D2.1.1 — Generation of new cells

Cell that divides = Parent cell ! produces 2 daughter cells

↳ New cells are needed for

i) Growth

ii) Repair

iii) Reproduction

↳ New cells come from pre existing cells

D2.1.2 — Cytokinesis

Cytokinesis => division of the cytoplasm of a cell to form 2 daughter cells

↳ Not the division of the nuclear material

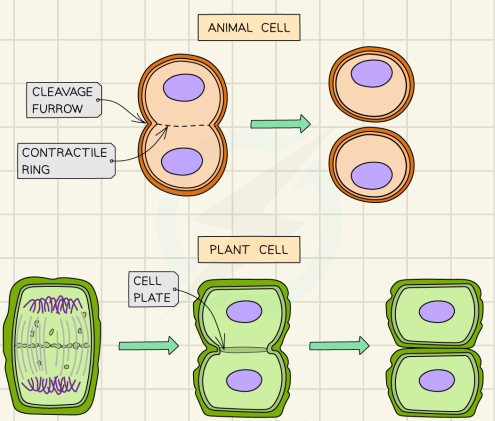
↳ Animal cells:

1. a "cleavage furrow" forms ! separates daughter cells
   a) forms when actin ! myosin proteins form a "contractile ring" under plasma membrane
   b) Ring = equator of cell
   c) When proteins contract, daughter cells are pinched apart

The contractile ring creates the cleavage furrow

↳ Plant cells:

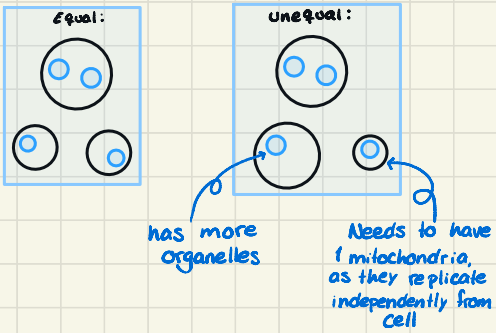
1. "cell plate" - what goes before a cell wall - forms @ equator
2. Once cell plate reaches cell walls of parent cell, new walls = produced
   a) formed from vesicles fusing to create 2 plasma membranes
   b) Vesicles (carrying pectin/cellulose) via exocytosis deposit substances => leads to creation of 2 cell walls

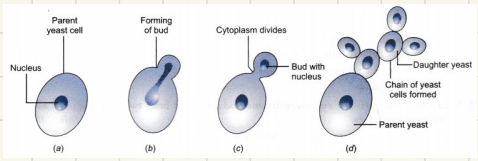


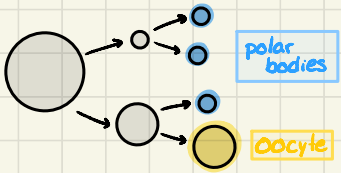
D2.1.3 — Equal ! unequal cytokinesis

a) Usually:
- Parent cell equally divides into 2 daughter cell

b) Sometimes:
- Unequal division occurs => as long as new cell has nucleus, 1 mitochondrion ! other organelles that can't be synthesized first by cell itself
  - Ex. => budding in yeast
    => Asexual reproduction
    i) Nucleus replicates/divides
    ii) Bud receives a nucleus ! some cytoplasm
    iii) New cell wall constructed to separate both
  - Ex. => Oogenesis => egg production
    => Meiosis has 2 cell divisions
    => Produces 1 viable oocyte ! 3 polar bodies (won't develop cause lack organelles)







D2.1.4 — Mitosis ! meiosis

↳ Cells must replicate the nucleus before division to prevent anucleate cells
- Anucleate cells cannot synthesize proteins
  - Limited lifespan
  - Ex. => red blood cells

1. Mitosis:
   - Produces 2 genetically identical daughter cells
     - Each are diploid (2n) — Chromosomes come in pairs
     - All cells have an identical / complete copy of genome
     - In asexual reproduction, full genome = passed to offspring

Used for growth, repair (tissue), replacement (cells) ! asexual reproduction

2. Meiosis:
   - Produces 4 genetically unique daughter cells
     - Each are haploid (n) — Chromosomes not in pairs
     - Half the chromosomes
     - Random assortment of genes results in variation

