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Photocopy Master Sheets

Years 9-10

Cell Division & DNA

Disk filename = "17.DNA"

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Topics Available

Year 7-8 General Science

Disk Filename	Topic Name
01.Energy	Energy
02.Forces	Forces
03.Matter	Solids, Liquids & Gases
04.Mixtures	Separating Mixtures
05.Elements	Elements & Compounds
06.Cells	Living Cells
07.Life	Living Things
08.LifeSystems	Plant & Animal Systems
09.Astronomy	Astronomy
10.Earth	The Earth
11.Ecosystems	Ecosystems

Year 9-10 General Science

Disk Filename	Topic Name
12.Waves	Wave Energy (inc. Light)
13.Motion	Forces & Motion
14.Electricity	Electricity
15.Atoms	Atoms & Elements
16.Reactions	Compounds & Reactions
17.DNA	Cell Division & DNA
18.Evolution	Evolution of Life
19.Health	Health & Reproduction
20.Universe	The Universe
21.EarthScience	Earth Science
22.Resources	Resources & Technology

Year 11-12 Science Courses

Biology

Preliminary Core
Local Ecosystem
Patterns in Nature
Life on Earth
Evolution Aust. Biota
HSC Core
Maintain. a Balance
Blueprint of Life
Search for Better Health
Options
Communication
Genetics:Code Broken?

Chemistry

Preliminary Core
Chemical Earth
Metals
Water
Energy
HSC Core
Production of Materials
Acidic Environment
Chem.Monit.&Mngment
Options
Shipwrecks, Corrosion...
Industrial Chemistry

Earth & Envir. Science

Preliminary Core
Planet Earth...
Local Environment
Water Issues
Dynamic Earth
HSC Core
Tectonic Impacts
Environs thru Time
Caring for the Country
Option
Introduced Species

Physics

Preliminary Core
World Communicates
Electrical Energy...
Moving About
Cosmic Engine
HSC Core
Space
Motors & Generators
Ideas to Implementation
Options
Quanta to Quarks
Astrophysics

All Topics Available as PHOTOCOPY MASTERS and/or KCiC

Photocopy Masters (PDF files)
Black & White, A4 portrait-orientation for clear, economical photocopying.

KCiC = Key Concepts in Colour
Full colour, formatted for on-screen study and data projection. PDF + Powerpoint®
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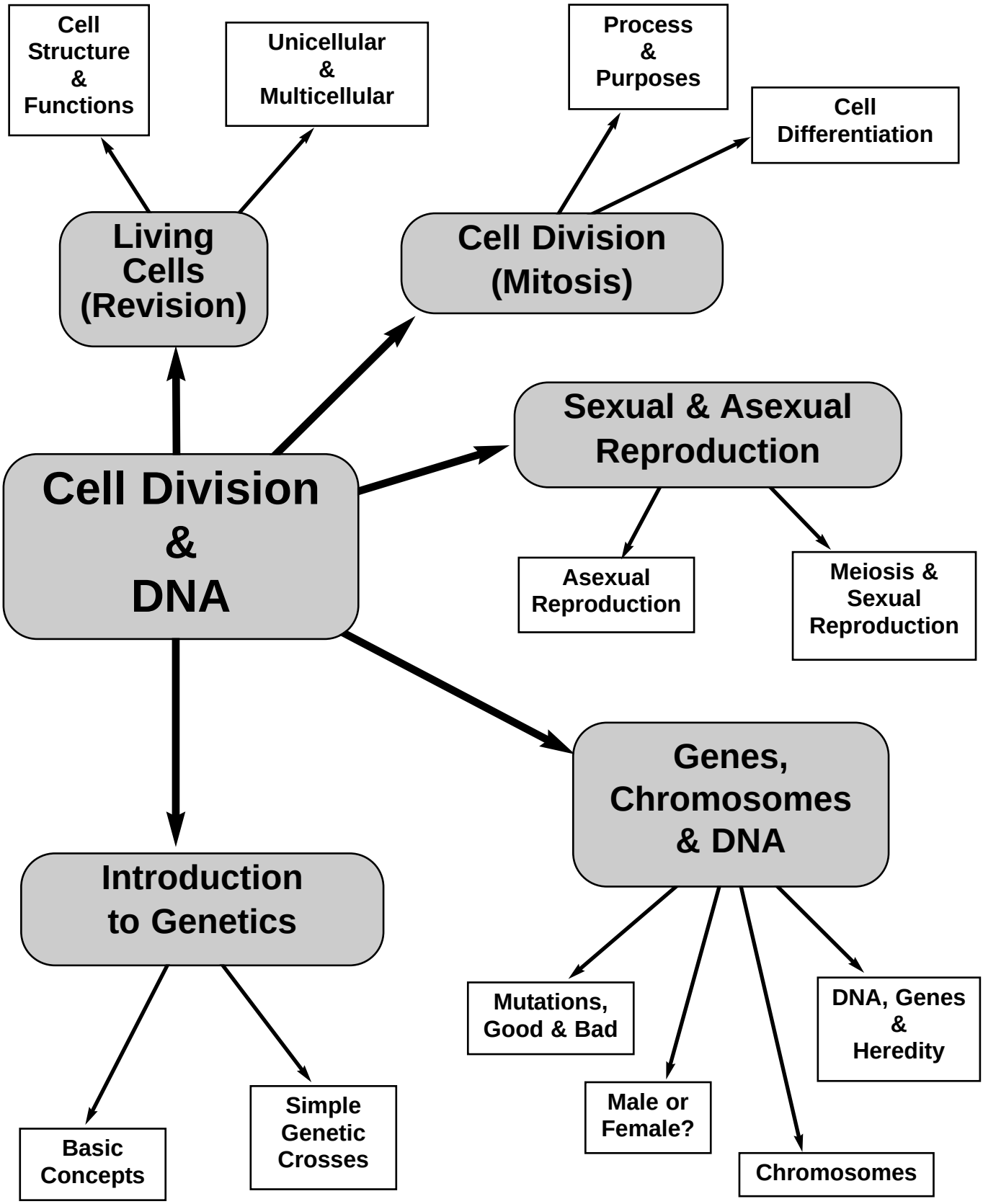
"Mind-Map" Outline of Topic

This topic belongs to the Biology branch of Science.
It follows on from previous studies of living cells and takes you into cell reproduction and an introduction to how biological inheritance works.



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Make your own "Mind-Map" TITLE PAGE.
Cut out the boxes. Sort them into an appropriate lay-out on a page of your workbook, then glue them down. Add connecting arrows and colour in.

Cell Division & DNA

Living Cells (Revision)

Introduction to Genetics

Genes, Chromosomes & DNA

Process & Purposes

Cell Structure & Functions

Cell Division (Mitosis)

DNA, Genes & Heredity

Male or Female?

Sexual & Asexual Reproduction

Basic Concepts

Chromosomes

Simple Genetic Crosses

Meiosis & Sexual Reproduction

Unicellular & Multicellular

Mutations, Good & Bad

Asexual Reproduction

Cell Differentiation

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Unicellular & Multicellular

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Asexual Reproduction

Cell Differentiation

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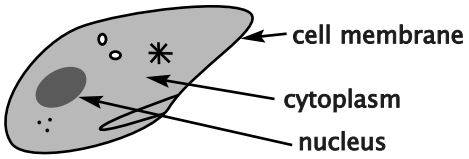
The Structure & Function of Living Things

The Structure of Life: CELLS

You have already studied living cells. Cells give us a structural way to define what a living thing is.

"All living things are composed of cells, or are the product of cells".

This statement is called "The Cell Theory".



Some living things are unicellular... they are composed of one, single cell.

All the familiar plants and animals are multicellular... they are composed of many cells, usually billions.

The Functions of Life

Every cell and all living things carry out certain, basic "life functions".

Every cell, and all living things:

- take in substances from their surroundings, and assimilate them.
  (Things taken in include food, water & oxygen. "Assimilation" means that the substances taken in are used to build new cells and grow body parts... they become part of the organism.)
- extract energy from their food.
- excrete their wastes.
- grow.
- reproduce their own kind.
- respond to things that happen.

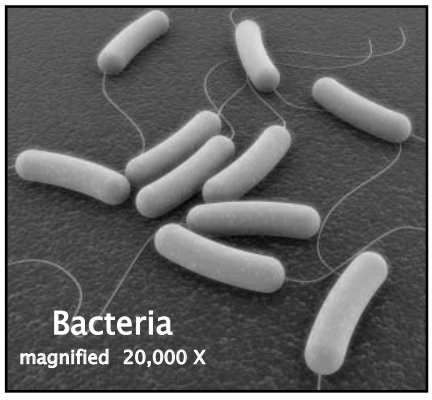
Unicellular & Multicellular Organisms

"Uni-" = one. "Multi-" = many. "cellular" = made of cells.

Unicellular Organisms

There are many types of living things which are composed of just one, single cell.

One of the most common types is the bacteria.



