Higher Secondary Focus Area Based Notes-2022

NV'S ZOOLOGY

Class:12

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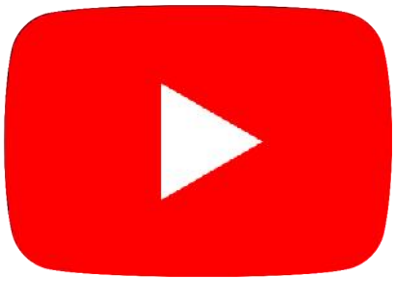

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ZOOLOGY

Revised Weightage to Content (Zoology) (Plus Two)

Sl. No	Name of the chapter	Focus Area
1	Chapter 3 Human reproduction	3.1 Male reproductive system
		3.2 Female reproductive system
		3.3 Spermatogenesis ,Oogenesis, Function of acrosome
		3.4 Menarche, Menopause, LH surge, Ovulation, Corpus Luteum
		3.5 Fertilisation (definition), Cleavage, Morula, structure of blastocyst, fate of the cells in blastocyst
		3.6 Placental hormones, Stem cells, Major features of embryonic development at various months of pregnancy
		3.7 Significance of Colostrum
2	Chapter 4 Reproductive Health	4.2 Various Contraceptive methods
		4.4 Sexually transmitted diseases
		4.5 Assisted Reproductive Technologies
3	Chapter 5 Principles of Inheritance and Variation	5.2.1 Law of Dominance
		5.2.2 Law of Segregation
		5.2.2.1 Incomplete Dominance
		5.2.2.2 Co-dominance and its example
		5.4.1 Sex determination in Humans
		5.6.1 Pedigree analysis (definition) , symbols used in pedigree analysis
		5.6.2 Sickle Cell Anaemia, Haemophilia, Phenylketonuria
		5.6.3 Down's Syndrome, Klinefelter's Syndrome, Turner's Syndrome
4	Chapter 6 Molecular basis of inheritance	6.1 Salient features of DNA double helix,Central Dogma
		6.4 DNA replication is Semiconservative why?
		6.4.2 The Machinery and the Enzymes
		6.5 Transcription (Definition)
		6.5.1 Transcription Unit
		6.6 Genetic code
		6.8 Levels of regulation of gene expression in eukaryotes and prokaryotes
		6.8.1 Lac Operon
		6.9 BAC, YAC
		6.9.1 Salient Features of Human Genome
		6.10 DNA fingerprinting -steps and applications

5	Chapter 7 Evolution	7.3 What are the evidences of evolution?
		7.7 Hardy Weinberg principle
		7.9 Origin and Evolution of man
6	Chapter 8 Human health and disease	8.1 Common diseases in humans
		8.2 Immunity - Structure of Antibody
		8.3 AIDS
		8.4 Cancer
		8.5.3 Effects of Drug/Alcohol abuse
		8.5.4 Prevention and control
7	Chapter 10 Microbes in human welfare	10.1 Microbes in Household Products
		10.2.3 Chemicals enzymes and other bioactive molecules
		10.4 Microbes in Production of Biogas
		10.5 Microbes as biocontrol agents - Bacillus thuringiensis, Trichoderma
		10.6 Microbes as Biofertilisers
8	Chapter 15 Biodiversity and Conservation	15.1 Genetic, Species & Ecological Diversity
		15.1.2 Patterns of Biodiversity
		15.1.4 Causes of biodiversity loss
		5.2.2 In situ conservation, Ex situ conservation

01
Human Reproduction

Introduction

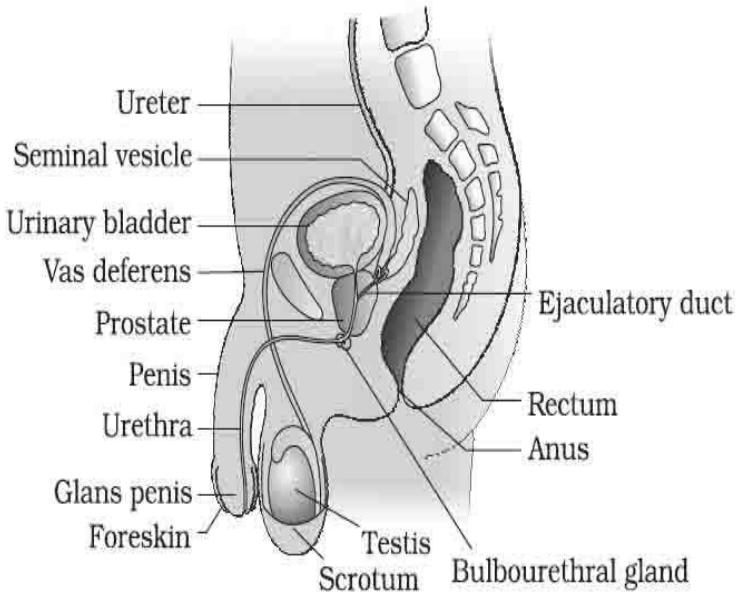
✓ Humans are sexually reproducing andviviparous organisms.

Reproduction

✓ It is ability to reproduce individuals of same species. The main events in reproduction include-

Gametogenesis------->Insemination----> Fertilsation----->Implanation----> Gestation----> Delivery/Parturition.

The Male Reproductive System



The male reproductive system is located in the **pelvis region**. It consists of

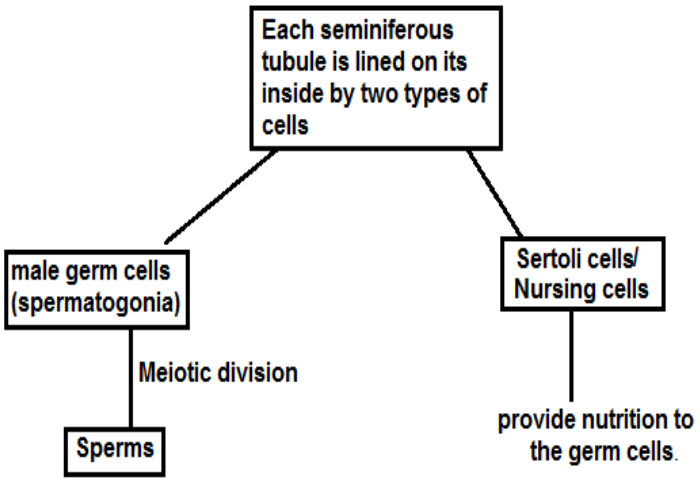
a) A pair of testis
b) Accessory ducts
c) Glands
d) External genitalia.

a)Testes

- The testes are situated outside the abdominal cavity (Extra abdominal) within a pouch called **scrotum**.
- **The scrotum helps in maintaining the low temperature of the testes (2–2.5°c lower than the normal internal body temperature) necessary for spermatogenesis**.

Shape of Each Testis: **Oval**
Length: **4 to 5 cm**
Width: **2 to 3 cm**
Position: **Within scrotum**

- The testis is covered by a dense covering.
- Each testis has about **250 compartments called testicular lobules.**
- Each Testicular lobule contains **one to three** highly coiled **seminiferous tubules** in which sperms are produced.
- Each seminiferous tubule is lined on its inside by two types of cells called
  - Male **germ cells (spermatogonia) and**
  - **Sertoli cells.**
- The male germ cells undergo **meiotic divisions** finally leading to sperm formation, while **Sertolicells (Nursing cells) provide nutrition to the germ cells**.



- The regions outside the seminiferous tubules called interstitial spaces, contain small blood vessels and **interstitial cells or Leydig cell**.
- **Leydig cells synthesise and secrete testicular hormones** called **androgens**. Other immunologically competent cells are also present.

b)Accessory Duct

- The male sex accessory ducts include
  - **Rete testis,**
  - **Vasa efferentia,**
  - **Epididymis and**
  - **Vas deferens.**
- The seminiferous tubules of the testis open into the **vasa efferentia** through **rete testis(They are irregular cavities present in testes**).
- The vasa efferentia leave the testis and open into **epididymis.**
- The epididymis leads to **vas deferens**.
- Vas deferens receives a duct from seminal vesicle and opens into urethra as the **ejaculatory duct** .
- These ducts store and transport the sperms from the testis to the outside through **urethra**.
- The urethra originates from the urinary bladder and extends through the penis to its external opening called **urethral meatus.**

Seminiferous tubules→Rete testis→ Vasa efferentia→ Epididymis→Vas deferens →Ejaculatory duct → Urethra → Urethral meatus

c)External Genitalia

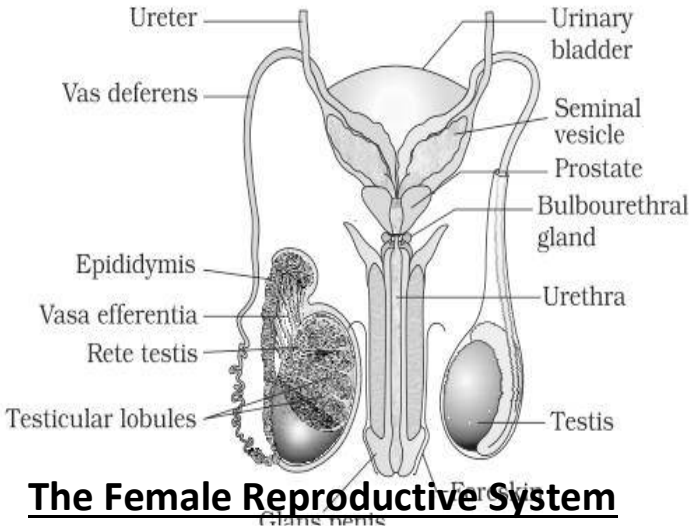
- ✓ The **penis** is the male external genitalia .
- ✓ It is made up of **special tissue**(Spongy erectile tissue) that helps in erection of the penis to **facilitate insemination.**
- ✓ The enlarged end of penis called the **glans penis** is covered by a loose fold of skin called **foreskin.**

d) Accessory Glands

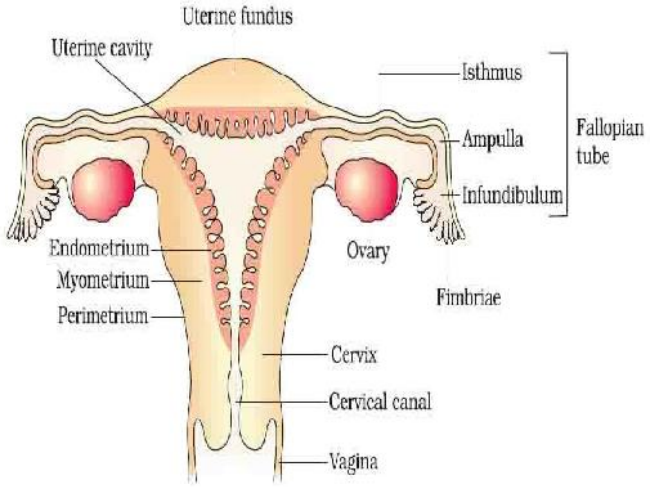
- It include
  i)Paired seminal vesicles,
  ii)A prostate and
  iii)Paired bulbourethral glands (Cowper's gland).
- Secretions of all these glands constitute the **seminal plasma**which is rich in **fructose, calcium and certain enzymes**.

- ✓ **The secretions of bulbourethral glands also helps in the lubrication of the penis**.
- ✓ **Seminal plasma along with sperm is called Semen**

Seminal Plasma+Sperm= Semen



The Female Reproductive System



- ➢ The female reproductive system is **l**ocated **in pelvic region** and
- ➢ it consists of
  a)**A pair of ovaries,**
  b)**Accessory ductsand**

c)External genitalia

These parts of the system along with **a pair of the mammary glands**are integrated structurally and functionally to support the processes of ovulation, fertilisation, pregnancy, birth and child care.

a)Ovary

- Ovaries are the primary female sex organs
- Ovaries produce **the female gamete (ovum)** and **several steroid hormones**

(ovarian hormones-**Estrogen and progesteron**).

- The ovaries are located one on each side of **the lower abdomen**
- Each ovary is about **2 to 4 cm** in length and is connected to the pelvic wall and uterus by **ligaments**.
- Each ovary is covered by a thin epithelium which encloses the ovarian **stroma**.
- **The stroma is divided into two zones – a peripheral cortex and an inner medulla**

b) Accessory ducts

- **Accessory ducts include**
  - ❖ **The oviducts (fallopian tubes),**
  - ❖ **Uterus and**
  - ❖ **Vagina**

Oviduct :

- Each fallopian tube is about **10-12 cm** long), the part closer to the ovary is the funnel-shaped **infundibulum.**
- The edges of the infundibulum possess **finger-like projections** called **fimbriae, which help in collection of the ovum after ovulation.**
- The infundibulum leads to **a wider part of the oviduct** called **ampulla**.
- The last part of the oviduct, **isthmus** has a **narrow lumen** and it joins the uterus

Uterus (Womb) ;

- The shape of the uterus is like an **inverted pear**.
- The uterus opens into **vagina through a narrow cervix**.
- The cavity of the cervix is called **cervical canal** which alongwith vagina forms the **birth canal**.

❖ The wall of the uterus has three layers of tissue.

i) Perimetrium:-

It is the The external thin membranous layer of uterus

ii) Myometrium:-

- It is the middle thick layer of uterus. It contains smooth muscle. The **myometrium** exhibits **strong contraction** during delivery of the baby.

iii)Endometrium

It is the inner most layer of uterus and is a **glandular layer**.The Endometrium undergoes **cyclical changes during menstrual cycle**

c) External genitalia

The female external genitalia include

i)Mons pubis,
ii)Labia majora,
iii)Labia minora,
iv)Hymen and
v)Clitoris

i)Mons pubis:

It is a cushion of fatty tissue covered by skin and pubic hair.

ii)The labia majora:

They are fleshy folds of tissue, which extend down from the mons pubis and surround the vaginal opening.

iii)**The labia minora:**

They are paired folds of tissue under the labia majora.

iv)Hymen :

The opening of the vagina is often covered **partially** by a membrane called **hymen**.

[The hymen is **often torn during the first coitus** (intercourse). *However, it can also be brokenby a sudden fall or jolt, insertion of a vaginal tampon, active participation in some sports like horseback riding, cycling, etc. In some women the hymen persists even after coitus. In fact,* ***the presence or absence of hymen is not a reliable indicator of virginity or sexual experience]***

v)Clitoris :

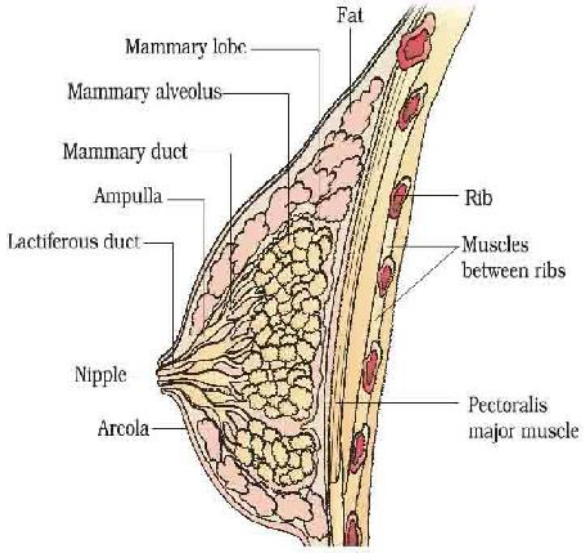
The clitoris is **a tiny finger-like** structure which lies at the upper junction of the two labia minora above the urethral opening.

