

# Cancer

- Cancer is one of the most common diseases in the developed world:
- 1 in 4 deaths are due to cancer
- 1 in 17 deaths are due to **lung cancer**
- Lung cancer is the most common cancer in men
- Breast cancer is the most common cancer in women
- There are over 100 different forms of cancer

How Cancer Begins ????????

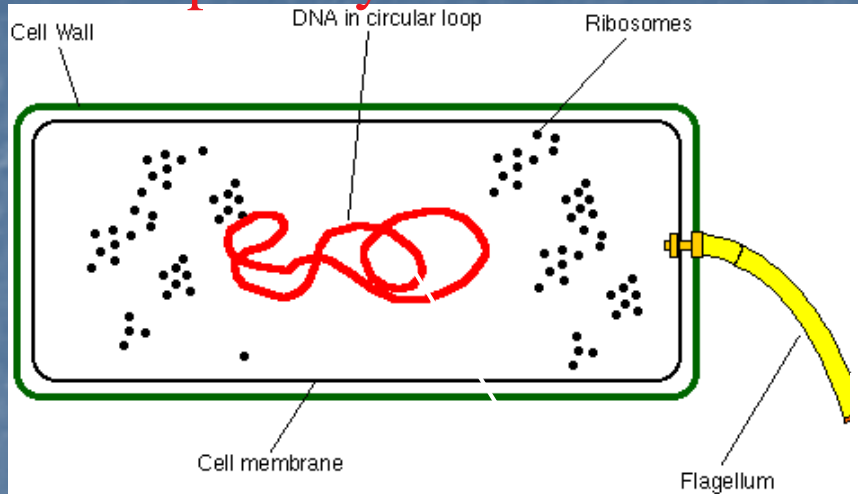
Chithra Manikandan – Nov 2009

# Cancer

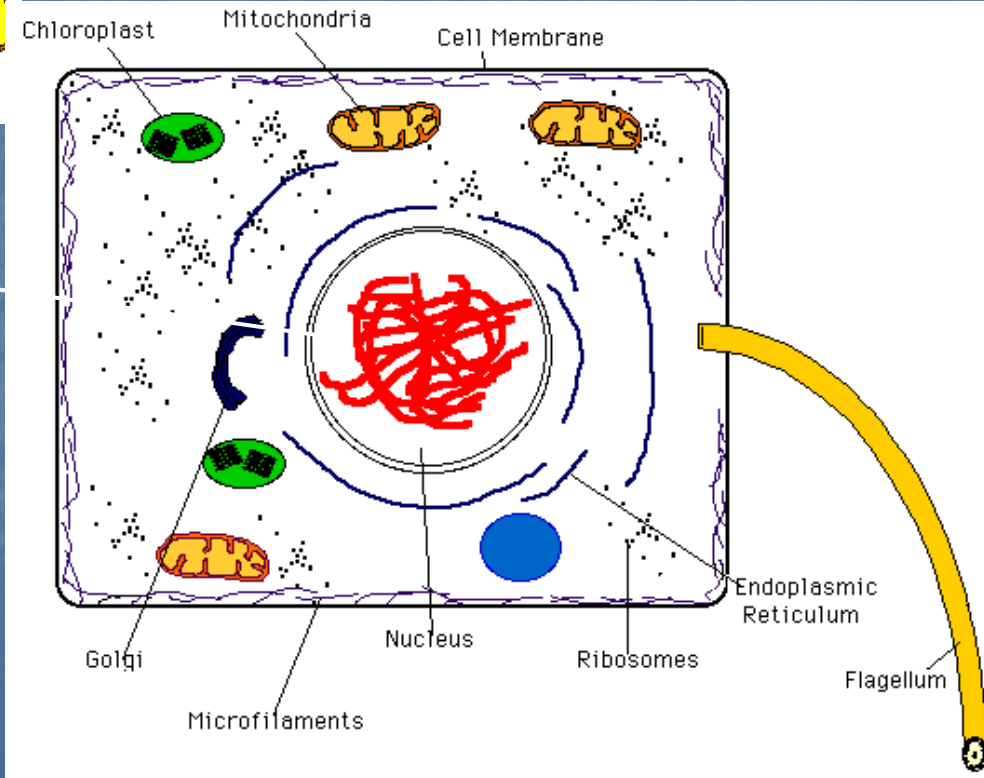
- The division of normal cells is precisely controlled. New cells are only formed for growth or to replace dead ones.
- Cancerous cells divide repeatedly out of control even though they are not needed, they crowd out other normal cells and function abnormally. They can also destroy the correct functioning of major organs.

# Packaging of genetic material in prokaryotes and eukaryotes

## prokaryote cell

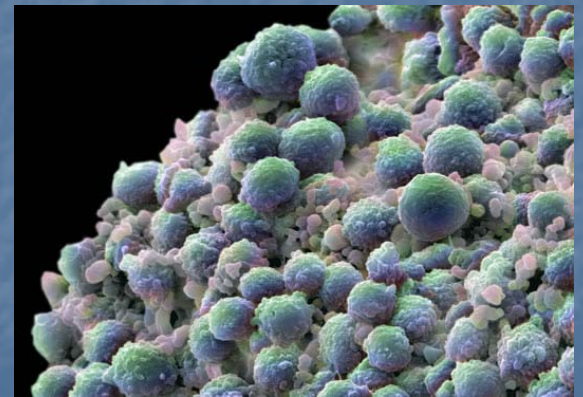
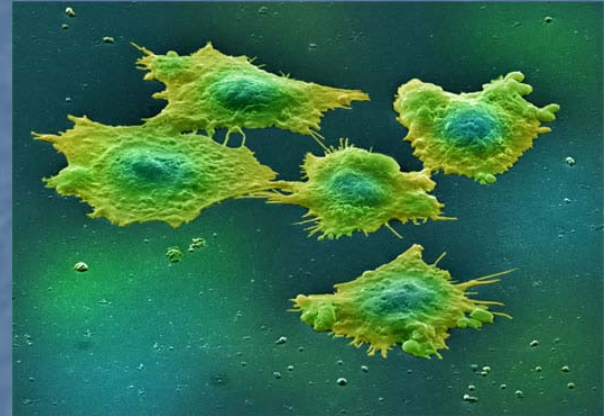
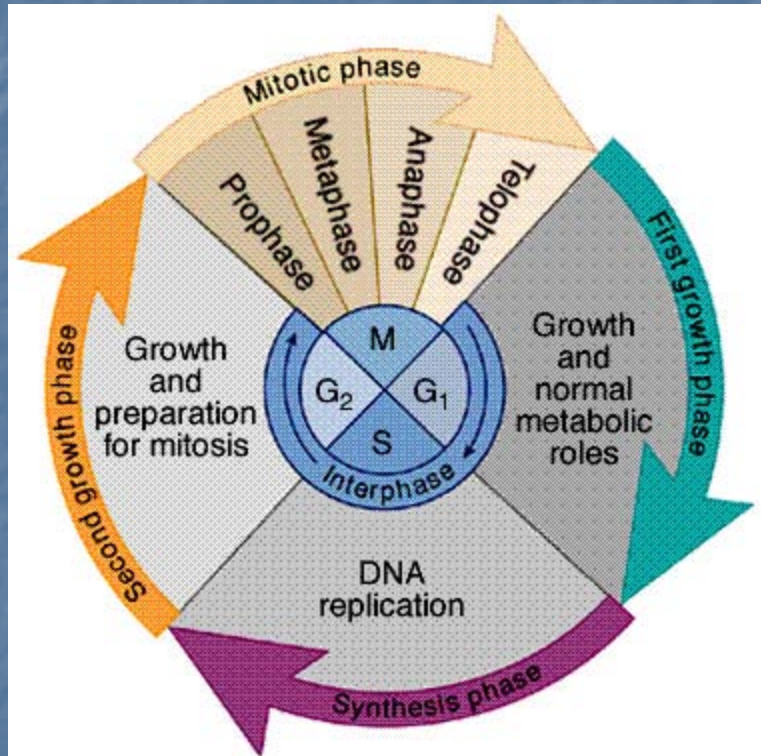