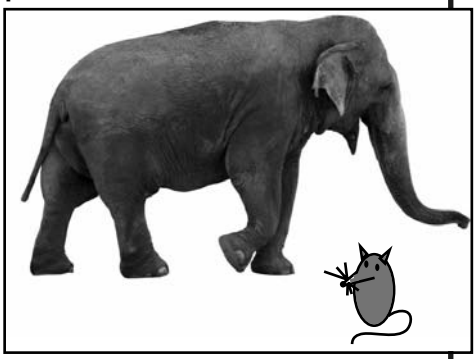
Bacteria live in every place you can imagine. They live in water & soil, and on and inside other living things.

You have millions of bacteria on your skin, in your mouth and throughout your gut.

Bacterial cells are very small, often only about $^{1}/_{1,000}$ mm long.

Multicellular Organisms

All the familiar plants and animals are multicellular... they are made up of billions of cells.



The cells are all pretty much the same size. For example, the cells in a mouse are exactly the same size as the cells in an elephant... the elephant simply has a lot more cells.

The single cell of a unicellular life-form must be able to do everything.

In a multi-cellular creature, however, each part of the body is specialised to do a particular job, and usually has many different specialist cells. For example, muscle cells are different to nerve cells, and blood cells are different again.

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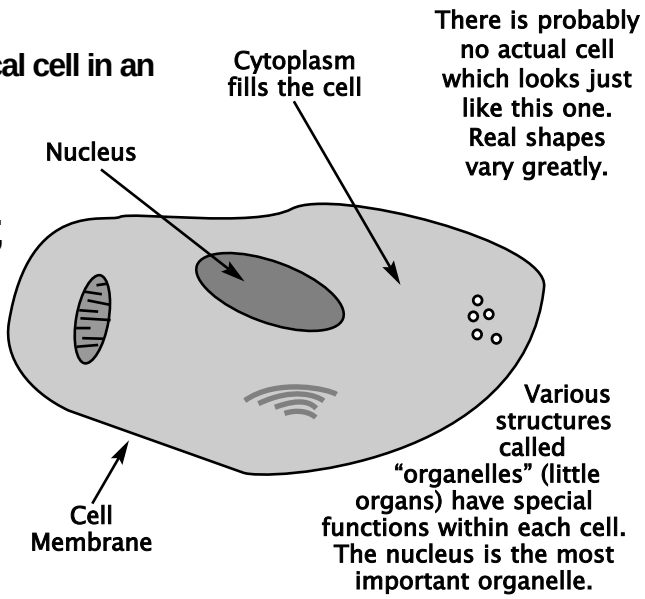
Living Cells

All living things are composed of microscopic "bags of life"... cells.
Here is a quick revision of what you have studied previously, AND MUST KNOW.

Animal Cells

The diagram shows the main features of a typical cell in an animal.



Nucleus
This organelle is the "control centre" of the cell. The nucleus sends out "chemical messengers" to every part of the cell, to control all the cell processes.

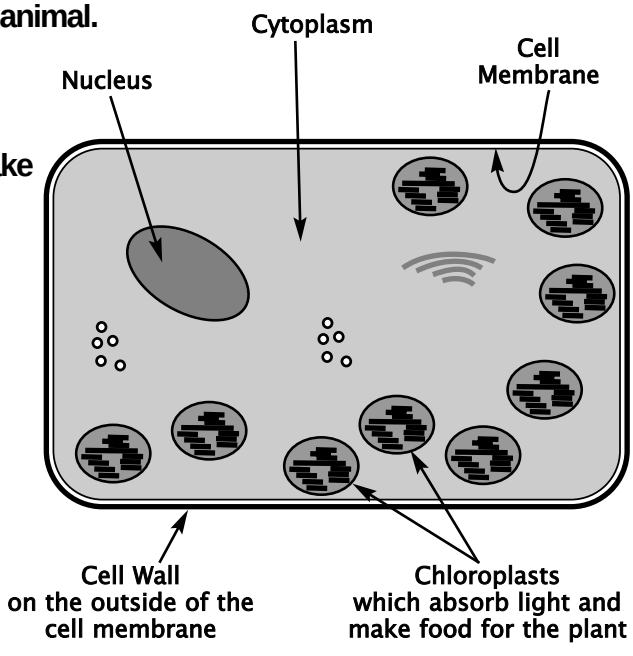
Cytoplasm
This a jelly-like liquid which completely fills the cell. It is mostly water, with thousands of different kinds of chemicals dissolved in it. Also suspended in the cytoplasm are many small structures called "organelles".

Many chemical reactions are constantly occurring in the cytoplasm solution, and within the organelles. "Life" is mostly a matter of chemistry.

Cell Membrane
Surrounding the cell, and containing it, is an extremely thin, flexible layer. This membrane not only holds all the cell parts together to form a little bag of life, but it controls all the chemicals which enter or leave a cell.

Plant Cells

Plant cells have all the same features of animal cells, but have 2 extra features that you need to know about. These are never present in an animal.



Chloroplasts
These are green-coloured organelles which absorb the energy of the Sun and use it to make food for the plant by the process of photosynthesis.

Not every plant cell has chloroplasts; only the leaves and sometimes the green stem.

Cell Wall
This is a tough, fibrous, non-living layer on the outside of the cell. It makes plant cells stronger and helps to maintain the stiffness and shape of thin leaves, petals and fragile roots.

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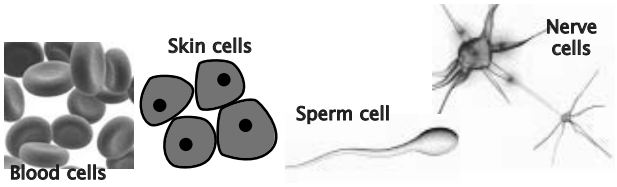
Body Structure of Multicellular Organisms

Plants and animals are made of many cells, but each organism is not just a jumble of cells living and growing in a big lump. There is always an organised structure to the way their bodies are built.

Different Cells

Firstly, not all the cells in a multicellular organism are the same. They are differentiated into many shapes and sizes.



Each cell type does a different "job" in the body, and has the shape, size and ability to match that function.

Tissues

A cell does not work alone. Thousands of cells of the same type band together to form a "tissue", such as muscle tissue, nerve tissue, bone tissue, and so on.

Organs

At the next level of organisation, a number of tissues are combined to form an organ, such as a heart, a kidney, a shin bone or an eye.

With muscle tissues, nerve tissues, connective tissues, etc, all working together, the organ carries out a particular function. e.g. the heart pumps blood, the eye senses light.

Organ Systems

A number of organs work with each other to carry out an overall task. For example, the heart, arteries, veins and capillary organs all connect to form the circulatory system which distributes substances around the body.
Other systems include the digestive system, the nervous system and so on.

Body Systems Serve the Needs of Cells

Every Cell Needs Things

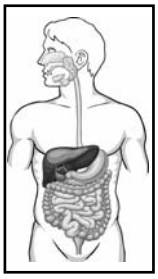
Every living cell needs food, water and oxygen. Each cell must be able to get rid of its waste products.

In a multicellular organism most of the cells are deep inside the body. They cannot get food, water or oxygen unless it is carried to them.

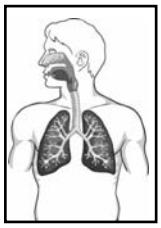
The major body systems carry out the tasks of getting food, water and oxygen and transporting them around so that every cell gets what it needs.

Digestive System

Cells need food.
The digestive system breaks food into suitable molecules and absorbs them into the bloodstream.



Respiratory System



Cells need oxygen, and must excrete carbon dioxide. The lungs, breathing tubes, blood vessels, etc carry out "gas exchange" so that each cell's requirements are met.

Circulatory System

The blood, heart, veins, etc have the job of distributing food, water, gases, wastes and heat to or from every living cell.

Other body systems allow for moving around to find food, to respond to the environment and to co-ordinate all activites.

Basically, it's all about meeting the needs of the body's cells.

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Worksheet 1
Cells & Organisms

Student Name.....

Fill in the blank spaces.

The Cell Theory states that "all living things are composed of a)..... or are the b)....."

Every cell, and every organism, carries out the basic "life functions":

- they take in substances and c)..... them.
- they extract d)..... from food.
- they e)..... their wastes.
- they f)..... (get bigger).
- they g)..... (make babies)
- they h)..... to things.

Some living things are i)..... and have only 1 cell. All the familiar plants and animals are j).....

All cells have certain basic parts:

- the k)....., or control centre.
- the cell l)..... which controls what gets in or out.
- the m)..... which is a liquid containing many chemicals and various structures called n).....

In addition, plant cells have o)..... for making food, and a cell p)..... on the outside.

Multicellular organisms have an organisation as follows. Cells of the same type form q)..... Various types are connected together to form an r)..... which has a particular function. A number of these work together in a s)..... which serves the needs of the t).....

