Organisms are not immortal. They die due to aging, predation, diseases, natural disasters & accidental deaths. Therefore the ability to reproduce in order to ensure continuity of the species, is one of the fundamental characteristics of all living organisms.

There are two types of reproduction: (1) ____________________ (2) ____________________

**Asexual Reproduction** - rapidly reproduces large numbers of individuals, usually have an genetic composition to each other and to the single parent from which they are derived.

**Sexual Reproduction** - less rapid, often involves _______ parents and produces offspring which are genetically different. The fusion of haploid ______________ is often involved.

Apart from purely increasing numbers, reproduction may involve one or more of the following:

(a) a means of ____________________ and therefore helping a species ______________ to changing environmental circumstances;
(b) the development of ______________ stages in a life cycle which are capable of withstanding periods of drought, cold or other adverse conditions.
(c) the formation of spores, seeds or larvae which may be used to ______________ offspring and so reduce _________ competition as well as capitalizing on any genetic variety among the offspring.

### 12.1 Comparison of Asexual and Sexual Reproduction

<table>
<thead>
<tr>
<th></th>
<th>Asexual Reproduction</th>
<th>Sexual Reproduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Fusion of gametes</td>
<td>none</td>
<td>yes</td>
</tr>
<tr>
<td>2 Type of cell division</td>
<td>mitosis</td>
<td>meiosis</td>
</tr>
<tr>
<td>3 Genetic variety</td>
<td>usually identical</td>
<td>great genetic variety</td>
</tr>
<tr>
<td>4 Adaptation to environment</td>
<td>less adapted</td>
<td>better adapted</td>
</tr>
<tr>
<td>5 Number of parents</td>
<td>one</td>
<td>two</td>
</tr>
</tbody>
</table>

**Advantage of asexual reproduction:**
An individual with a genetic make-up suitable to a particular environment can reproduce rapidly in large numbers.

* In mosses & ferns, gametes are produced by a __haploid______ gametophyte generation by __mitosis___. These gametes do not introduce genetic variety.

* Spores are produced by __meiosis____ which give rise to genetic variability.

- **Dioecious:**
- **Monoecious:**
- **Cross-fertilization:**
- **Self-fertilization:**
Main methods by which variety among offspring are:
1. ____________________________
2. ____________________________
3. ____________________________
4. ____________________________

The process of asexual reproduction is normally more simple and straightforward. It is rapid and involves no parental care, the number of offspring is normally large.
Almost all organisms have a sexual phase at some stage in their life cycle. While simpler animals have retained the asexual process, most complex ones have abandoned it.
A major disadvantage of being totally reliant on the sexual process is that it is difficult to maintain a favourable genotype. Once an organism has adapted to a particular set of conditions, sexual reproduction will tend to produce different offspring. These may not be as well adapted as identical copies of the parents would be.
At least animals, with their ability to move from place to place, can search out conditions that suit any new variety. Plants do not move, therefore they retain the asexual process as part of their life cycle. Once a plant has successfully established itself in a suitable environment, it uses asexual means to rapidly establish a colony of identical, and therefore equally well-suited, individuals. They could reduce competition from other plant species, although with its identical genotypes it may be vulnerable to disease.

12.2 Asexual Reproduction
- production of _____________ from a single parent by mitosis without the fusion of gametes
- new organism is exactly like its parent
- takes place under _____________ conditions and it results in a rapid growth of the population
- There are several types of asexual reproduction:
  (1)_______________________, (2)__________________, (3)______________________, (4)_______________________, (5)_____________________________

12.2.1 Binary or Multiple Fission
- This occurs in single-celled organisms,
  e.g. protozoa and bacteria
  - In bacteria:
  Under favourable conditions, bacterial DNA replicates first then nucleoplasm divides into two, followed by the cell as a whole.
  Under unfavourable conditions, __________________________ forms which is resistant to desiccation, extremes of temperature and toxic chemicals.
  - Schizogamy (_______________________) occurs
    when a cell divides into many parts rather than just two,
    e.g. Plasmodium
12.2.2 Budding

- by yeast (a unicellular fungus) reproduces asexually under favourable conditions
- differs from binary fission in that the new part produced is smaller in size than the parent
- other examples: flatworms, annelids, cnidarians
- In colonial cnidarian Obelia: blastostyles give out buds called medusae for sexual reproduction

12.2.3 Fragmentation

- In Spirogyra, portions of the filamentous alga break away when the filament reaches a certain length. This drift away, attach themselves elsewhere and begin vegetative growth again.
- **Regeneration**: cell division to regenerate the missing parts of a body as a result of injury

Fragmentation: an organism regularly and spontaneously divides itself up

12.2.4 Sporulation

- *Mucor*, a saprophytic mould living on decaying bread
- **hyphae**: spreading the colony into a mycelium
- **sporangium**: contains spores
- **sporangioaphore**: erect hyphae with *columella* at tip
- **spores**: liberated when sporangium matures; small & light weight; can be carried over great distances by wind; germinate into new mycelium when suitable substratum is found
12.2.5 Vegetative propagation

- many flowering plants can reproduce asexually by **vegetative propagation**

**perennating organs:** plants possessing storage organs can survive from year to year

examples: (1)______ (2)______ (3)______ (4)_______

**Tuber,** e.g. potato
- swollen ends of underground stems
- buds develop into aerial shoots in the growing season;
  old tubers ___________ as their food is used up for growth
- axillary buds of aerial shoot develop into side branches with
  their **tips** swollen with stored food manufactured by photosynthesis of the aerial shoot
- food stored is ___________

**Bulb,** e.g. ________________________
- modified shortened, vertical ______________ surrounded by fleshy scale leaves
  with bases swollen with food stores (simple sugars)
- outermost layer: brown scale leaves which are remains of last year's fleshy scale after using up their
  food stores; protects fleshy scale leaves inside
- buds (apical & axillary) can develop into new bulbs
- adventitious roots are formed during growth of the bulb