Mammary Gland

- The mammary glands are paired structures (breasts) that contain
  - ➢ Glandular tissue and
  - ➢ Variable amount of fat.
- The glandular tissue of each breast is divided into **15-20 mammary lobes**

containing clusters of cells called **alveoli .**The cells of alveoli **secrete milk**, which is **stored in the cavities (lumens) of alveoli**.

- The alveoli open into **mammary tubules**.
- The mammary tubules of each lobe join to form a **mammary duct**.
- Several mammary ducts join to form a wider **mammary ampulla** which is connected to lactiferous duct through which milk is sucked out.



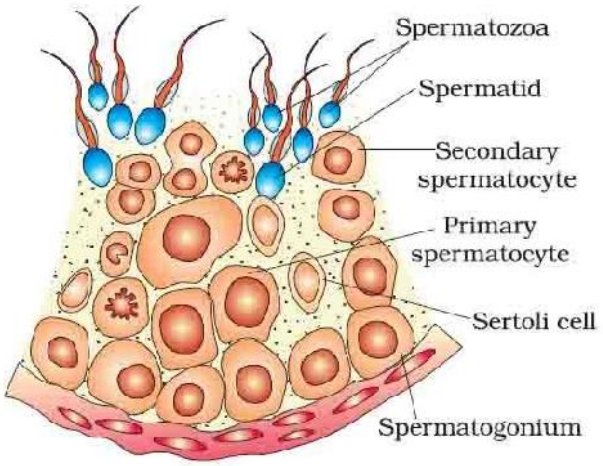
Alveoli→ Mammary tubules→ Mammary ducts→Mammary ampulla→ Lacteiferous duct

GAMETOGENESIS

- ✓ The process of formation of gamete is called **gametogenesis**.
- ✓ **The gametes of male is called Sperm and of female is called Egg/Ovum**
- ✓ The process of formation of sperm is called **spermatogenesis**.
- ✓ The process of formation of egg/Ovum is called **Oogenesis.**

a)Spermatogenesis

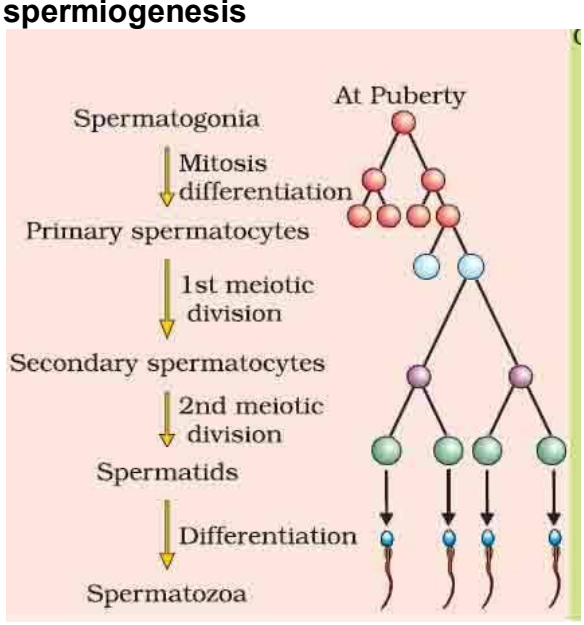
- The process of formation of sperm is called spermatogenesis.
- It takes place at testis.
- Each testis has about **250 compartments called testicular lobules.** Each Testicular lobule contains **one to three** highly coiled **seminiferous tubules** in which sperms are produced.
- Each seminiferous tubule is lined on its inside by two types of cells called male **germ cells (spermatogonia/Sperm mother cells) and Sertoli cells**



- Each spermatogonium is **diploid** and contains 46chromosomes.

Steps in Spermatogenesis

- Some of the spermatogonia called **primary spermatocytes** periodically undergo **meiosis.**
- **A primary spermatocyte** completes the **first meiotic** division (reduction division) leading to formation of two **equal**, haploid cells called **secondary spermatocytes,** which have only **23 chromosomes** each.
- The secondary spermatocytes undergo the **second meioticdivision** to produce **four equal, haploidspermatids**
- The spermatids are transformed intospermatozoa (sperms) by the process called **spermiogenesis**.
- Ie: Spermiogenesis is the **conversion of spermatid into sperm is called spermiogenesis**



- After spermiogenesis, sperm heads become embedded in the **Sertoli cells**, and are finally released from the seminiferous tubules by the process called **spermiation**.
- **The release of sperm after spermatogenesis from seminiferous tubule is called spermiation**

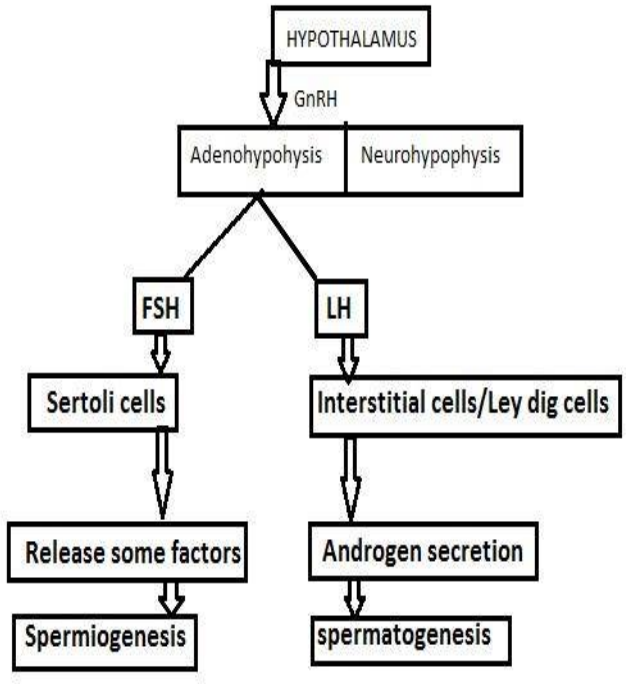
- From a single Primary spermatocyte 4 sperms are produced
- From a single secondary Spermatocyte 2 sperms are produced

Qn. How many sperms are produced from 100 primary spermatocyte ?
Ans:

Qn. Which of the following is haploid cell/s ?
Spermatogonia, Primary spermatocyte, secondary spermatocyte, spermatid, Sperm

Ans:

Hormonal Control of Spermatogenesis / Male reproductive system



- Spermatogenesis starts at the age of **pubertydue to significant** increase in the secretion of **gonadotropin releasing hormone** (GnRH-GnRH is secreted by Hypothalamus).
- The increased levels of GnRH then acts **at the anterior pituitary gland (Adenohypophysis)**and stimulates secretion of two **gonadotropins – luteinising hormone (LH) and follicle stimulating hormone (FSH**).

LH (luteinisinghormone)
- ✓ **LH acts at the Leydig cells and stimulates synthesis and secretion of androgens.**
- ✓ **Androgens, in turn, stimulate the process of spermatogenesis**.

FSH (follicle stimulating hormone)
- ✓ **FSH acts on the Sertoli cells and stimulates secretion of some factors which help in the process of spermiogenesis**

Structure of sperm

It is a microscopic structure composed of
- ✓ A**head,**
- ✓ **Neck,**
- ✓ **A middle piece and**
- ✓ **A tail.**

A plasma membrane envelops the whole body of sperm.

The sperm head:

The head contains an elongated haploid nucleus, the anterior portion of which is covered by a cap-like structure**, acrosome**.

Functions of acrosome:The acrosome is filled with enzymes (Hyaluronidase) that help fertilisation of the ovum**.**

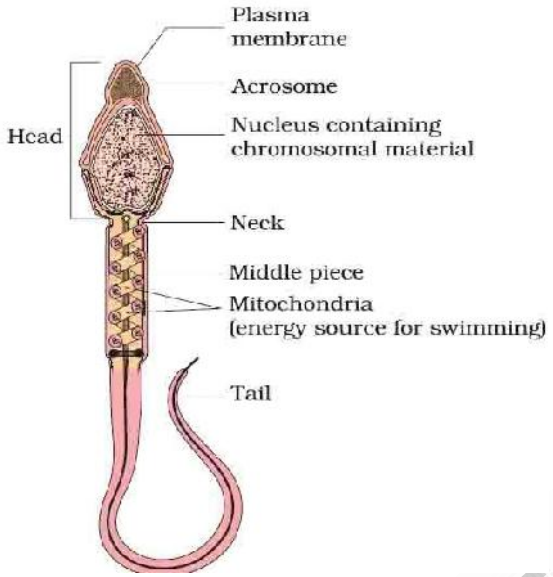
The middle piece:

Middle Piece possesses numerous mitochondria, which produce energy for the movement of tail that facilitate sperm motility essential for fertilization

Tail :

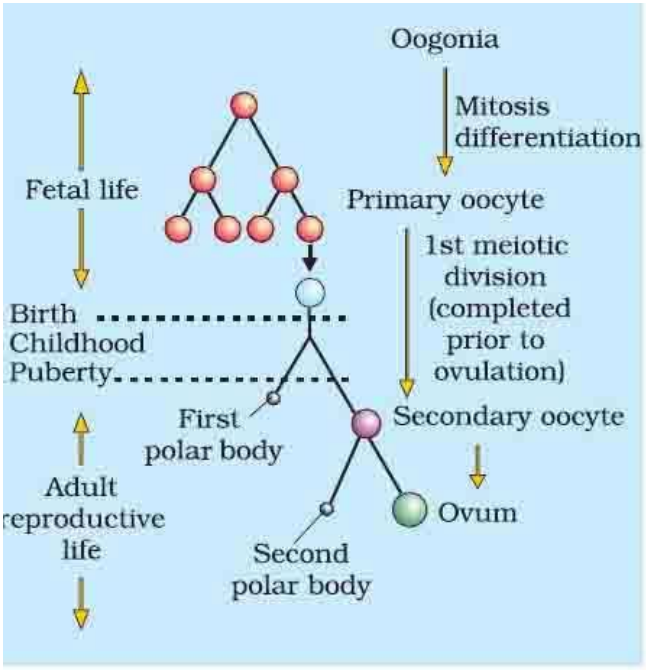
it helps in sperm movement

- ✓ The human male ejaculates about **200 to 300** million sperms during a coitus of which, for normal fertility, at least **60 per cent sperms must have normal shape and size and at least 40 per cent of them must show vigorous motility.**
- The seminal plasma along with the sperms constitute the **semen**

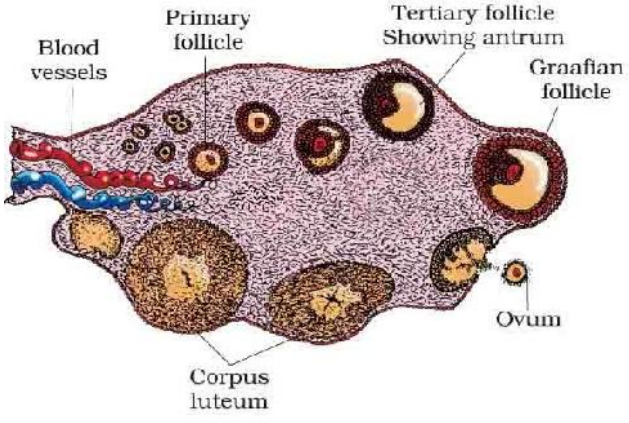


b)Oogenesis

- The process of formation of a mature female gamete is called **Oogenesis**.
- Oogenesis is initiated during the **embryonic development stage** when a couple of million gamete mother cells (oogonia) are formed within each fetal ovary; **no more oogonia are formed and added after birth.**
- **These cells start division and enter into prophase-I of the meiotic division and get temporarily arrested at that stage,called primary oocytes**.
- Each primary oocyte then gets surrounded by a layer of granulosa cells and is called the **primary follicle**.
- A large number of these follicles degenerate during the phase from birth to puberty. Therefore, at puberty only **60,000-80,000** primary follicles are left in each ovary.
- The primary follicles get surrounded by more layers of granulosa cells and a new theca and are called **secondary follicles**.



- The secondary follicle soon transforms into **a tertiary follicle** which is characterised by a fluid filled cavity called **antrum**. The theca layer is organised into an inner theca interna and an outer theca externa..
- **First meiotic division an unequal division** resulting in the formation of **a large haploid secondary oocyte and a tiny first polar body**
- The secondary oocyte retains bulk of the nutrient rich cytoplasm of the primary oocyte.
- The tertiary follicle further changes into the **mature follicle or Graafian follicle**.
- The secondary oocyte forms a new membrane called **zona pellucid** surrounding it.
- The Graafian follicle now ruptures to release **the secondary oocyte (ovum)** from the ovary by the process called **ovulation.**



MENSTRUAL CYCLE

- Menarche:

  The first menstruation begins at puberty and is called **menarche**.

- Menopause:

  Menstrual cycles ceases around 50 years of age; that is termed as **menopause**

- **LH Surge :**

  Both LH and FSH(luteinizing hormone and follicle-stimulating hormone) attain a peak level in the middle of Menstrual cycle (about 14th day).Rapid secretion of LH leading to its maximum level during the mid-cycle called **LH surge** It induces rupture of Graafian follicle and thereby the release of ovum (ovulation).

- **Ovulation:**

  The release of ovum from the ovary is called Ovulation. It is induced by LH.

- **Corpus Luteum:**

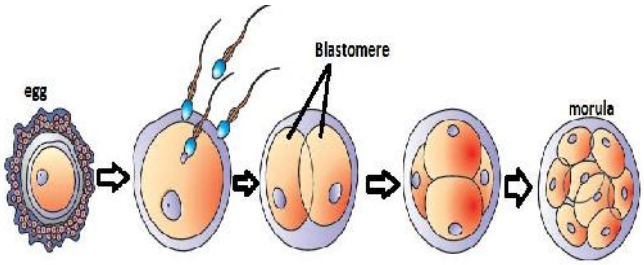
  After ovulation, remaining parts of the Graafian follicle transform as the **corpus luteum.** The corpus luteum secretes large amounts of **progesterone** which is essential **for maintenance of the endometrium.** Such an endometrium is necessary for implantation of the fertilized ovum and other events of pregnancy.

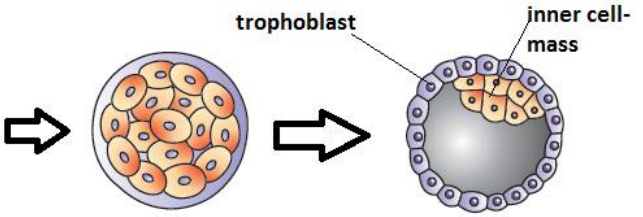
- **Fertilisation:**

  The process of fusion of a sperm with an ovum is called fertilization.

.Clevage

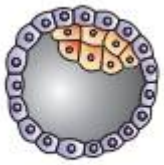
- **After fertilzation zygote starts mitotic division .**
- **The mitotic division** starts as the zygote moves through the isthmus of the oviduct called cleavage towards the uterus and forms 2, 4, 8, 16 daughter cells called **blastomeres.**
- **The embryo with 8 to 16 blastomeres is called a morula** .
- The **morula** continues to divide and transforms into **blastocyst** as it moves further into the uterus.





Structure of Blastocyst

- The blastomeres in the blastocyst are arranged into an outer layer called trophoblast and an inner group of cells attached to trophoblast called the inner cell mass.