Worksheet 2
Cells to Systems

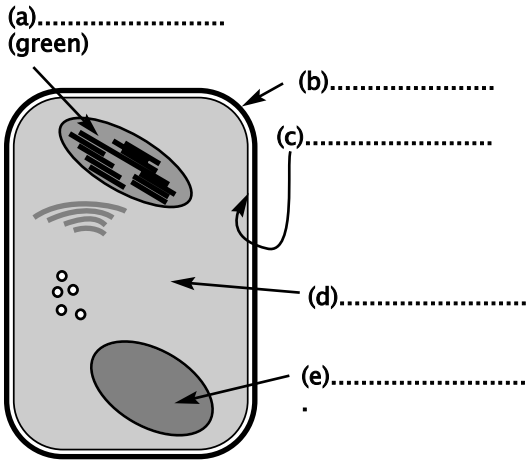
Student Name.....

1. Name a type of living thing which is unicellular. .....

2. How does the size of cells in an ant compare to the size of cells in a whale?

.....

3. Label the parts of this plant cell.



4. Re-arrange this list to show the levels of organisation in a multicellular organism.
List: tissues, body systems, cells, organs.

....
(simplest) ----------> (most complex)

5.
Explain the concept that "body systems serve the needs of cells".

To answer, refer to a body system (e.g. respiratory system) and link its function to the needs of all cells.

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Genetic Information

("Genetic" = to do with genes, which control inheritance)

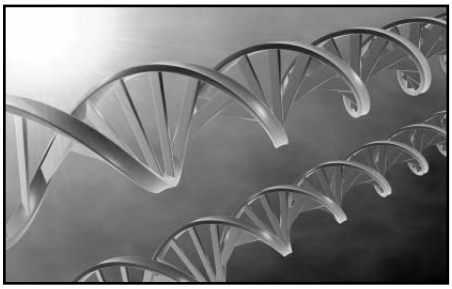
Every type of living thing must reproduce. Mice have baby mice, gum trees make seeds which grow into new gum trees, and bacteria make more bacteria.

Each living thing carries information on how to make offspring of its own type. Mice never make gum tree seeds, and horses do not give birth to cats.

The genetic information needed to accurately reproduce the same type of living thing is located in the nucleus of every living cell.

DNA

Genetic information is stored in a chemical known as DNA. DNA molecules are the largest known and carry a "code" within their helix-shape structure.



It is the DNA inside every cell nucleus which controls the cell and all its functions.

The key to reproduction is to make copies of the DNA and pass it on to the next generation.

How Does It Work?

For the exact details, you need to study Biology in years 11-12. Here is a basic outline:

DNA molecules are huge, but very simple in one sense... they are made of just 4 different "nucleotide" chemical units joined together by the thousands.

The exact sequence of nucleotides is a "genetic code" or chemical language.

A cell can "read" this code to make protein molecules to build functioning cells, tissues and organs. Every cell in your body contains all the DNA instructions to build a unique human organism... YOU!

Cell Differentiation

Every cell in the body has a complete set of all the DNA.
However, each cell only uses a small part of the total genetic information.

During the early stages of pregnancy, the tiny embryo grows rapidly by mitosis.

The cells divide, then divide again, doubling the number of cells each time.

At this stage the cells are all the same. They do not have any particular function. The embryo does not have any limbs, muscles, a heart, etc. If this continued, each animal (including you) would be just a big rubbery "blob" like a jellyfish.

Cells Become Specialised

Within a week after fertilisation, "cell differentiation" begins. Cells begin to follow particular instructions in their DNA so that they become specialised. For example, some cells follow DNA instructions to become (say) muscle cells.

Others ignore the "muscle instructions" and follow other parts of the DNA instructions to become nerve cells, or bone cells, etc.

Body organs, limbs and blood vessels begin to grow, so that the "cell blob" develops into a perfect little human, or kitten or gum tree, according to the DNA instructions.

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Purposes of Cell Division

All living cells are able to reproduce themselves by dividing in two.
The process is called "mitosis" and is detailed below.
The purpose of cell division depends on what kind of organism you consider.

Unicellular Life

Mitosis cell division is the way that unicellular organisms reproduce. Under ideal conditions, some bacteria can go through the whole cycle in an hour or even less.

If you started with 1 bacterial cell, and it divided in two every hour, how many would there be after 1 day?

Time (hours) >	0	1	2	3	4	5
No. of Bacteria	1	2	4	8	16	32

If you continue this calculation to 24 hours, you will have over 16 million cells!

Multicellular Life

In multicellular organisms, mitosis is how new cells are made for growth and repair. You started out as 1 single cell, but you now have billions. All multicellular organisms grow by adding new cells produced by mitosis.

Cells constantly need replacing as well. Blood cells have a short life span and must be replaced. Skin constantly flakes off, so new layers grow. The new cells are produced by mitosis.

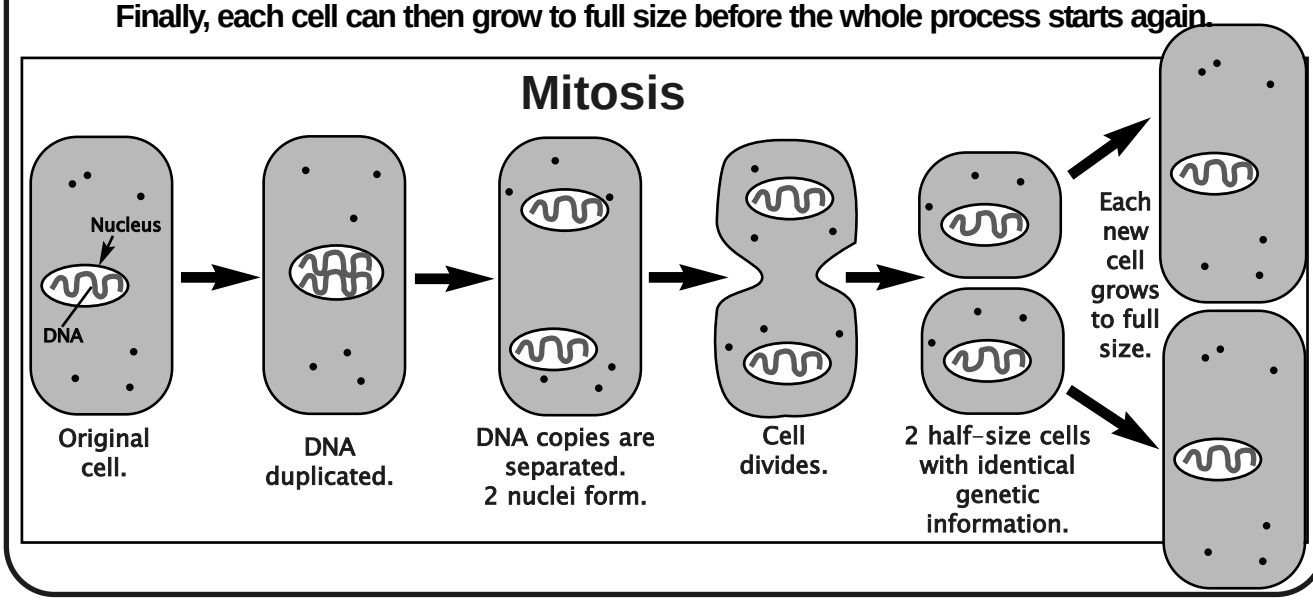
Cell Division - Mitosis

Each cell first makes a duplicate copy of the DNA in the cell nucleus. In many cells, DNA is contained within structures called "chromosomes". The DNA contains the genetic information which controls the structure and functioning of the cell and the entire organism.

Next, the 2 sets of genetic information are separated.
At this point it is as if the cell has 2 nuclei (plural of nucleus).

Then the cell itself divides into 2 smaller cells. Each new cell is only half-size but has a complete nucleus with a full copy of the genetic information in its DNA.

Finally, each cell can then grow to full size before the whole process starts again.



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Worksheet 3
DNA & Cell Division

Student Name.....

Fill in the blank spaces.

Living things reproduce their own kind according to the a)..... information stored in the chemical b)..... which is found in the c)..... of every living cell.

DNA molecules are huge, but are very simple in structure. They are made from just d)..... (number) different chemicals called "e)....." joined together in thousands. The precise sequence of these is a f)..... which cells can use to build g)..... and make cell parts, new cells, etc.

Every cell in your body has the complete set of h)..... molecules to specify every part of you. However, each cell only uses i)..... of the information.

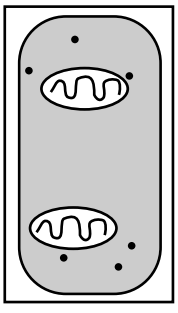
In an early embryo, the cells are all the same. Later, they begin to specialise or "j)....." Each cell has all the DNA, but only follows k)..... of the instructions, so it becomes a l)..... cell, or a m)..... cell, etc.

Simple cell division is called "n)....." In unicellular organisms, this is how they o)..... In p)..... organisms it is used for q)..... and to r)..... worn-out or damaged cells.