**Corm,** e.g. gladiolus
- short, erect, swollen ______________________;
- food is stored in the base of stem which forms a new corm
- **contractile roots** are formed to __________________________
Rhizomes, e.g. ginger, iris

- horizontally growing underground stems
- bears *nodes, scale leaves, adventitious roots & axillary buds*
- apical buds at tips & branches develop aerial shoots;
  photosynthesized food delivered to rhizome enables axillary buds to grow horizontally and form branches

**Summary of vegetative propagation in angiosperms**

<table>
<thead>
<tr>
<th>Name of perennating organ</th>
<th>Origin of organ</th>
<th>Region of food storage</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bulb</td>
<td>short, vertical stem</td>
<td>fleshy scale leaves</td>
<td>onion</td>
</tr>
<tr>
<td>2. Corm</td>
<td>short, vertical stem</td>
<td>swollen stem base</td>
<td>gladiolus</td>
</tr>
<tr>
<td>3. Rhizome</td>
<td>horizontal stem</td>
<td>entire length of stem</td>
<td>iris</td>
</tr>
<tr>
<td>4. Tuber</td>
<td>side branch of stem</td>
<td>tip of stem side branch</td>
<td>potato</td>
</tr>
</tbody>
</table>

**Comparison of the advantages & disadvantages of vegetative propagation**

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. a __________ way of reproduction</td>
<td>1. ______________ may occur as daughter plants are close to parent plant. This leads to __________ for water, space and light</td>
</tr>
<tr>
<td>2. __________ characters can be retained because offspring are genetically identical to parent</td>
<td>2. ______________ occurs. It cannot give better quality offspring which are __________ adaptable to changes in the surroundings. Bad traits are transmitted to daughter plants.</td>
</tr>
<tr>
<td>3. large __________ reserves are provided for daughter plants</td>
<td>3. ______________ of parent plant are rapidly transmitted to offspring</td>
</tr>
<tr>
<td>4. It does not involve __________ agents or another plant (no pollination &amp; fertilization takes place)</td>
<td></td>
</tr>
</tbody>
</table>
Artificial Propagation

**Cutting**

An African vioet

- select and cut a healthy leaf;
- insert leaf stalk into a small pot containing suitable soil; keeping soil moist;
- roots will form in about 4 weeks; a tiny plant within 8 weeks

**Grafting** (for fruit trees)

- scion is transplanted on to stock;
- stock is chosen for its good root system and resistance to diseases
- cambium of scion & stock must be in direct contact with joint wrapped up with tape & covered with wax to prevent water loss & bacterial and fungal invasion

**Layering**

- a branch of a shrub is bent until one of its nodes touches the soil & kept in position until adventitious roots have formed at the nodes
- stem can then be cut off from the parent plant

12.2.6 Cloning

A clone is _______________________

The nucleus of a cell contains all the genetic information needed to develop an entire organism under suitable conditions. If a cell divides mitotically it will produce a clone. If each cell of the clone is separated and allowed to develop into the complete organism, a group of genetically identical offspring is formed. This is known as cloning, e.g. carrot root cells & frogs

12.2.7 Parthenogenesis

Parthenogenesis is the further _______________________

Diploid parthenogenesis: the gamete is produced by mitosis and offspring are diploid (actually by meiosis with all chromosomes showing non-disjunction), e.g. aphid
Haploid parthenogenesis: haploid gametes are produced which give rise to haploid eggs and eventually develop into haploid offspring, e.g. in honey bee:  

\[
\text{unfertilized haploid eggs} \rightarrow \text{fertilized eggs} \rightarrow \text{female bees} \rightarrow \text{workers when feed on honey & pollen} \quad \text{OR} \quad \text{queen when feed on the royal jelly}
\]

**Apomixis**

In some plants a diploid cell of the ovule may develop directly into an embryo without the involvement of a male gamete. As the diploid cell is not itself a gamete, the process is not strictly sexual at all.

**12.3 Reproduction in Flowering Plants**

Vegetative structures:

Reproductive structures:

Vegetative propagation:

Sexual reproduction: introduce variation through meiosis by

1. independent assortment chromosomes during **metaphase**
2. recombination of genes by **crossing over** between homologous chromosomes at prophase I

**12.3.1 Floral Structure**

Both self-fertilization and cross-fertilization introduce variation. External agents, e.g. _____________________, help in transfer of genetic material when they assist in pollination of flowers. This, however, exposes the vulnerable gametes to desiccation. Spermatophytes thus have evolved their male gamete within a spore, the _____________________ or pollen grain.
Structures of a typical flower:

- **the flower** is the organ of sexual reproduction in flowering plants
- flowers are usually **hermaphrodite** or _______ but sometimes **unisexual**
- **sepals**: outermost whorl; form the **calyx**: green in colour; function —
- **petals**: form the **corolla**: often **brightly coloured & attractive**; with **insect guides** which guide insects to the base of the petals for nectar secreted by the **nectary**;
- In some flowers, the calyx & corolla are undistinguishable and are collectively called the **perianth**
- **stamens**: male reproductive parts or **androecium**;
  - each stamen consists of an **anther** and a long **filament**;
  - each anther contains four **pollen sacs** with **pollen grains** inside;
- the pollen grains contain the **male gametes**
carpels: female reproductive parts or **gynoecium** (or pistil); each carpel consists of an **ovary** which contains **ovules** with ova inside; at the top of the ovary is the **style**, with a **stigma** at the tip to receive pollen grains for fertilization

