
Animal Cells

- After _____ , microtubule filaments form a concentric ring around the centre of the cell
- The _____ constrict to form a cleavage _____ , which deepens from the periphery towards the centre
- When the furrow meets in the centre, the cell becomes completely _____ off and two cells are formed
- Because this separation occurs from the outside and moves towards the centre, it is described as _____



Plant Cells

- After anaphase, _____ vesicles form in a row at the centre of the cell (equatorial plane)
- The vesicles fuse _____ and an early cell plate begins to form within the middle of the cell
- The cell plate extends _____ and _____ with the cell wall, dividing the cell into two distinct daughter cells
- Because this separation originates in the centre and moves laterally, it is described as _____



The mitotic index is a measure of the proliferation status of a cell population (i.e. the proportion of dividing cells)

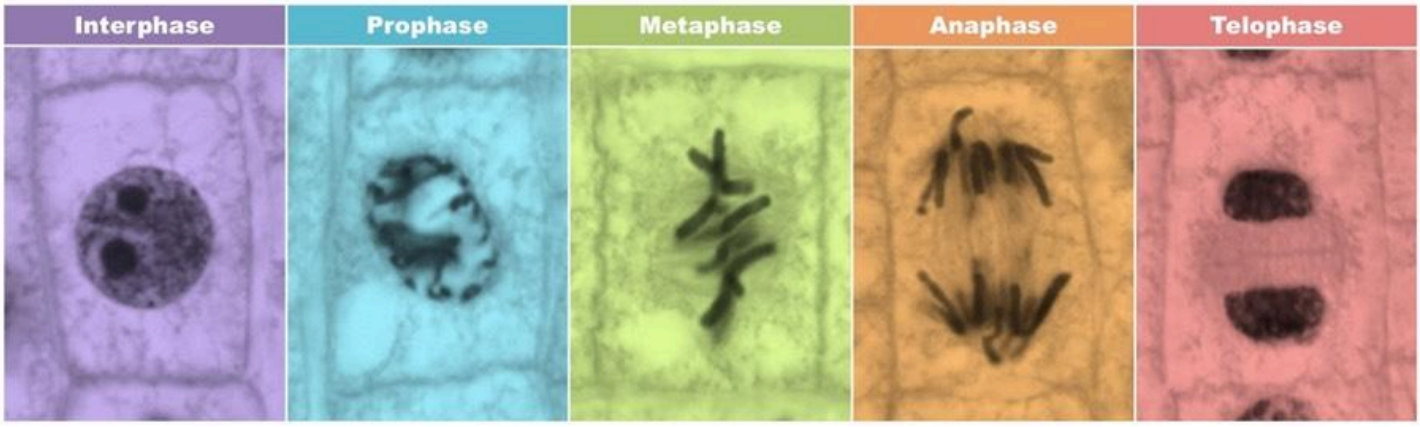
The mitotic index may be elevated during processes that promote division, such as normal growth or cellular repair

- It also functions as an important prognostic tool for predicting the _____ of _____ cells to _____

Identifying Mitotic Cells

Cells undergoing mitosis will _____ a clearly defined _____ and possess visibly _____ chromosomes

- _____ – Chromosomes condensed but still confined to a nuclear region
- _____ – Chromosomes aligned along the equator of the cell
- _____ – Two distinct clusters of chromosomes apparent at poles of the cell
- _____ – Two nuclear regions present within a single cell (difficult to see as cytokinesis occurs concurrently)