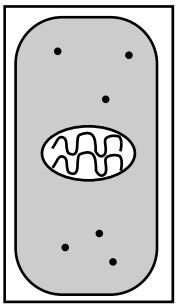
The first step in cell division is to make s)..... of the DNA. Next these copies are t)..... so the cell now has 2 u)..... The cell now divides into two cells, each one only about v)..... Finally, both new cells w)..... to full size before the process starts again.

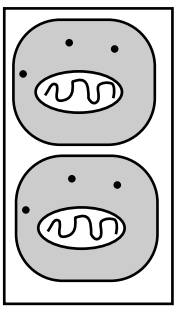
Worksheet 4 Mitosis

The process of cell division by Mitosis is all jumbled up in these diagrams and captions. Cut them out and re-arrange into correct order. Connect with arrows.



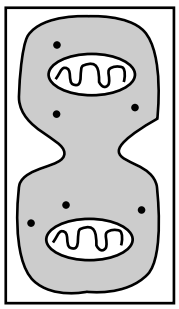
Each new cell grows to full size.





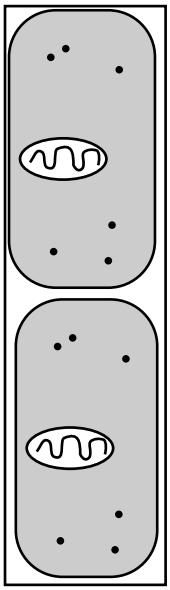
2 half-size cells with identical genetic information.

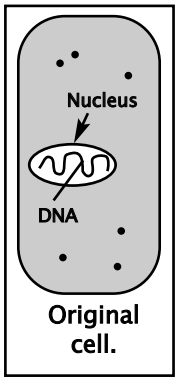
DNA duplicated.



DNA copies are separated. 2 nuclei form.

Cell divides.





Original cell.

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How Current Research Might Affect People's Lives

One of the areas of current biological research which may have enormous impacts on people's lives is known as "stem cell research".

What are "Stem Cells"?

Stem cells are unspecialised human cells that have not differentiated. They can be grown in the laboratory. If correctly stimulated, stem cells can differentiate into any kind of specialist cells such as nerve cells.

Possible Benefits of Research

By studying the way stem cells differentiate into specialist cells, scientists may learn how cancer cells begin. This could enable doctors to be able to "turn-off" tumour cells and cure many types of deadly cancer.

By stimulating stem cells to differentiate into specialist cells, scientists might eventually be able to replace damaged tissue to cure conditions such as Parkinson's Disease in which brain cells degenerate.

Another possibility is to replace the destroyed cells in the panceas which is the cause of diabetes.

Heart muscle damaged by a heart attack could be repaired.

Ultimately, it is possible (although probably far into the future) that stem cells could help to repair a kidney or liver which requires a transplant.

The promise of stem cell research is to be able to cure cancers, diabetes and many other diseases, plus repair organs which currently require transplants.

Social Factors Influence the Acceptance of Science

Stem cell research has the potential to benefit many people.
However, that does not automatically mean it will be accepted and used.
In fact, the research is currently restricted by law in Australia and many other countries because there are certain ethical, moral and religious issues involved.

Sources of Stem Cells

The best source of stem cells for research is from human embryos which are "left-overs" from IVF programs.

(IVF = in-vitro fertilisation or "test-tube baby" programs. This is where eggs are fertilised in the laboratory and the embryo is artificially implanted in the womb later. This helps some couples who are unable to have children normally.)

Although these embryos do not have a nervous system or any organs, many people consider them to be a human person. This raises the ethical issue of killing a person for research purposes.

The law in Australia currently allows excess IVF embryos to be used, but under strictly controlled licencing conditions. In some countries the research is banned completely.

Adult Stem Cells?

A type of stem cell can be extracted from adults. These stem cells are not as good for research because they will not undergo such a wide range of possible differentiations as embryo cells will.

A lot of research is going on to try to "re-program" adult stem cells to act like embryonic cells. This would remove most ethical, moral or religious objections to stem cell research.

Despite the huge potential to benefit human health, stem cell research is limited by social factors, such as people's religious and ethical beliefs.

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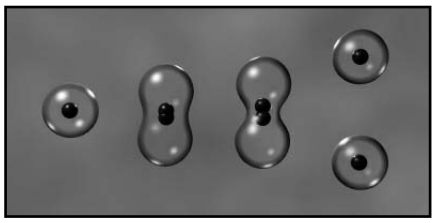
Sexual & Asexual Reproduction

("Sexual" = having male & female sexes. "Asexual"= no sexes.)
All living things reproduce themselves.
We are used to the idea that reproduction involves male and female parents who combine their genetic information to produce offspring.
However, many organisms do not need male and female parents to reproduce.

Asexual Reproduction

Unicellular Reproduction



Single-celled organisms such as bacteria reproduce by simply dividing in two by mitosis.

There is no need for "males" and "females". Each cell can be a parent.

The offspring cells are genetically identical to each other, and to their single "parent cell".

Regardless of the details, asexual reproduction always:

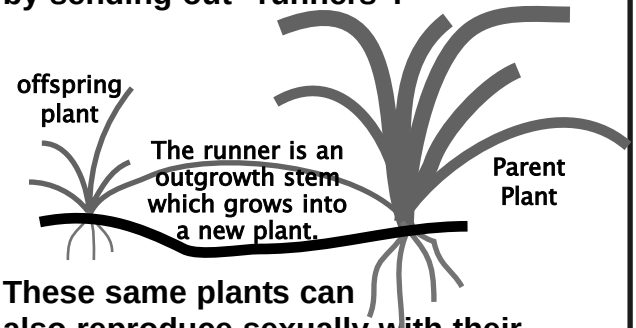
- **requires only one parent.**
- **involves mitosis cell division.**
- **produces offspring which are genetically identical to the parent and to each other.**

Asexual Reproduction in Multicellular Life

Many multi-cellular organisms are able to reproduce asexually.

Fungi, such as mushrooms, reproduce by releasing "spores". Each spore is a single cell which can grow into a new fungus. The spore cells are produced by mitosis, and released from a single "parent".

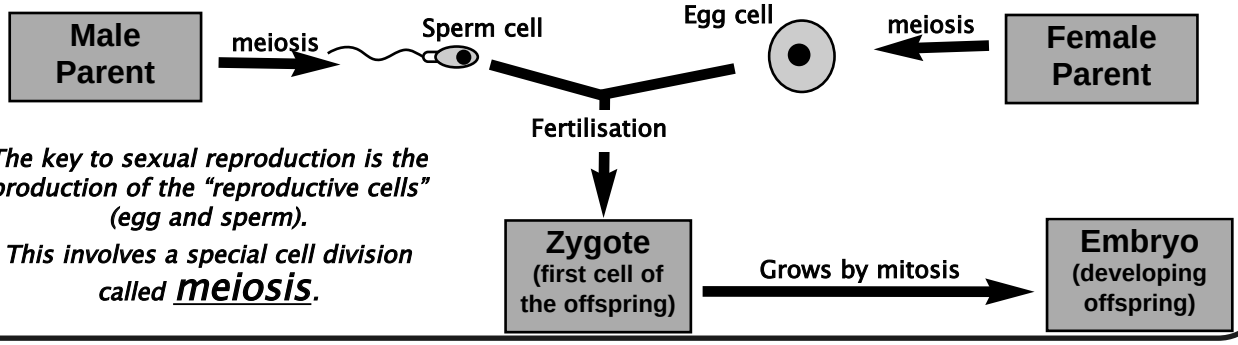
Many Plants can reproduce asexually by sending out "runners".



These same plants can also reproduce sexually with their flowers.

Sexual Reproduction

Sexual reproduction always involves 2 parents who combine part of their genetic information to produce offspring which are different to both parents.



The key to sexual reproduction is the production of the "reproductive cells" (egg and sperm).

This involves a special cell division called ***meiosis****.*

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Meiosis & Sexual Reproduction

In a later topic you will study the human reproductive systems.
Here we are concerned only with what is happening at the level of cells.

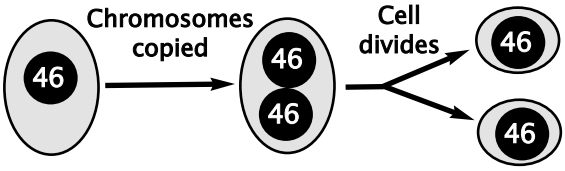
Meiosis Cell Division

Chromosomes

You will learn more in the next section, but for now you need to know that the genetic information (DNA) in each cell is located in thread-like structures called chromosomes. These can be seen within the cell nucleus during cell division.

The number of chromosomes varies from species to species. In humans, every body cell has 46 chromosomes in the nucleus.