**Actinomorphic** (regular): flowers with petals & sepals of similar size and shape exhibiting radial symmetry

**Zygomorphic** (irregular): flowers with unequal sepals & petals of different shapes and arranged in bilateral symmetry

### 12.3.2 Pollination

- meiosis occurs inside the **pollen sacs** of anther;
- when mature, pollen sacs split open expose their pollen grains
- female gametes (egg nuclei) are inside ovules

funicle: ovule stalk

integuments: protective layer

micropyle: a small __________ through which pollen tube grows into ovule

Development of the pollen grain (for reference):

pollen mother cells (2n) → meiosis → tetrad (4) haploid (n) cells

→ microspores (pollen grains) → mitosis → generative nucleus & tube nucleus

→ mitosis → 2 male nuclei & tube nucleus

Development of the ovule (for reference):

nucellus → megaspore mother cell (2n) → meiosis → 4 megaspores (n)

→ 3 degenerated, 1 → embryo sac → mitosis 3 times

→ 8 nuclei (3 antipodal cells, 2 polar nuclei, 2 synergids with 1 egg cell)

Pollination: the transfer of pollen grains from anthers to the stigmas;

external agents are needed - (1) by _______________ (2) by _______________

Anther - produces pollen grains

Filament - supports anther

Style - down which pollen tubes grow

Petal - provides landing stage for visiting insect

Nectar guides - series of hairs which help insect locate nectar

Ovary - contains female gamete, the egg nucleus

Placenta - point of attachment for ovules

Nectary - produces sugary solution as reward for insects

Half-flower of antirrhinum, an irregular (zygomorphic) flower

Half-flower of buttercup (Ranunculus), a regular (actinomorphic) flower
Comparison of wind and insect-pollinated flowers

<table>
<thead>
<tr>
<th>Anemophilous ( )</th>
<th>Entomophilous ( )</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.g.</td>
<td>e.g.</td>
</tr>
<tr>
<td>Plants often occur in dense groups covering large areas</td>
<td></td>
</tr>
<tr>
<td>Flowers occur in groups ( ) on the plant</td>
<td></td>
</tr>
<tr>
<td>Flowers often unisexual with an excess of male flowers</td>
<td></td>
</tr>
<tr>
<td>Petals are dull and much reduced in size</td>
<td></td>
</tr>
<tr>
<td>No scent or nectary</td>
<td></td>
</tr>
<tr>
<td>Stigmas protrude outside flower on long styles</td>
<td></td>
</tr>
<tr>
<td>Stigmas are feathery, giving them a large surface area to filter pollen from the air</td>
<td></td>
</tr>
<tr>
<td>Anthers hang outside flower on long filaments so the pollens are easily released into the air</td>
<td></td>
</tr>
<tr>
<td>Large number of pollens are produced to offset the high degree of wastage during dispersal</td>
<td></td>
</tr>
<tr>
<td>Pollen is smooth, light &amp; small and sometimes have wing-like extensions to aid wind transport</td>
<td></td>
</tr>
</tbody>
</table>

12.4.1
Fertilization & Development in Flowering Plants
poulan grains send out\textit{ pollen tubes} which grows down the style & ovary, towards the micropyle
- pollen grains are attracted by sugars in stigma and secrete enzymes to digest a pathway through the style

\textbf{Double Fertilization:}
- male gamete goes into the ovule and fertilizes with the egg cell
- the other male gamete fuses with the polar nuclei to form the \textit{triploid endosperm}

12.4.2 Methods of Preventing Inbreeding

\textit{Self-pollination}: the transfer of pollen from the anther to the stigma of the \textit{same flower}, or of another flower of the \textit{same plant}

\textit{Cross-pollination}: the transfer of pollen to a flower on a \underline{__________________} plant of the same species

*If pollen lands on the stigma of a plant of a different species, it usually dies.
- Since cross-pollination results in a great \underline{__________________} of \underline{________} adaptable offspring, many plants prefer cross-pollination

\begin{table}[h]
\centering
\begin{tabular}{|l|l|}
\hline
\textbf{Method} & \textbf{Explanation} \\
\hline
a) Dichogamy & anthers & stigmas mature \underline{at different times} to minimize self-pollination \\
i) protandry & \underline{__________________} ripen first \\
ii) protogyn & \underline{__________________} ripen first \\
b) Heterostyly & thrum-eyed: anthers high up & stigmas low down \\
 & pin-eyed: stigmas high up & anthers low down \\
c) Incompatibility & produce chemical in stigma to prevent germination of their own pollens \\
d) Unisexual flowers & only male or \underline{__________________} flowers on a plant \\
 & \underline{monoecious}: \\
 & \underline{dioecious}: \\
\hline
\end{tabular}
\end{table}
12.4.3 Development of Fruits and Seeds

Fate of floral parts after fertilization

<table>
<thead>
<tr>
<th>Floral Part</th>
<th>Fate after Fertilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) sepals, petals &amp; stamens</td>
<td></td>
</tr>
<tr>
<td>(b) ovary</td>
<td></td>
</tr>
<tr>
<td>i) ovary wall</td>
<td></td>
</tr>
<tr>
<td>ii) ovule</td>
<td></td>
</tr>
<tr>
<td>iii) integuments</td>
<td></td>
</tr>
<tr>
<td>iv) fertilised egg</td>
<td></td>
</tr>
</tbody>
</table>

The most common food store in seeds is carbohydrates (in the form of starch). Many young seeds store sugar but this changes to starch as they mature. Lipid are often stored in the cotyledons and may form a high percentage of the dry weight, e.g. peanuts. Proteins are found to a lesser extent in seeds but wheat has an aleurone layer and protein is stored in the cotyledons of legumes and nuts.