## eukaryote cell

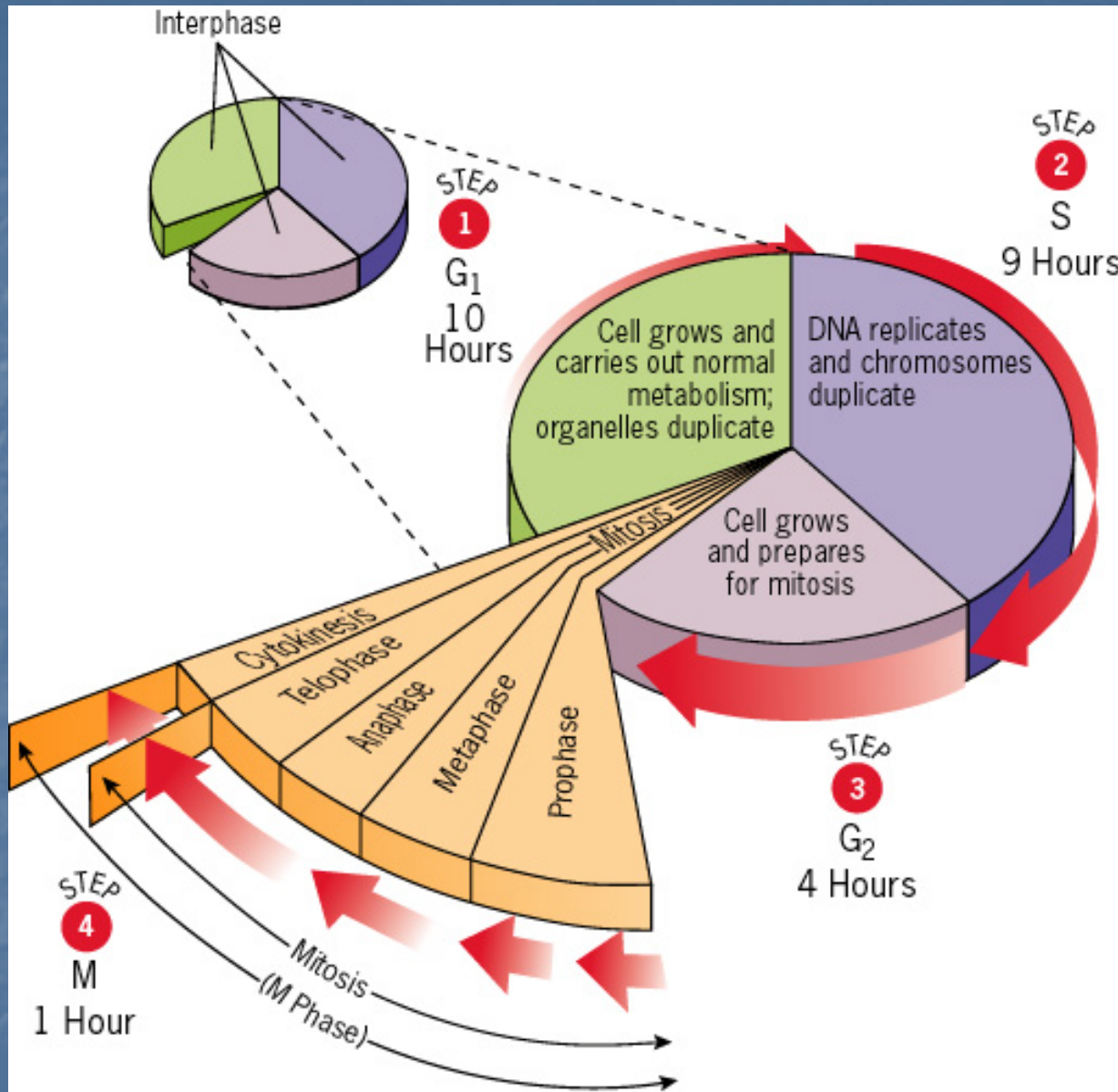


chromosomes

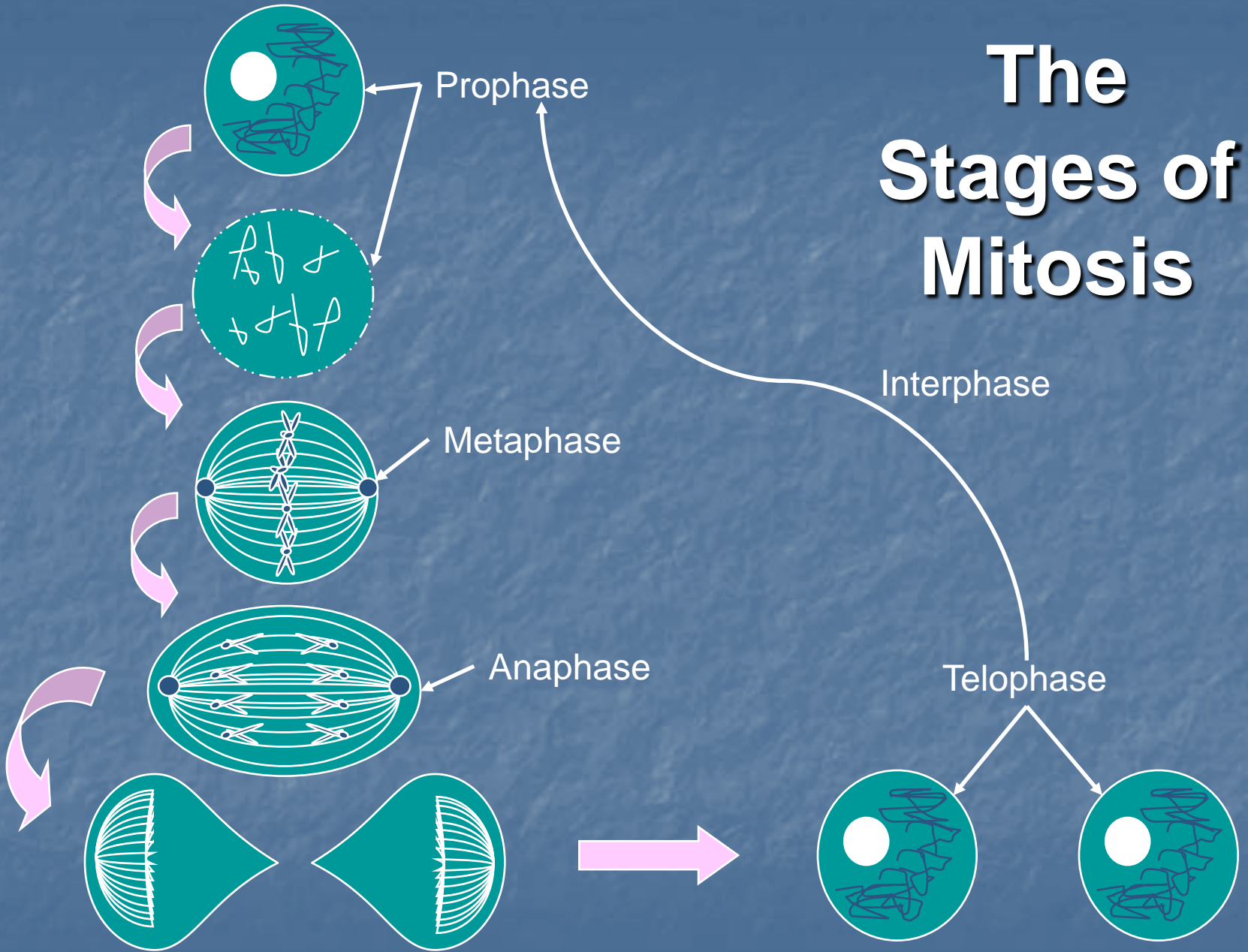
# The Cell Cycle and Cancer

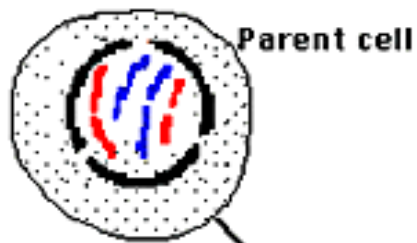


# The cell cycle.

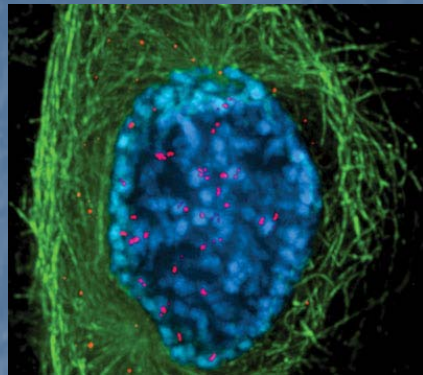
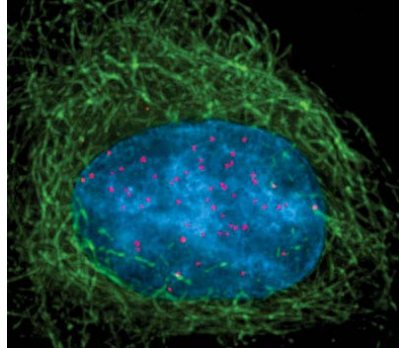
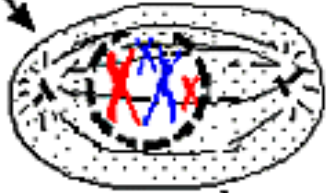


# The Stages of Mitosis

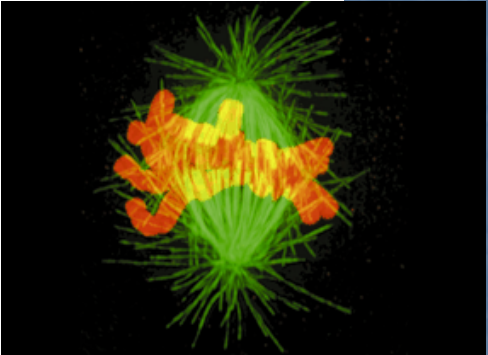
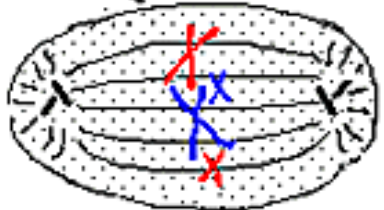




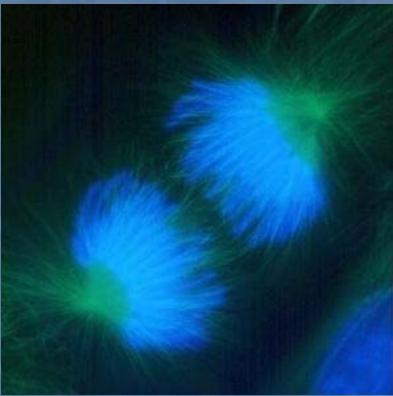
Prophase



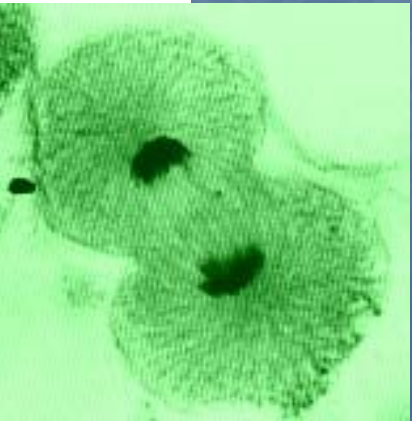
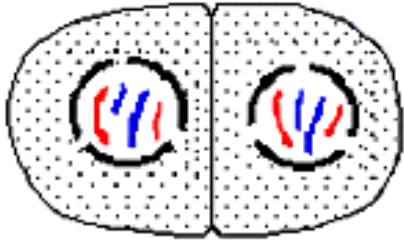
Metaphase