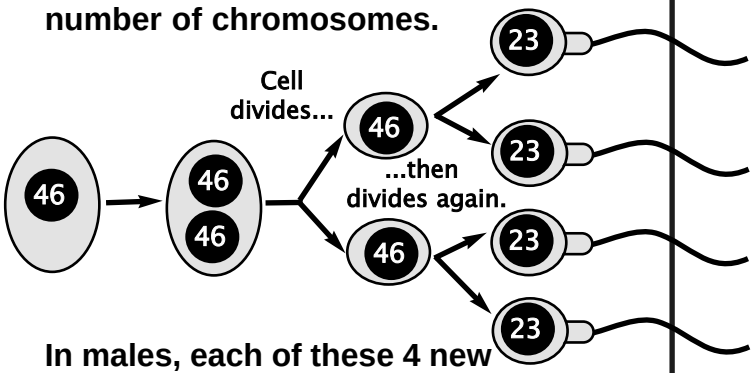
During mitosis, the chromosomes (and the DNA they contain) are first copied, then divided between the "daughter cells".



The result is that each new cell has a full set of chromosomes and complete copy of all the genetic information.

Meiosis Halves the Chromosomes

To produce the reproductive cells or "gametes" a different cell division occurs. In meiosis, the chromosomes are copied, but then the cell divides twice to form 4 cells with only half the number of chromosomes.



In males, each of these 4 new cells becomes a sperm cell.

In human females, only 1 of the 4 new cells develops into an egg. The other 3 never develop.

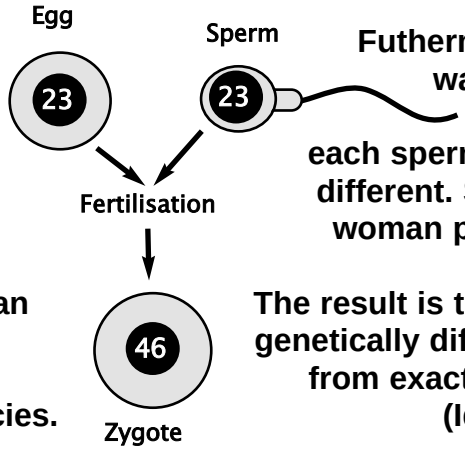
The main point is that both sperm and egg have only half the normal number of chromosomes.

Fertilisation Restores the Chromosome Number

When a sperm cell fertilises an egg, their nuclei combine and the chromosomes of each are added together.

This restores the chromosome number so the offspring has the correct number for that species.

Meiosis is essential for sexual reproduction so that 2 parents can contribute chromosomes to the offspring, while maintaining the correct total number for the species.



Since the offspring receives DNA from both parents, it is different to both.

Futhermore, because of the way the chromosomes separate in meiosis, each sperm a man produces is different. Similarly, each egg a woman produces is different.

The result is that each offspring is genetically different, even siblings from exactly the same parents. (Identical twins are an exception to this.)

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Worksheet 5
Sexual & Asexual Reproduction

Student Name.....

Unicellular organisms reproduce by simply a)..... Many multicellular organisms can reproduce b)..... as well. Fungi (such as c).....) produce special cells called d)..... which can grow into a new organism. Many plants can reproduce by sending out "e)....." which grow into a new plant.

Regardless of the details, asexual reproduction always:
- involves only f)..... parent.
- involves g)..... cell division.
- results in offspring which are genetically h)..... to each other and to their i).....

Sexual reproduction always involves j)..... parents and a special cell division called "k).....".

During this division, the number of chromosomes is reduced to l)..... of the number in a body cell. The special cells are known generally as "m).....", being n)..... cells in males and o)..... in females.

During sexual reproduction, the 2 gametes join together ("p).....") to form a new offspring cell called a "q).....". It then grows by r)..... cell division into an embryo. The number of s)..... in the offspring is restored by the joining of the t)..... at u).....

Worksheet 6
Comparing Processes

Student Name.....

Complete each table of comparison

Table 1	Asexual Reproduction	Sexual Reproduction
No. of Parents	a)	b)
Type of Cell Div. involved	c)	d)
Are offspring same as each other? (genetically)	e)	f)
Are offspring same as parent(s)? (genetically)	g)	h)

Table 2	Mitosis	Meiosis
No. of cells produced	a)	b)
No. of chromosomes in new cells (compared to original)	c)	d)
Are new cells the same as each other? (genetically)	e)	f)
Are new cells the same as parent cell? (genetically)	g)	h)
Type of Reproduction	i)	j)

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Genes, Chromosomes & DNA

You may be a little confused by these words and how they relate to each other. This section aims to make this clear.

What is a "Gene"?

A gene is a unit of inheritance. What colour eyes you have is determined by which "eye-colour genes" you inherited from your parents. Whether your hair is naturally straight, wavy or curly depends on the genes you inherited.

In some plants, the colour of the flowers depends on the genes inherited from its parents. In flies there is a gene which causes "hairy body" and another gene for "hairless". Other genes control wing shape and eye colour, etc.

In some cases the situation is much more complicated. Human height is determined by dozens of genes as well as by childhood health and nutrition.

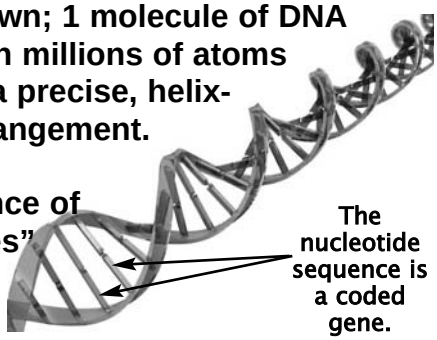
However, to keep it simple (K.I.S.S.)

one gene → one characteristic

is often true.

Genes & DNA

DNA is a chemical. Its molecules are the largest known; 1 molecule of DNA may contain millions of atoms bonded in a precise, helix-shaped arrangement.



The sequence of "nucleotides" along the DNA molecule is a chemical code.

This tells the cell how to build particular proteins and structures, or how to develop in a particular way.

Each gene is specified by the code in a different DNA molecule.

DNA molecule = a gene

Whether your hair is straight or curly is due to just a slight difference in the "code" sequence of a DNA molecule in the nucleus of your cells.

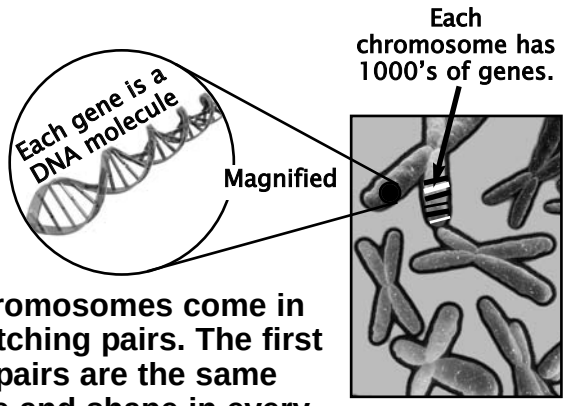
Chromosomes

The DNA molecules which are your genes are not just rattling around loose in the cell nucleus.

Thousands of genes are wrapped up together with protective proteins to form a thread-like structure called a chromosome. Many are roughly "X-shaped" as in the diagram.

Chromosomes are only visible (by microscope) during cell division.

In a human body cell there are 46 chromosomes. A sperm or egg cell has only half that number.



Chromosomes come in matching pairs. The first 22 pairs are the same size and shape in every human.

The 23rd pair are different in each half of the population. This pair of chromosomes are the "sex chromosomes" and determine if you are male or female.

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Male or Female? The Sex Chromosomes

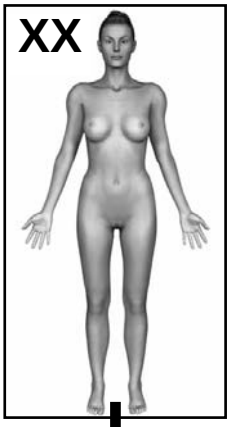
Human body cells have 46 chromosomes which are arranged in 23 pairs. The first 22 pairs are the same for everyone, although of course each person has their own particular set of genes.

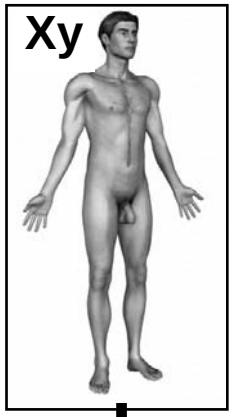
The 23rd pair of chromosomes are special... they determine your sex.

Female

A woman's 23rd pair are a matching pair of large, X-shaped chromosomes. This is referred to as "XX".

When she produces eggs by meiosis, each egg gets one of each pair, so every egg carries a single "X" chromosome.



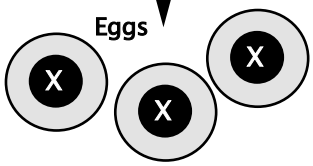


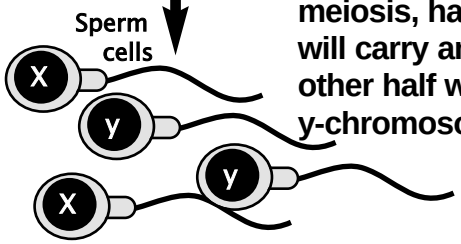
Male

A man's 23rd pair do not match. He has one large "X" chromosome, but its partner is a small, stubby chromosome called "y". He is "Xy".