A **fruit** is an **ovary after fertilization** and it contains **seeds**

Functions: (1)______________________________________________________________________________  
(2)______________________________________________________________________________

**Fruits and Seeds Dispersal**

Dispersal of seeds by fruits - by ____________________, by ___________________  
by ___________________ & by ___________________

Significance of dispersal:
(1) prevents _____________________________________________________________________________  
(2) allows the plants to ________________________________________________________________

**1. Wind Dispersal**

- fruits are **light** and have a ____________________________ to catch wind  
- examples: sycamore (pericarp extended to form a wing), dandelion (hairy parachute)

**2. Animal Dispersal**

- fruits possess **hooks** or **spines** to cling to animals’ bodies  
- fruits as **food** for animals: ‘stoned seeds’ remain intact & pass out with the animals’ faeces, e.g. apple, cherry
3. Water Dispersal
- fruits like coconut contain air space which makes the fruit buoyant
- seed is covered in a spongy or fibrous layer

4. Mechanical Dispersal
- pods with a leathery skin which splits open to throw seeds away over a fairly wide area, e.g. pea

5. Censer Mechanisms
- fruits are borne at the ends of long stalks with holes through which seeds are shaken as they blow in the wind; pores are closed in wet conditions, e.g. poppy

6. Casual Mechanisms
- taking opportunities & using any available means of dispersal, e.g. acorns (from oak tree) may be rolled along the ground by wind or carried about by squirrels or float downstream in rivers

The Structure of Seeds

12.4.4 Dormancy
The water content of seeds is very low (5-10% weight) and is the major factor in preventing germination. Periods of dormancy may last for a number of years. Some seeds fail to germinate for one reason or another:
1. Light is necessary for germination of certain seeds
2. A sustained period of cold is needed to make some seeds of temperate climates germinate to ensure their seeds do not germinate in dry autumn & cold winter
3. Some seeds need the heat of a flash-fire for germination
4. Time is needed for maturity / internal chemical changes to complete before germination
5. Seed coat impermeable to water &/or gases; time for decay of seed coat; some seeds need physical abrasion or partial digestion in intestine to break dormancy
6. Presence of natural chemical inhibitors
12.4.5 Germination & Early Growth in Flowering Plants

Conditions necessary for seed germination

1. **Water** - taken up through the micropyle; softens seed coat; cotyledons swell up & burst through seed coat; enzymes are activated to break down starch to ____________ and proteins to ____________: fats are converted into fatty acids & glycerol; these dissolve in water & are transported to the __________________________ of the embryo.

   Glucose, fatty acids & glycerol provide respiratory substrates from energy for growth is released; glucose is also used in the formation of cellulose cell walls; amino acids are used to form new enzymes and structural proteins within new cells.

2. **Temperature** - warmer temperatures enable __________ to work

3. **Oxygen** - enables seeds to ______________ aerobically to supply energy for growth

   **epigeal germination:**

   **hypogeal germination:**

<table>
<thead>
<tr>
<th>EPIGEAL GERMINATION</th>
<th>HYPOGEAL GERMINATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil level</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Cotyledons</strong></td>
<td><strong>Soil level</strong></td>
</tr>
<tr>
<td><strong>Plumule</strong></td>
<td><strong>Cotyledons</strong></td>
</tr>
<tr>
<td><strong>Epicotyl</strong></td>
<td><strong>Plumule</strong></td>
</tr>
<tr>
<td><strong>Hypocotyl</strong></td>
<td><strong>Epicotyl</strong></td>
</tr>
<tr>
<td><strong>Radicle</strong></td>
<td><strong>Hypocotyl</strong></td>
</tr>
<tr>
<td><strong>GROWTH OCCURS MAINLY IN HYPOCOTYL</strong></td>
<td><strong>GROWTH OCCURS MAINLY IN EPICOTYL</strong></td>
</tr>
<tr>
<td><strong>Hooked hypocotyl</strong></td>
<td><strong>Hooked plumule</strong></td>
</tr>
<tr>
<td><strong>Lateral root</strong></td>
<td><strong>Lateral root</strong></td>
</tr>
<tr>
<td><strong>Cotyledons above soil surface</strong></td>
<td><strong>First true leaves</strong></td>
</tr>
<tr>
<td><strong>Soil level</strong></td>
<td><strong>Cotyledons below soil surface</strong></td>
</tr>
</tbody>
</table>

Examples include sunflower, castor oil

Examples include broad bean, wheat

To show differences between epigeal and hypogeal germination
12.5 Reproduction in Mammals

In animals the gametes are usually differentiated into a small motile male gamete or sperm which is produced in large numbers, and a larger, non-motile food-storing female gamete or ovum which is produced in much smaller numbers.

More primitive animals may be monoecious (hermaphrodite) - bisexual. Even though these animals frequently have mechanisms to avoid ____________________________, they still have less variety in the offspring. Higher animals are dioecious, producing only one type of gamete. Their offspring have more variety.

12.5.1 Gametogenesis

Gametogenesis is the formation of gametes.

Primordial germ cell → MITOSIS → Spermatogonia which grow into Primary spermatocytes → 1st MEIOSIS → Secondary spermatocytes → 2nd MEIOSIS → Spermatids which differentiate into Spermatozoa

Primordial germ cell → MITOSIS → Oogonia which grow into Primary oocytes → 1st MEIOSIS → 1st Polar body (degenerates later) + a Secondary oocyte → 2nd MEIOSIS → 2nd Polar body (degenerates later) + an Ovum

---

Human spermatozoon based on electron micrograph
Gonads:
In mammals, the reproductive and excretory systems are closely associated with one another - they are often represented together as the urino-genital system.