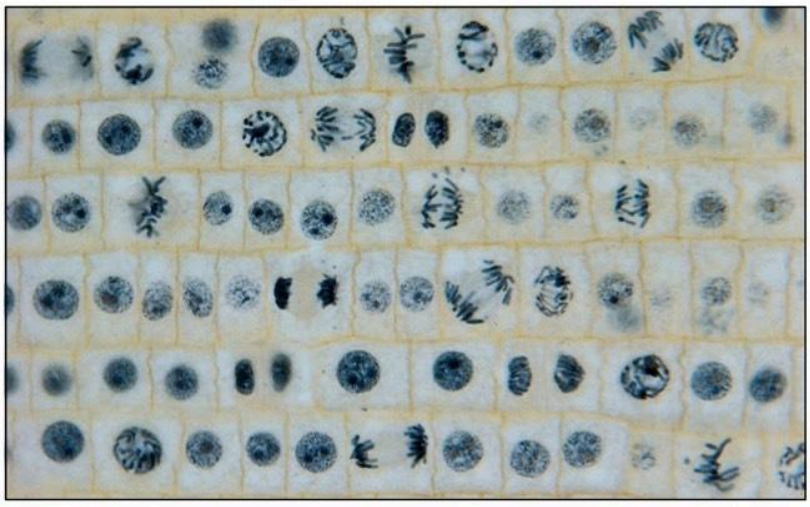


Calculating Mitotic Index

The mitotic index is the _____ between the number of cells in _____ and the _____ number of cells

It can be determined by analysing _____ and counting the relative number of mitotic cells versus non-dividing cells

For the slide below, determine the mitotic index using the equation in the box below. For reference, you may highlight all cells that are going through the process of mitosis. Show your work below.



Mitotic Index

$$\frac{\text{Cells in mitosis}}{\text{Total number of cells}}$$

Cells with visible chromosomes:

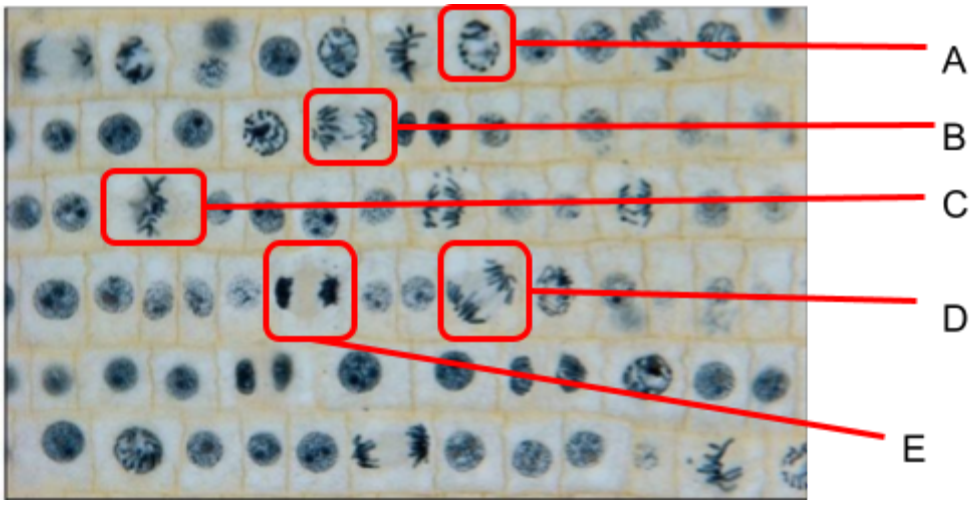
?

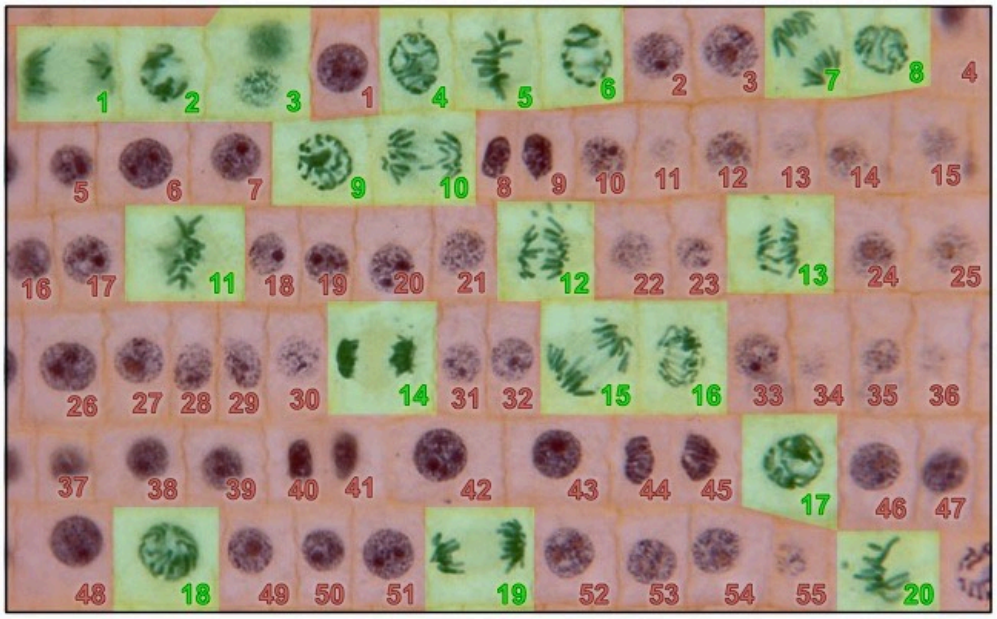
Cells without visible chromosomes:

?

Mitotic Index:

?





Mitotic Index

Cells in mitosis

Total number of cells

Cells with visible chromosomes:

20

Cells without visible chromosomes:

55

Mitotic Index:

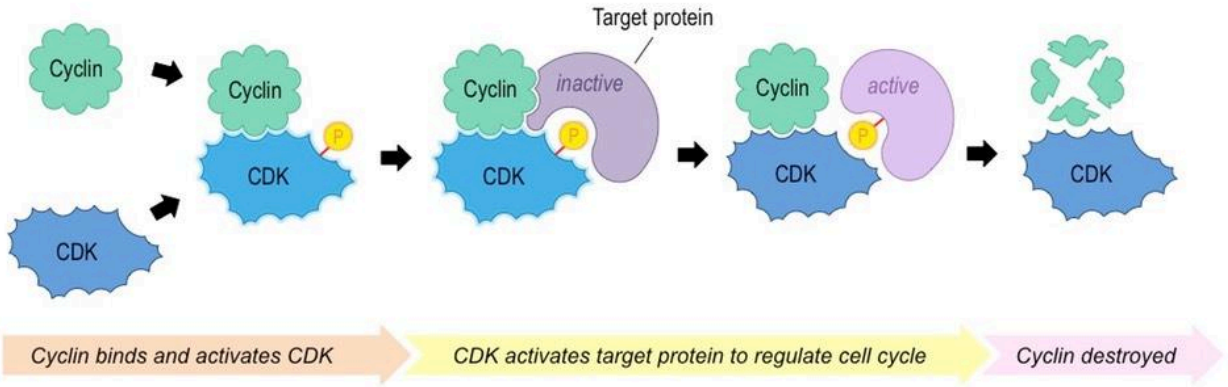
20 ÷ (20 + 55) = 0.267

Mechanism of Cyclin Action

Cyclins are a family of _____ proteins that control the _____ of the cell cycle

Cyclins _____ cyclin dependent kinases (_____), which control cell cycle processes through _____

- When a _____ and _____ form a complex, the complex will _____ to a target protein and modify it via phosphorylation
- The phosphorylated target protein will trigger some specific _____ within the cell cycle (e.g. _____ duplication, etc.)
- After the event has occurred, the cyclin is _____ and the CDK is rendered inactive again