* for generating genetic diversity

D 2.1.5 — DNA replication prerequisite for mitosis ! meiosis

↳ Prior to cell division, DNA = elongated
- Chromatin form
- Allows for transcription ! translation

↳ To prepare for cell division, DNA = replicated ! condenses into chromosomes

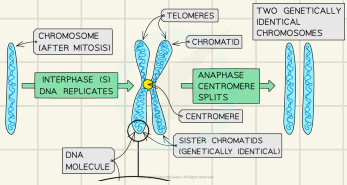
Chromosomes -> structures that consist of 2 identical chromatids held together by cohesin loops

> Replication occurs in S-phase of interphase

1. Before replication

2. After replication

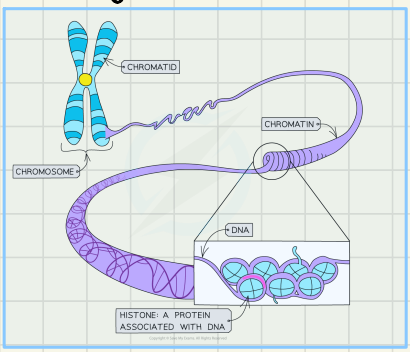
3. After anaphase



D 2.1.6 — Condensation ! movement of chromosomes

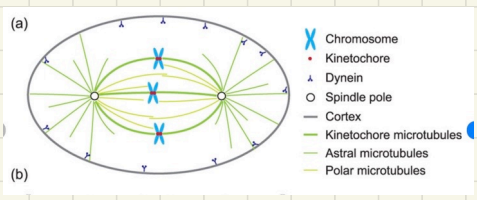
↳ Condensation of chromosomes helps move DNA safely ! efficiently
- From chromatin to chromosome state

Supercoiling => DNA is wrapped around histone protein, which then link together

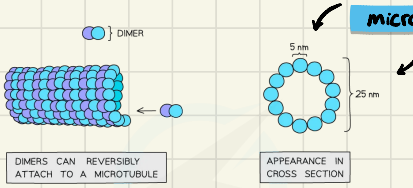


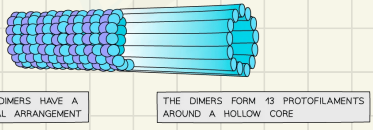
↳ After chromosomes have condensed, they have to move to edges to form 2 daughter cells
- Cytoskeleton microtubules are disassembled to form spindle
  - Used to move chromosomes during mitosis
- Spindle microtubules link w/ structure called kinetochore on centromere of each chromosome
- Kinetochore proteins (kinesin/dyenin) act as microtubule motor
  - They remove microtubule dimers to shorten spindle
    => pulls chromatids apart

> The "Spindle" is the structure as a whole



microtubules





=> α tubulin

=> β tubulin

D2.1.7 — Mitosis phases

Por Meliche Acabó Todo

4. Four phases
   1. Prophase
   2. Metaphase
   3. Anaphase
   4. Telophase

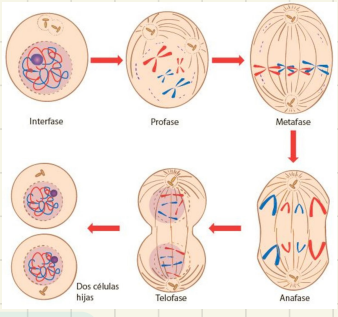
0. During **interphase**
   a) DNA = chromatin form
   b) Growth, normal cell function
   c) Synthesis/replication of DNA

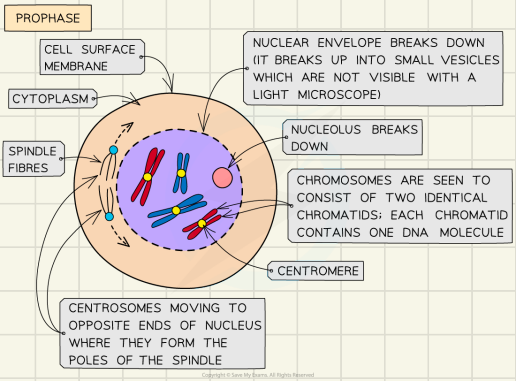
1. **Prophase**
   a) Chromosomes condense
   b) Spindle microtubules assemble
   c) Nuclear membrane breaks down