12.5.2 Human Male Reproductive System

The Human Male Reproductive System

**Testis**
- paired organs producing *sperms*; lying outside abdominal cavity in *scrotum* with a lower (about 20°C) body temperature for optimum sperm production;
- **spermatic cords** contain arteries & veins joining the testes;
- **seminiferous tubules** → epididymis → urethra → penis

**Penis (TS)**

**Testis (LS)**

*Male urinogenital system (simplified) – front view*

*Male urinogenital system – side view*
seminal vesicles - store sperms & secrete some fluid;  
with secretions from prostate gland & Cowper's gland,  
they form seminal fluid (semen) for:  
1. _________________________________________________  
2. _________________________________________________

12.5.3 Human Female Reproductive System

ovaries - produce female gametes or ________________; lie in the abdominal cavity;  
funnel of oviduct → oviduct → uterus  
uterus - __________________ the embryo; provides a _______________  
internal environment for embryo to develop;  
expels the baby at birth by contractions of its _______________ wall  
cervix - opening of the uterus  
vagina - receives penis during copulation;  
acts as the birth canal for the foetus;  
* Both uterus & vagina secrete much mucus which helps the sperms to swim upwards  
clitoris - at opening of urethra; a sensitive structure analogous to the penis  
vulva - composed of labia majora & labia minora protecting the openings of vagina  
& urethra, with the hymen partially closing the opening of the vagina
F 6 Biology - Ch 12: Reproductive, Development & Growth

Name: ________________________ ( )

Ovary
- produces ova from germinal epithelium
- each ovum is nourished in a follicle
- a girl has thousands of follicles in her ovaries at birth, but only about 500 of these will mature (i.e. up to about 50 years old)

follicle  ➔ mature (Graafian) follicle
 ➔ ovulation
 ➔ yellow body

12.6 Sexual Cycles
Many animals have cycles of sexual activity in both males and females. These cycles often occur so that fertilization takes place at a time which gives the offspring the best chance of survival, e.g. the offspring are produced at a time when the climate and food availability are most favourable.

There are 3 main types (for reference only):
1. Female undergo a single period of sexual activity during the year, e.g. deer
2. Female undergoes a number sexual activity during the year, each separated by a period of sexual inactivity, e.g. horse
3. Female has a more or less continuous cycle of activity where the end of one cycle is followed immediately by the start of the next, e.g. humans

12.6.1 The Menstrual Cycle - lasts about 28 days
menarche: the onset of the first menstrual cycle at around 12 years old
Menstruation continues until menopause at the age of ________________________.
The cycle is controlled by hormones which prepares the uterus for the fertilized egg to implant onto it. Menstrual flow is due to the shedding of the uterine lining, along with a little blood. After the shedding, the uterine lining regenerates (thickens) in readiness for a fertilized ovum.

ovulation:
The ovum is moved down the oviduct mostly by muscular contractions of the oviduct wall, assisted by beating of the cilia. The journey takes about 3 days during which time the ovum may be fertilized. If not, the ovum quickly dies and passes out via the vagina. The uterine lining is maintained for some time but finally breaks down again about 28 days after the start of the cycle.

12.6.2 Hormonal Control of the Menstrual Cycle
Four hormones are involved:
- 2 being secreted by the anterior pituitary:
  these pituitary hormones are called gonadotrophic hormones
- 2 being secreted by the ovaries:
Functions of these hormones

FSH: ____________________________________________________________________________

Oestrogen: _________________________________________________________________________

LH: _______________________________________________________________________________

Progesterone: ______________________________________________________________________

Progesterone at the end of the sequence inhibits the production of FSH. In turn, the production of the other hormones stops, including progesterone itself. The absence of progesterone now means that the inhibition of FSH ceases and so progesterone production commences again. In turn, all the other hormones are produced. This alternate switching on and off of the hormones produces a cycle of events - the menstrual cycle.
12.6.3 Artificial Control of the Menstrual Cycle

Either as a   device by prevent   or as a fertility device by stimulating   Contraceptive pills

- contains both oestrogen & progesterone
- when taken daily it maintains high levels of oestrogen & progesterone in blood  
  ----- inhibits production of gonadotrophic hormones  ----- LH absence prevents

- The Pill is taken for 21 consecutive days  +  7 days of vitamins
- Menstrual flow occurs as in normal individuals

'Morning after' pill
- with oestrogen & other chemicals to prevent implantation of the fertilized egg

** Other methods of birth control see TABLE 19.1 on page 271. 

Fertility drugs - induce ovulation in one of two ways:
1. Provide gonadotrophins such as FSH which stimulate the development of follicles
2. Provide some chemical which inhibits the production of oestrogen and promotes FSH production to stimulate follicle development

Fertility drugs often result in multiple births.

12.6.4 Male Sex Hormones

FSH stimulates sperm development
LH (as interstitial cell stimulating hormone) stimulates testis to secrete testosterone (a group of male hormones called androgens) which controls the development of the male reproductive organs, especially at puberty.

Castration (removal of the ) prevents male reproductive organs to mature and secondary sexual characteristics to occur at puberty.
12.6.5 Factors Affecting Breeding Cycles - not required in syllabus

12.7 Fertilization & Development in Mammals
12.7.1 Courtship & 12.7.2 Mating - not required in syllabus

12.7.3 Semen contains
1. ________________
2. ________________ which nourish the sperm & help to make them mobile
3. ________________ which forms a semi-viscous fluid in which the sperms swim
4. ________________ which neutralize the acid conditions in the vagina and urethra, which could kill the sperms
5. ________________ are hormones which help sperm reach the ovum by causing muscular contractions of the uterus & oviducts

12.7.4 Fertilization
Fertilization takes place in the top third of the oviduct if ovum is still alive. When the sperm reaches it, the egg dies within 24 hours after ovulation and the journey down the oviduct takes 3 days. The fertilizing sperm firstly releases acrosin, a trypsin-like enzyme, from the acrosome. This softens the vitelline membrane which covers the ovum. Inversion of the acrosome results in a fine needle-like filament developing at the tip of the sperm and this pierces the already softened portion of the vitelline membrane. In addition it is lifted from the plasma membrane by a fluid layer which separates the two, forming the fertilization membrane.
The sperm discards its tail, and the head & middle piece enter the cytoplasm. The 2nd meiotic division of the ovum nucleus normally occurs immediately following the penetration of the sperm. The sperm & ovum nuclei fuse, restoring the diploid state. A spindle forms, the two sets of chromosomes line up and the cell undergoes mitotic division at once.