Anaphase



Telophase



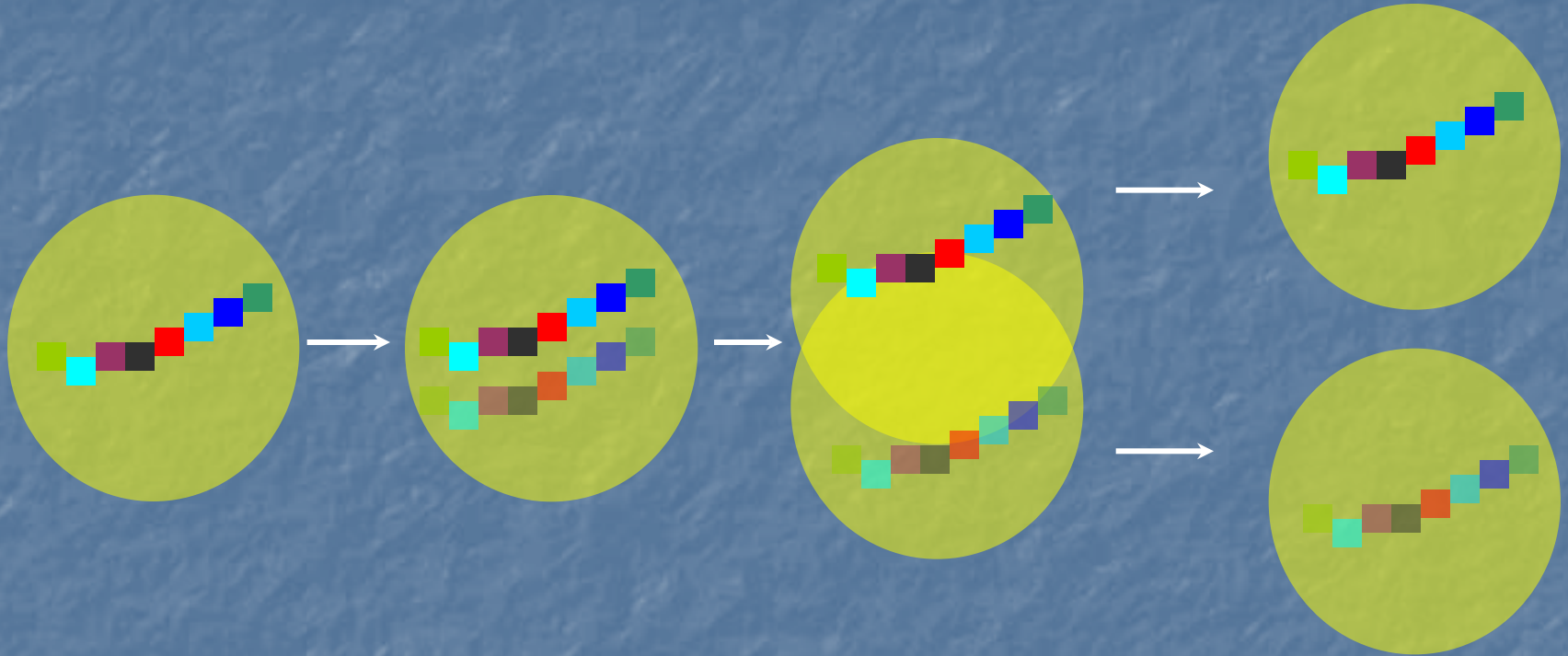
Two daughter cells

# Mitosis



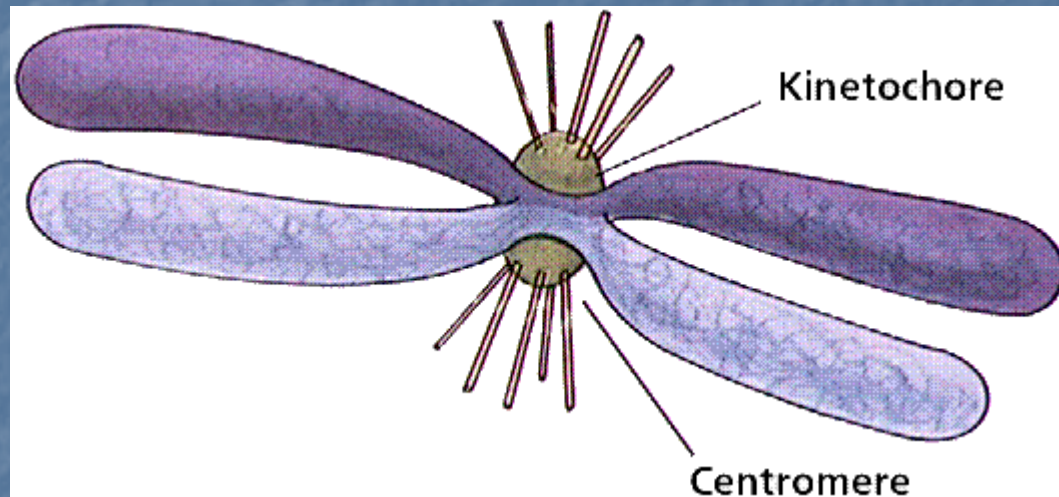
# DNA Structure

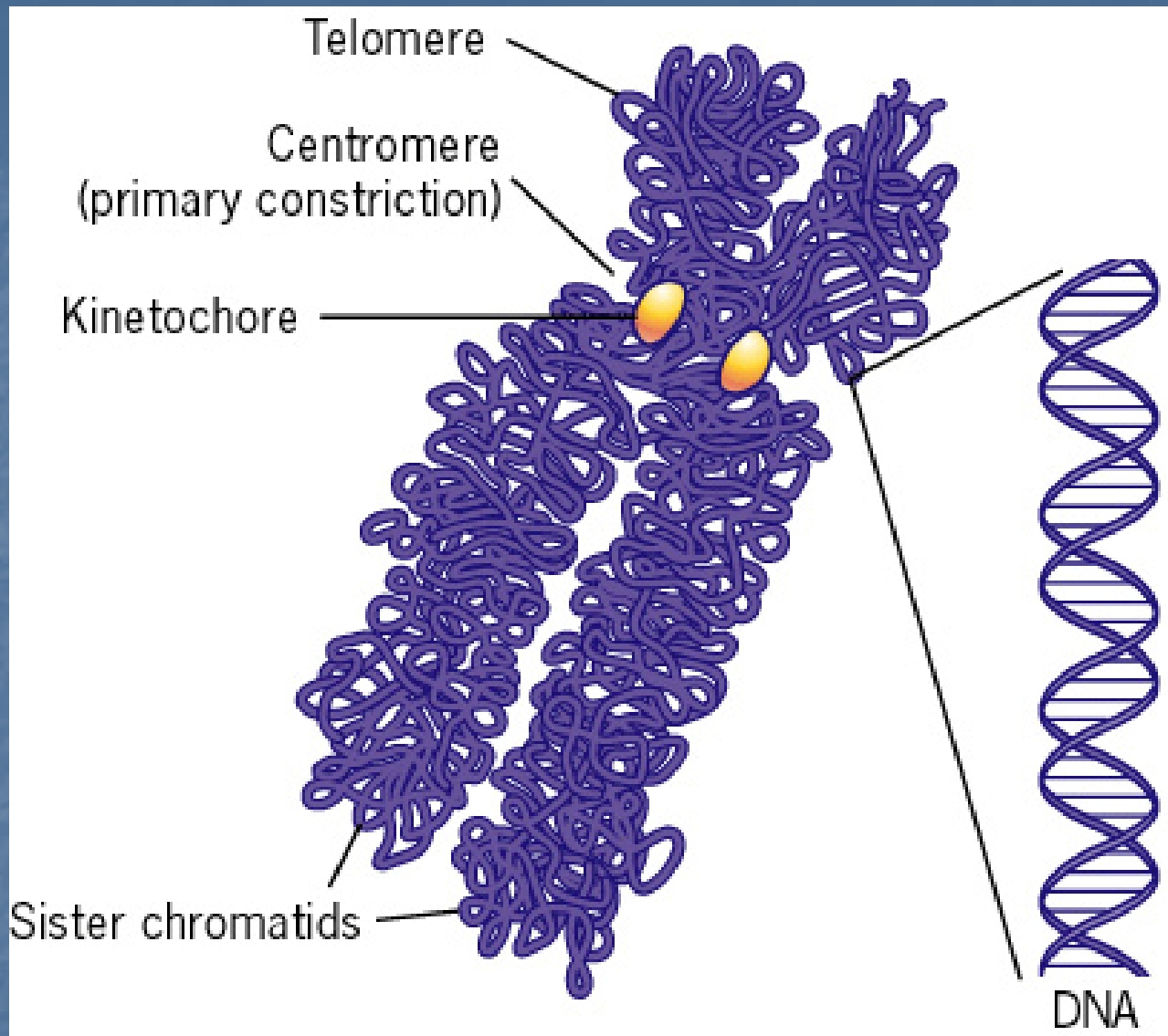
One of life's solutions to this challenge: "Package" the bits of information into single units called **chromosomes**



■ = one bit of  
genetic information

# A Chromosome



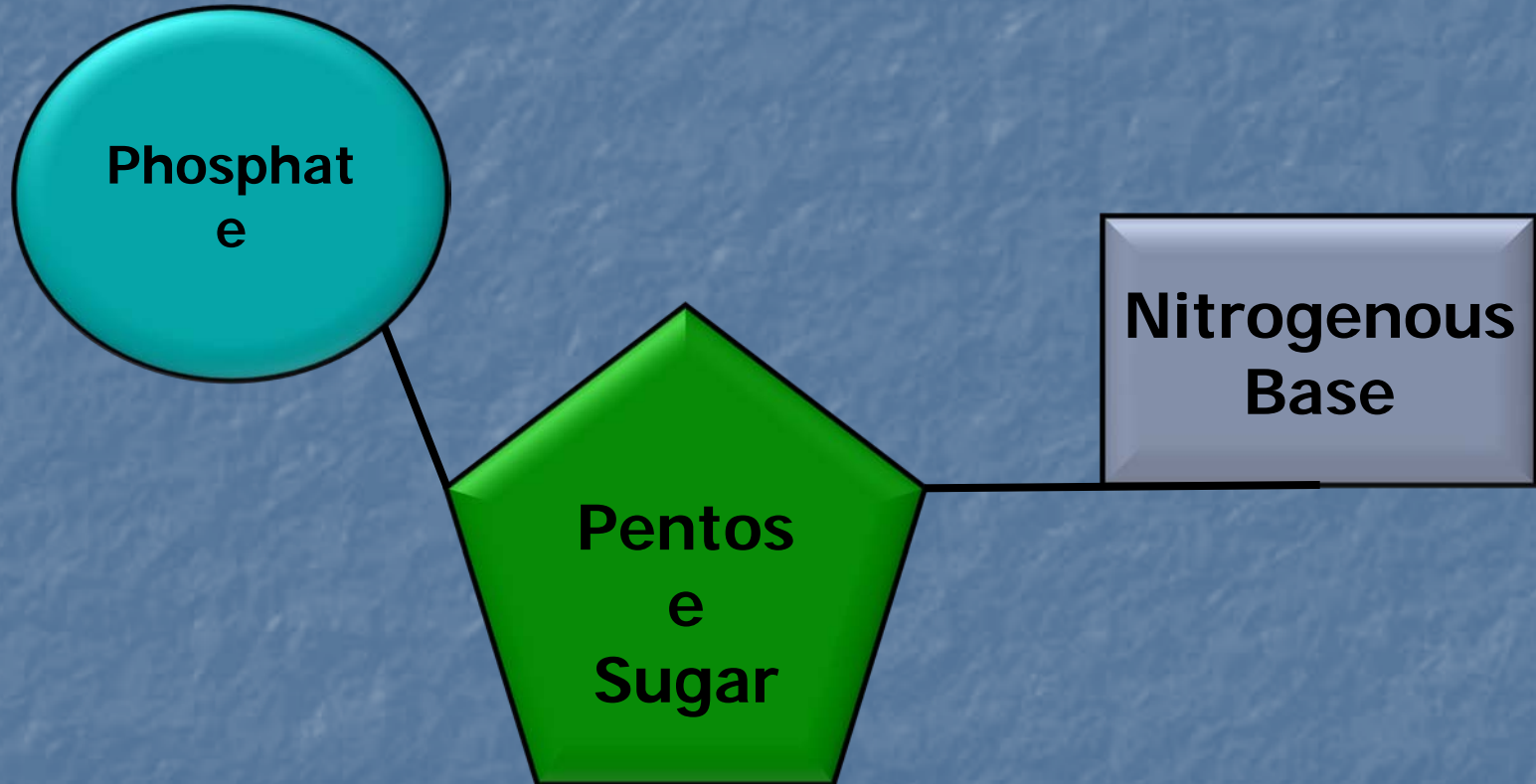


**Fig 2.4 The structure of a highly condensed, replicated chromosome.**

# DNA Structure

- DNA consists of two molecules that are arranged into a ladder-like structure called a **Double Helix**.
- A molecule of DNA is made up of millions of tiny subunits called **Nucleotides**.
- Each nucleotide consists of:
  1. Phosphate group
  2. Pentose sugar
  3. Nitrogenous base