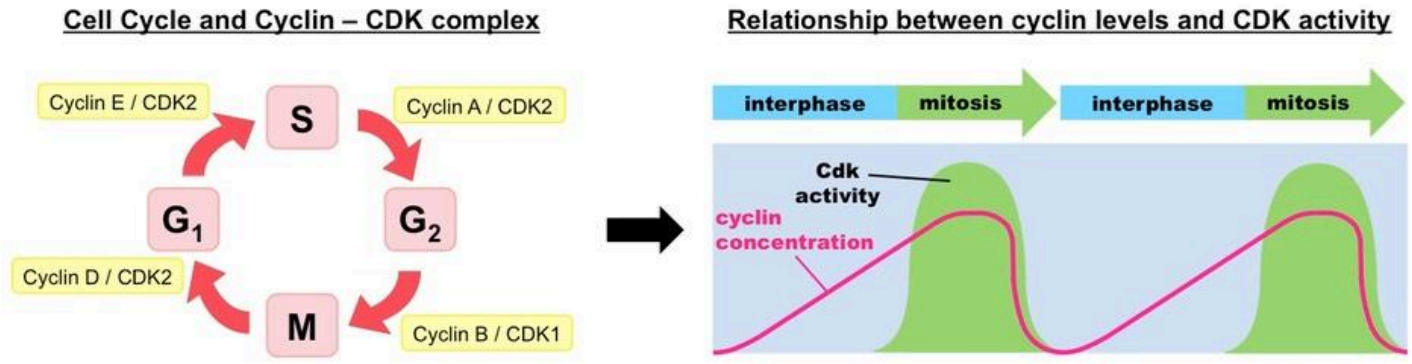


Cyclin Expression Patterns

Cyclin concentrations need to be _____ regulated in order to ensure the cell cycle progresses in a proper sequence

- _____ cyclins specifically bind to, and activate, different _____ of cyclin dependent kinases

- Cyclin levels will _____ when their target protein is required for _____ and remain at _____ levels at all other times



_____ are abnormal cell growths resulting from uncontrolled cell division and can occur in any _____ or _____

- Diseases caused by the growth of tumours are collectively known as _____

Mutagens

A mutagen is an _____ that _____ the _____ material of an organism (either acts on the DNA or the replicative machinery)

Mutagens may be physical, chemical or biological in origin:

- _____ – Sources of radiation including X-rays (ionising), ultraviolet (UV) light and radioactive decay
- _____ – DNA interacting substances including reactive oxygen species (ROS) and metals (e.g. arsenic)
- _____ – Viruses, certain bacteria and mobile genetic elements (transposons)

Mutagens that lead to the formation of cancer are further classified as _____

Oncogenes

An oncogene is a _____ that has the _____ to cause cancer

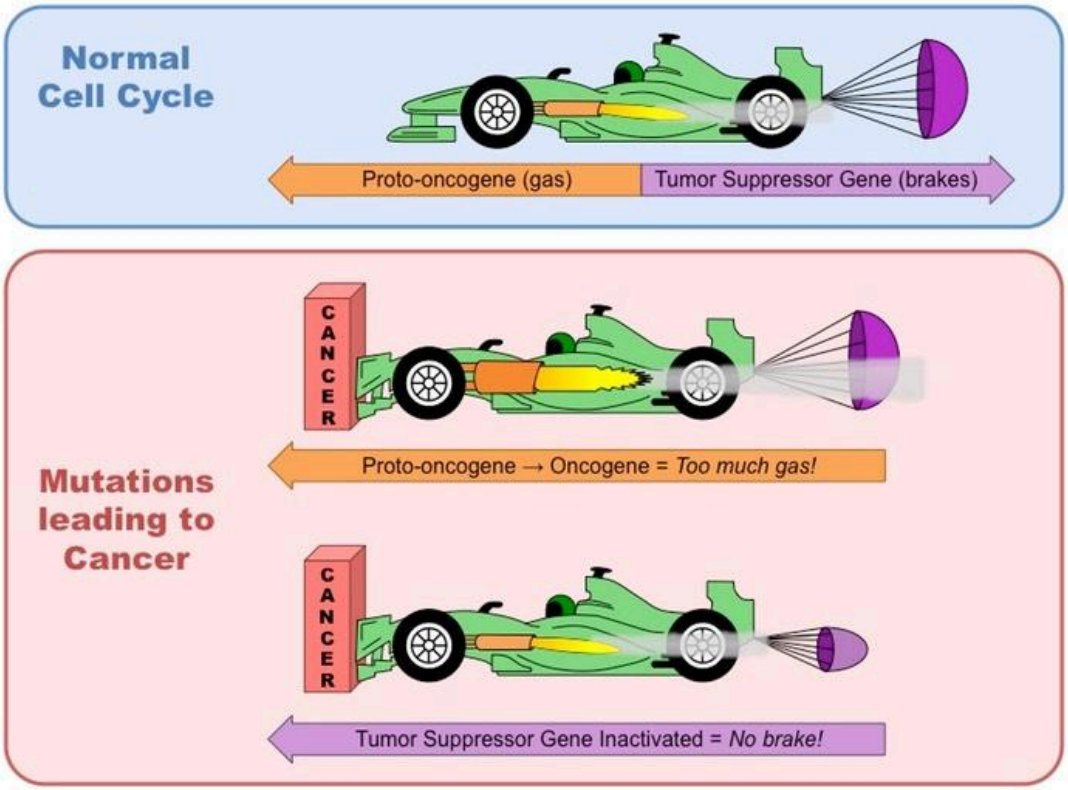
Most cancers are caused by mutations to two basic classes of genes – _____ and tumour _____ genes