When he makes sperm cells by meiosis, half of them will carry an X, the other half will have a y-chromosome.

Meiosis

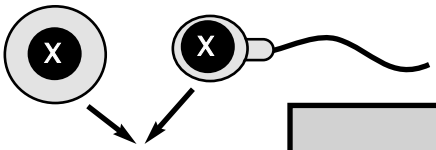




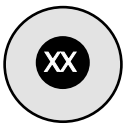
Dad Determines the Sex of the Baby

Millions of sperm cells race to fertilise the egg. Which one wins the race is pretty much random chance.

If the egg is fertilised by a sperm cell carrying an X-chromosome:



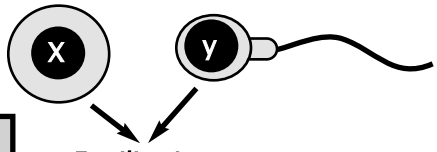
Fertilisation



This zygote will develop into a baby girl.

At puberty her hormones will re-shape her body and bring eggs to maturity on a regular cycle.

If the egg is fertilised by a sperm cell carrying a y-chromosome:



Fertilisation

This zygote will develop into a baby boy.

The y-chromosome contains just a few critical genes which cause the development of male organs. At puberty, his hormones do the rest.

Punnett Squares

A Punnett Square is a way to work out the probabilities of inheritance.
All the possible genes or chromosomes from each parent are shown on the outside, and then all the possible combinations are shown inside the table.

Father's sperm	Mother's eggs: X	Mother's eggs: X
X	XX	XX
y	Xy	Xy

Offspring Probabilities: Boys = 50% chance, Girls = 50% chance

DNA Replication

One of the critically important steps in cell division is when duplicate copies of the genetic information, the DNA, is made. This copying is called "replication".

Most of the time the copying is perfect, but occasionally mistakes occur.

Importance of Accurate Replication

Every cell depends on its DNA instructions to operate properly and efficiently.

If an error occurs in DNA replication during mitosis cell division, the "daughter cells" may receive DNA in which the genetic code has been changed. Sometimes a small change might not make any difference, but some changes could be fatal to the cell, or the entire organism.

For example, if a mistake in DNA replication changed a gene needed for cellular respiration, the cell would not be able to get energy from food. The cell would die.

If this happened frequently to many cells, then an entire body organ might shut down and the whole organism could die. Luckily, it's not that common.

Mutation

Accidental changes to DNA, or to an entire chromosome, do happen. These changes are called "mutations".

Certain chemicals or radiations can cause mutations, but sometimes they just happen by accident during DNA replication.

In a Body Cell, a mutation may cause the death of that cell, but this may have no effect on the whole organism. In some cases, a mutated body cell may develop as a cancer cell. This may become life-threatening.

In a Gamete, a mutation may kill the egg or sperm cell, or kill the embryo. Some disorders, such as Cystic Fibrosis, can be caused by a mutation which has carried through an egg or sperm to affect the whole person.

Generally, mutations are not good news!

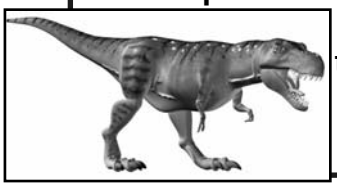
Beneficial Mutations

Most mutations are detrimental to the cell, or the organism, in which they occur. However, a very small percentage of mutations do no harm. These are vital to life on Earth!

Evolution of Life

We know that life on Earth has changed dramatically over many millions of years. In a later topic you will learn more about the facts of these changes.

You will also study the scientific explanation for how these changes have occurred. This is the Theory of Evolution, which underpins modern Biology.



Importance of Variations

When you study Evolution, you will find out how important it is for any species to have variations from one individual to another. Ultimately, these variations all begin as mutations.

Mutations are usually bad for individuals, but are good for the survival and evolution of the whole species. Look out for this idea again later!

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Worksheet 7
Genes & Chromosomes

Student Name.....

Fill in the blank spaces.

A unit of inheritance is called a "a).....". Each simple characteristic of every organism is controlled by a gene inherited from the parent(s).

Each gene is actually a molecule of b)..... These molecules are huge, but are simple in structure. They are composed of only c)..... (number) chemical units called "d)....." joined in thousands in long, coiled chains. The exact e)..... of these is a f)..... which the cell can "read" to build g)..... molecules to make cell parts, or to develop in a cetain way.

The DNA molecules are packed into structures called h)..... visible during cell division.

Each i)..... may contain 1000's of j)..... packed with protective proteins in structures that are often k).....-shaped.

In humans, a body cell contains l)..... chromosomes, arranged in 23 m)..... One pair are the "n)..... chromosomes" which determine if you are o)..... or ..... Females have a matching pair described as p)..... Each egg passes on q)..... from each pair, so all eggs contain one r).....

Males have sex chromosomes s)..... Sperms cells contain either t)..... or ..... Which type of sperm cell u)..... the egg determines the v)..... of the baby.

Worksheet 8
Replication & Mutations

Student Name.....

Answer the following questions.

1. What is "DNA replication" and when does it occur?

2. Why is it important that DNA replication is done accurately?

3. What is a "mutation"?

4. What things can cause mutations?

5. a) If mutation occurs in a body cell, and the cell dies, is this a problem for the organism?

b) If the mutated cell does not die, what might happen?

c) When can a mutation affect every cell in an organism?

6. In general terms:
a) is mutation usually good or bad for an individual?

b) is mutation good or bad for the survival of a species?

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Introduction to Genetics

Genetics is the study of how the inheritance of characteristics works.

A Little History

A good way to learn the basics of genetics is to learn about how it was discovered. About 150 years ago, in a monastery in central Europe, a monk with an interest in Science did some breeding experiments in the vegetable garden. His name was Gregor Mendel (1822-84).

Mendel's Pea Plants

Mendel noticed that some of the garden pea plants always grew tall, but others were dwarf, no matter how well they were cared for. He decided that the difference must be inherited, and that parent plants must be passing on genes for height; either "tallness" or "dwarfness".

He figured out (from the later results) that each plant must have two genes for either tall stem (symbol "T") or for dwarf stem (symbol "t").

Plant gametes are called "ovules" (eggs) and "pollen" (sperm). They are produced in the flowers.

Mendel controlled the breeding by placing pollen from his selected "father plants" onto the flowers of "mother plants".

Pea plants can also be "self-pollinated", or crossed with themselves.

When these parent plants made gametes by meiosis, only one of these genes was passed into each gamete.

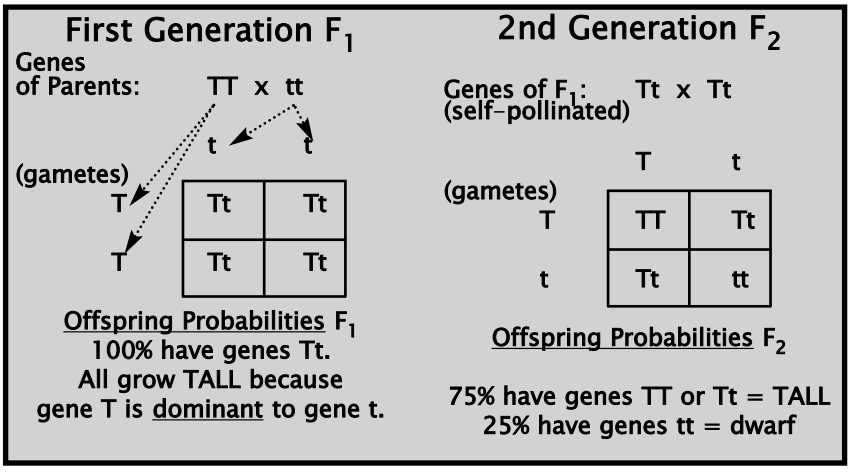
The fertilised eggs became seeds which Mendel planted and grew. Every one grew tall.