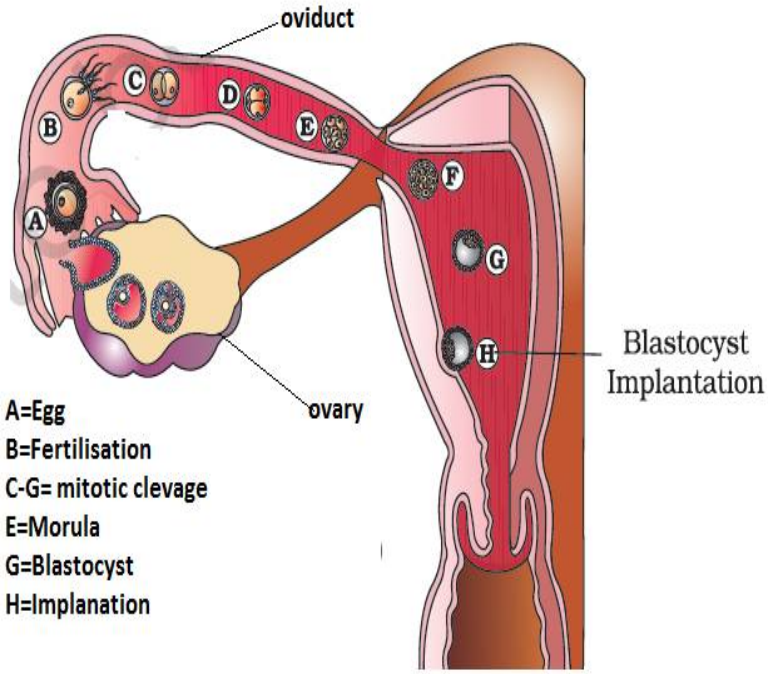
(Blastocyst)

- **Attachment of Blastocyst on the inner wall of uterus (Endometrium) is called implantation**

Fate of cells in the blastocyst

- The trophoblast layer of blastocyst gets attached to the endometrium and **the inner cell mass gets differentiated as the embryo.**
- Immediately afterimplantation, the inner cell mass (embryo) differentiates into an outer layer called ectoderm and an inner layer called endoderm. A mesoderm soon appears between the ectoderm and the endoderm. These three layers give rise to all tissues (organs) in adults**.**

Inner cell mass contains certain cells called stem cells which have the potency to give rise to all the tissues and organs



Placenta

- After implantation, finger-like projections appear on the trophoblast called **chorionic villi** which are surrounded by the uterine tissue and maternal blood.
- The chorionic villi and uterine tissue become interdigitated witheach other and jointly form **a structural and functional unit between developing embryo (foetus) and maternal body called placenta**
- The placenta is connected to the embryo throughan umbilical cord which helps in the transport of substances to and fromthe embryo

Functions of placenta

1.The placenta facilitate the supply of oxygen and nutrients to theembryo

2. it helps in the removal of carbon dioxide and excretory/waste materialsproduced by the embryo.

3. Placenta also acts as an endocrine tissue and produces several hormones **called Placental Hormones- like**

- **Human chorionic gonadotropin (hCG),**
- **Human placental lactogen (hPL),**
- **Estrogens,**
- **Progestogens, etc.**

- **hCG, hPL and relaxin** are produced in women only during pregnancy.

- In the later phase of pregnancy, a hormone called **relaxin** is also secreted by the **ovary.**

Gestation

- The duration between fertilization and parturition is called gestation.

- **1st month** of pregnancy=**Heart** is formed
- 1st sign of growing foetus may be noticed by the listing to the heart sound
- By the end of **second month-Limbs and digits formed**
- By the end of **12 weeks** (1st trimester)= **major organs formed (Limbs and external genital organs formed)**
- **5th month= 1st movement of foetus, appearance of hair on head**
- By the end of **24th week** (2ndtrimsester)= **Body covered with fine hairs, eye lids separate, eye lashes formed**
- By the end of **9 months** of pregnancy, =the foetus is fully developed and is **ready for delivery**

During pregnancy the levels of hormones like **estrogens, progestogens, cortisol, prolactin, thyroxine, etc., are increased several folds in the maternal blood**. Increased production of these hormones is essential **for supporting the fetal growth, metabolic changes in the mother and maintenance of pregnancy.**

Significance of colostrum

- The milk produced during the initial few days of lactation is called colostrums
- Which contains several antibodies (IgA) absolutely essential to develop resistance for the new-born babies.
- Breast-feeding during the initial period of infant growth is recommended by doctors for bringing up a healthy baby

02
Reproductive Health

Contraceptive methods

- It helps to prevent unwanted pregnancies.

Qualities of a good contraceptive method

An ideal contraceptive should be

1. User-friendly,
2. Easily available,
3. Effective and
4. Reversible
5. No or least side-effects.
6. It should not interfere with the sexual drive, desire and/or the sexual act of the user.

❖ A wide range of contraceptive methods are presently available which could be broadly grouped into the following categories, namely

A) Natural/Traditional method
B) Barrier method
C) IUDs
D) Oral contraceptives,
E) Injectables
F) Implants
G) Surgical methods

A) Natural methods

Natural methods work on the principle of avoiding chances of ovumand sperms meeting.

i)Periodic abstinence :

❖ It is one of natural method in whichthe couples avoid or abstain from coitus from day **10 to 17 (Fertile period-Because chances of fertilization re very high during this period)** of the menstrualcycle when ovulation could be expected.

❖ Therefore, **by abstaining (Avoiding) from coitus during this period, conception could be prevented**

ii) Withdrawal or **coitus interruptus :**

❖ Here the male partner withdraws his penis from the vagina **just before ejaculation** so as to avoid insemination.

iii)Lactational amenorrhea :

(Absence of menstruation)

❖ This method is based on the fact that ovulation and therefore the cycle do not occur during the period of intense lactation following parturition.

❖ Therefore, as long as the mother breast-feeds the child fully, chances of conception are almost nil.

❖ However, this method has been reported to be effective only upto a maximum period of **six months** following parturition.

1. **Adventages of Natural methods :**
   No medicines or devices are used in natural , side effects are almost nil.
2. **Disdventage of Natural methods:**
   Chances of failure by this method are also high

B) Barrier method

In **barrier** methods, ovum and sperms are prevented from physically meeting with the help of barriers. Such methods are available for both males and females.Barrier methods include

i) Condoms :

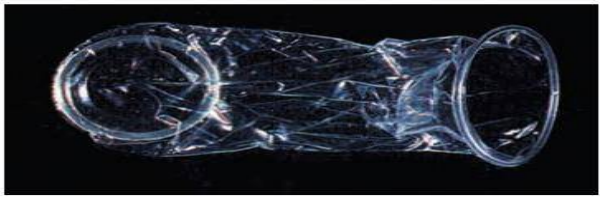
❖ they are barriers made of thin **rubber/ latex sheath**

❖ It is used to cover the **penis in the male or vagina and cervix in the female**,

❖ It is used just before coitus so that the ejaculated semen would not enter into the female reproductive tract. This can prevent conception.

'Nirodh' is a popular brand of condom for the male.

Condom for male



Condom for female

Advantages of Condoms

1. Use of condoms protecting the user from contracting STIs/STDs and AIDS.
2. Both the male and the female condoms are disposable,
3. It can be self-inserted
4. It gives privacy to the user

ii) Diaphragms, cervical caps and **vaults**

- Theyare also barriers made of rubber
- They are inserted into the female reproductive tract to cover the cervix during coitus.

Mechanism of action :

- They prevent conception by blocking the entry of sperms through the cervix.
- Spermicidal creams, jellies and foams are usually used alongwith these barriers to increase their contraceptive efficiency
- **They are reusable**.

C) IUDs (Intra Uterine Devices)

- These devices are inserted by doctors or expert nurses in the uterus through vagina.
- IUDs increase phagocytosis of sperms within the uterus
- These Intra Uterine Devices are presently available are

i) Non-medicated IUDs

E.g., Lippes loop

ii)Copper releasing IUDs

Eg.CuT, Cu7, Multiload 375

Mechanism of action :

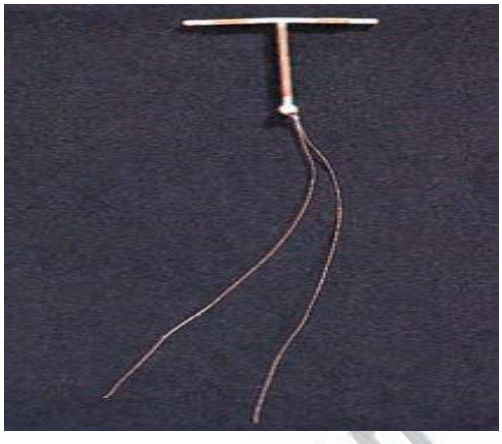
- Cu ions released suppress sperm motility and the fertilising capacity of sperms.
- Non medicated IUD either retard the sperm motility or have the spermicidal effect

iii) Hormone releasing IUDs

Eg:Progestasert, LNG-20

Mechanism of action :

- ✓ It make the uterus unsuitable for implantation
- ✓ It make and the cervix hostile to the sperms.
- ✓ Medicated IUD release certain hormones that alter the hormonal balance in the female body and prevent conception



Cu-T

IUDs are ideal contraceptives for the females who want to delay pregnancy and/or space children. **It is one of most widely accepted methods of contraception in India.**

D) Oral contraceptive (Oral Pills)

- Oral administration of small doses of either **progestogens or progestogen–estrogen** combinations is another contraceptive method used by the females.
- They are used in the form of tablets and hence are popularly called the **pills**.
- Pills have to be taken daily for a period of **21 days** starting preferably within the first five days of menstrual cycle. After a gap of 7 days (during which menstruation occurs) it has to be repeated in the same pattern till the female desires to prevent conception.

Mechanism of action:

- They inhibit ovulation and implantation
- It alter the quality of cervical mucus to prevent/ retard entry of sperms.

Advantage of pills

- Pills are very effective
- It has lesser side effects
- They are well accepted by the females.

Saheli-Once a Week Pill

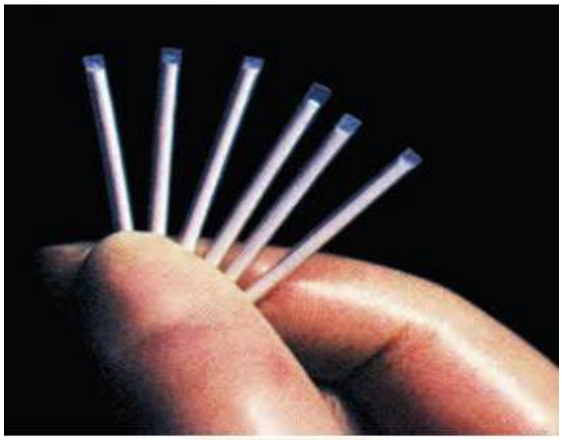
- ***Saheli*–the new oral contraceptive for the females contains a non-steroidal preparation. It is a 'once a week'**

pillwith very few side effects and high contraceptive value.

- **'Saheli was developed by scientists at Central Drug Research Institute (CDRI) in Lucknow**

E) Injectabale and Implants

- **Progestogens alone or in combination with estrogen** can also be used by females as injections or implants **under the skin**
- Their mode of action is **similar to that of pills and their effective periods are much longer.**



Implants

Emergency Contraceptive method

- Administration of progestogens or progestogen-estrogen combinations or IUDs within **72 hours of coitus** have been found to be very effective as emergency contraceptives as they could be used to avoid possible pregnancy due to rape or casual unprotected intercourse.

G) Surgical Methods (sterilisation)

- Surgical methods, also called **sterilisation,**
- They are generally advised for the male/female partner as a **terminal method to prevent any more pregnancies.**
- **Mchanism of action:**Surgical intervention blocks gamete transport and thereby prevent conception.
- The two types of surgical methods are Vasectomy and tubectomy

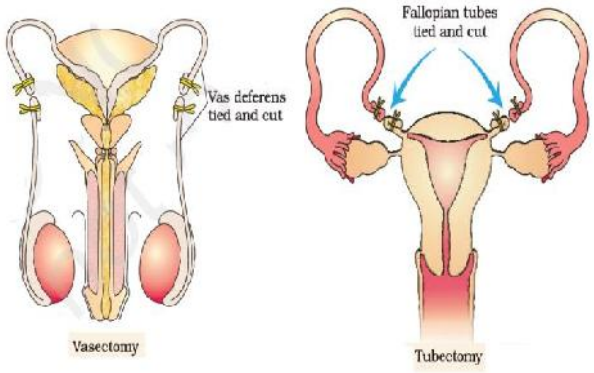
i)Vasectomy :

- Sterilisation procedure in the **male** is called 'vasectomy'.
- In vasectomy, a small part of the vas deferens is removed or tied up through **a small incision on the scrotum.**

ii)Tubectomy

- Sterilisation procedure in the **Female** is called tubectomy.
- In tubectomy, a small part of the fallopian tube is removed or tied up through a small incision in the **abdomen or through vagina.**

These techniques are highly effective but their reversibility is very poor.



Difference between vasectomy and Tubectomy

Vasectomy	Tubectomy
Sterilisation procedure in the **male** is called 'vasectomy'.	Sterilisation procedure in the **Female** is called tubectomy.
In vasectomy, a small part of the vas deferens is removed or tied up through **a small incision on the scrotum.**	intubectomy, a small part of the fallopian tube is removed or tied up through a small incision in the **abdomen or through vagina.**
Passage of sperm is prevented	Passage of egg is prevented

Ill-Effect of the usage of contraceptive methods /Birth Controls

ill-effects include

- Nausea,
- Abdominal pain,
- Breakthrough bleeding,
- Irregular menstrual bleeding
- Breast cancer,

Though not very significant, should not be totally ignored.

SEXUALLY TRANSMITTED INFECTIONS (STIs)

- **Diseases or infections which are transmitted through sexual intercourse are collectively called sexually transmitted infections (STIs) or venereal diseases (VD) or reproductive tract infections (RTI).**

  Eg :
  - **Gonorrhoea**
  - **Syphilis**
  - **Genital herpes**
  - **Chlamydiasis**
  - **Genital warts**
  - **Trichomoniasis**
  - **Hepatitis-B**
  - **AIDS (HIV infections)**

- **Except for hepatitis-B, genital herpes and HIV infections**, other diseases are completely curable if detected early and treated properly.

Hepatitis–B and HIV can also be transmittedby sharing of injection needles, surgical instruments, etc., with infected persons, transfusion of blood, or from an infected mother to the foetus too

Symptoms of STIs

Early symptoms of most of these are minor and **include**

- ☑ **Itching,**
- ☑ **Fluid discharge,**
- ☑ **Slight pain,**
- ☑ **Swellings, etc., in the genital region**.

Infected females may often be asymptomatic and hence, may remain undetected for long.

Complications of STIs

- Absence or less significant symptoms in the early stages ofinfection and the social stigma attached to the STIs, deter the infectedpersons from going for timely detection and proper treatment.
- This couldlead to complications later, which include
  - ☑ **Pelvic inflammatory diseases (PID),**
  - ☑ **Abortions,**
  - ☑ **Still births (Birth of dead foetus)**
  - ☑ **Ectopic pregnancies (Tubular pregnanacy),**
  - ☑ **Infertility**
  - ☑ **Cancer of the reproductive tract**
- All persons are vulnerable to these infections, their incidence are reported to be very high among persons in the age group of 15-24 years-the age group to which you also belongs

STD can be prevented by

1. Avoid sex with unknown partners/multiple partners
2. Always use condoms during coitus.
3. In case of doubt, one should go to a qualified doctor for early detection and get complete treatment if diagnosed with disease.

Infertility

- Inability to produce children inspite of unprotected sexual co-habitation is called infertile.