**In Vitro Fertilization and Test Tube Babies**

In 1978, the 1st test tube baby was born through in vitro fertilization and successful transfer into the uterus of the mother. The process begins with a fertility drug being administered to the potential mother to increase her ova production. Around 6 of these are collected using a fine needle, via the vagina. Around 100,000 sperms, collected from the potential father's semen sample by centrifugation, are added to the ova in a petri dish. When the embryo is two days old it is transferred into the mother's uterus where, if all goes well, it will develop normally.

**12.7.5 Causes of Infertility and Its Cures**

1. ____ - These prevent ova & sperm meeting. An operation may be undertaken to unblock the tubes or IVF can be attempted.
2. ____ - This may make the chance of fertilization remote & hormone treatment necessary to regularize the cycle.
3. ____ - may make conception unlikely and couples may be counselled on the most appropriate time for sexual intercourse.
4. ____ - impossible for the female to contribute genetically to their offspring. Adopt or use a donated ovum from another female through IVF. Artificial insemination of a surrogate (substitute) mother with the potential father's sperms is another option.
5. ____ - none or so few sperms for conception. Use donated semen from another male for artificial insemination.
6. Impotence - unable to erect the penis &/or ejaculate semen. It is psychological or result of prolonged drug/alcohol abuse. Counselling & guidance can sometimes remedy the problem.
7. ____ - sexually transmitted diseases, e.g. gonorrhoea, syphilis, mumps
8. Others - embryo could not implant in the uterus wall; miscarriage; Use IVF, then a surrogacy.

*** Surrogate motherhood, IVF and artificial insemination all raise complex legal and moral issues!!!

**12.7.6 Implantation**

- the fertilized egg (zygote) goes down the oviduct to the uterus and carries out mitosis to form the embryo
- embryo then becomes embedded within the lining of the uterus OR becomes implanted
- initial hollow ball of cells: the blastocyst, with the outer layers
of cells (trophoblast) develop into the embryonic membranes

amnion - covers embryo & secretes amniotic fluid which serves to

12.7.7 The Placenta

The chorionic villi will develop about 14 days after fertilization and represent the beginning of the placenta. It rapidly develops into a disc of tissue covering 20% of the uterus. The capillaries of the mother and foetus come into close contact without actually combining.

12.7.8 Functions of The Placenta

1. It allows exchange of materials between the mother & foetus without the two blood mixing. Foetal blood type may be different from mother, thus agglutination could occur.
2. It supplies nutrients from maternal blood to foetal blood.
3. Wastes, CO₂ & urea are removed from foetal blood.
4. It allows maternal ________ to pass into the foetus to provide some immunity against diseases.
5. It prevents some pathogens & their toxins from crossing the placenta.
6. It acts as a barrier to maternal hormones & other chemicals in maternal blood to affect the foetus.
7. It allows foetal & maternal blood to operate at different pressures.
8. It gradually takes over the role of hormone production, e.g. progesterone which prevents ____________, human choriogonadotrophin (HCG), whose presence in urine is the basis of most pregnancy test.
12.7.9 Birth (Parturition)

During pregnancy the placenta continues to produce progesterone & small amounts of oestrogen. The amount of progesterone decreases during pregnancy while oestrogen increases. These changes help to trigger the onset of birth. As the end of pregnancy, posterior lobe of pituitary produces **oxytocin** which causes the uterus to __________. These contractions increase in force & frequency during labour.

The process of birth can be divided into 3 stages:
1. Dilation of the cervix & the rupture of the embryonic membranes
2. The expulsion of the embryo
3. The expulsion of the placenta which is eaten by most animals

12.7.10 Lactation
- During pregnancy, progesterone & oestrogen cause lactiferous glands in mammary gland to develop
- After birth, prolactin from anterior pituitary causes the lactiferous glands to begin milk production
- Suckling by the baby causes the reflex expulsion of milk from mammary gland
- Colostrum: a milky laxative helps the baby to expel the bile which accumulated in the gut during foetal life
- Milk contains essential nutrients & antibodies to give passive immunity to the newly born baby.

12.7.11 Parental Care
- Babies need care & protection from their parents after birth. This ensures a better development & hence increases the chance of survival of the young. Mother feeds the baby with milk from her mammary glands in the nipple. Milk provides the baby with a balanced diet and antibodies which protect the baby from infections.

**Human milk is the best food** for babies but milk powder are used because of convenience.

- Fish produces numerous eggs at a time because there is little or no parental care & the majority of offspring fail to reach maturity, most being eaten by predators
- Birds & mammals reduce their number of offspring but expend much time and energy in caring for them in order to ensure a high survival rate
- In mammals, the provision of milk is the most obvious example of parental care.
  As the offspring develop they are gradually introduced to other, more solid type of food, a process called weaning.
- Some birds regurgitate food from the crop, provide nests to raise their young.
  Offspring are raised in the relative safety of a warm, dry environment remote from their predators.
12.8 Growth

The growth in size of an individual cell is limited by the ____ over which the nucleus can exert its control. Therefore, one celled organisms reach a maximum size they divide to give two separate individuals. In order to attain greater size, organisms became __________.