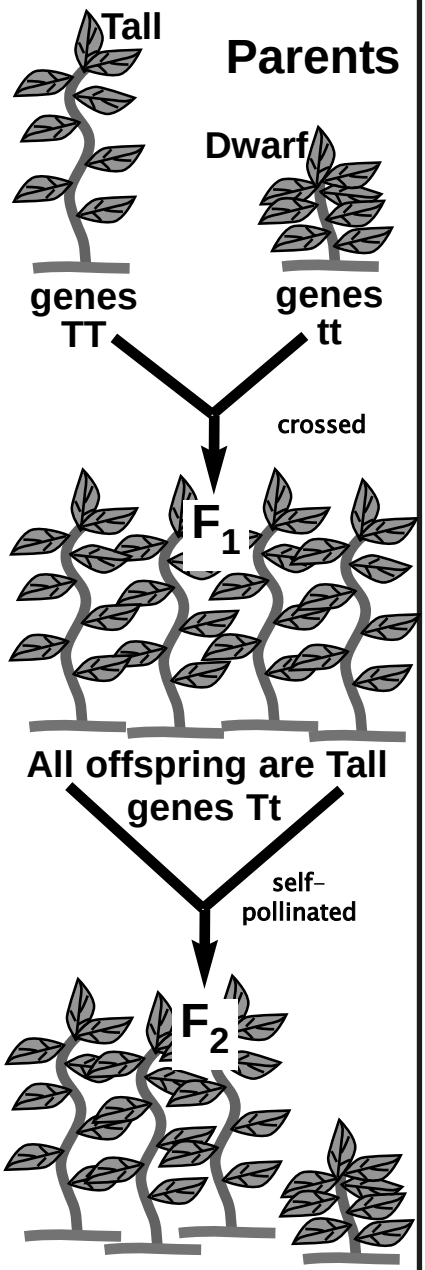
He explained this as follows:

- **Each parent has passed on one of its height genes.**
- **All the offspring plants (F_1) received genes Tt.**
- **Gene "T" is dominant to gene "t", so all are tall.**

Next he bred a second generation (F_2) by self-pollinating the F_1 plants. They produced seeds which he grew in hundreds. 75% of these grew tall and 25% were dwarf.

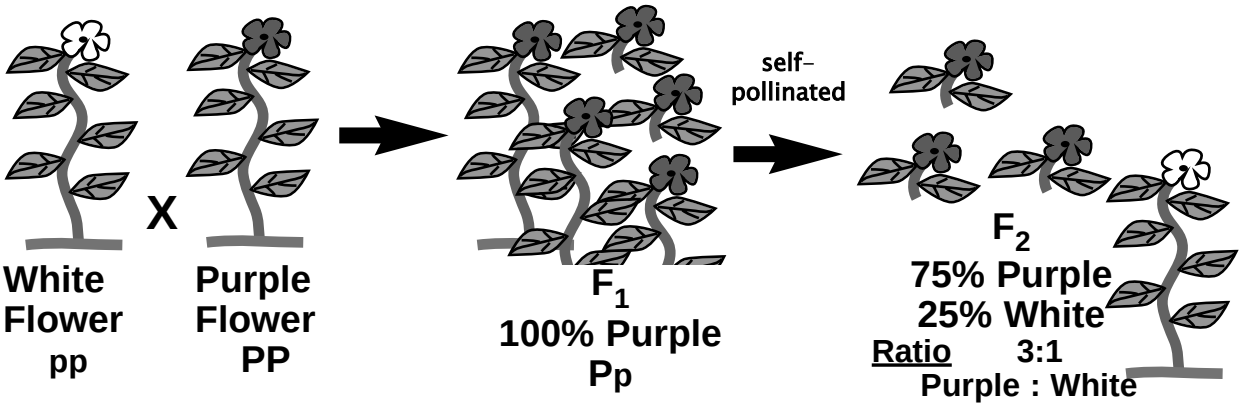
These Punnett Squares explain why:





More about Mendel

Gregor Mendel didn't stop with plant heights.
He also experimented with flower colours, seed shape, pod shapes, etc.



Everytime Mendel carried out the experiment he got the same results:

- **F_1 plants were 100% like one parent only, because one gene is dominant to the other.**
  (The other one is said to be "recessive")
- **F_2 plants always showed a ratio approximately 3:1 (75% : 25%) of the dominant type to the recessive type.**

F_1

Genes of Parents: PP x pp

(gametes)	p	p
P	Pp	Pp
P	Pp	Pp

Offspring Probabilities F_1
100% have genes Pp.
All have PURPLE FLOWERS because gene P is dominant to gene p.

F_2

Genes of F_1: Pp x Pp (self-pollinated)

(gametes)	P	p
P	PP	Pp
p	Pp	pp

Offspring Probabilities F_2

75% are PP or Pp = PURPLE
25% have genes pp = white

We now know that many genes operate this way.
Many characteristics have 2 alternative forms (e.g. tall-dwarf, purple-white, etc) controlled by 2 genes, one of which is dominant, the other recessive.

For each characteristic, an organism carries 2 genes in its DNA. The 2 genes could be the same (e.g. TT or tt) or may be different (Tt). When gametes (sex cells) are formed by meiosis, only one of the 2 genes is passed on. The offspring receives one gene from each parent. Dominance-recessiveness then determines which characteristic the offspring will have.

Be aware also, that many genes DO NOT operate in this "Mendelian" way... but that's another story.

Some Genetics Words to Learn

Alleles = the alternative genes for a characteristic. e.g. "T" and "t" are the alleles for stem height in Mendel's peas.

Genotype = the genes an individual has for a characteristic. e.g. a dwarf pea has the genotype "tt". Genotype "Tt" would grow TALL.

Notice how dominant genes are symbolised by CAPITAL letters and recessive genes by the same letter in lower case.

Phenotype = the appearance of the organism caused by its genes. (e.g. genotype "tt" results in the phenotype "dwarf". Phenotype "TALL" could have genes TT or Tt.

Homozygous = having 2 genes the same. (e.g. "TT" or "tt")

Heterozygous = having 2 different genes. (e.g. "Tt")

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Tutorial Worksheet 9
Simple Genetic Crosses

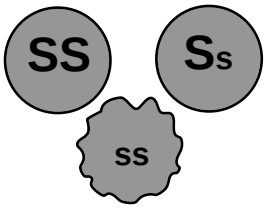
Student Name.....

1. Fill in the blank spaces.

Another characteristic that Mendel studied was seed shape. He found that there are 2 alleles:

Gene "S" causes smooth seeds.

Gene "s" causes wrinkled seeds.



Smooth is a)..... over wrinkled, which is b).....

Possible Genotypes & Phenotypes

c)..... = wrinkled

Ss = d).....

SS = e).....

A plant with genotype Ss was crossed with a plant with wrinkled seeds.

f) Genotypes of these plants? ..... x .....

Complete the Punnett Square by filling in the blank spaces.

wrinkled seed parent gametes

Ss parent gametes	g).....	.....
h).....	i).....	.....
.....	.....	.....

Phenotypes of Offspring	Smooth seeds	:	wrinkled seeds
j) percentages	.....%	:	.....%
k) ratio	.....	:	.....

2. Some fruit-flies have bodies covered in hairs, some are "hairless".

hairless

hairy

If you cross "pure-breeding" hairy flies with "pure-breeding" hairless flies, the offspring are 100% hairy.

a) Which characteristic is dominant? .....

b) Suggest a suitable symbol for this gene. .....

c) Which characteristic is recessive? .....

d) Suggest a suitable symbol for this gene. .....

Complete the Punnett Squares for the following crosses.

e) Hh x Hh

gametes	.....	.....
.....	.....	.....
.....	.....	.....

Offspring Phenotypes Hairy : hairless

ratio ..... : .....

f) Hh x HH

gametes	.....	.....
.....	.....	.....
.....	.....	.....

Offspring Phenotypes Hairy : hairless

percent ..... : .....

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Worksheet 10
Simple Genetics Problems

Student Name.....

For each genetic cross described, fill in:
a) the genotypes of parents (if not given)
b) the genes passed on in gametes.
c) the genotypes of offspring (in the body of the Punnet Square table).
d) the phenotypes of the offspring, as percentages, fractions or a ratio, as instructed.

1. In mice, black fur (B) is dominant to albino (b). ("albino" produces white fur).

a) Show the details of crossing a pure-breeding black mouse (BB) with an albino.

Parents: ..... x .....

gametes ....

.....		
.....		

Phenotypes of Offspring Black : Albino

percentages ..... : .....

b) The offspring from this cross were allowed to mate among themselves. Work out the result in the F_2 generation.

Parents: ..... x .....

gametes ....

.....		
.....		

Phenotypes of Offspring Black : Albino

ratio ..... : .....

2. In fruit flies, a gene "H" causes hairs to grow on the body. Gene "h" causes no hair to grow.


Work out the details of the cross:

Parents: Hh x hh

gametes ....

.....		
.....		

Phenotypes of Offspring hairy : hairless

percentages ..... : .....

3. Another set of alleles in fruit flies controls wing shape. A gene "N" produces normal wing shape, while "n" causes "vestigial wing" which is short, stubby and useless for flying.
(insects with vestigial wings are not called flies... they are "walks")


Normal wing fly Vestigial wing

Work out the outcome of this cross.

Parents: Nn x Nn

gametes ....

.....		
.....		

Phenotypes of Offspring Normal : vestigial

ratio ..... : .....

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Mendel's Genes, Cell Division & Chromosomes

Gregor Mendel knew nothing about chromosomes or the details of cell division because these things had not been discovered when he was breeding pea plants. You may have already noticed how Mendel's genes follow "rules" which match what happens to chromosomes during cell divisions, especially meiosis.

Comparison:

Mendel's Genes	Chromosomes
Each plant has 2 genes for each characteristic.	Chromosomes in body cells are always in pairs.
Only 1 of the 2 genes is passed into a gamete.	Meiosis halves the chromosome number.
The offspring receive 1 gene from each parent at fertilisation.	The offspring get chromosomes from each parent and get back to having pairs.