The reasons for this could be many–

- Physical
- Congenital,
- Diseases,
- Drugs,
- Immunological
- Psychological

- In India, often the female is blamed for the couple being childless**, but more often than not, the problem lies in the male partner.**
- **Specialised health care units** called **infertility clinics** could help in diagnosis and corrective treatment of some of these disorders and enable these couples to

have children. However, where such corrections are not possible, the couples could be assisted to have children through certain special techniques commonly known as **assisted reproductive technologies (ART).** The ART includes the following

a) ***In vitro* fertilization and Embryo transfer (IVF-ET)**

- Fertilisation **outside the body** is called Invitro fertilisation.
- Invitro fertilisation is done in almost similar conditions (as that in the body) followed by **embryo transfer.** This method ispopularly known as **test tubebaby** programme.

Steps/Procedure in IVF-ET

- Ova/Egg from the wife/donor (female) and sperms from the husband/donor (male) are collected
- Oth sperm and egg are induced to form zygote under simulated conditions in the laboratory (**This step is called IVF)**
- The zygote or early embryos thus formed (**with upto 8 blastomeres**) could then be transferred into the fallopian tube (ZIFT**– zygote intra fallopian transfer**) and embryos with **more than8 blastomeres**, into the uterus (IUT **– intra uterine transfer**), to complete its further development. (This step is called Embryo transfer)
- Embryos formed by **in-vivo fertilisation**(fusion of gametes within the female) also could be used for such transfer to assist those females who cannot conceive

b) GIFT(Gamete Intra Fallopian Transfer)

Transfer of an ovum collected from a donor into the fallopian tube (GIFT – **gamete intra fallopian transfer**) of another female who cannot produce one, but can provide suitable environment for fertilisation and further development .

c) Intra cytoplasmic sperm injection (ICSI)

it is another specialised procedure to form an embryo in the laboratory in which a sperm is directly injected into the ovum.

d)AI (Artificial insemination):

infertility cases either due to **inability of the male partner to inseminate the female or due to very low sperm counts in the ejaculates**, could be corrected by **artificial insemination** (AI) technique.

In this technique, the semen collected either from the husband or a healthy donor is artificially introduced either into the vagina or into the uterus (IUI – **intra-uterine insemination**) of the female.

- The ultimate aim of ART is to have children
- Though options are many, all these techniques require extremely high precision handling by specialised professionals and expensive instrumentation. Therefore, these facilities are presently available only invery few centres in the country. Obviously their benefits is affordable toonly a limited number of people.

- Since the ultimate aim of all these procedures is to have children, in India we have so many orphaned and destitute children, who would probably not survive tillmaturity, unless taken care of. Our laws permit legal adoption and it isas yet, one of the best methods for couples looking for parenthood

03
PRINCIPLES OF INHERITANCE AND VARIATION

Mendel's Laws on Inheritance

(Principles of inheritance)

Based on **Mendel's observations on monohybrid crosses**, Mendel proposed **two general rules** to consolidate his understanding of inheritance inmonohybrid crosses. **Today these rules are called the Principles or Laws of Inheritance:**

1-The First Law or Law of Dominance
2- Second Law or Law of Segregation

1. Law Of Dominance (1st law)

The main points are …

I. The characters are controlled by discrete units called **factors**.
II. Factors occur in **pair.**
III. In a dissimilar pairs of factors (Heterozygous), one member of pairs dominates over the other. (The dominated one is called Dominant , and other character is called Recessive)

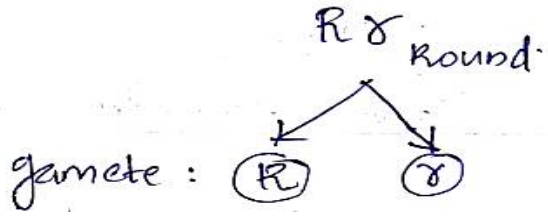
- This law is used to explain the expression of only one of the parental character in the F1 of monohybrid cross.
- This law explains the proportion of 3:1 obtained at the F2

2. Law of segregation

(2nd law/law of purity of gamete)

- This law is based on the fact that the **alleles do not show any blending** and that both the characters are recovered as such in the F2 generation though one of these is not seen at the F1 stage .
- This law states that,

"During gamete formation 2 factors for a character present in an individual will separate from each other and enter into each gamete, such that a gamete receives only one of the two factors."



- Thus, a homozygous parent produces all gametes that are similar.
- While a Heterozygous one produces two kinds of gametes each having one allele with equal proportion.

- Both 1st and 2nd law of Mendel obtained from monohybrid cross .

DEVIATION FROM MENDELIAN PRINCIPLE/ NON MENDELIAN INHERITANCE

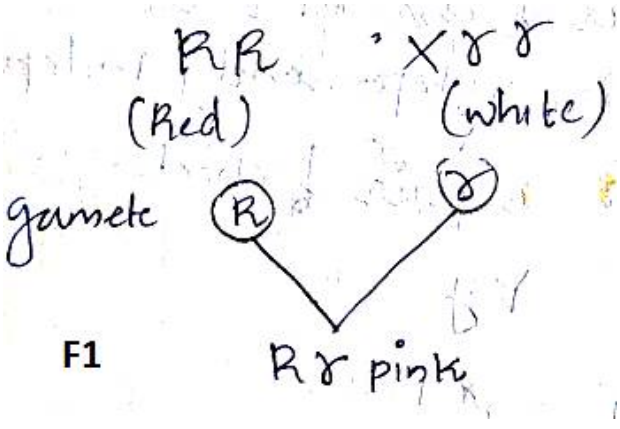
- Non-Mendelian inheritance is any pattern of inheritance in which traits **do not segregate in accordance with Mendel's laws**

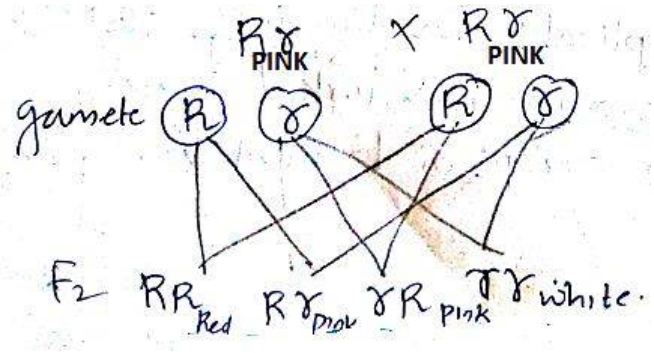
1. Incomplete dominance

- It is the inheritance in which the heterozygous offspring show **intermediate character between 2 parents**.

Example-1

- Inheritance of flower colour**in the dog flower (snapdragon or *Antirrhinum sp.)*** and ***Mirabilis jalapa*** **(4 o' clock plant)** is a good example to understand incomplete dominance. It was studied by Carl Correns of Germany .



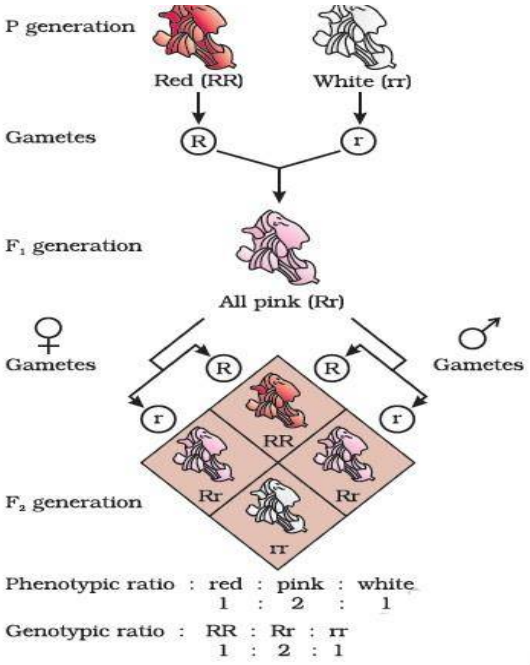


Phenotypic ratio=1:2:1
Genotypic ratio=1:2:1

- When Correns crossed a true-breeding red-flowered (RR) *Antirrhinum* and true breeding white-flowered *Antirrhinum* plants (rr), the F1 (Rr) was **pink**
- When the F1 was self-pollinated **the F2** resulted in the following ratio

1(RR) Red: 2 (Rr) Pink: 1 (rr) White.

- Here the genotype ratios were exactly as **we would expect in any mendelian monohybrid cross, but the phenotype ratios had changed from the 3:1 dominant: recessive ratio.**
- What happened was **that R was not completely dominant over r and this made it possible to distinguish Rr as pink** from RR (red) and rr (white) .**This is due to incomplete dominance. So the heterozygous offsprings** shows intermediate character **between 2 parents.**



Example-2

Starch grain size in Pea seed

- Starch synthesis in pea seeds is controlled by one gene. It has two alleles **(B and b)**
- BB-----→starch synthesized effectively (Large sized starch grains)
- bb-------→ lesser efficiency in starch synthesis (Small sized starch grains)
- **Bb-----→ Intermediate sized starch grains**

2. Co Dominance

- Here **both alleles of gene are expressed** in **heterozygous condition**.
- in the case of co-dominance, the F1 generation resembles both parents

Example-1

ABO Blood group

- ABO blood group is controlled by the gene 'I'
- 'I' gene has 3 alleles **–I^A ,I^B, i**
- The allele $I^A$and ,I^B produce slightly different form of the sugar .
- This sugar are protrudes **from the plasma membrane of RBC.**
- 'i' donot produce sugar
- When 'I^A' and 'i' are present in an organism (I^Ai), only I^A expressed because 'i' donot produce any sugar .

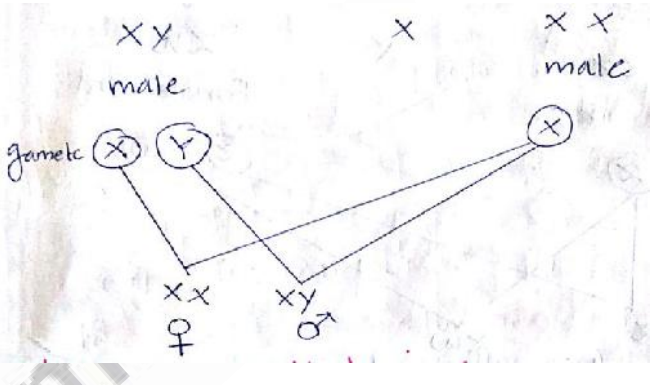
- When '$I^{B'}$ and 'i' are present in an organism (I^Bi), only I^B expressed because 'i' donot produce any sugar .
- **When I^A and I^B are present in an organism (I^AI^B), they both express their own type of sugars. This is due to co dominance. Such RBC contains both sugar 'A' and 'B' type of sugars.**

Blood Group (Phenoype)	Genotype
A	I^AI^A,I^Ai
B	I^BI^B,I^Bi
AB	I^AI^B
O	ii

- There are **4 different phenotype** present in ABO blood group
- There are **6 different genotype** present in ABO blood group

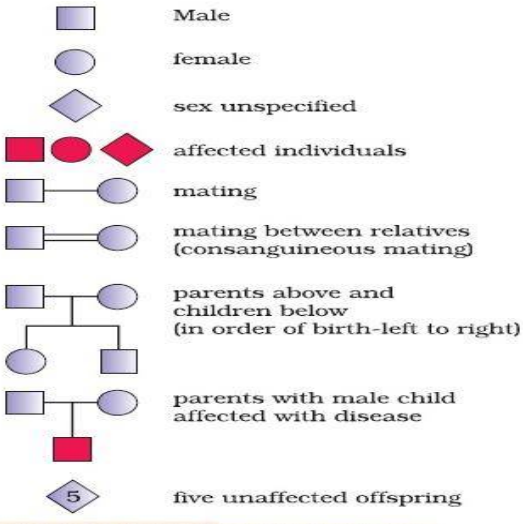
Sex Determination in Humans

- Sex determining mechanism in case of humans is XY type.
- Out of 23 pairs of chromosomes present, 22 pairs are exactly same in both males and females; these are the autosomes. A pair of X-chromosomes are present in the female (XX), whereas the presence of an X and Y chromosome (XY) are determinant of the male characteristic .
- During spermatogenesis among males, two types of gametes are produced. 50 per cent of the total sperm produced carry the X-chromosome and the rest 50 per cent has Y-chromosome besides the autosomes.
- Females, however, produce only one type of ovum with an X-chromosome.
- **There is an equal probability of fertilisation of the ovum with the sperm carrying either X or Y chromosome.**
- In case the ovum fertilises with a sperm carrying X-chromosome the zygote develops into a female (XX) and the fertilisation of ovum with Y-chromosome carrying sperm results into a male offspring.
- Thus, it is evident that it is the **genetic makeup of the sperm that determines the sex of the child**.
- It is also evident that in each pregnancy there is always 50 per cent probability of either a male or a female child.
- It is unfortunate that in our society women are blamed for giving birth to female children and have been ostracised and ill-treated because of this false notion.



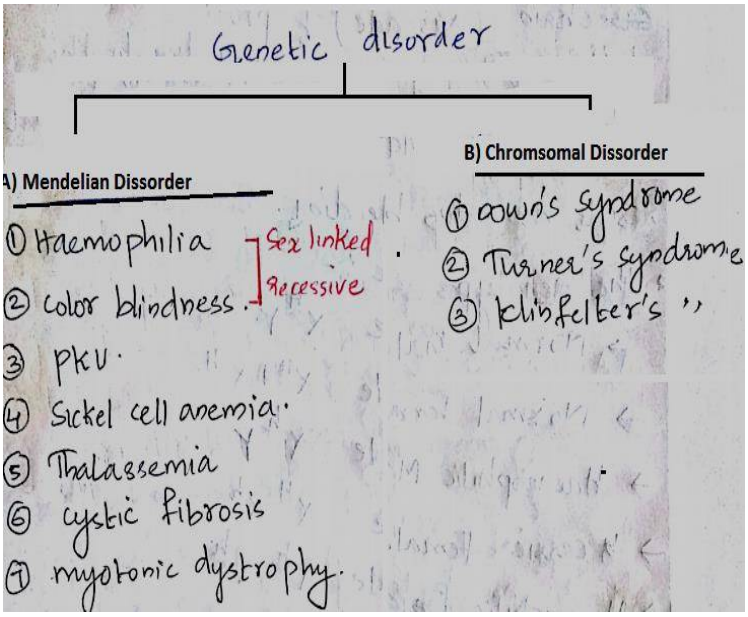
PEDIGREE ANALYSIS

- It is the analysis of trait in a several generations of a family is called pedigree analysis.
- Here inheritance of a particular trait is represented in the family tree (Chart showing family history) over generation.
- This analysis is used to trace the inheritance of a specific trait or abnormality or a disease
- The symbols used in pedigree analysis is given below



Symbols used in the human pedigree analysis

GENETIC DISSORDERS



A)Mendelian disorders

- It is due **to mutation or alteration in the single gene.**
- This disorder are transmitted to the offspring as we studied in the principles of inheritance
- This disorder can be traced in a family using **pedigree analysis.**

1.HAEMOPHILIA/BLEEDER'S DISEASE/ROYAL DISEASE

- It is a **sex linked (X-linked)recessive** disease
- Here a single protein that is a part of chain (cascade) of protein involved **in clotting of blood is affected**. Due to this, in affected individual a simple cut will result nonstop bleeding

Genotypes are

- Normal male X^HY
- Normal female X^HX^H
- Hemophilic male X^hY
- Hemophilic female X^hX^h
- Hemophilic carrier (Female-) X^HX^h
- The disease is transmitted from an unaffected carrier female (X^HX^h)to some of male progeny
- The possibility of a female becoming hemophilic is extremely rare, because mother of such female has to be at least carrier and father should be hemophilic (He is unviable in the later stage of life)
- **The family pedigree of Queen Victoria shows number of hemophilic descends. she was a carrier for this disease**

2. PKU (PHENYLKETONURIA)

- This is **the autosomal linked recessive trait.**
- PKU is an **inborn error in amino acid metabolism**
- The affected individual **lacks an enzyme (phenylalanine hydroxylase)** that converts the amino acid **phenylalanine into tyrosine**. As a result of this phenylalanine is accumulated and converted into **phenylpyruvic acid** and **other derivatives**.
- Accumulation of these in brain results in mental retardation. These are also excreted through urine because of its poor absorption by kidney.