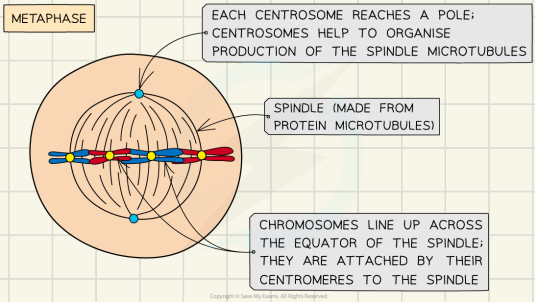
2. **Metaphase**
   a) Microtubules attach to the centromeres
   b) Chromosomes align on the equator

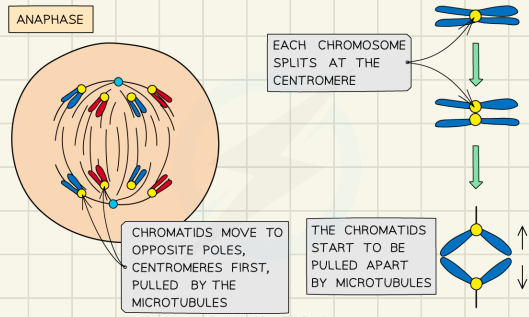
3. **Anaphase**
   a) Cohesin loops are cut
   b) Tension from spindle pulls sister chromatids apart
   c) ~~Sister chromatids~~ Chromosomes move to poles

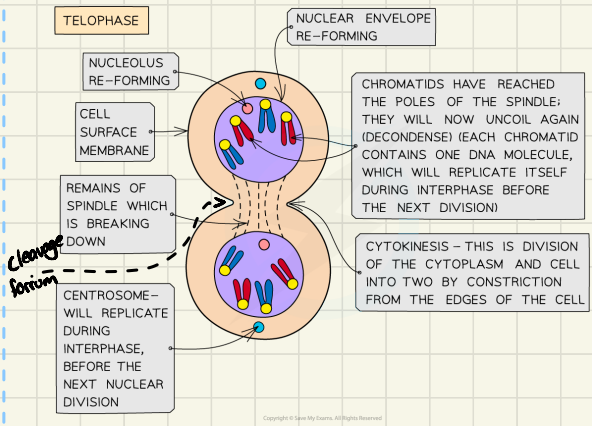
4. **Telophase** T for 2
   a) New nuclear membranes form
   b) Chromosomes decondense back into chromatin
   c) Happens simultaneously w/ cytokinesis