# Nucleotides



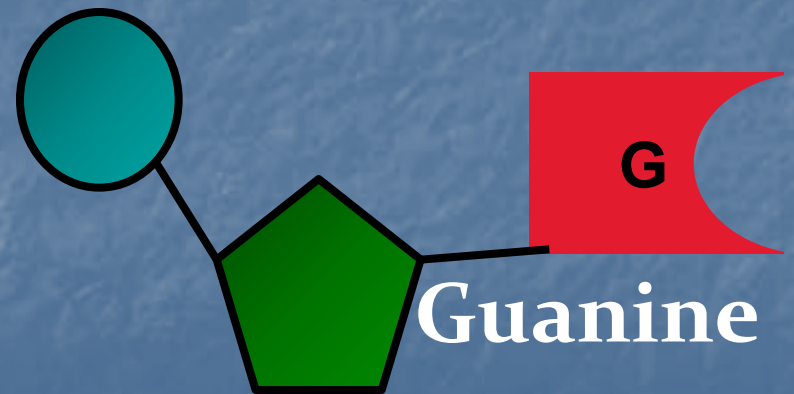
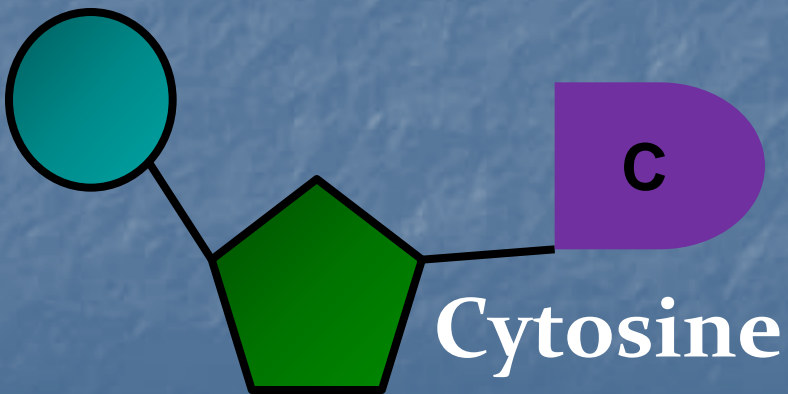
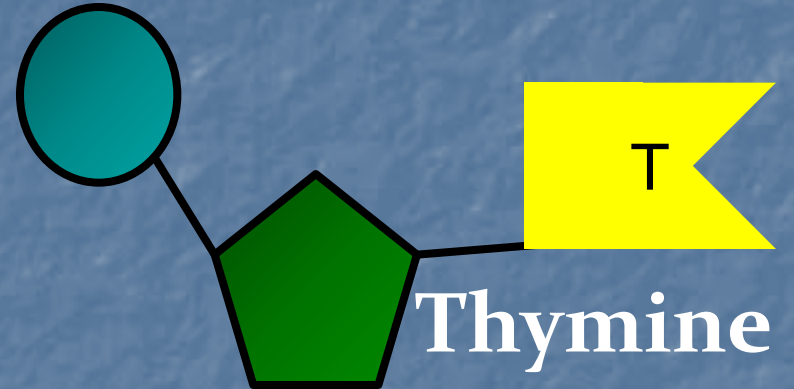
# Nucleotides

- The phosphate and sugar form the backbone of the DNA molecule, whereas the bases form the “rungs”.



- There are four types of nitrogenous bases.

# Nucleotides





# Nucleotides

- Each base will only bond with **one** other specific base.

- Adenine (A)

- Thymine (T)

} Form a base pair.

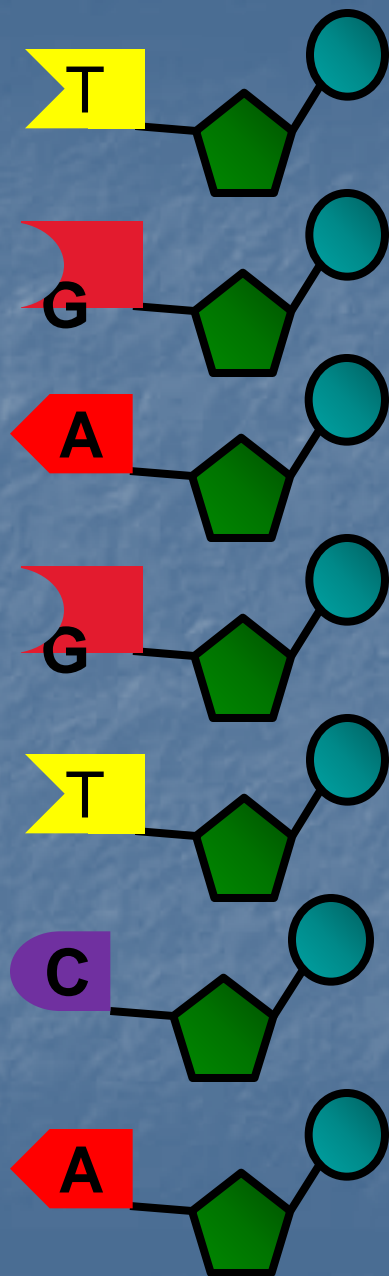
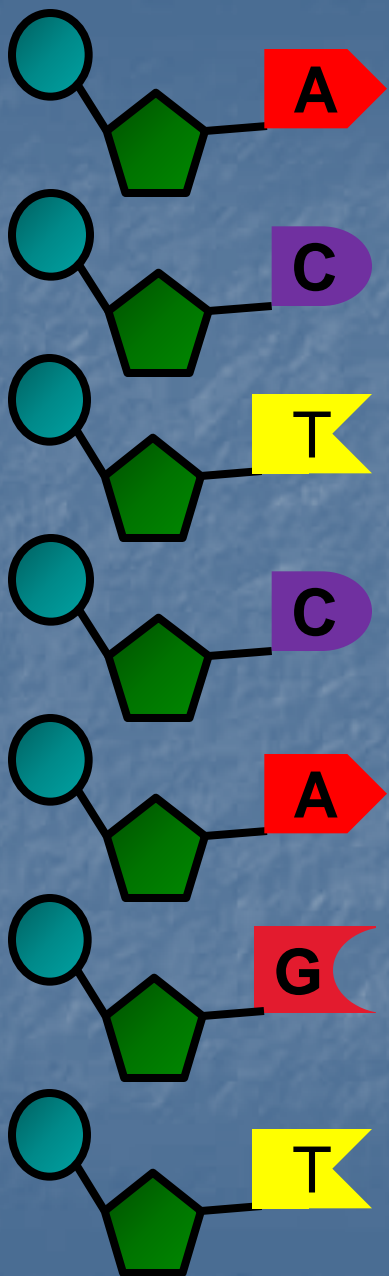
- Cytosine (C)

- Guanine (G)

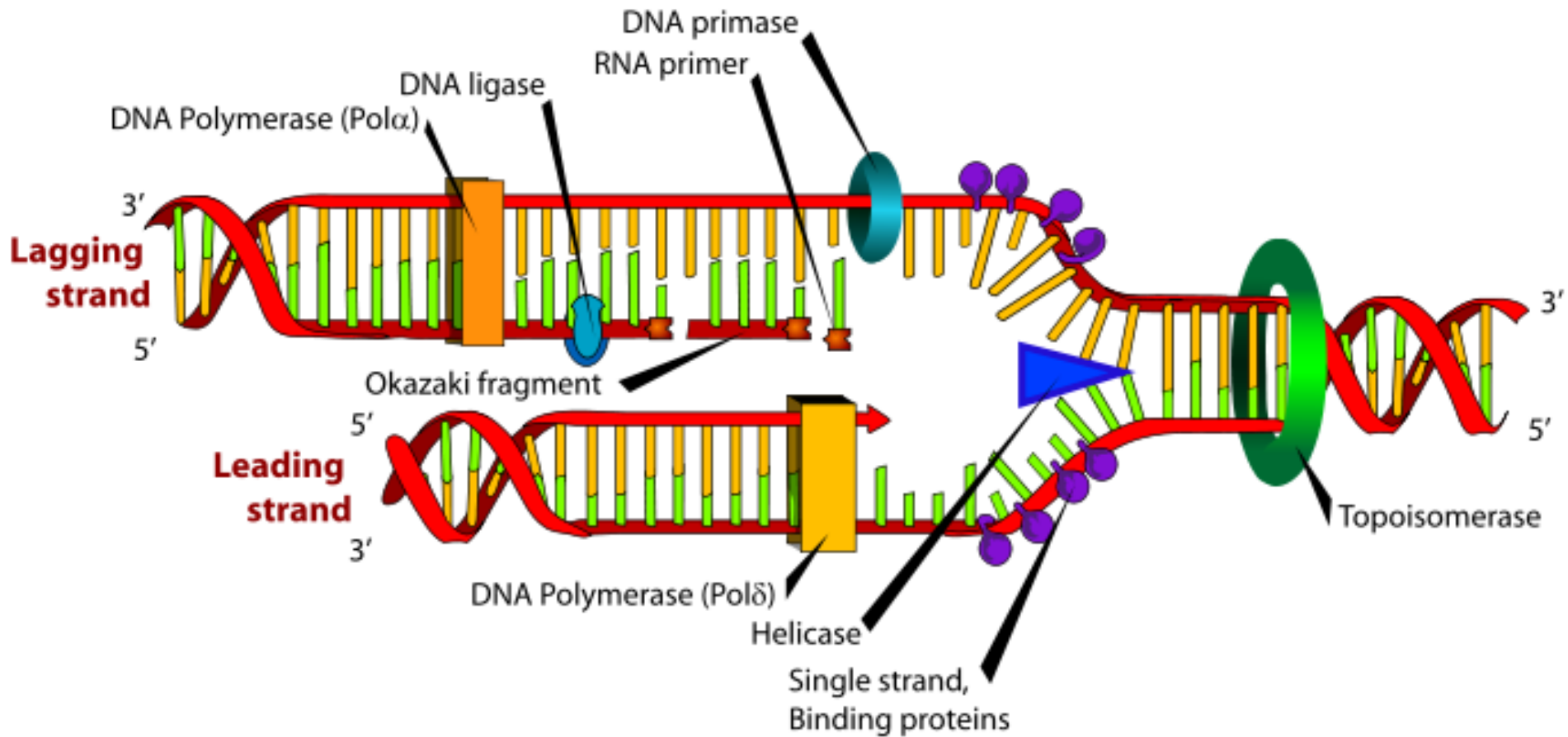
} Form a base pair.

# DNA Structure

- Because of this **complementary** base pairing, the order of the bases in one strand determines the order of the bases in the other strand.



# DNA Replication



# DNA Structure

- To crack the genetic code found in DNA we need to look at the sequence of bases.
- The bases are arranged in triplets called **codons**.

A G G - C T C - A A G - T C C - T A G  
T C C - G A G - T T C - A G G - A T C

# DNA Structure

- A gene is a section of DNA that codes for a **protein**.
- Each unique gene has a unique sequence of bases.
- This unique sequence of bases will code for the production of a unique protein.
- It is these proteins and combination of proteins that give us a unique **phenotype**.