The genotypes are

- Normal AA
- Carrier Aa
- Affected aa
- This disease is transmitted from parents to the offspring when both parents are carried (Heterozygous)

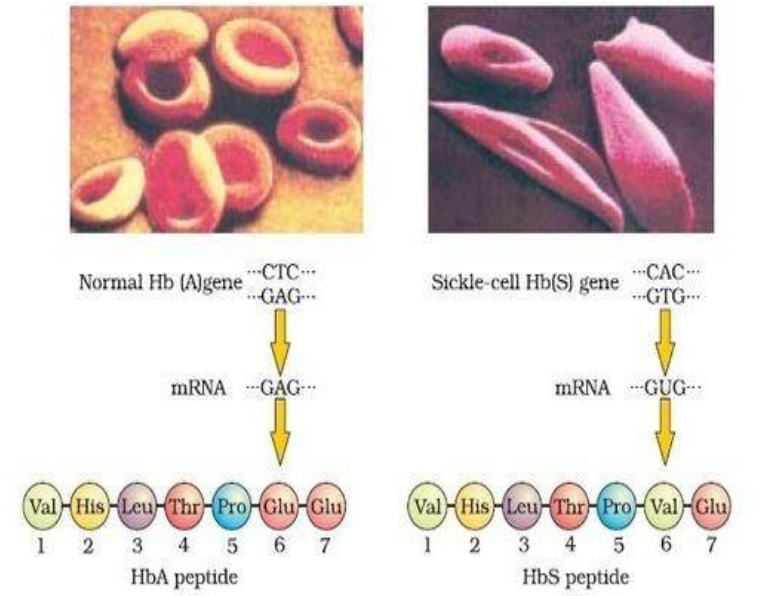
3. SICKLE CELL ANAEMIA

- This is **an autosome linked recessive trait**
- This can be transmitted from parents to the offspring when both the partners are carrier for the gene (or heterozygous).
- The disease is controlled by a single pair of allele, Hb^A and Hb^S.

Genotypes are

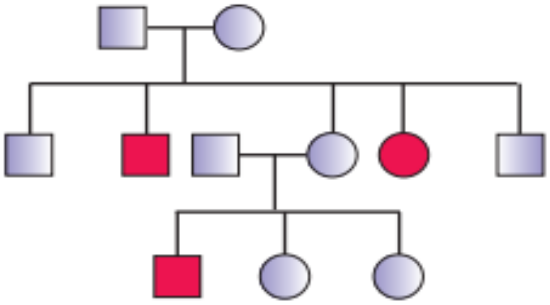
- Normal Hb^AHb^A
- Carrier Hb^AHb^S

- Affected Hb^sHb^s
- This disease is transmitted from parents to the offspring when both parents are carrier (Heterozygous)
- The defect is caused by the substitution of Glutamic acid (Glu) by Valine (Val) at the sixth position of the beta globin chain of the haemoglobin molecule.
- The substitution of amino acid in the globin protein results due to the single base substitution at the sixth codon of the beta globin gene from GAG to GUG.
- The mutant haemoglobin molecule undergoes polymerisationunder low oxygen tension causing the change in the shape of the RBC from biconcave disc to elongated sickle like structure



Micrograph of the red blood cells and the amino acid composition of the relevant portion of β-chain of haemoglobin: (a) From a normal individual; (b) From an individual with sickle-cell anaemia

Pedigree analysis-Sickle cell anaemia



B)chromosomal disorders

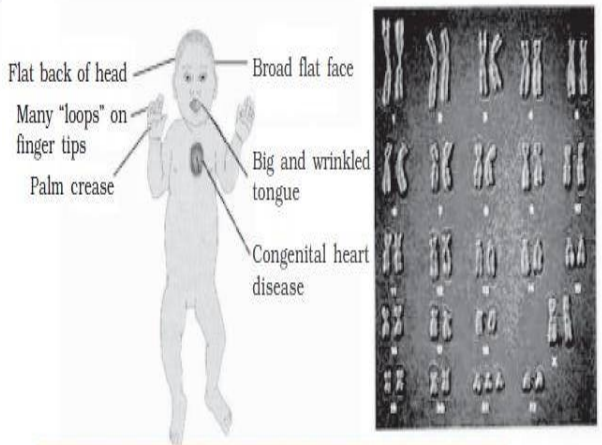
- It is due to **absence or excess or abnormal arrangement** of one or more chromosome

1. Down's Syndrome (45+XX or 45A+XY)

- This is due to an additional copy of the **chromosome number 21 (trisomy of 21).**
- This disorder was first described by **Langdon Down (1866).**

Symptoms

- The affected individual is
  - ✓ short statured
  - ✓ with small round head,
  - ✓ with furrowed tongue and with partially open mouth
  - ✓ Their Palm is broad with characteristic palm crease.
  - ✓ Physical, psychomotor and mental development is retarded.



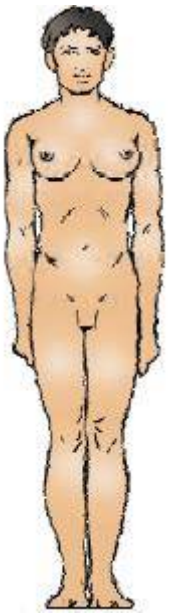
A representative figure showing an individual inflicted with Down's syndrome and the corresponding chromosomes of the individual

2. Klinefelter's Syndrome (44A+XXY)

- This genetic disorder is also caused due to **the presence of an additional copy of X-chromosome** resulting into a karyotype of 47, XXY.

Symptom

- Such an individual has overall masculine development , however, the feminine development (development of breast, i.e., **Gynaecomastia**) is also expressed . Such individuals are sterile



Klinfelter's syndrome

3. Turner's Syndrome : (44A+XO)

- It is due **to the absence of one of the X chromosomes,** i.e., 45 with X0,

Symptoms

Such females are

- sterile
- ovaries are rudimentary
- lack of other secondary sexual characters

Turner's syndrome

05
Molecular Basis Of Inheritance

The salient features of the Double-helix structure of DNA

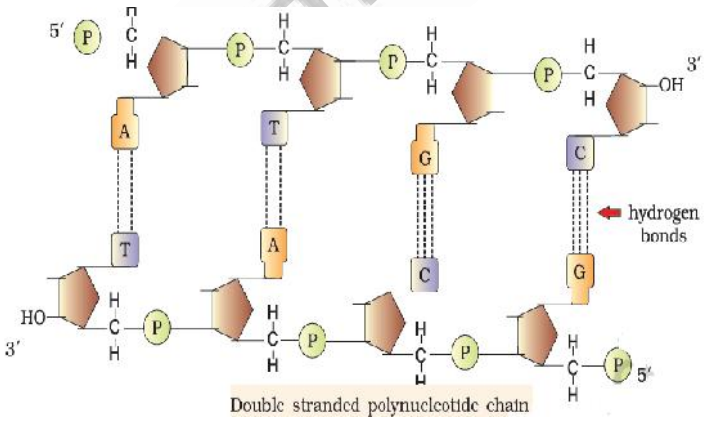
01- DNA is made of **two polynucleotide chains**, where the **backbone is constituted by sugar - phosphate, and the bases project inside.**

02- The two chains have **anti-parallel polarity**. It means, if one chain has the polarity **5'→3', the other has 3'→5'.**

03- The bases in two strands are **paired through hydrogen bond** (H-bonds) forming base pairs (bp). Adenine forms two hydrogen bonds with Thymine from opposite strand and vice-versa. Similarly, **Guanine is bonded with Cytosine with three H-bonds. As a result, always a purine comes opposite to a pyrimidine. This generates approximately uniform distance between the two strands of the helix (20A^{O})**

04- The two chains are coiled in **a right -handed fashion**. The pitch of the helix is 3.4 nm (a nanometre is one billionth of a metre, that is 10^{-9} m) and there are roughly **10 bp in eachturn**. Consequently, the distancebetween a bp inahelix isapproximately equal to 0.34 nm.

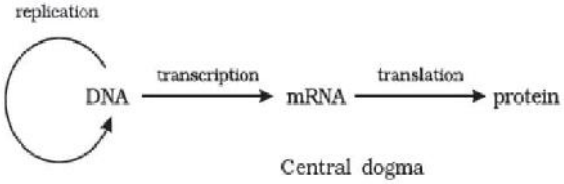
05- The plane of one base pair stacksover the other in double helix. This,in addition **to H-bonds, confer stability of the helical structure**



Double stranded polynucleotide chain

CENTRAL DOGMA IN MOLECULAR BIOLOGY

- Proposed by **Francis Crick**
- It is the unidirectional flow of Genetic information from DNA-RNA-Protein



Central dogma

- In some viruses the flow of information is in reverse direction

RNA----Reverse transcription----> DNA

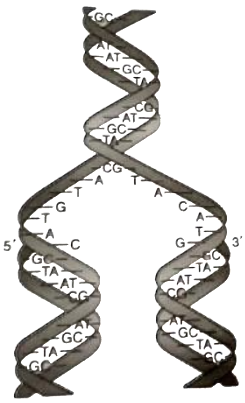
- It is an exception to central dogma of molecular biology.

DNA REPLICATION

- DNA replication is the copying of DNA from parent DNA
- Watson and crick proposed **Semiconservative method of DNA replication**
- According to this ,2 daughter DNA are produced from parent DNA. Each daughter DNA consists of 2 strands, one strand is newly synthesised and other strand belongs to parent.

  Ie: After the completion of DNA replication, each DNA molecule would have one parental and one newly synthesised strand.

  Ie: **Parent's strand is conserved**



Watson-Crick model for semiconservative DNA replication

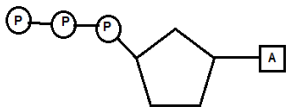
- ✓ In eukaryotes, the replication of DNA takes place at **S-phase of the cell-cycle.**
- ✓ The replication of **DNA and cell division cycle should be highly coordinated**.
- ✓ A failure in cell division after DNA replication results into **polyploidy**(a chromosomal anomaly)

Enzymes in DNA Replication

a) DNA Dependent DNA polymerase

- It is **the main enzyme** in DNA replication
- It uses **a DNA template** to catalyse **polymerisation of dexoy nucleotides**
- In E.Coli, it polymerise the nucleotides in faster rate (**2000BP/second).**
- In E.coli DNA replication completes **in 18 minutes.**
- This enzyme has high accuracy (**Any mistake during replication would result into mutations**)
- It polymerise the nucleotides in 5'→ 3 direction

Deoxy Ribonucleoside Triphsophate



ATP (adenosine tri phosphate)

- It has 2 functions,

i) It act as substrate.
ii) It provide energy for polymerisation

The 2 terminal phosphate in a dexoyribo nucleoside triphosphates are high energy phosphate. It provides energy for polymerisation.

Replication Origin

There is a definite region in E. coli DNA where the replication originates. Such regions are termed as origin of replication

Replication Fork

For long DNA molecules, since the two strands of DNA cannot be separated in its entire length (**Due to very high energy requirement**), the replication occur within a small opening of the DNA helix, referred to as **replication fork**

Template

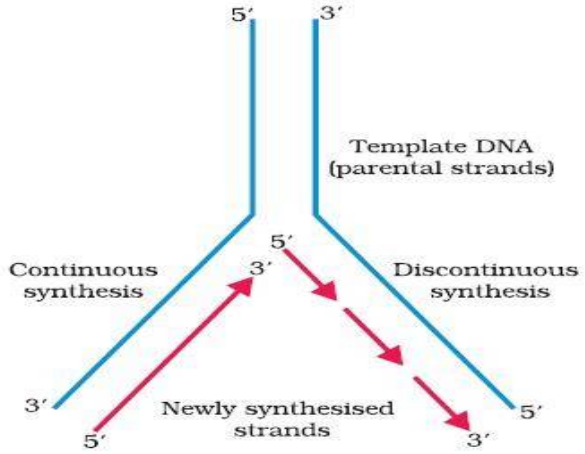
During DNA replication, the 2 strands separate and act as a template for the synthesis of new strand. New strands are synthesised based on template sequence.

Leading strand and Lagging strand (Continuous and discontinuous strand)

- ✓ In the presence of DNA dependent DNA polymerase, many nucleotides are joined to one another to form poly nucleotide (new strand).
- ✓ on one strand (the template with polarity 3'→5'), the replication is continuous (Continous strand/Leading strand), while on the other (the template with polarity 5'→3'), it is discontinuous.

b) DNA Ligase

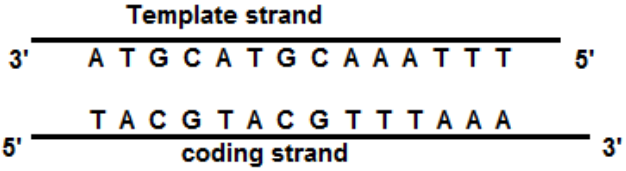
- ✓ The discontinuously synthesised fragments are joined by the enzyme **DNA ligase**



Replicating Fork

DNA transcription

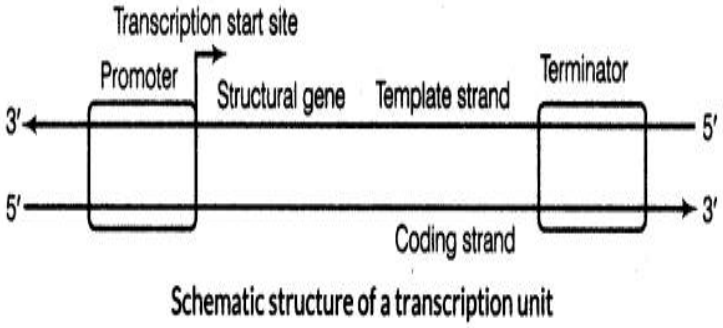
- ✓ The process of copying genetic information from **one strand of DNA (Template) into RNA** is called **transcription.**
- ✓ The enzyme involved in transcription **is DNA dependent RNA polymerase.**
- ✓ In DNA transcription **only a segment** of DNA (Gene,A gene is defined as the functional unit of inheritance) and **only one of the strand** (Template strand, 3'—5') is copied to RNA



✓ The strand with polarity **3'—5' act as a template** (For mRNA synthesis), the other strand with polarity **5'—3' is called coding strand** (It do not code for anything).