Advantages of being 'big':
1. Cells may become differentiated in order to perform a particular function
2. Specialization leads to greater efficiency
3. Store more materials to withstand periods when these are scarce
4. If some are damaged, enough may still remain to carry out the repair
5. To separate regions of opposing conditions in a multicellular organism than in a single cell
6. Have competitive advantage, e.g. large plants compete better for light
7. Large size may provide some protection from predators for being too large to ingest

12.8.1 Measurement of Growth

Growth is estimated by measuring some parameter (variable) over a period of time. The parameter chosen depends upon the organism whose growth is to be measured. It could be weight (mass), length, height, area, volume, etc. There are two types of mass to be measured:

1. __________ - This is the mass of the organism under normal conditions
   - easy to measure, no damage to the organism
   - inaccurate because __________
2. __________ - This involves removing all water by drying, before weighing
   - difficult to carry, permanently damaging to the organism
   - BUT accurate

A good estimate of the growth rate is usually by growing groups of organisms rather than an individual, e.g. growth of peas using dry mass.

12.8.2 Growth Patterns

1. Sigmoid Curve:

   With respect to time, the curve can be divided into:
   - lag phase
   - acceleration phase
   - steady phase
   - retardation phase
   - stationary phase

   With respect to growth rate, the curve can be divided into:
   - initial period of increasing growth
      - slow growth at first, because there are so few cells that even when dividing rapidly the actual increase in size is small central period of rapid growth

   [Diagram of sigmoid growth curve]
- as the number of cells becomes larger the size increases more quickly because more cells carry out division

**final period of growth**
- a limit to rapid growth due to genotype, external factors like food
- grow rate decreases & stops when no. of cell dividing = no. of cells dying

2. Human Growth Curve:

- **rapid growth**: first 2 years after birth
- **slow growth**: next 10 years
- **rapid growth**: between 13 to 17
- **stops growth**: at 20 years but carries out cell division for worn-out tissues
- two phases of rapid growth during infant & during adolescence
- resembles 2 sigmoidal curves, one on top of the other

3. Annual Plant Growth Curve:
- live for _______ year
- complete their life cycle in one growing season, e.g. wheat
- initial **negative growth** during germination due to _____________ of food reserves in the seed;
- at X, positive growth because _______________ have grown above ground and photosynthesis is _____________ than that of respiration
- at 20th week, a sudden decrease in dry mass due to the ______________ of fruits and seeds
- a typical S-shaped (**sigmoid**). curve

4. Biennial plants:
- lives for__________ years with ________ growing seasons to complete its life cycle
- 1st season: produces green leaves, photosynthesis occurs, food stored underground
- 2nd season: stored food is used to produced flowers & seeds
- growth curve: 2 sigmoid curves joined together, example: carrot
5. Perennial Plant Growth Curve:
- may live for many years
- two types: ____________________ and ____________________

herbaceous perennials
- aerial shoots die away in autumn but develop underground storage organs (perennating organs) to survive the winter, e.g. tubers

woody perennials
- persists above ground throughout the year; grow continues from year to year, e.g. trees
- growth curve: a cumulative series of sigmoid curves, each of which represents one year's growth
- variations occur from year to year according to environmental conditions:
cold dry year has less growth than a mild wet year

6. Arthropod Growth Curve:
- characteristic of an intermittent growth in ____________________
- insects have a hard cuticle made of chitin (exoskeleton);
Function:
- exoskeleton is rigid and cannot grow, therefore mouling occurs:
  old skeleton splits & is shed;
insect expands rapidly by swallowing air or water as long as the new skeleton stretches
- once new skeleton hardens, body size remains fixed until the next moult
- curve is a step-like pattern;
- at mouling: _______________ increases rapidly but _______________ decreases because of the shedding of the skeleton
7. Isometric Growth:
- Certain organs of an individual grow at the **same** rate as the organism as a whole, e.g. leaves of most plant.

8. Allometric Growth:
- Different parts of body grow at different rates:
  
  a) _______________ grow rapidly for the first 3 years but relatively slowly later;
  
  b) _______________ grow slowly until **puberty** (at about 12 to 14) because ____________________________
  
  c) _______________ grow slowly at the early age and speed up later
  
  d) Lymph tissue (not shown in graph) grow rapidly in early life but adults have less than half of what it was in early adolescence because ____________________________

12.8.3 Rate of Growth

The **actual growth** of an organism is the cumulative increase in size over a period of time, e.g. a small annual plant.

The **rate of growth** is a measure of size increase over a series of equal time intervals, e.g. increase in height over each 3-DAY INTERVALS Fig. 12.30(b) shows a **bell-shaped graph**.
12.8.4 Meristems
The presence of a semi-rigid ______________ around plant cells effectively restricts their ability to divide & grow. Therefore, plants retain ______________ which form the only actively growing tissues:
1. Apical meristems-
2. Lateral meristems -
3. Intercalary meristems -

Typical meristem cells are simple & undifferentiated, constantly carrying out ______________. They are small in size, with thin cell wall BUT METABOLICALLY VERY ACTIVE. Therefore, they have ______ nuclei, _______ cytoplasm and ______ vacuoles.

Primary Growth

root cap
- ______________ the root as it grows through the soil

region of cell division
- cells go on dividing to make new cells; cells are small & young

region of elongation
- cells draw in water by _______ to expand or elongate;

vacuolation causes the thin cell wall to stretch & helps to push the root down into soil

region of differentiation
- gradual thickening of the cell wall until cells are rigid to prevent further expansion;
- cells differentiate into specialized tissues such as cortex, xylem, phloem & cambium which enable them to perform various ______________

* Some of the meristem cells do not vacuolate. Instead they remain meristematic in character and form long strands extending back from the apex - the procambium.
The procambium divides towards the inside to give ______________ and towards outside to give ______________.
Later procambium give rise to ______________ & ______________ which are larger cells and tend to crush the protoxylem & protophloem.

** The differentiation of procambial cells into metaxylem & metaphloem involves quite considerable changes. By contrast, differentiation of the apical meristem into parenchyma involves little more than an increase in size and vacuolation. Depending upon the extent, location and type of wall laid down, collenchyma and sclerenchyma tissues may be produced. Epidermal cells are derived from differentiation of meristematic cells of the tunica.
In roots, only a single, central procambial strand is produced. Protophloem develops first from this strand, followed by protoxylem. Finally, metaphloem and metaxylem respectively develop. As this differentiation occurs mostly at the centre of the procambial strand, some of it remains to the outside of the central vascular tissue it forms - the pericycle which is meristematic & divides to give lateral roots.