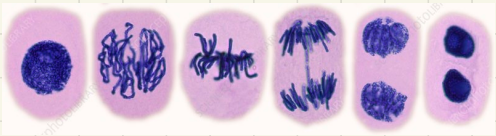








D2.1.8 — Identifying mitosis phases



Interphase

Chromatin = visible
Nuclei = dark appearance

Prophase

- Chromosomes = visible
- Nuclear envelope = breaking down

Metaphase

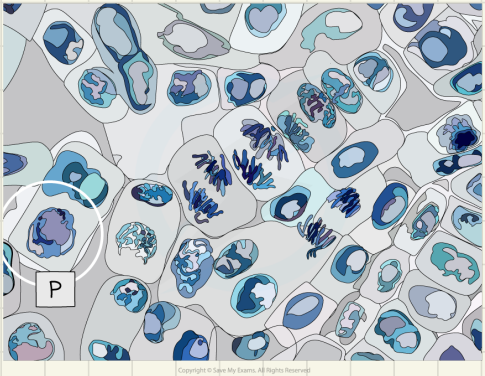
- Chromosomes lined up in cell's middle

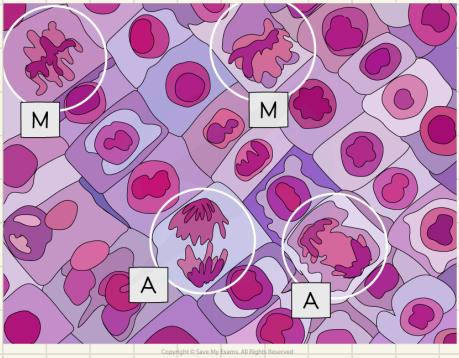
Anaphase

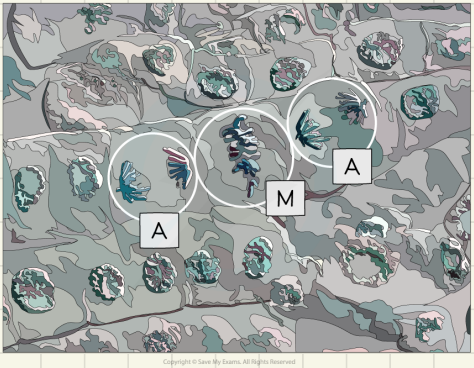
- Chromosomes moving away from center
- Pulled from centromere (kinetochore)
- V-Shaped

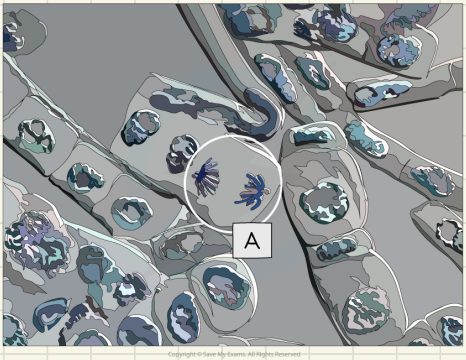
Telophase

- Chromosomes have arrived @ opp. sides of cell
- Chromosomes begin to uncoil
- Nuclear envelope reforming







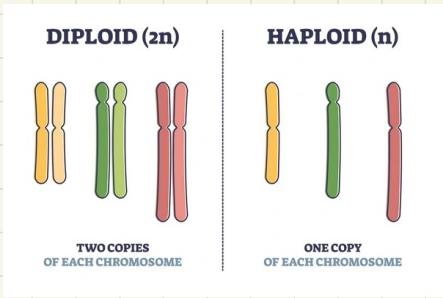


D2.1.9 — Meiosis as a reduction division

↳ Homologous chromosomes
- Diploid cells (2n)
- One from each parent
- Same genes in same location
- Dif. alleles

Diploid	Haploid
- 2n	- n
- Body cells	- Gameles
- Pairs	- Not in pairs
- Produced by mitosis	- Produced by meiosis
- or fusion of n cells	

↳ Gameles must be produced by meiosis in order for chromosome # to be reduced by $\frac{1}{2}$
- This ensures zygole has correcl # of chromosomes (2n)

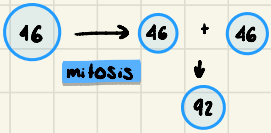


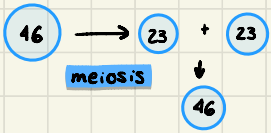
Gameles fuze together... if they were produced by mitosis, the zygole would have 92 chromosomes

↳ Done by:
- DNA = replicated once but, 2 cell divisions
  - Meiosis I ; Meiosis II refer to these cell divisions

↳ Anaphase I => separation of homologous chromosomes
↳ Anaphase II => separation of sister chromatids
↳ Normal meiosis results in 4 daughter cells

*





Meiosis I

Prophase I => crossing over

Metaphase I => Instead of all chromosomes lining up in middle —mitosis— homologous pairs line up next to each other. (contain matching alleles from mom/dad)

As bivalents.

Anaphase I => homologous chromosome pairs (now shuffled) are moved to poles ! separate.