Transcription Unit

- A transcription unit in DNA is defined by **3 regions**
  a) A promoter
  b) The structural gene
  c) A terminator



Schematic structure of a transcription unit

a) A promoter

- It is the site where DNA dependent RNA polymerase bind
- Transcription starts from promoter site.
- Promoter is located towards the 5' end (Upstream) of the structural gene (The reference is made with respect to the polarity of Coding strand)
- It is the presence of a promoter in a transcription unit that defines the template and coding strands.
- By switching its position with terminator, the definition of coding and template strands could be reversed

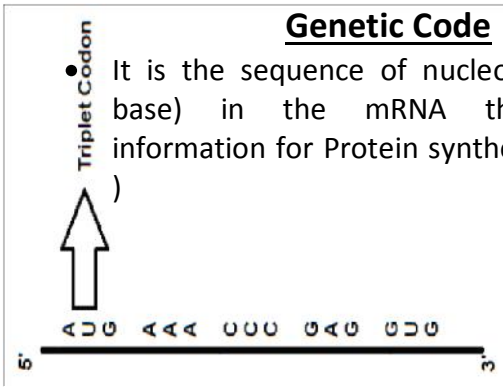
b) **The structural gene**

- The promoter and Terminator flank the structural gene in transcription unit.
- RNA is Copied from the structural gene

c) Terminator

- It is located towards the 3' end (Down stream) of coding strand
- it usually defines the end of the process of transcription

Genetic Code



- It is the sequence of nucleotides (Nitrogen base) in the mRNA that containing information for Protein synthesis (Translation)

Scientists involved in cracking/Deciphering the Genetic code

Several scientists belongs to several branches of science involved in cracking the genetic code such as it physicists, organic chemists, biochemists and geneticists. Some of the scientists are given below

1-George Gamow (Physicist) :he argued that since there are only 4 bases and if they have to code for20 amino acids, the code should constitute a combination of bases. He suggested that in order to code for all the 20 amino acids, the code should be made up of three nucleotides (Triplet codon)

2-Har GobindKhorana : The chemical method developed by HarGobind Khorana was instrumental in synthesising RNA molecules with defined combinations of bases (homopolymers and copolymers).

3-Marshall Nirenberg : He developed cell free system for protein synthesis

4-Severo Ochoa : Severo Ochoa enzyme (polynucleotide phosphorylase) was also helpfulin polymerising RNA with defined sequences **in a template independent manner (enzymatic synthesis of RNA).**

➢ Finally a checker-board for genetic code was prepared which is given below .

	U		C		A		G		
U	UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys	U
	UUC	Phe	UCC	Ser	UAC	Tyr	UGC	Cys	C
	UUA	Leu	UCA	Ser	UAA	Stop	UGA	Stop	A
	UUG	Leu	UCG	Ser	UAG	Stop	UGG	Trp	G
C	CUU	Leu	CCU	Pro	CAU	His	CGU	Arg	U
	CUC	Leu	CCC	Pro	CAC	His	CGC	Arg	C
	CUA	Leu	CCA	Pro	CAA	Gln	CGA	Arg	A
	CUG	Leu	CCG	Pro	CAG	Gln	CGG	Arg	G
A	AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser	U
	AUC	Ile	ACC	Thr	AAC	Asn	AGC	Ser	C
	AUA	Ile	ACA	Thr	AAA	Lys	AGA	Arg	A
	AUG	Met	ACG	Thr	AAG	Lys	AGG	Arg	G
G	GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly	U
	GUC	Val	GCC	Ala	GAC	Asp	GGC	Gly	C
	GUA	Val	GCA	Ala	GAA	Glu	GGA	Gly	A
	GUG	Val	GCG	Ala	GAG	Glu	GGG	Gly	G

The salient features of genetic code are as follows:

i) **The codon is triplet**. **61 codons** code for aminoacids and **3 codons do not code for any amino acids, hence they function as stop codons (UAA,UGA,UAG)**

ii) One codon codes for only one amino acid, hence, it is **unambiguous and specific.**

iii) Some amino acids are coded by more than one codon, hence the code is **degenerate**.

Non degenerate codon
AUG :Methionine
UGG: tryptophan

iv) The codon is read in mRNA in a **contiguous fashion. There are no punctuations**.

v) The code is nearly universal: for example, from bacteria to human UUU would code for Phenylalanine (phe). Some exceptions to this rule have been found in mitochondrial codons, and in some protozoans.

vi) AUG has dual functions.
-It codes for Methionine (met) ,
- it also act as initiator/startcodon

Qn. Following is the sequence of amino acids coded by an mRNA. Predict the nucleotide sequence in the RNA:

Met-Phe-Phe-Phe-Phe-Phe-Phe

Can you now correlate which two properties of genetic code you have learnt?

Ans:

REGULATION OF GENE EXPRESSION

A. Regulation of gene expression in Eukaryotes

In eukaryotes, the regulation could be exerted at

i) Transcriptional level (formation of primary transcript),
ii) Processing level (regulation of splicing),
iii) Transport of mRNA from nucleus to the cytoplasm,
iv) Translational level.

B. Regulation of gene expression in Prokaryotes

- **The metabolic, physiological and environmental conditions regulate expression of genes in Prokaryotes**
- Eg: In E coli the enzyme, beta galactosidase hydrolyses lactose into glucose and galactose. In the absence of lactose, the synthesis of beta galactosidase stops.
- The development and differentiation of embryo into adult organisms are also a result of the coordinated regulation of expression of several sets of genes.

OPERON

- Operons are cluster of genes responsible for controlling metabolic reaction within a living system.

OR

- a polycistronic structural gene is regulated by a common promoter and regulatory genes. Such arrangement is very common in bacteria and is referred to as **operon**
- All the genes regulating a metabolic reaction constitute an Operon.

Eg: **Lac operon**
Trp Operon
Ara Operon
His Operon
Val Operon

LAC OPERON

- Proposed by a geneticist, **Francois Jacob and a biochemist, Jacque Monod**
- They were the **first to elucidate a transcriptionally regulated system**
- The operon controlling lactose metabolism is called Lac Operon. It consists of

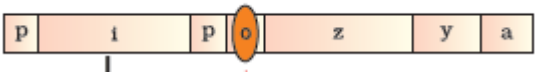
1-A regulator gene (i gene/ inhibitor gene) :
It code for repressor protein

2-Three structural gene

a)Lac Z gene : It code for **Beta galactosidase**(β-gal . It hydrolyze lactose to glucose and galactose)

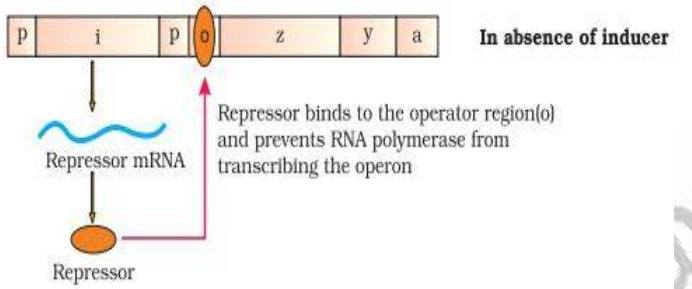
b)Lac y gene : It code for **Permease** (Increase permeability of cell to β-galactosides/ Lactose)

c)Lac a gene :it code for **Transacetylase**



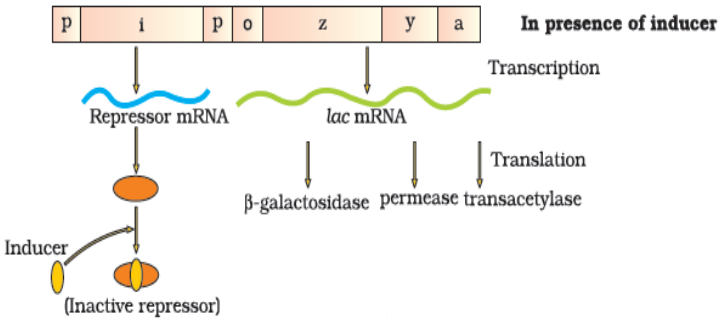
In the Absence of Lactose (Inducer)

- If there is no inducer (Lactose), lac operon remains switched off. The regulator gene synthesizes mRNA to produce the **repressor protein**. This protein binds to the **operator gene and blocks RNA polymerase movemen**t. So structural genes are **not expressed.**



In the presence of Lactose (Inducer)

- If lactose is provided in the growth medium, the lactose is transported into E.coli cells by the action of **permease.**
- Lactose (Inducer) binds with **repressor protein**. So Repressor protein cannot bind to operator gene. The operator gene become free and induces the RNA polymerase to bind with promoter gene. Then RNA polymerase transcribe the structural RNA results in lac mRNA formation. The lac mRNA translated to produce beta galactosidase, permease andtrans acetylase



- Regulation of lac operon by **repressor** is referred to as **negative regulation.**

- **Each operon has its specific operator and specific repressor.**
- **For example, *lac* operator is presentonly in the *lac* operon and it interacts specifically with *lac* repressor only.**

Qn. Why lactose is called as an Inducer in Lac Operon ?

Ans. Lactose is the substrate for the enzyme beta-galactosidase and it regulates switching on and off of the operon. Hence, it is termed as inducer

Qn. how long the Lac operon would be expressed in the presence of lactose?

Ans. The Lactose operon expresses as long as the Lactose is present. When **all lactose** is converted into glucose and galactose, the reaction stops

Qn. Why glucose or galactose cannot act as inducers for lac operon ?

Ans. Glucose structures are not sufficient to bind with repressor, so they cannot acts as inducer for Lac operon. whereas lactose acts as an inducer because it binds with the repressor.

BAC and YAC

They are cloning vectors. BAC (bacterial artificial chromosomes), and YAC (yeast artificial chromosomes).Their hosts are Bacteria and yeas respectively. . The cloning resulted into amplification of each piece of DNA fragment.

Salient Features of Human Genome

I. The human genome contains **3164.7 million nucleotide bases.**

II. The average gene consists of 3000 bases, but sizes vary greatly, with the largest known human gene being **dystrophin at 2.4 million bases.**

III. The total number of genes is estimated at 30,000–much lower than previous estimates of 80,000 to 1,40,000 genes. Almost all (99.9 per cent) nucleotide bases are exactly the same in all people.

IV. The functions are unknown for over 50 per cent of the discovered genes.

V. **Less than 2 per cent of the genome codes for proteins.**

VI. Repeated sequences make up very large portion of the human genome.

VII. Repetitive sequences are stretches of DNA sequences that are repeated many times, sometimes hundred to thousand times. They

are thought to have no direct coding functions, but they shed light on chromosome structure, dynamics and evolution.

VIII. **Chromosome 1 has most genes (2968), and the Y has the fewest (231).**

IX. Scientists have identified about 1.4 million locations where singlebase DNA differences **(SNPs – single nucleotide polymorphism, pronounced as 'snips')** occur in humans. This information promises to revolutionise the processes of finding chromosomal locations for disease-associated sequences and tracing human history.

DNA FINGERPRINTING

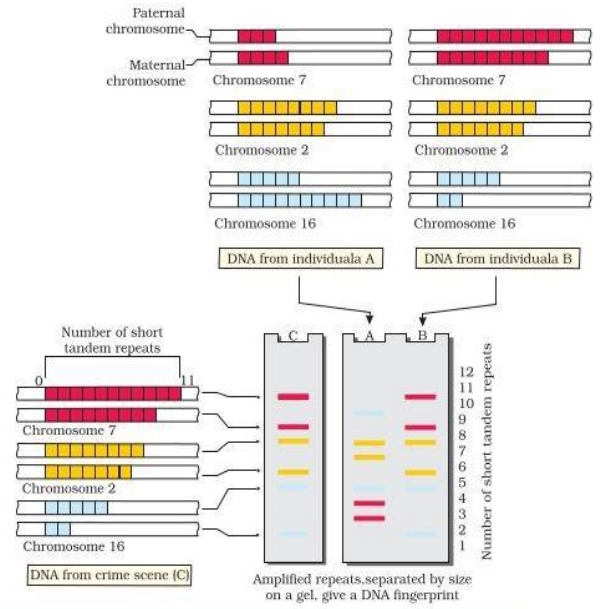
- ✓ DNA fingerprinting was initially developed by **Alec Jeffreys.**
- ✓ DNA finger printing is **a very quick way to compare the DNA sequences of any two individual.**
- ✓ **The DNA from a single cell is enough to perform DNA fingerprinting**.
- ✓ DNA fingerprinting involves **identifying differences in some specific regions in DNA called repetitive DNA,** because in these sequences, a small stretch ofDNA is repeated many times
- ✓ Alec Jeffrey used **satellite DNA as the basis of DNA fingerprinting** that shows very high degree ofpolymorphism**. It was called as Variable NumberTandem Repeats.(VNTR**)

• **Different steps** of DNA fingerprinting are:-

- ➢ **Isolation of DNA.**
- ➢ **Digestion of DNA** by restriction endonucleases.
- ➢ **Separation of DNA fragments** by gel electrophoresis.
- ➢ **Transferring (blotting) of separated DNA** fragment to synthetic membranes, such as nitrocellulose or nylon.
- ➢ Double stranded DNA made single stranded.
- ➢ **Hybridization** using labeled VNTR probe.
- ➢ **Detection of hybridized DNA fragments** by autoradiography
- ➢ After hybridization with VNTR probe the autoradiogram gives many bands of different sizes
- ➢ These bands give a characteristic pattern for an individual DNA. It differs from individual to individual.

Applications:

- Test of paternity.
- Identify the criminals.
- Population diversity determination.
- Determination of genetic diversity.
- It has immense applications in the field of forensic science, genetic biodiversity and evolutionary biology



Schematic representation of DNA fingerprinting: Few representative chromosomes have been shown to contain different copy number of VNTR. For the sake of understanding different colour schemes have been used to trace the origin of each band in the gel. The two alleles (paternal and maternal) of a chromosome also contain different copy numbers of VNTR. It is clear that the banding pattern of DNA from crime scene matches with individual B, and not with A.

05
Evolution

Evidences of evolution

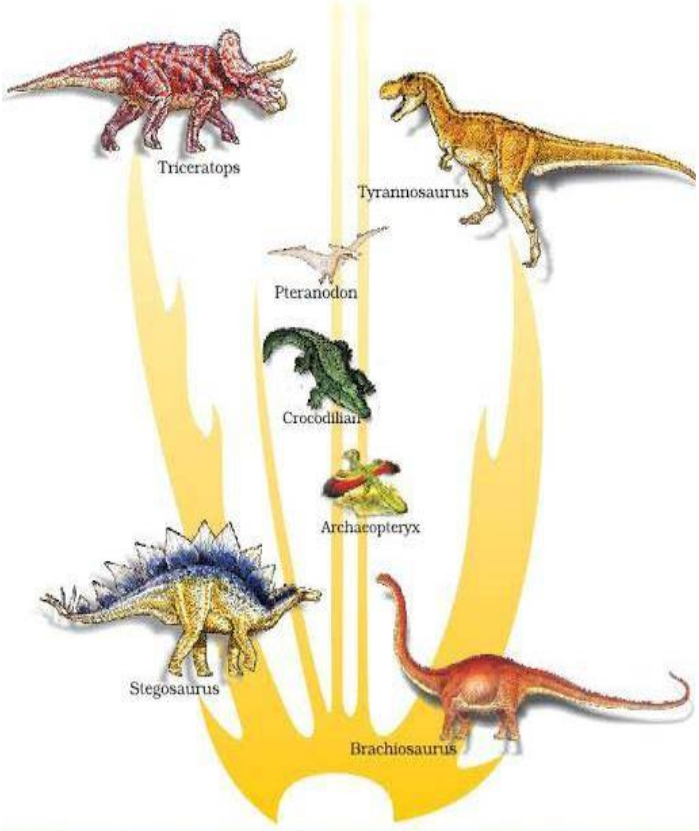
1. Paleontological evidence

- Study of fossils is called **paleontology.**
- Fossils are remains of hard parts of life-forms found in rocks
- They represent extinct organisms (e.g., Dinosaurs).

Significance of fossil study

i. It help to study the form and structure of extinct animal
ii. It help to study the habit and behaviors of extinct organisms
iii. A study of fossils in different sedimentary layers indicates the geological period in which they existed.
iv. The study showed that life-forms varied over time and certain life forms are restricted to certain geological timespans. Hence, new forms of life have arisen at different times in the history of earth.