**endogenous growth**: Formation of lateral roots from the pericycle which is deep within the root tissues

**exogenous growth**: Formation of lateral roots from the cambium which lies near the shoot surface

---

**Growth at the shoot tip**

Diagram of the meristems at the shoot apex

- similar to the root with regions of _______________ and _______________

- no protective layer at tip but leaf primordium

**Secondary Growth**

![Diagrams to show the early stages of secondary growth in a dicotyledonous stem](image)

- a plant cannot grow very tall if only primary growth occurs, because there are insufficient tissues for ______________ and ______________

- **secondary growth** by ______________ which can carry out cell division:
forming new xylem tissue (secondary xylem or wood) towards the inside, and forming new phloem tissue (secondary phloem) towards the ________________

- **intrafascicular cambium**:

- more xylem than phloem is formed, thus cambium & phloem get pushed outwards (an increase in diameter) and the epidermis is ruptured;
  - **cork cambium** (phellogen) is formed to make **cork cells** to replace the epidermis;

- cork cells are non-living & impermeable to water; cork cells become ___________ of the tree;

- Functions of the bark: 1)___________________________________________________
  2)___________________________________________________
  3)___________________________________________________

- **lenticels**: regions of loose cork cells which permit gaseous exchange

*** The pattern of secondary growth in roots is very similar.

Very few monocotyledonous plants undergo secondary growth.

- **annual rings**
  - **spring wood**: in spring & early summer, larger xylem vessels are formed in order to supply water to growing buds; located near the inside
  - **autumn wood**: in late autumn & winter, growth slows down or even stops; located towards the outside

- age of the tree can be estimated by counting the number of ________________

12.8.5 Growth and Development in Insects

**Insect Metamorphosis**

There are 2 forms of insect metamorphosis:

1. Incomplete metamorphosis - e.g. cockroach

2. Complete metamorphosis - e.g. mosquito

Metamorphosis is ________________
Implications:
- Juvenile & adult to live in different habitats and exploit different food sources (niches), thus reduce competition, e.g. dragonfly nymphs prey upon aquatic insects and gaseous exchange via gills, while the adults attack terrestrial insects, live in air & respire with tracheae
- Adults grow little after the last moult, metamorphosis allow the immature stages to provide the feeding and growing periods of the insect’s life history.

Life cycle: incomplete metamorphosis
e.g. cockroach, grasshopper, dragonfly, mayfly, damselfly, aphid, etc.

Nymph & adult live in different habitats
**Complete Metamorphosis in Other Insects:**

- e.g. beetles, butterflies, moths, flies, mosquitoes, fleas, bees, ants.

**Insect** | **Larva**
--- | ---
beetle | grub
fly | maggot
mosquito | wiggler
butterfly | caterpillar
moth | caterpillar

**The Larva:** - for feeding and growing.
- does not resemble the adult.
- the gonads remain quite undeveloped.

![Larva diagram](image)

**The Pupa:** - inactive.
- resembles the adult.
- most of the larval organs are broken down to nourish the development of certain groups of cells (buds) which were set aside and have retained their original embryonic capacity for development. The cells then give rise to the adult.

**Buds** are found distributed throughout the larval body.

**Life Cycle of Housefly**

- after mating, female lays 5-6 batches of 100 eggs on organic debris
- 24 h
- very small larva hatch
- feed continuously, moult twice or three times
- four days
- pupation
- metamorphosis 3-4 days midsummer
- some survive through winter
- adults appear in May - aerial fertilisation
- produces eggs (second brood) in August
- first brood (larva) emerge - short rest to dry wings and harden exoskeleton
- summer metamorphosis 2-3 weeks
- pupa
- female lays first brood eggs in batches of 10-100 on underside of *Brassica* leaves
- ten days
- small larvae (caterpillars) emerge and eat their egg shells; they have no antennae or compound eyes, and breathe via spiracles
- feed voraciously on leaves and grow rapidly
- results 5-6 times in three weeks
- NB larvae and imagos are very different from each other in feeding habits and structure; feeding larval stage and imago separated by obligatory pupal stage - complete metamorphosis

NB preparation may last for only a few weeks in summer; if insect overwinters, then the pupa is the stage maintained - complete metamorphosis.
Metamorphosis involves a profound destruction & re-organization of body tissues, and followed by fundamental physiological changes.

<table>
<thead>
<tr>
<th>Complete metamorphosis</th>
<th>Incomplete metamorphosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) 4 stages: egg, larva, pupa &amp; imago</td>
<td>1) 3 stages: egg, nymph &amp; imago</td>
</tr>
<tr>
<td>2) Larva &amp; pupa completely different from the imago</td>
<td>2) Nymph is similar to image in structures &amp; habits</td>
</tr>
<tr>
<td>3) Advantage: larva feeds &amp; grows voraciously without competition</td>
<td>3) Disadvantage: nymph competes with imago for food, shelter, etc.</td>
</tr>
<tr>
<td>4) Disadvantage: Life history is more complicated with 2 habitats. Pupa is immobile &amp; easily preyed by predators</td>
<td>4) Advantage: Life history more direct &amp; less hazardous</td>
</tr>
</tbody>
</table>

**Significance of metamorphosis:**
1) In a relatively short period of time, the animal can give large number of offspring.  
2) Reduce intraspecific competition in different habitat, e.g. mosquito larvae & adult  
3) Reduce intraspecific competition by having different locomotive organs & diets, e.g. mosquito larvae feed on planktons but adult on blood or plant juice