Telophase I/Cytokinesis => cell pinches ! divides

Meiosis II

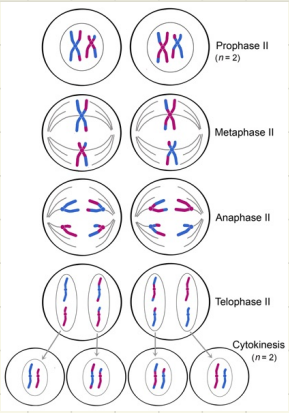
Prophase II => no replication has occurred

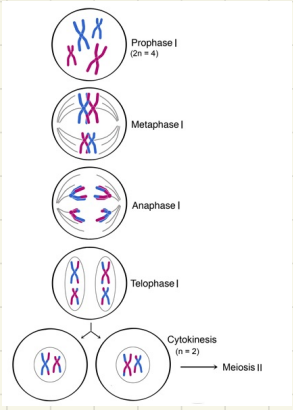
Metaphase II => Chromosomes line up

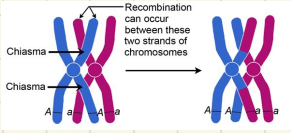
Anaphase II => Chromatids split @ centromere ! pulled to opp. sides

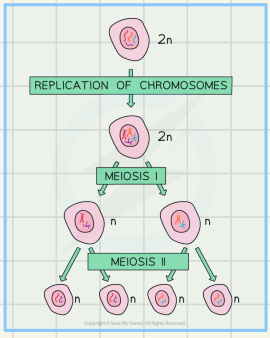
Telophase II/Cytokinesis => cells pinch @ center ! divide. Results in 4 gametes

Same as mitosis









D2.1.10 — Down Syndrome ⁉ nondisjunction

Nondisjunction => failure of the chromosomes to separate

↳ During anaphase, chromosomes are MEANT to separate — either meiosis I or II

↳ Results in gametes w/ too many / too few chromosomes

- One extra copy / no copy of particular chromosome

↳ usually results in cell death

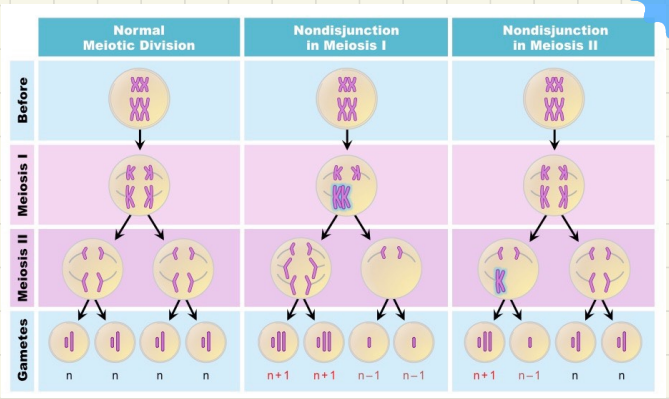
- Can happen in either meiosis I or II

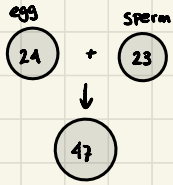
↳ If abnormal gamete + fertilized => zygote will have incorrect # chromosomes

↳ Ex. => Down Syndrome

- Down Syndrome results from **Trisomy 21**
- Nondisjunction in anaphase I
- 21st pair of homologous chromosomes don't separate
- Results in 3 copies of chromosome 21 (total of 47 chromosomes)

Highly correlated w/ maternal age.

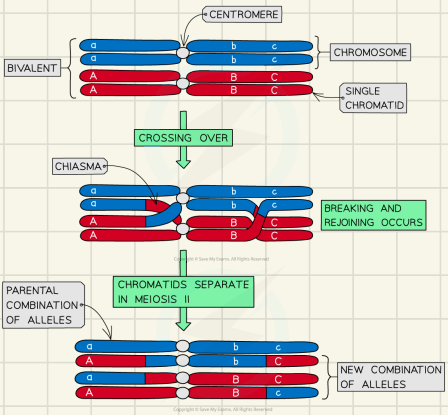


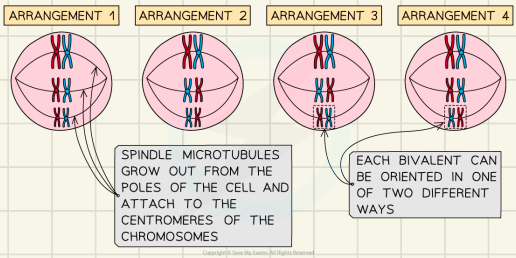


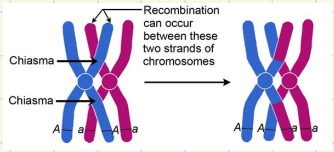
D2.1.11 — Meiosis => variation

↳ Diversity in sexually-reproducing organisms:

1. Mutation
2. Meiosis
3. Fertilization







Crossing over

↳ Happens in prophase I

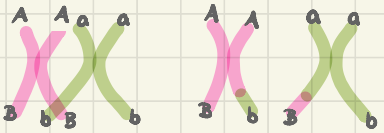
Bivalent => pair of homologous chromosomes attached to one another

Synapsis => formation of a bivalent (event resulting in bivalent)

Chiasma => point of crossing over (may be several places)

Crossing over => exchange of alleles between non-sister chromatids of homologous chromosomes

↳ # of chiasma ! amount of genetic exchange = random



Random orientation

↳ Happens in metaphase I or II

↳ Alignment of chromosomes = random

- dif. alignments produce dif. combinations of alleles when chromosomes/chromatids are separated

↳ Mathematically possible to see possible combos (2^n)

In humans:

$n = 23 \Rightarrow 2^{23} = 8388608$

n = haploid #

D2.1.12 — Cell proliferation

Cell proliferation => rapid increase in the # of cells

↳ Reasons:

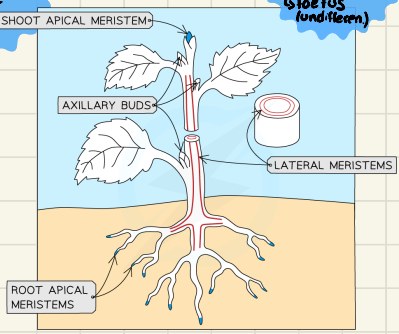
i) Growth (proliferation for growth)

- Multicellular organisms grow by adding more cells
  1. Animal embryos
  2. Plant meristems

} occurs here

Meristem cells are undifferentiated so they divide by mitosis to create plant tissue

Early-stage animal embryos: cells divide until blastocyst & foetus (undifferen.)

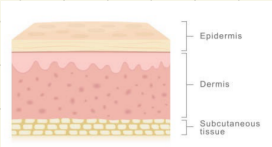


Apical meristems => stem cell tissue in the plant roots & shoots

Zones of high cell division

ii) Cell replacement

- Some cells have short/definite lifetimes ! need to be replaced continually
  => Ex: skin cells

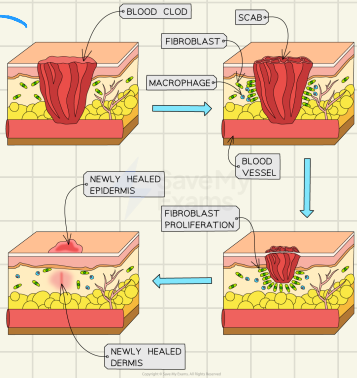


iii) Tissue repair

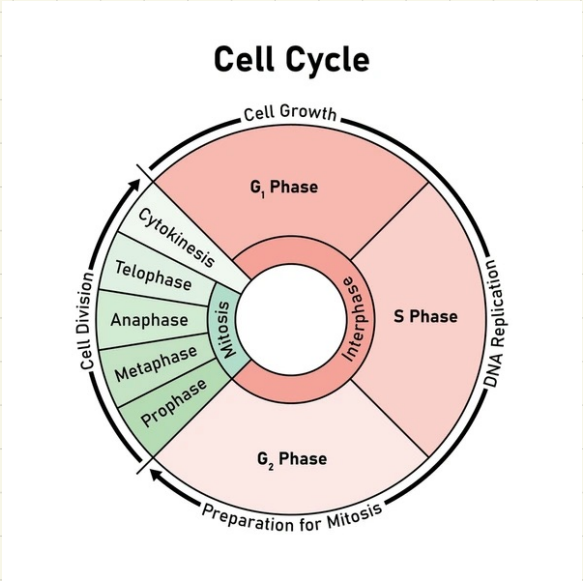
- Wounds require replacement of dead/damaged cells
- Faster in some organs than others due to # of cells that can readily undergo mitosis

  skin heals quickly bc there are plenty of cells on the dermis already undergoing mitosis

ex.