❖ ***The age of the fossils are calculated by radioactive dating***



A family tree of dinosaurs and their living modern day counterpart organisms like crocodiles and birds

2. Embryological evidence

❖ It is proposed by **EarnstHeckel**.
❖ According to his observation **certain features are common to all vertebrates during their embryological stage. It is absent in their adult** (Ontogeny repeats phylogeny/ re capitulation theory)
Eg: Appearance of **vestigial gill slit** behind the head during embryological development in all vertebrates. But it is functional only in fishes
❖ This observation was disproved by **Karl Ernst von Baer.**
❖ **He noted that embryos never pass through the adult stage of other animal**.

3. Comparative anatomy and morphology

❖ Comparative anatomy and morphology shows similarities and differences among organisms of today and those that existed years ago.
❖ Such similarities can be interpreted to understand **whether common ancestors were shared or not.**

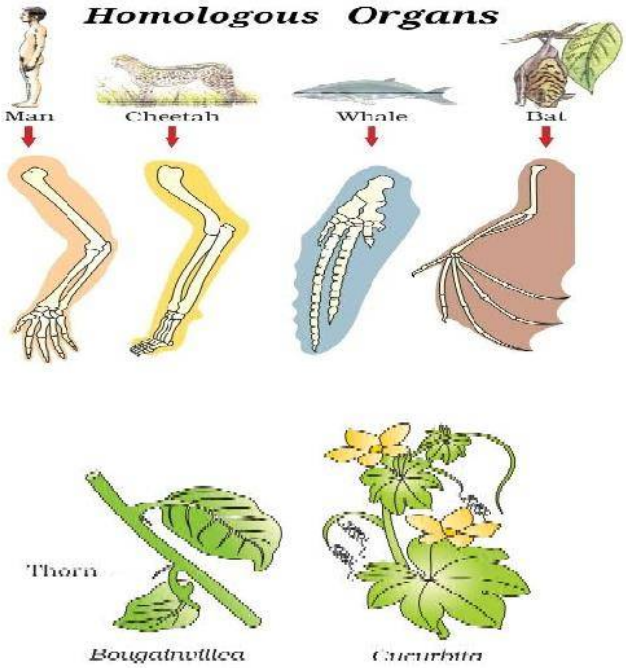
a)Homologous organs

Homologus organs are organs having **same structure** and origin **but different functions**. This phenomenon is called **homology**. Such organs are developed due to **divergent evolution**.

Eg:1)whales, bats, Cheetah and human (all mammals) share similarities in the pattern of bones of forelimbs

Though these forelimbs perform different functions in theseanimals, they have similar anatomical structure – all of them have humerus, radius, ulna, carpals, metacarpals and phalanges in theirforelimbs. Hence, in these animals, the same structure developed alongdifferent directions due to adaptations to different needs. This is divergentevolution and these structures are homologous.

Eg;2)the thorn and tendrils of *Bougainvillea* and *Cucurbita* represent homology
Eg;3) vertebrate hearts or brains



b) Analogous organ

Organs having **same function** but different structure and origin. This phenomenon is called Analogy. Such organs are developed due to **Convergent evolution**. (**Different structures evolving for the same function and hence having similarity**

Eg;1)Wings of butterfly and of birds look alike. They are not anatomically similar structures though they perform similar functions. –here different structures evolving for the same function and hence having similarity
Eg;2) the eye of the octopus and of mammals
Eg;3) the flippers of Penguins and Dolphins.
Eg;4) Sweet potato (root modification) and potato (stem modification)

- So one can say that it is **the similar habitat** that has resulted in selection of similar adaptive features in **different groups** of organisms but toward the same function. It results in the formation of **Convergent evolution**

3. Biochemical evidence

Similarities in proteins and genes performing a given function among diverse organisms give clues to common ancestry.

4. Molecular evidence

Similarity of organism at the molecular level indicate phylogenetic (Evolutionary history) relationship.

- Human DNA differs in only 1.8% of its bp from chimpanzee DNA and there is no difference between two in the amino acid sequence for protein cytochrome C. S
- imilarly molecular structure of **actin and tubulin** protein in all animal point their common ancestory.
- A common **genetic code** is overhelming evidence that all organisms are related

5. Industrial Melanism

- Interesting observation supporting evolution by natural selection comes from **England**.
- In a collection of **moths** made in **1850**s, i.e., before industrialisation set in, it was observed that there were **more white-winged moths on trees than dark-winged** or melanised moths.
- However, in the collection carried out from the same area, but after industrialisation, i.e., in **1920**, there were more dark-winged moths in the same area, i.e., the proportion was reversed.
- The explanation put forth for this observation was that 'predators will spot a moth against a contrasting background'.
- During post industrialization period, the **tree trunks became dark due to industrial smoke and soots.** Under this condition the white-winged moth did not survive due to predators, dark-winged or melanised moth survived**.**
- **Beforeindustrialisation set in, thick growth of almost white-coloured lichen covered the trees** - in that background the white winged moth survivedbut the dark-coloured moth were picked out by predators.
- **The lichens can be used as industrial pollution indicators**They will not grow in areas that are polluted. Hence, moths that were able tocamouflage themselves, i.e., hide in the background, survived.
- This understanding is supported by the fact that in areas where industrialisation did not occur e.g., in rural areas, the count ofmelanic moths was low.
- **This showed that in a mixed population, thosethat can better-adapt, survive and increase in population size**

6. Evolution by anthropogenic action

- The excess use of herbicides, pesticides, etc., has only resulted in selection of resistant varieties in a much lesser time scale.
- This is also true for microbes against which we employ antibiotics or drugs against eukaryotic organisms/cell.
- Hence, resistant organisms/cells are appearing in a time scale of months or years and not centuries. These are examples of evolution by anthropogenic action.
- This also tells us that evolution is not a directed process in the sense of determinism. It is a stochastic process based **on chance** events in nature and chance mutation in the organisms

HARDY-WEINBERG PRINCIPLE

- In a given population one can find out the frequency of occurrence of alleles of a gene or a locus. This frequency is supposed to remain fixed and even remain the same through generations.
- Hardy-Weinberg principle stated it using algebraic equations.
- This principle says that **'allele frequencies in a population are stable and is constant from generation to generation'**. The gene pool (total genes and their alleles in a population) remains a constant. This is called genetic equilibrium

P+q=1

$(p + q)^2 = p^2 + 2pq + q^2 = 1$

Where:

p = the frequency of allele A
q = the frequency of allele a
p^2 = the frequency of individual AA
q^2 = the frequency of individual aa
2pq = the frequency of individual Aa

- .Disturbance in genetic equilibrium, or Hardy- Weinberg equilibrium, i.e., change of frequency of alleles in a population would then be interpreted as **resulting in evolution**

Five factors are known to affect Hardy Weinberg equilibrium. These are

i) Gene migration or gene flow,
ii) Genetic drift,
iii) Mutation,
iv) Genetic recombination and
v) Natural selection

i) Gene migration or gene flow,

- When migration of a section of population to another place and population occurs, gene frequencies change in the original as well as in the new population.
- New genes/alleles are added to the new population and these are lost from the old population. There would be a gene flow if this gene migration, happens multiple times.

ii) Genetic drift,

Change in gene frequency occurs by chance is called genetic drift.

(c) Sixteen percent of the population of Europe is Rhesus negative. Use the Hardy-Weinberg equation to calculate the percentage of this population that you would expect to be heterozygous for the Rhesus gene. Show your working. (2)

$q^2 = \frac{16}{100}$

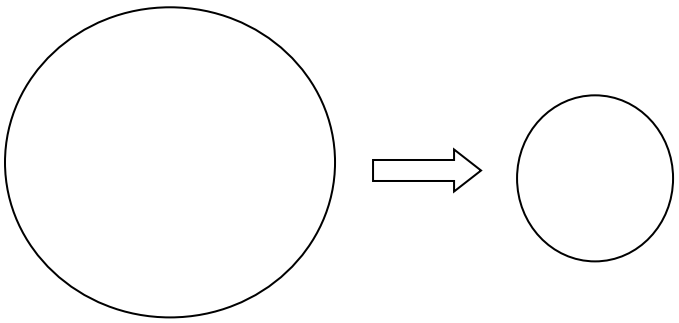
$q = \sqrt{0.16} = 0.4$

$p = 1 - 0.4 = 0.6$

$2pq$ = heterozygotes = $2 \times 0.6 \times 0.4 = 48\ \%$

Founder Effect

- ✓ The **founder effect** is change in allele frequency that occurs when a new population is established by a very small number of individuals from a larger population.
- ✓ Here the change in allele frequency is so different in the new sample of population that they become a different species. The original drifted population becomes founders and the effect is called **founder effect**.



iii) Mutation,

Microbial experiments show that pre-existing advantageous mutations when selected will result in observation of new phenotypes. Over few generations, this would result in Speciation.

v) Natural selection

- ❖ Natural selection is a process in which heritable variations enabling better survival are enabled to reproduce and leave greater number of progeny.

a)Stabilsing selection/Normalizing selection

Here more individuals acquire mean character value. This occurs when the environment doesnot change.Fossil evidence shows that , many species remain unchanged for long period of geological time.One of the most stable environment on earth is the deep sea.

Eg: Birth weight of human. The heaviest and lightest babies have the highest mortality

b)Directional selection

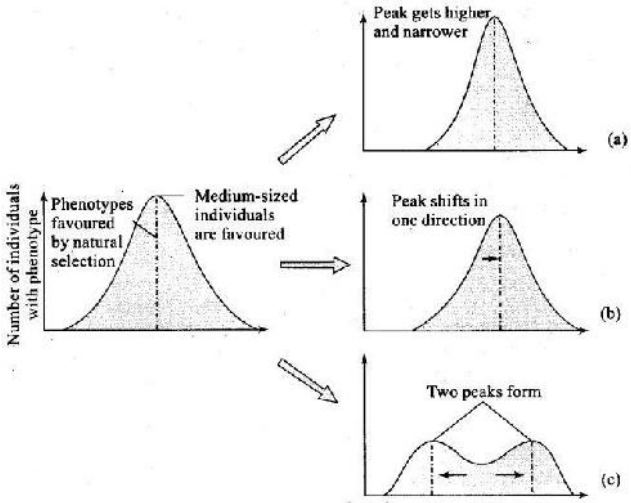
Here more individuals acquire value other than the mean character

Eg:Industrialmelansim

c)Disruptive selection

Here more individuals acquire peripheral character value at both ends of the distribution curve

Eg: adaptive radiation



Operation of naturals selection on different traits (a) Stabilising (b) Directional and (c) Disruptive

ORIGIN AND EVOLUTION OF MAN

- ✓ About **15 mya**, primates called ***Dryopithecus and Ramapithecus***were existing. They were hairy and walked like gorillas and chimpanzees.*Ramapithecus*was more man-like while *Dryopithecus*was more ape-like.
- ✓ Few fossils of man-like bones have *been* discovered in **Ethiopia and Tanzania** . These revealed hominid features leading to the belief that about 3-4 mya, man-like primates walked in eastern Africa. They were probably not taller than 4 feet but walked up right.
- ✓ **Two mya, *Australopithecines***probably lived in East African grasslands. Evidence shows they **hunted with stone weapons but essentially ate fruit**. Some of the bones among the bones discovered were different. This creature was called the first human-like being the hominid and was called ***Homo habilis*.** The brain capacities were between **650-800cc**. They probably **did not eat meat.**
- ✓ Fossils discovered in **Java in 1891** revealed the next stage, i.e., *Homoerectus*about **1.5 mya.***Homo erectus* had a large brain around **900cc.***Homo erectus* probably **ate meat**.
- ✓ The **Neanderthal man** with a brain size of **1400cc lived** in near east and central Asia

between 1,00,000- 40,000 years back. **They used hides to protect their body and buried their dead**.

- ✓ ***Homo sapiens* arose in Africa** and moved across continents and developed into distinct races.
- ✓ **During ice age between 75,000-10,000 years ago modern *Homo sapiens* arose.**
- ✓ Pre-historic cave art developed about 18,000 years ago. Agriculture came around 10,000 years back and human settlements started.
- ✓

Ape→Drypithecus→Ramapithecus→ Australopithecus→*Homo habilis*→*Homo erectus*→ Neanderthal man→*Homo sapiens*

06
HUMAN HEALTH AND DISEASE

Introduction

- A wide range of organisms belonging to bacteria, viruses, fungi, protozoans, helminths, etc., could cause diseases in man.
- Such disease causing organisms are called **pathogens.**
- The pathogens can enter our body by various means, multiply and interfere with normal vital activities, resulting in morphological and functional damage.
- Pathogens have to adapt to life within the environment of the host.
- For example, the pathogens that enter the gut must know a way of surviving in the stomach at low pH and resisting the various digestive enzymes.

COMMON DISEASES IN HUMANS

A) Bacterial disease

It include Typhoid fever, pneumonia, Dysentery, plague, diphtheria…

a)Typhoid fever

- **Pathogen :** *Salmonella typhi*
- **Part of the body it infect :**
  These pathogens generally enter the **small intestine through food and water** contaminated with them and migrate to other organs through blood.
- **Symptoms :**
  - **Sustained high fever (39° to 40°C),**
  - weakness,
  - stomach pain,
  - constipation,
  - headache and
  - loss of appetite.
  - **Intestinal perforation and death may occur in severe cases.**
- **Spread :**
  Contaminated food and water
- **Test :**
  Typhoid fever could be confirmed by **Widal test.**

Mary Mallon :
A classic case in medicine, that of **Mary Mallon** nicknamed **Typhoid Mary**, is worth mentioning here. She was **a cook by profession** and was a typhoid carrier who continued to spread typhoid for several years through the food she prepared

b)Pneumonia

- **Pathogen :** *Streptococcus pneumonia*
  Haemophilus influenza
- **Part of the body it infect:**
  Alveoli (air filled sacs) of the lungs. As a result of the infection, the alveoli get filled with **fluid** leading to severe problems in respiration.
- **Symptoms:**
  - Fever,
  - **Chills,**
  - Cough
  - Headache.
  - **In severe cases, the lips and finger nails may turn gray to bluish in colour.**
- **Spread:**
  It can be spread by
  - **Inhaling the droplets/aerosols released by an infected person**
  - By sharing glasses and utensils with an infected person.

B) Viral disease

It include Common cold, AIDS…

a)Common cold

- **Pathogen : Rhino viruses** (It represent one such group of viruses which cause one of the most infectious human ailments – the common cold).
- **Part of the body it infect :**
  Nose and respiratory passage but not the lungs.
- **Symptoms:**
  - Nasal congestion and discharge,
  - Sore throat,
  - Hoarseness,
  - Cough,
  - Headache,
  - Tiredness, etc.,

These symptoms usually last for **3-7 days.**

- **Spread :**
  - Droplets resulting from cough or sneezes of an infected person are either inhaled directly
  - Transmitted through contaminated objects such as pens, books, cups, doorknobs, computer keyboard or mouse, etc., and cause infection in a healthy person.

b) Acquired Immuno Deficiency Syndrome (AIDS)

Introduction

- AIDS means, Deficiency of immune system, acquired during the lifetime of an individual indicating that it is **not a congenital disease**.
- 'Syndrome' means a group of symptoms.
- AIDS was first reported in **1981 in USA** and in the last twenty-five years or so, it has spread all over the world killing more than **25 million persons**.