When chromosomes were first discovered and scientists studied what happened to the chromosomes during mitosis and meiosis, this comparison became obvious.

The genes must be located on the chromosomes.

About 100 years after Mendel's experiments, the structure of the DNA molecule was discovered.

Genes are made of DNA.
The 2 genes for any characteristic are located one on each of the chromosomes in a pair.

Genetics versus Environment

Is every characteristic of every living thing determined entirely by its genes? No, definitely not! The genes give each organism a "potential" to which it may develop, but the environment determines if that potential is reached.

Tall Plants in Poor Soil

Imagine growing some of Mendel's pea plants. You have plants which have genotype "TT". These genes will cause them to grow tall... or will they?

If these plants are grown from seed in very poor soil and choked with weeds they cannot grow tall, and may be "stunted" and have fewer leaves. Although genetically tall, their environment has not allowed them to reach their genetic potential for height.

Nature v. Nurture

(nurture = how you are brought up)

Statistics show that, on average, Australians have been getting taller every generation for about 100 years.

Why are humans getting taller?
(Be aware that the genetics of height in humans is much more complicated that in pea plants.)

Scientific studies have shown that it's not the genes that have changed, but improvements to health and nutrition available in society. 100 years ago, fewer people reached their genetic potential, so average height was less.

Similarly, the high rate of obesity in our society is not due to genetics, but to changes in eating habits and lifestyles.

Overall, scientists believe that many characteristcs are about 50% due to genes, and about 50% due to environment.

keep it simple science

Topic Test
Cell Division & DNA

Student Name..... Score = /25

Answer all questions in the spaces provided.

1. (5 marks)
Match each description to an item from the list. To answer, write the letter (A,B,C, etc) of the list item beside the description.

Description	matches with	List Item
a) Part of a cell where DNA is located		.....
b) Cell division which produces gametes.		.....
c) Thread-like structure containing genes.		.....
d) Cell division involved in asexual reproduction.		.....
e) Change to DNA during replication.		.....

List Items Not all will be used. Some may be used more than once.

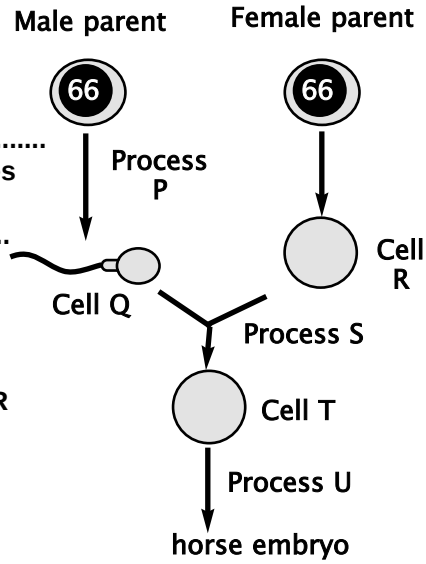
A. mitosis
B. meiosis
C. nucleus
D. mutation
E. gene
F. chromosome

2. (4 marks)
With reference to a named body system and what it does, discuss the idea that "body systems serve the needs of cells".

3. (3 marks)
a) What is cell "differentiation"?

b) For cells to take different roles, does this mean each cell has different genetic "instructions"?

4. (8 marks)
This diagram summarizes the process of sexual reproduction in a horse. The circle shapes represent various cells. The number of chromosomes in a horse body cell is 66.



a) Name the process "P".

.....

b) Name cell types

Q = ...

R= .....

c) How many chromosomes would cells Q & R each have?

.....

d) Name cell "T" and state how many chromosomes it has. ....

e) Name process "S" .....

f) Name process "U" .....

5. (5 marks)
In Mendel's pea plants a gene for purple flowers (P) is dominant to white flowers (p). A plant with genotype Pp was crossed with a white flowering plant.

Predict the outcome by filling in the Punnet Square.

Parents: ..... x .....

gametes ....

.....		
.....		

Phenotypes of Offspring Purple : White

ratio ..... : .....

Answer Section

Worksheet 1

a) cells	b) products of cells
c) assimilate	d) energy
e) excrete	f) grow
g) reproduce	h) respond
i) unicellular	j) multicellular
k) nucleus	l)membrane
m) cytoplasm	n) organelles
o) chloroplasts	p) wall
q) tissues	r) organ
s) (body) system	t) cells

Worksheet 2

1. Bacteria
2.They are the same size.
3. a) chloroplast d) cytoplasm
b) cell wall e) nucleus
c) cell membrane
4. cells, tissues, organs, body systems
5. Every cell needs to get oxygen and to get rid of CO_2. The job of the respiratory system is to absorb oxygen into the blood and remove the CO_2. The respiratory system is doing this to meet the needs of all the cells in the body.

Worksheet 3

a) genetic	b) DNA
c) nucleus	d) 4
e) nucleotides	f) code
g) proteins	h) DNA
i) part	j) differentiate
k) part	l) muscle
m) nerve	n) mitosis
o) reproduce	p) multicellular
q) growth	r) replace

s) a duplicate copy

t) separated	u) nuclei
v) half-size	w) grow

Worksheet 4

See page 10 for correct sequence.

Worksheet 5

a) dividing in 2	b) asexually
c) mushrooms	d) spores
e) runners	f) one
g) mitosis	h) identical
i) parent	j) two
k) meiosis	l) half
m) gametes	n) sperm
o) eggs	p) fertilisation
q) zygote	r) mitosis
s) chromosomes	t) gametes

u) fertilisation

Worksheet 6

Table 1

a) 1	b) 2
c) mitosis	d) meiosis
e) yes	f) no
g) yes	h) no

Table 2

a) 2	b) 4
c) same	d) half
e) yes	f) no
g) yes	h) no
i) asexual	j) sexual

Worksheet 7

a) gene	b) DNA
c) 4	d) nucleotides
e) sequence	f) code
g) protein	h) chromosomes

i) chromosome
j) genes or DNA molecules
k) thread-shaped or X-shaped

l) 46	m) pairs
n) sex	o) male or female
p) XX	q) one chromosome
r) X-chromosome	s) Xy
t) X or y	u) fertilises

v) sex

Worksheet 8

1. It is the copying of the DNA which occurs just before a cell division.
2. It must be accurate or else the "daughter cells" would receive altered DNA instructions which might make them act abnormally, or be unable to function.

(cont. over)

Worksheet 8 (cont.)

3. An accidental change to DNA (a gene) or to a chromosome.
4. Some chemicals or radiation (or they just happen by accident)
5. a) Usually not. A single dead cell in a multicellular organism is totally insignificant and happens all the time.
b) It may develop into a cancer cell and become life-threatening.
c) If it occurs in a gamete, which then is involved in fertilisation, it can affect the whole offspring.
6. a) Generally bad, because if there is any effect it usually is detrimental.
b) Good. Mutations create new variations which contribute to species survival and evolution.

Tutorial Worksheet 9

1.

a) dominant	**b) recessive**
c) ss	**d) smooth**
e) smooth	**f) Ss x ss**
g) s, s	**h) S, s**
i) Ss, Ss,ss,ss	**j) 50% : 50%**

k) 1 : 1

2.

a) hairy	**b) H**
c) hairless	**d) h**

e)

Parents: Hh x Hh

gametes

	H	h
H	**HH**	**Hh**
h	**Hh**	**hh**

Phenotypes of Offspring **hairy : hairless**
3 : 1

f) Hh x HH

	H	h
H	**HH**	**Hh**
H	**HH**	**Hh**

Offspring **hairy : hairless**
100% : 0

Worksheet 10

1. a) BB x bb

	b	b
B	**Bb**	**Bb**
B	**Bb**	**Bb**

Offspring **Black : albino**
100% : 0

b) Bb x Bb

	B	b
B	**BB**	**Bb**
b	**Bb**	**bb**

Offspring **Black : albino**
3 : 1

2. Hh x hh

	h	h
H	**Hh**	**Hh**
h	**hh**	**hh**

Offspring **hairy : hairless**
75% : 25%

Worksheet 10 (cont.)

3. Nn x Nn

	N	n
N	NN	Nn
n	Nn	nn

Offspring **Normal : vestigial**
3 : 1

Topic Test

1.
a) C b) B c) F d) A e) D

2.
All cells need food, but large food molecules cannot get into a cell. The digestive system breaks food into smaller molecules for absorption into cells, via the blood. So, the system serves the needs of the cells.

3.
a) Differentiation is when cells specialise and take on different functions. e.g. muscle cell or nerve cell, etc.
b) No, all body cells have the same DNA instructions. To specialise, each one follows a different part of the total DNA.

4.
a) meiosis
b) Q = sperm, R = egg
c) 33
d) zygote, 66
e) fertilisation
f) mitosis (or growth)

5. Pp x pp

	p	p
P	Pp	Pp
p	pp	pp

Offspring **Purple : white**
1 : 1

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