Gene



DNA



Protein



Trait



# What causes cancer?

- Cancer arises from the **mutation** of a normal gene.
- Mutated genes that cause cancer are called **oncogenes**.
- It is thought that several mutations need to occur to give rise to cancer
- Cells that are old or not functioning properly normally self destruct and are replaced by new cells.
- However, cancerous cells do not self destruct and continue to divide rapidly producing millions of new cancerous cells.



- A factor which brings about a mutation is called a **mutagen**.
- A mutagen is **mutagenic**.
- Any agent that causes cancer is called a **carcinogen** and is described as **carcinogenic**.
- So some mutagens are carcinogenic.

# Carcinogens

- **Ionising radiation** – X Rays, UV light
- **Chemicals** – tar from cigarettes
- **Virus infection** – papilloma virus can be responsible for cervical cancer.
- **Hereditary predisposition** – Some families are more susceptible to getting certain cancers. Remember *you can't inherit cancer* its just that you maybe more susceptible to getting it.

# Benign or malignant?

- **Benign tumours** do not spread from their site of origin, but can crowd out (squash) surrounding cells eg brain tumour, warts.
- **Malignant tumours** can spread from the original site and cause secondary tumours. This is called metastasis. They interfere with neighbouring cells and can block blood vessels, the gut, glands, lungs etc.
- Why are secondary tumours so bad?
- Both types of tumour can tire the body out as they both need a huge amount of nutrients to sustain the rapid growth and division of the cells.

# The effect of mutations

- Not all are harmful
- Survival advantage
- Most common among bacteria and viruses but also seen in insects
- If no selective pressure may remain in population

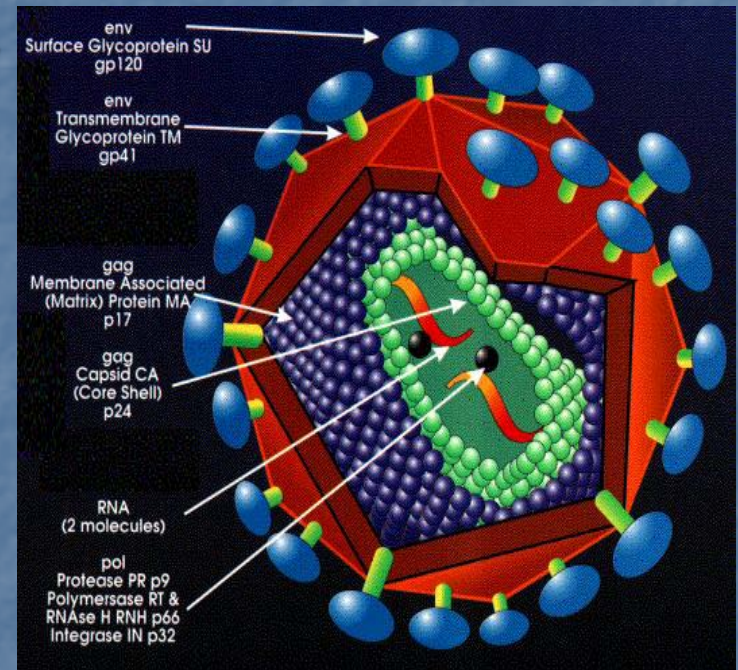
# Harmful mutations

- Cystic fibrosis and sickle cell anaemia
- Disfunctional proteins
- Albinism – caused by mutation in gene of enzyme pathway of melanin



# Beneficial mutations

- Bacteria – antibiotic resistance through mutation, transfer between bacterial species
- Superbugs such as MRSA have arisen this way
- RNA viruses – such as HIV – mutates it's protein coat so that the host human is unable to make antibodies quick enough against it



# Neutral mutations

- Neither harmful or beneficial to the organism but may be important in an evolutionary sense
- Silent mutations
- Virtually impossible to detect because no observable effect

There are several factors that regulate the cell cycle and assure a cell divides correctly.

Before a cell divides, the DNA is checked to make sure it has replicated correctly. (If DNA does not copy itself correctly, a gene **mutation** occurs.

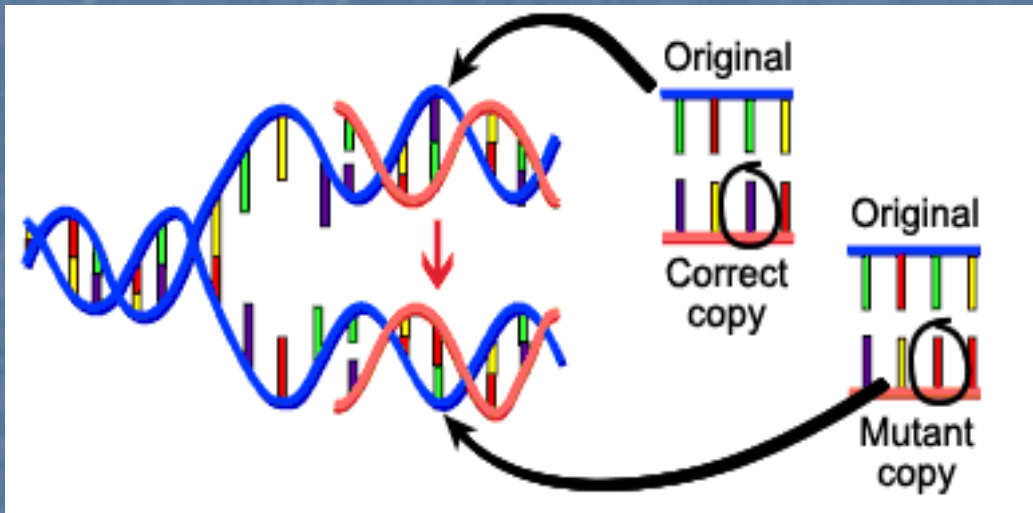




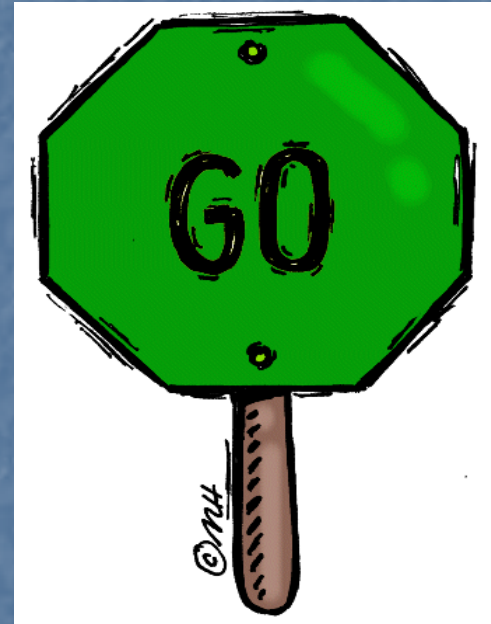
# DNA mutations disrupt the cell cycle.

Mutations may be caused by:

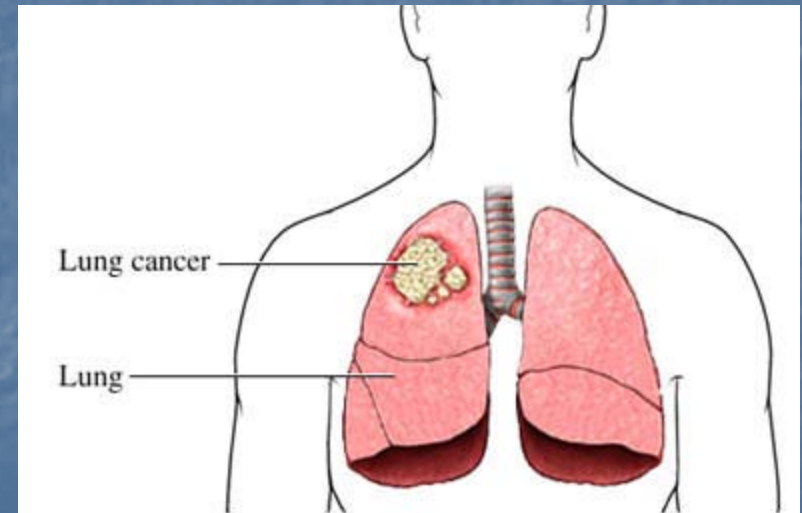
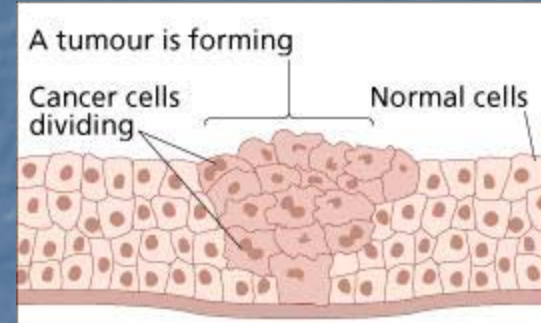
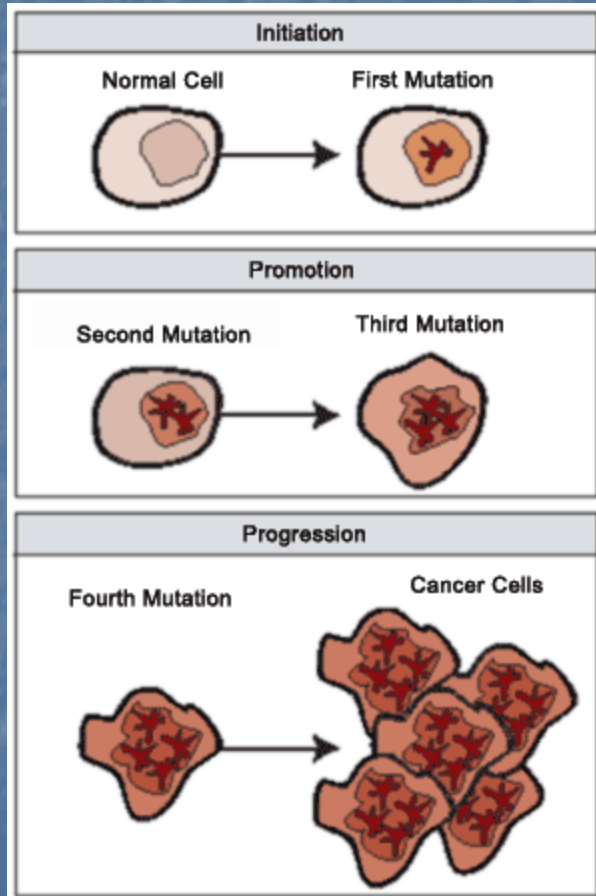
1. radiation
2. smoking
3. Pollutants
4. chemicals
5. viruses