- Proto-oncogenes _____ for proteins that _____ the cell cycle and _____ cell growth and proliferation
- Tumour _____ genes code for proteins that repress cell cycle progression and promote _____

When a proto-oncogene is _____ or subjected to _____ _____ it becomes a _____ oncogene

Tumour suppressor genes are sometimes referred to as _____ , as their normal function _____ cancer

Relationship between Proto-Oncogenes and Tumour Suppressor Genes



Metastasis

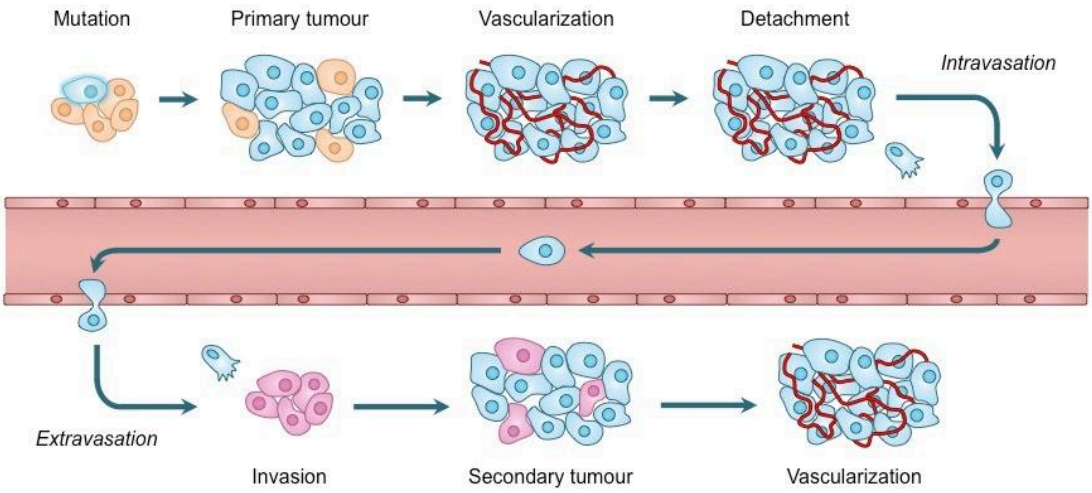
Tumour cells may either _____ in their original _____ (_____) or _____ and invade neighbouring tissue (_____)

Metastasis is the spread of cancer from one _____ (primary tumour) to _____ , forming a secondary tumour

Secondary tumours are made up of the same type of cell as the primary tumour – this affects the type of treatment required

- E.g. If breast cancer spread to the _____ , the patient has secondary breast cancer of the liver (treat with breast cancer drugs)

Formation of Secondary Tumours via Metastasis



Cancer cells can commonly _____ immune detection as they are not foreign bodies but _____ _____ body cells

This makes them _____ to treat – common strategies involve _____ removal and _____

However there are a number of differences between normal and cancerous tissues which may provide the basis for the development of future therapies

Normal Cells versus Cancer Cells

NORMAL CELLS			CANCER CELLS
Small, uniformly shaped nuclei Relatively large cytoplasmic volume			Large, variable shaped nuclei Relatively small cytoplasmic volume
Conformity in cell size and shape Cells arranged into discrete tissues			Variation in cell size and shape Disorganised arrangement of cells
May possess differentiated cell structures Normal presentation of cell surface markers			Loss of normal specialised features Elevated expression of certain cell markers
Lower levels of dividing cells Cell tissues clearly demarcated			Large number of dividing cells Poorly defined tumor boundaries