D2.1.13 — Phases of cell cycle



G_1 → S → G_2 — **Interphase:** → + mass ! size

1. G_1
   a) cell is doing its job
   b) makes RNA, enzymes ! proteins required for growth
   c) lots of respiration
2. S
   a) DNA in nucleus replicates
3. G_2
   a) cell continues to grow
   b) new DNA is checked
   c) synthesizing proteins needed for division
   d) Dismantling cytoskeleton holding organelles in place
   e) Growing in size (cytoplasm)

Cells that never receive the signal to divide during G_1, enter the G_0 phase => never dividing

Exception = animal embryos → # cells ↑, Size of individual cells ↓

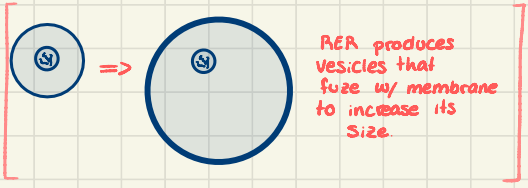
D2.1.14 — Cell growth during interphase

↳ The chromatin present in interphase = relaxed, making it possible for it to be transcribed ! translated in G_1

↳ Membrane increases in size

↳ Number of organelles must increase
   a) Manufactured by the cell (ribosomes)
   b) Replicate themselves (mitochondria can do this)

↳ High level of metabolism — lots happening

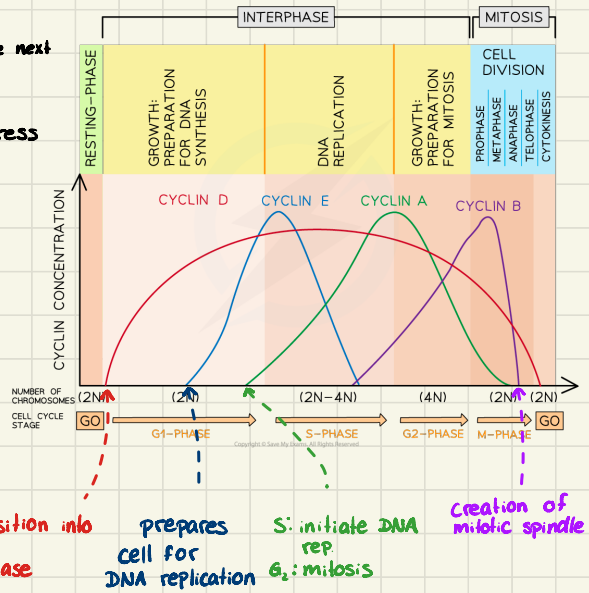


RER produces vesicles that fuse w/ membrane to increase its size.

D2.1.15 — control of cell cycle

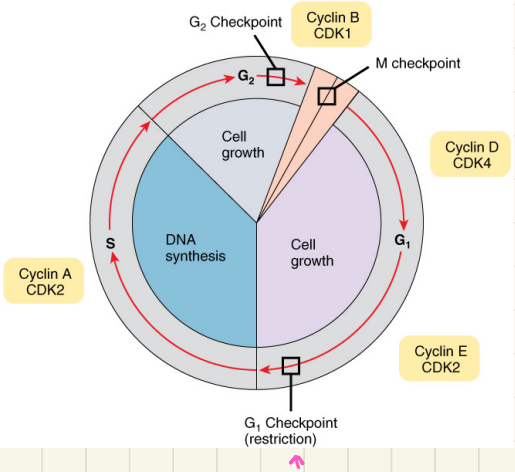
Cyclins => proteins that control the cell cycle

- Necessary in order to pass from 1 part of cycle to the next
- Dif. cyclins for each checkpoint in cell cycle
- Cell must produce enough of each cyclin to progress to next stage
  - Once a certain [Cyclin] threshold reached, the next phase = triggered
    - This ensures key processes occur @ correct time
- Cyclins bind to enzymes called **cyclin dependent kinases (CDK)** that move cells through cycle
  - ↓ [Cyclin] => CDK unactive