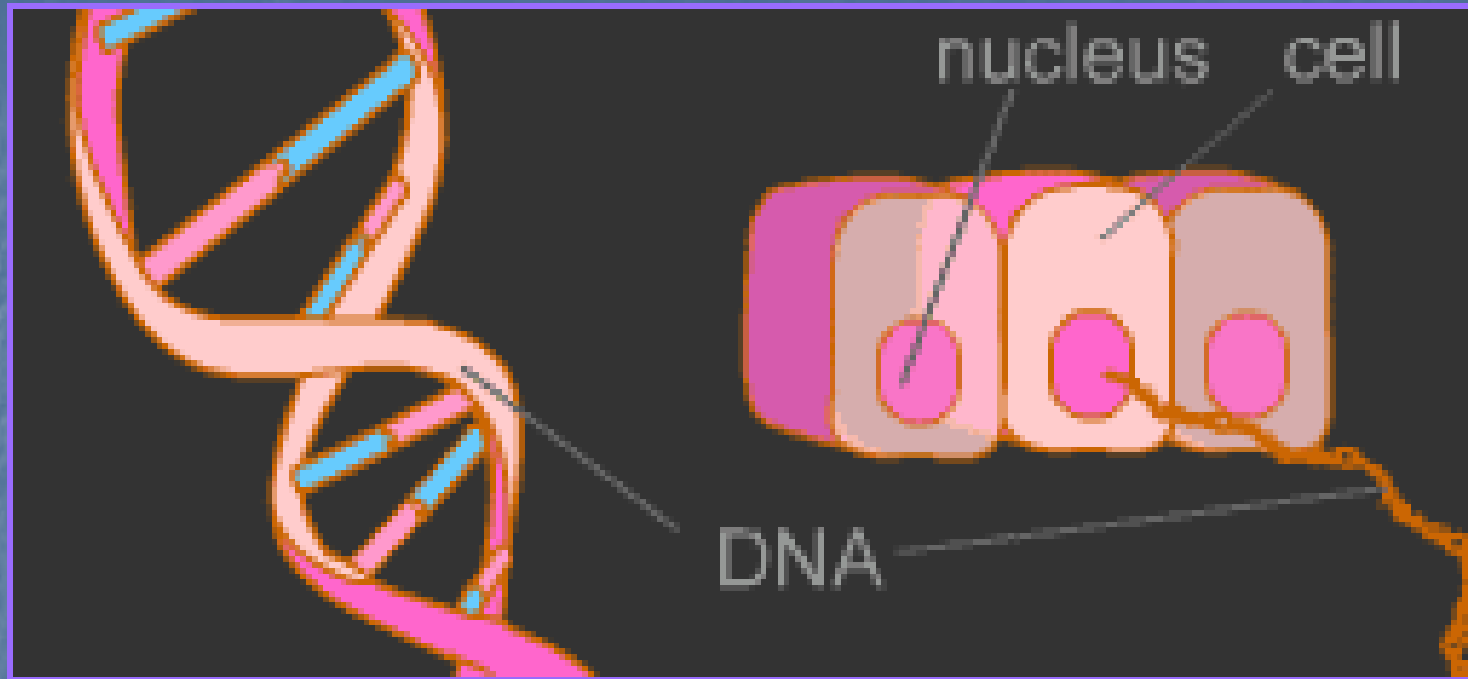
Chemical Signals tell a cell when to start and stop dividing.



While normal cells will stop dividing if there is a mutation in the DNA, cancer cells will continue to divide with mutation.

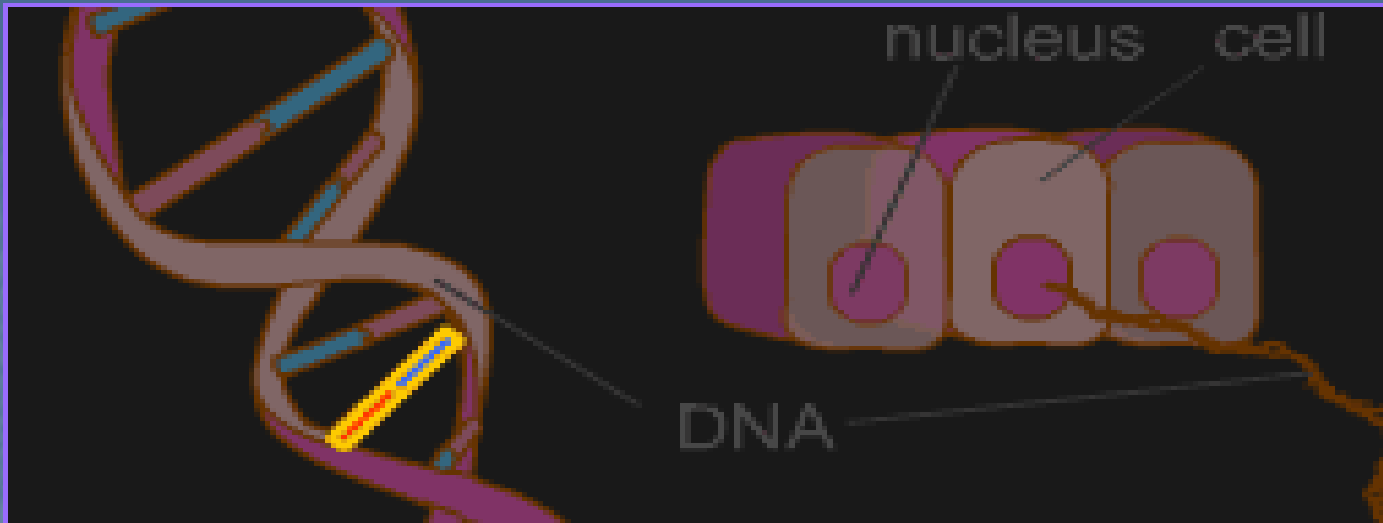


# 1. DNA of a normal cell



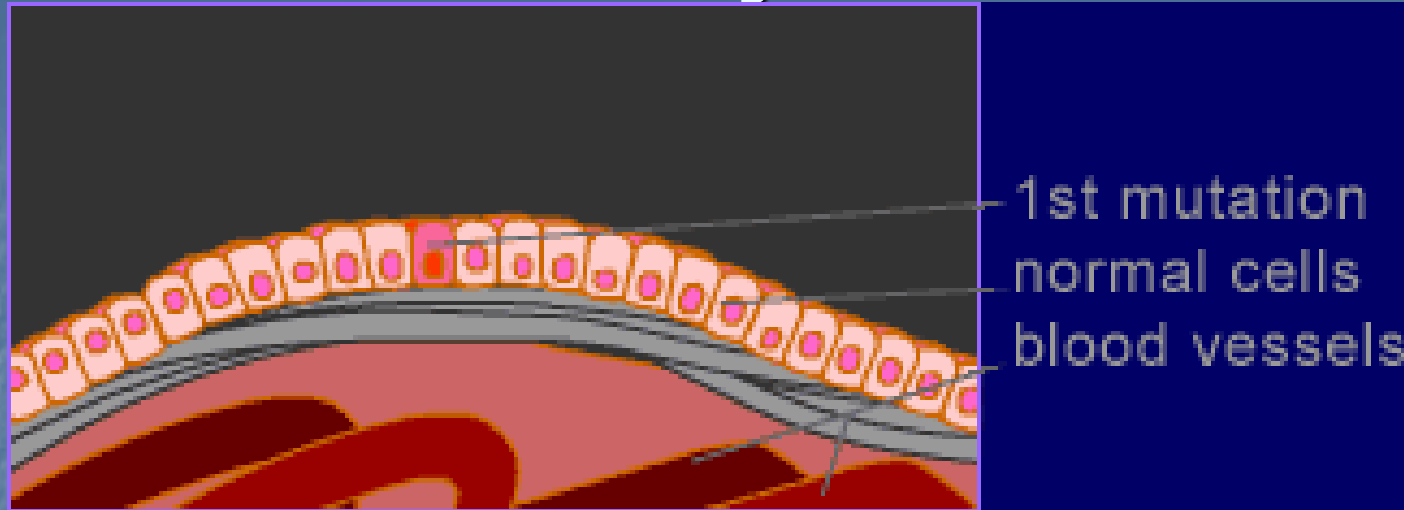
- This piece of DNA is an exact copy of the DNA from which it came. When the parent cell divided to create two cells, the cell's DNA also divided, creating two identical copies of the original DNA.

## 2. Mutation of DNA



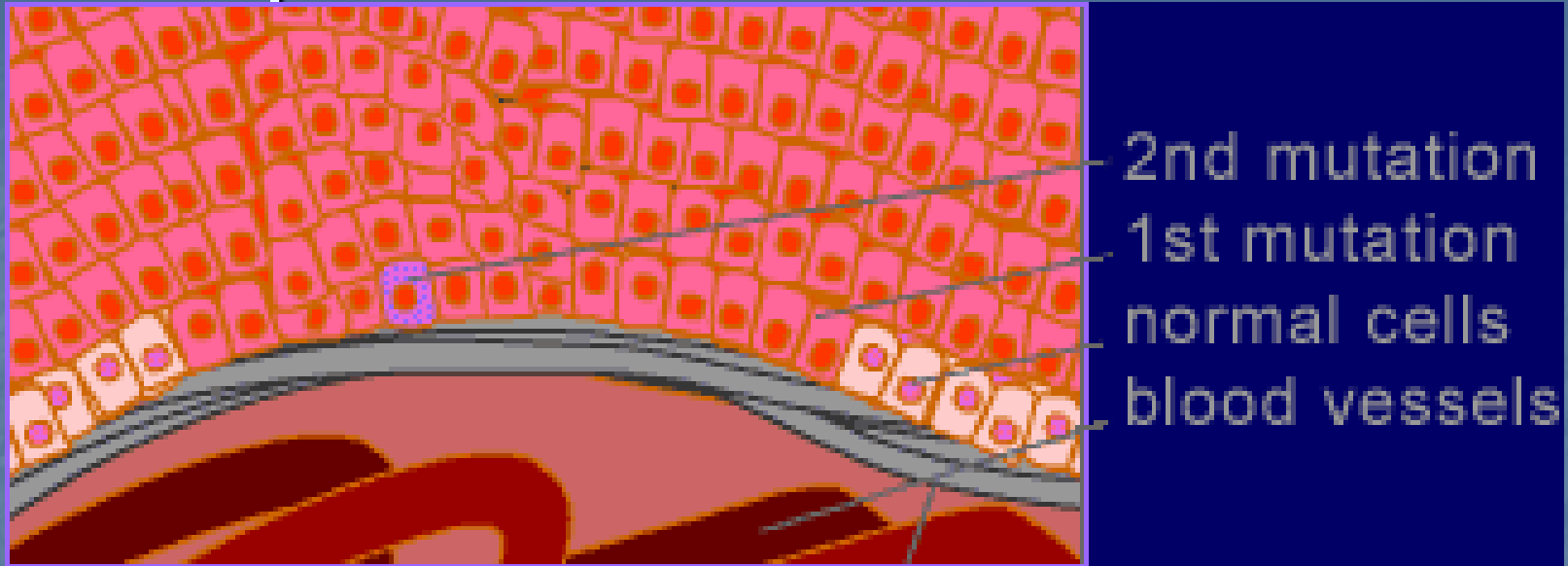
- This DNA has suffered a **mutation**, either through mis-copying (when its parent cell divided), or through the damaging effects of exposure to **radiation or a chemical carcinogen**.

### 3. Genetically altered cell



- The DNA of the cell highlighted above has a **mutation** that causes the cell to replicate even though this tissue doesn't need replacement cells at this time or at this place.

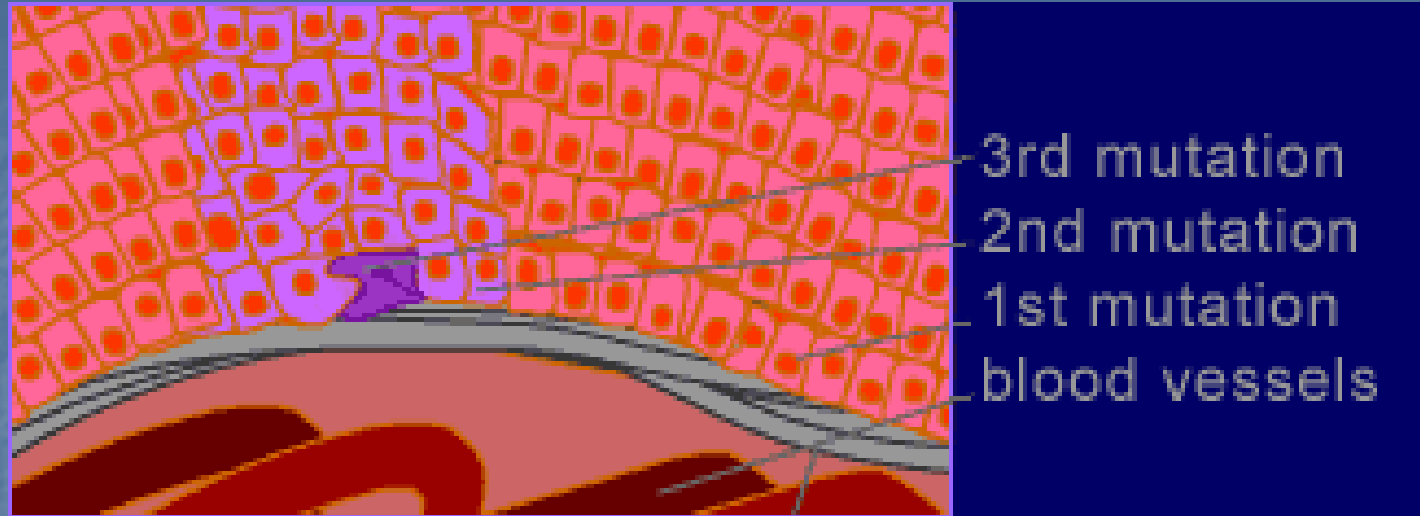
# 4. Spread and second mutation



- The genetically altered cells have, over time, **reproduced unchecked**, crowding out the surrounding normal cells. The growth may contain one million cells and be the size of a pinhead. At this point the cells continue to look the same as the surrounding healthy cells.

After about a million divisions, there's a good chance that one of the new cells will have **mutated further**. This cell, now carrying two **mutant genes**, could have an **altered appearance** and be even more prone to reproduce unchecked.

# 5. Third mutation

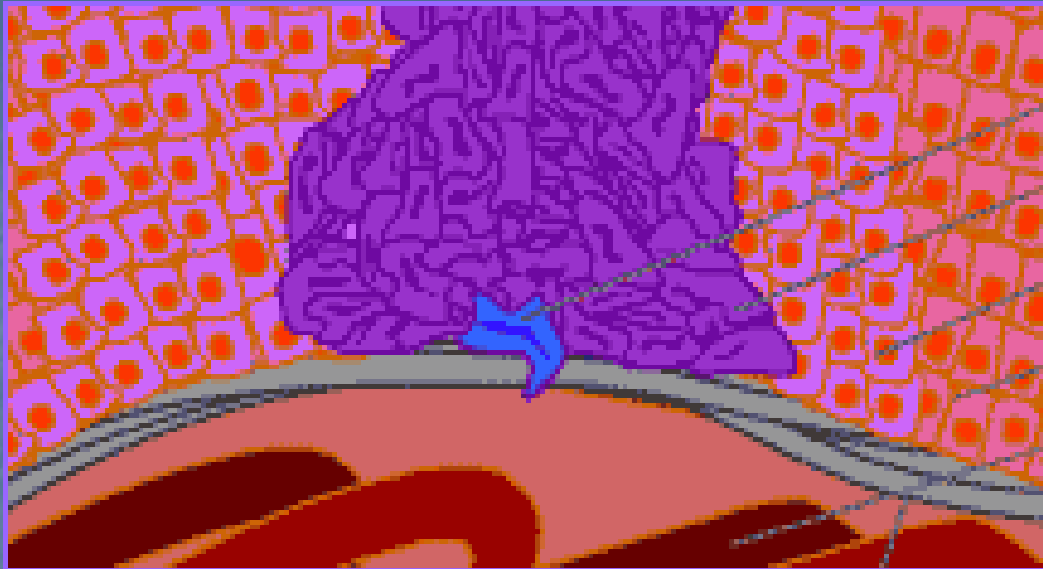


- Not all mutations that lead to cancerous cells result in the cells reproducing at a faster, more uncontrolled rate. For example, a mutation may simply cause a cell to keep from self-destructing. All normal cells have surveillance mechanisms that look for damage or for problems with their own control systems. If such problems are found, the cell destroys itself.

Over time and after many cell divisions, a **third mutation** may arise. If the mutation gives the cell some further advantage, that cell will grow more vigorously than its predecessors and thus speed up the **growth of the tumour**.



# 6. Fourth mutation

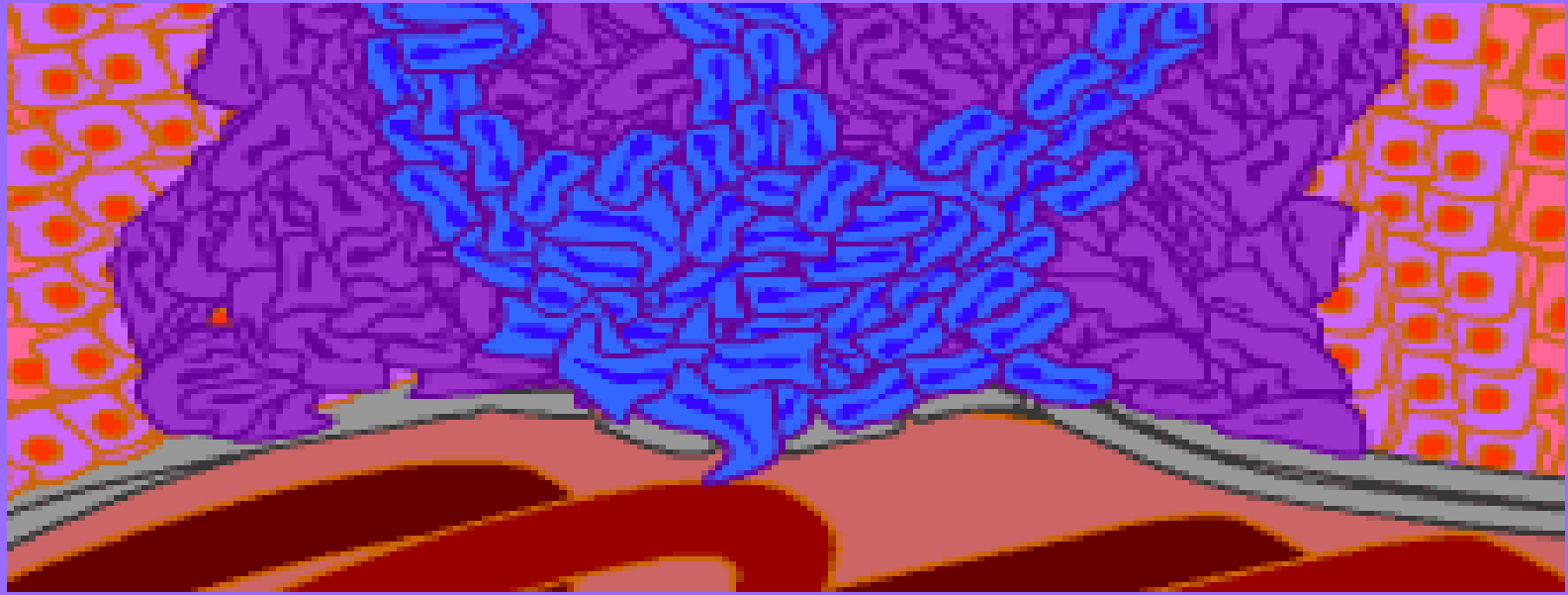


4th mutation  
3rd mutation  
2nd mutation  
1st mutation  
blood vessels

- The new type of cells grow rapidly, allowing for more opportunities for mutations. The next mutation paves the way for the development of an even more **aggressive cancer**.

**At this point the tumour is still contained.**

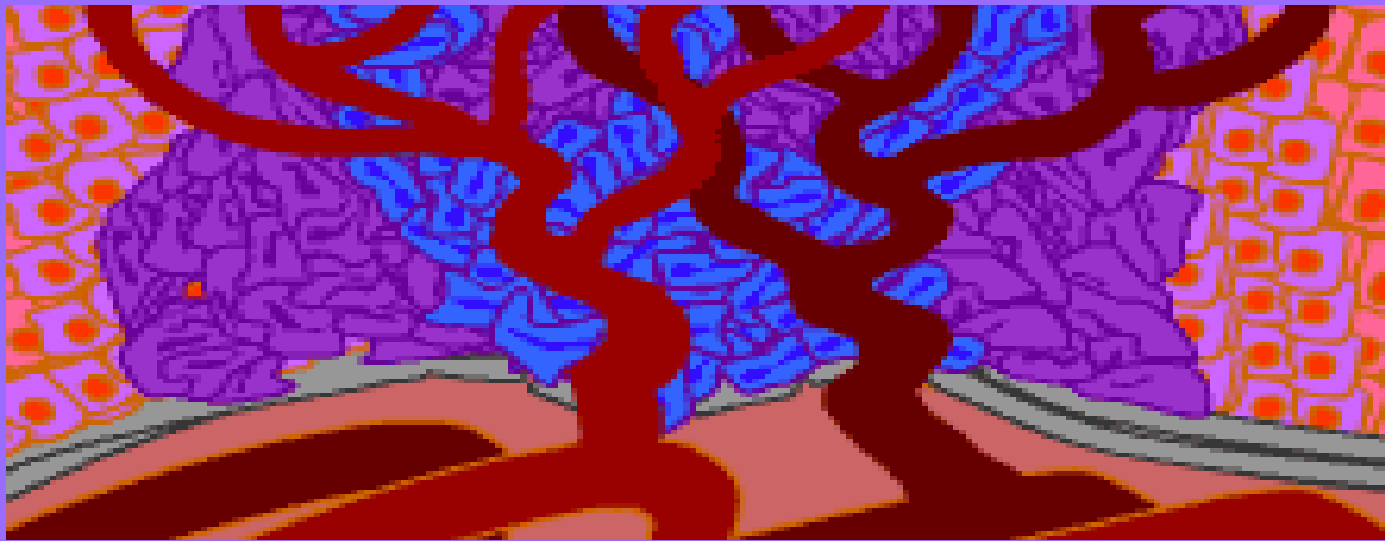
# 7. Breaking through the membrane



- The newer, wilder cells created by another mutation are able to **push their way through the epithelial tissue's basement membrane**, which is a meshwork of protein that normally creates a barrier. The invasive cells in this tumour are **no longer contained**.