After S phase

- DNA has been replicated correctly

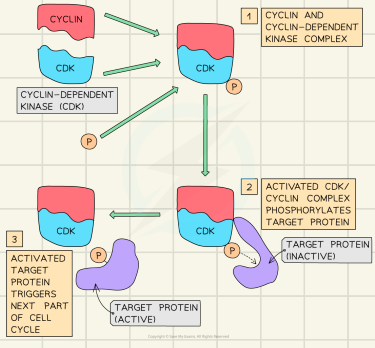


End of metaphase

- Chromatid attachment to spindle microtubules

- Growth
- DNA damage

Before entering S phase



D2.1.16 — mutations in genes that control spindle

↳ Genes that control mitosis

i) Proto-oncogenes
ii) Tumour-suppressor genes

→ SAME

Tumour => uncontrolled cell division due to mutation in division-controlling genes

↳ May happen in 3 ways:

1. Random mutation
2. Heritable mutation
3. Exposure to mutagens (chemicals/radiation/infectious agents)

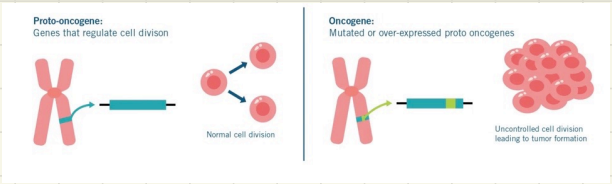
Proto-oncogenes => genes that control cell cycle → code for cell cycle "go"

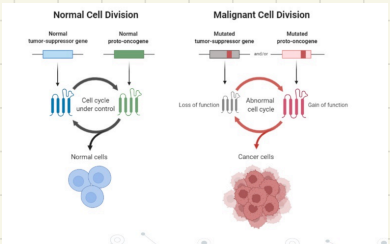
↳ Can mutate ! become oncogenes

- Oncogenes promote cell division ! are genetically dominant ! very active

over-ride proto-onco gene

Tumour types:
1. cancerous (malignant)
2. non-cancerous (benign)



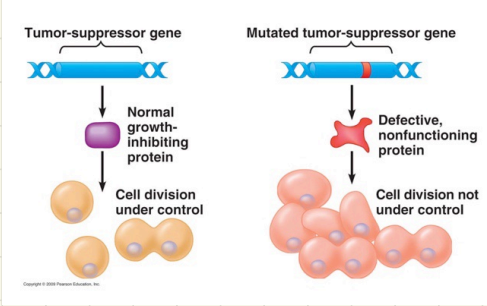


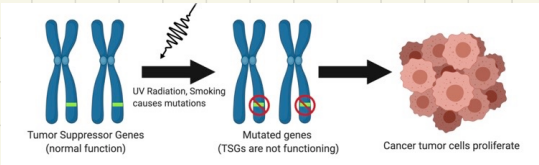
code for cell cycle "stop"

Tumour-supressor genes => genes that prevent cell proliferation ! correct errors due to DNA damage

↳ Mutation results in genetically RECESSIVE protein

- you would need 2 of them to actually get a tumor





cancer correlates w/ age!

↳ prolonged exposure to mutagens

↳ + time for random DNA errors

D2.1.17 — Dif. between tumors

Primary tumour => tumour cells that stick together

↳ Static in location

Secondary tumour => Some tumour cells migrate ! /or invade neighbouring tissue (only malignant tumours can cause these)

↳ The secondary locations

Metastasis => process of spreading tumour cells to dif. body parts

Malignant tumour => tumours capable of metastasizing (cancer)

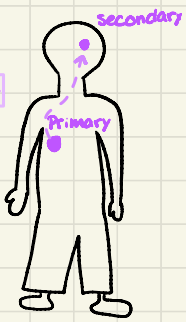
More likely to occur in areas of high cell division (ovaries, thyroid)

Cancer => disease caused by a malignant tumour

↳ Signs/Symptoms:

i) Fatigue
ii) Lump under skin
iii) Weight changes
iv) Muscle joint pain
v) Fevers

Cells are already differentiated when they move to a secondary location!



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

→ Between 0-1

Higher mitotic index → Faster cell division → More aggressive

Diagnosis

The higher the MI to a tissue's specific standard, the more likely a tissue = cancerous

Treatment

work by stopping cell division, fewer cells in mitosis ! MI decrease