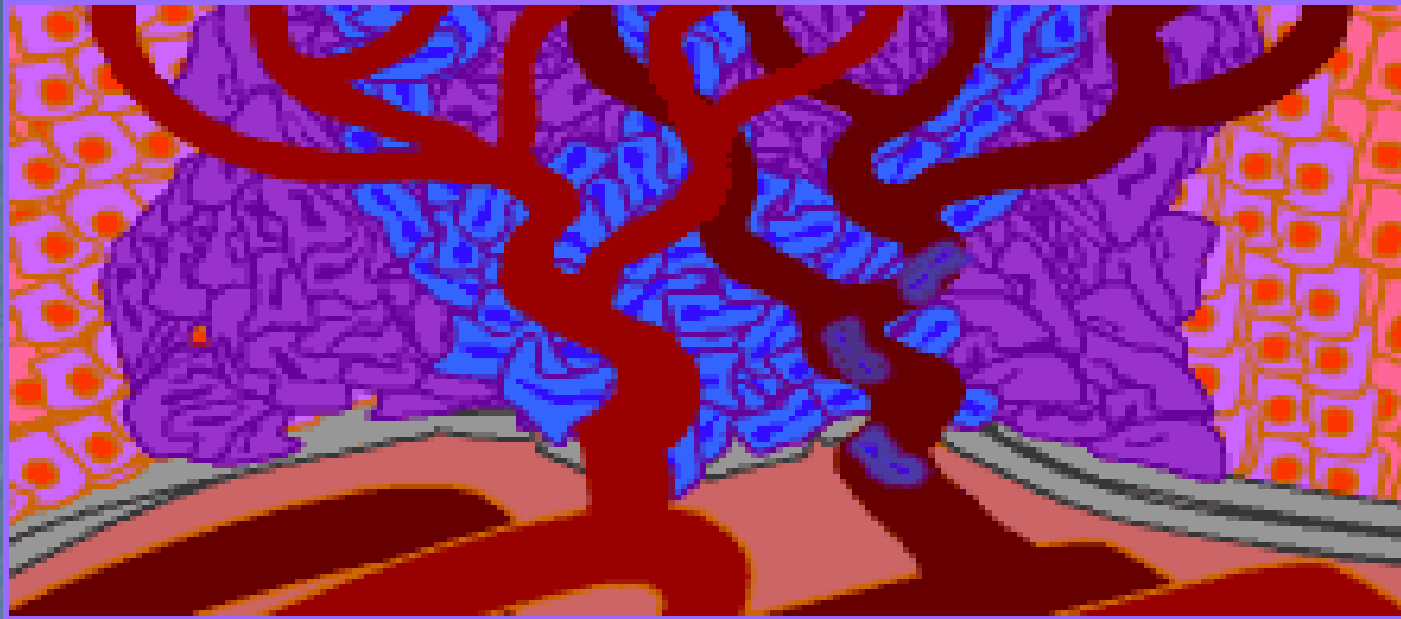
At this point the cancer is still **too small to be detected**.

# 8. Angiogenesis



- Often during the development of earlier stages of the tumour, or perhaps by the time the tumour has broken through the basement membrane (as pictured above), **angiogenesis** takes place. **Angiogenesis is the recruitment of blood vessels from the network of neighbouring vessels.**
- Without blood and the nutrients it carries, a tumour would be unable to continue growing. With the new blood supply, however, the **growth of the tumour accelerates**; it soon contains **thousand million cells** and, now the size of a small grape, is large enough to be detected as a lump

# 9. Invasion and dispersal

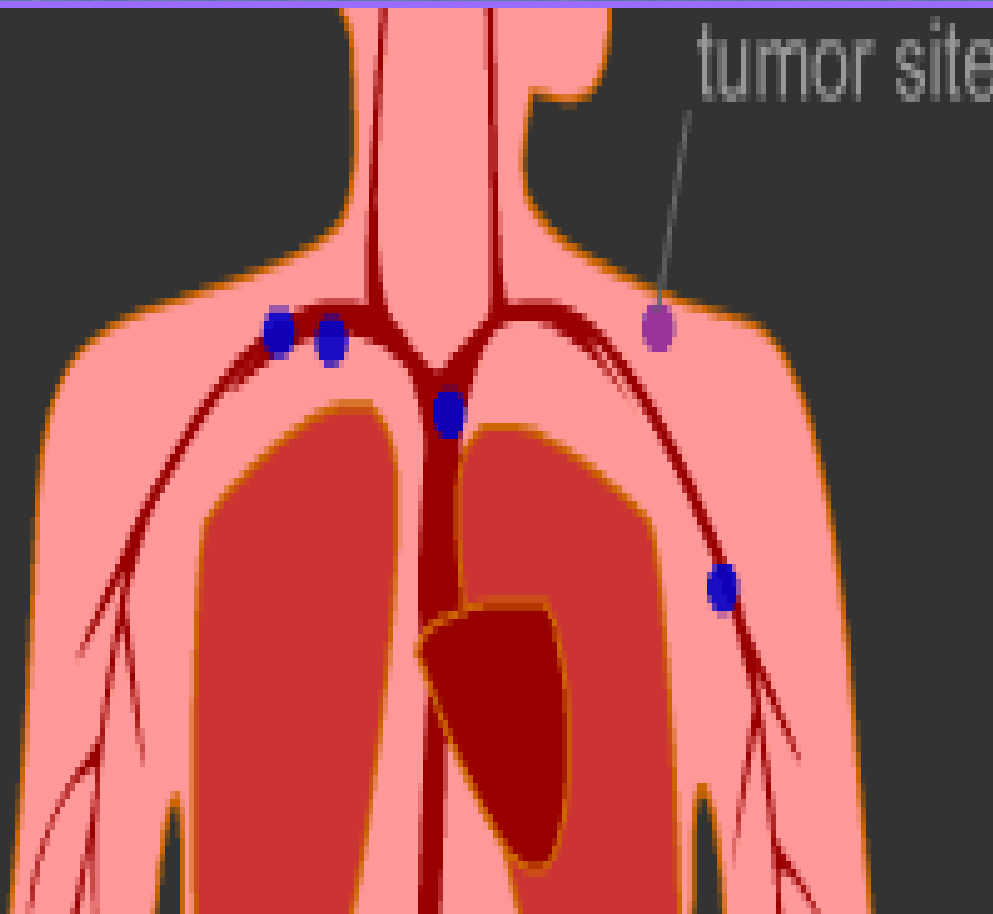


- The tumour has now **invaded the tissue** beyond the basement membrane.

**Individual cells from the tumour enter into the network of newly formed blood vessels**, using these vessels as highways by which they can move to other parts of the body. A tumour as small as a gram can send out a million tumour cells into blood vessels a day.

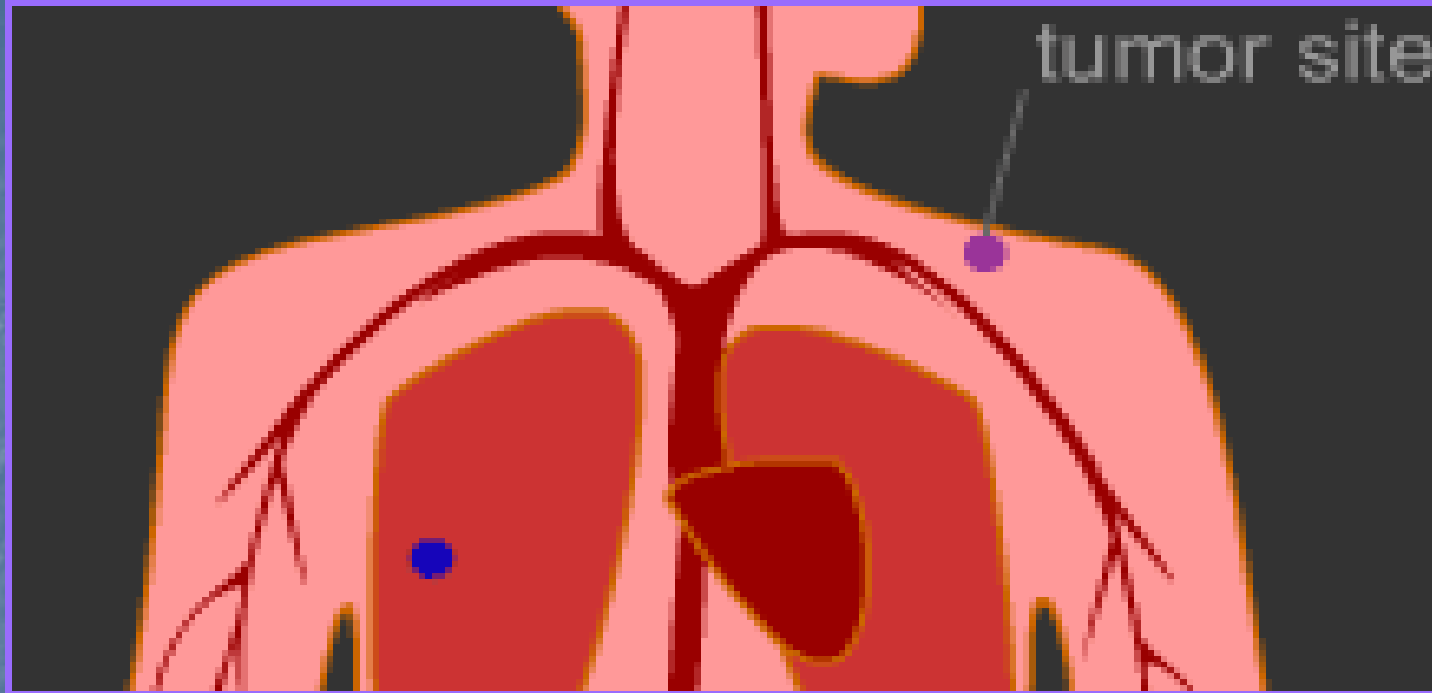
# 10. Tumour cells travel - metastasis

- What makes most tumours so lethal is their ability to **metastasize** -- that is, establish new tumour sites at other locations throughout the body. **Secondary tumours.**



- Metastasis is now underway, as tumour cells from the original cancer growth travel throughout the body. Most of these cells will die soon after entering the blood or lymph circulation.

# 11. Metastasis



- To form a **secondary tumour**, a tumour cell needs to leave the vessel system and invade tissue. The cell must **attach itself** to a vessel's wall. Once this is done, it can work its way through the vessel and enter the tissue.

Although perhaps less than one in 10,000 tumour cells will survive long enough to establish a new tumour site, a few survivors can escape and initiate **new colonies** of the cancer.

# SUMMARY

## Normal Cell Division

1. DNA is replicated properly.
2. Chemical signals start and stop the cell cycle.
3. Cells communicate with each other so they don't become overcrowded.

## Cancer Cells

1. Mutations occur in the DNA when it is replicated.
2. Chemical signals that start and stop the cell cycle are ignored.
3. Cells do not communicate with each other and tumors form.