- **Pathogen :**
  HIV (Human immuno deficiency virus)
- **Part of the body it infect :**
  helper T lymphocyte/Immune system
- **Symptoms :**
  - Progressive **decrease in the number of helper T lymphocytes.** During this period, the person suffers from bouts of **fever, diarrhoea and weight loss**..
  - Due to decrease in the number of helper T lymphocytes, the person starts suffering from infections that could have been otherwise overcome such as those due to bacteria especially **Mycobacterium, viruses, fungi and even parasites like Toxoplasma.**
  - The patient becomes so immuno-deficient that he/she is unable to protect himself/herself against these infections.
- There is always a time-lag between the infection and appearance of AIDS symptoms. This period may vary from a few months to many years **(usually 5-10 years).**
- **Spread :**
  Transmission of HIV-infection Generally occurs by

(a)Sexual contact with infected person,
(b)By transfusion of contaminated blood and blood products,
(c)By sharing infected needles as in the case of intravenous drug abusers and
(d)From infected mother to her child through placenta.

Following individual are at high risk of getting HIV infections

1. **Individuals who have multiple sexual partners,**
2. **Drug addicts who take drugs intravenously,**
3. **Individuals who require repeated blood transfusions and**
4. **Children born to an HIV infected mother.**

Test (Diagnostic test) :
Enzyme linked immune sorbent assay (ELISA)

Confirmatory test :
Western Blot

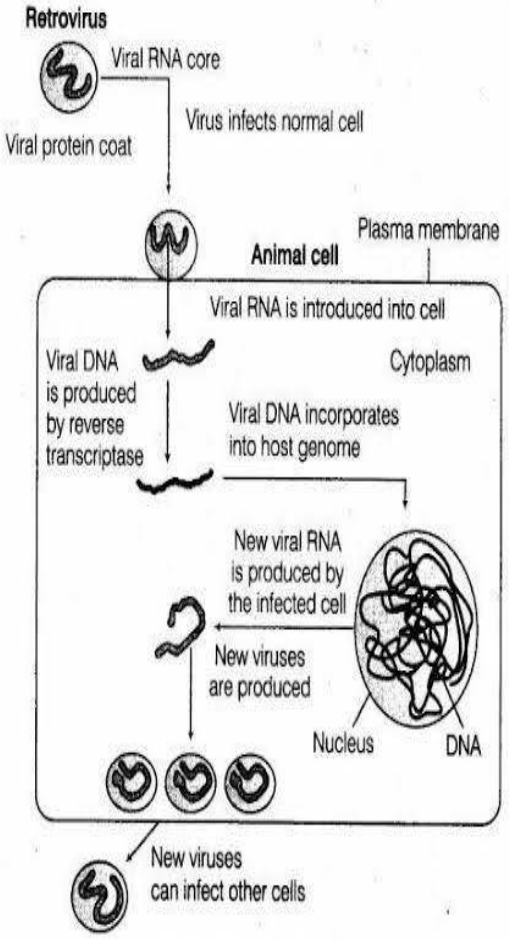
HIV/AIDS is not spread by mere touch or physical contact; **it spreads only through body fluids**. It is, hence, imperative, for the physical and psychological well-being, that the HIV/AIDS infected persons are not isolated from family and society.

Life cycle of HIV

- HIV is a **retro virus (RNA virus)**
- After getting into the body of the person (by endocytosis), the virus enters into **macrophages** where RNA genome of the virus replicates to form viral DNA with the help of the **enzyme reverse transcriptase (RNA dependent dna polymerase)**
- This viral DNA gets incorporated into host cell's DNA and directs the infected cells to produce virus particles
- The **macrophages** continue to produce virus and in this way acts like a **HIV factory.**
- Simultaneously, HIV enters into **helper T-lymphocytes (T_H),** replicates and produce progeny viruses. The progeny viruses released in the blood attack other helper T-lymphocytes. This is repeated leading to a

progressive decrease in the number of helper T lymphocytes in the body of the infected person.

- During this period, the person suffers from **bouts of fever, diarrhoea and weight loss**.



Replication of retrovirus

Treatment of AIDS :

Treatment of AIDS with **anti-retroviral drugs** is only partially effective. They can only prolong the life of the patient but cannot prevent death, which is inevitable.

Prevention of AIDS :

As AIDS has no cure, prevention is the best option. Moreover, HIV infection, more often, spreads due to conscious behavior patterns and is not something that happens inadvertently, like pneumonia or typhoid. Of course, infection in blood transfusion patients, new-borns (from mother) etc., may take place due to poor monitoring. The only excuse may be ignorance and it has been rightly said – "don't die of ignorance".

- In our country the **National AIDS Control Organisation (NACO)** and other non-governmental organisation (NGOs) are doing a lot to educate people about AIDS. WHO has started a number of programmes to prevent the spreading of HIV infection.

1. **Making blood (from blood banks) safe from HIV,**
2. **ensuring the use of only disposable needles and syringes in public and private hospitals and clinics,**
3. **free distribution of condoms, controlling drug abuse,**
4. **advocating safe sex and promoting regular check-ups for HIV in susceptible populations, are some such steps taken up. but cannot prevent death, which is inevitable.**

C)PROTOZOAN DISEASE

It include **Malaria and Amoebiasis**

a)Malaria

- **Pathogen :**

Plasmodium (a tiny protozoan) Different species of Plasmodium (***P. vivax, P. malaria*** **and** ***P. falciparum***) are responsible for different types of malaria.

Of these, malignant malaria caused by ***Plasmodium falciparum*** is the most serious one and can even be **fatal.**

- **Part of the body it infect :**

Liver, RBC

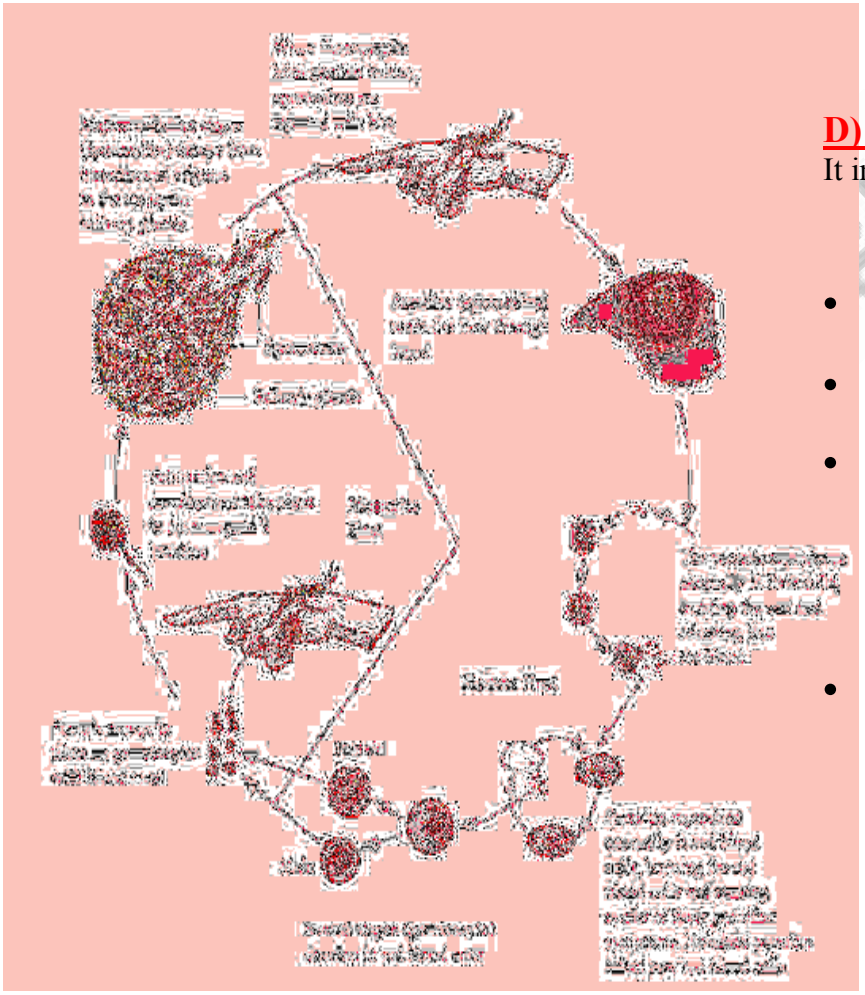
- **Symptoms :**
  - The rupture of RBCs is associated with release of a toxic substance, **haemozoin,** which is responsible for the chill and high fever **recurring** every three to four days
- **Spread :**

Female Anopheles mosquitoes transmitting agent

Life cycle of Plasmodium

- Plasmodium enters the human body as **sporozoites (infectious form)** through the bite of infected **female Anopheles mosquito.**
- The parasites initially multiply within the liver cells and then attack the red blood cells (RBCs) resulting in their rupture.

- The rupture of RBCs is associated with release of a toxic substance, **haemozoin**, which is responsible **for the chill and high fever recurring every three to four days**.
- When a female Anopheles mosquito bites an infected person, these parasites enter the mosquito's body and undergo further development. The parasites multiply within them to form sporozoites that are stored in their salivary glands.
- When these mosquitoes bite a human, the sporozoites are introduced into his/ her body, thereby initiating the events mentioned above.
- **It is interesting to note that the malarial parasite requires two hosts – human and mosquitoes – to complete its life cycle the female Anopheles mosquito is the vector (transmitting agent) too.**



b)Amoebiasis (amoebic dysentery).

- **Pathogen :** *Entamoeba histolytica*
- **Part of the body it:**
  The large intestine of human
- **Symptoms :**
  - constipation,
  - abdominal pain
  - cramps,
  - **stools with excess mucous and blood clots.**

- **Spread :**
  Houseflies act as mechanical carriers and serve to transmit the parasite from faeces of infected person to food and food products, thereby contaminating them. Drinking water and food contaminated by the faecal matter are the main source of infection

D) Helminth disease

It include Ascariasis and Filariasis

a)Ascariasis

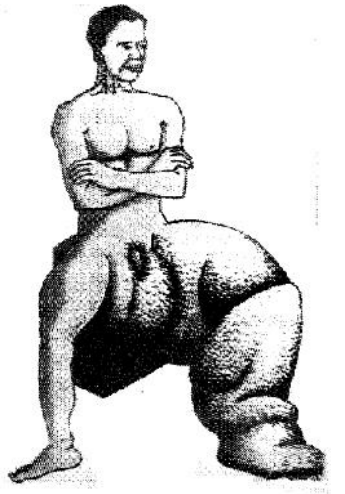
- **Pathogen :**
  Ascaris (Round worm)
- **Part of the body it infect :**
  Intestine
- **Symptoms :**
  - internal bleeding,
  - muscular pain,
  - fever,
  - anemia
  - blockage of the intestinal passage.
- **Spread :**

The eggs of the parasite are excreted along with the faeces of infected persons which contaminate soil, water, plants, etc. A healthy person acquires this infection through contaminated water, vegetables, fruits, etc

b)Fliariasis/Elephantiasis

- **Pathogen :**
  Wuchereria (W. bancrofti and W. malayi),
- **Part of the body it infect ;**
  The lymphatic vessels of the lower limbs .
  The genital organs are also often affected

- **Symptoms :**
  The filarial worms cause a slowly developing chronic inflammation of the organs in which they live for many years, usually the **lymphatic vessels of the lower limbs** and the disease is called elephantiasis or filariasis The genital organs are also often affected, **resulting in gross deformities.**
- **Spread:**
  The pathogens are transmitted to a healthy person through the bite by the **female mosquito vectors (Culex)**



E) Fungal disease

Ring worms

- **Pathogen :**
  Many fungi belonging to the genera **Microsporum, Trichophyton and Epidermophyton**

  Part of the body it infect :
  skin, nails and scalp
- **Symptoms :**
  - Appearance of dry, scaly lesions on various parts of the body such as skin, nails and scalp are the main symptoms of the disease.
  - These lesions are accompanied by intense itching.
  - Heat and moisture help these fungi to grow, which make them thrive in skin folds such as those in the groin or between the toes.

- **Spread :**
  Ringworms are generally acquired from **soil or by using towels**, **clothes or even the comb of infected individuals.**

PREVENTION AND CONTROL OF INFECTIOUS DISEASES

Maintenance of personal and public hygiene is very important for prevention and control of many infectious diseases

Personal hygiene

Measures for personal hygiene include
- Keeping the body clean;
- Consumption of clean drinking water, food, vegetables, fruits, etc.

Public hygiene

Public hygiene includes
- Proper disposal of waste and excreta;
- Periodic cleaning and disinfection of water reservoirs, pools, cesspools and tanks and observing standard practices of hygiene in public catering.

These measures are particularly essential where the infectious agents are transmitted **through food and water such as typhoid, amoebiasis and ascariasis**

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For air Borne disease

In cases of **air-borne diseases such as pneumonia and common cold**, in addition to the above measures, **close contact with the infected persons or their belongings should be avoided**

For vector borne disease

For diseases such as **malaria and filariasis** that are transmitted through insect vectors, the most important measure is **to control or eliminate the vectors and their breeding places**. This can be achieved By
- Avoiding stagnation of water in and around residential areas,
- Regular cleaning of household coolers, use of mosquito nets,

- Introducing fishes like **Gambusia** in ponds that feed on mosquito larvae,
- Spraying of insecticides in ditches, drainage areas and swamps, etc.
- Doors and windows should be provided with wire mesh to prevent the entry of mosquitoes. Such precautions have become all the more important especially in the light of recent widespread incidences of the vector-borne (Aedes mosquitoes-dengue fever and chikungunya) diseases like dengue and chikungunya in many parts of India.

Immunization

- ✓ The use of vaccines and immunisation programmes have enabled us to completely eradicate a deadly disease like smallpox.
- ✓ A large number of other infectious diseases like polio, diphtheria, pneumonia and tetanus have been controlled to a large extent by the use of vaccines.
- ✓ Biotechnology is at the verge of making available newer and safer vaccines.
- ✓ Discovery of antibiotics and various other drugs has also enabled us to effectively treat infectious diseases

CANCER

- Cancer is one of the most dreaded diseases of human beings and is a major cause of death all over the globe.
- More than **a million Indians** suffer from cancer and a large number of them die from it annually
- In Our body, **cell growth and differentiation is highly controlled and regulated**. In cancer cells, there is breakdown of these regulatory mechanisms.
- Normal cells show a property called **contact inhibition** by virtue of which contact with other cells inhibits their uncontrolled growth. Cancer cells appears to have lost this property. As a result of this, cancerous cells just continue to divide giving rise to masses of cells called tumors.
- Tumors are of two types: **benign and malignant**.
- **Benign tumors**

  It normally remain confined to their original location and do not spread to other parts of the body and cause little damage.

- **The malignant tumors**,

  This is a mass of proliferating cells called neoplastic or tumor cells. These cells grow very rapidly, invading and damaging the surrounding normal tissues. As these cells actively divide and grow they also starve the normal cells by competing for vital nutrients. **Cells sloughed from such tumors reach distant sites through blood, and wherever they get lodged in the body, they start a new tumor there. This property called metastasis is the most feared property of malignant tumors.**

Causes of cancer :

Transformation of normal cells into cancerous neoplastic cells may be induced by **physical, chemical or biological agents**. These agents are called **carcinogens.**

Eg :

- **Ionising radiations (X-rays and gamma rays**,
- **non-ionizing radiations (UV)cause DNA damage leading to neoplastic transformation.**
- The chemical carcinogens present in tobacco smoke have been identified as a major cause of lung cancer.
- Cancer causing viruses called **oncogenic viruses** have genes called viral oncogenes.
- Furthermore, several genes called **cellular oncogenes (c-onc) or proto oncogenes** have been identified in normal cells.which When activated under certain conditions, could lead to oncogenic transformation of the cells.

Cancer detection and diagnosis :

- Early detection of cancers is essential as it allows the disease to be treated successfully in many cases.
- Cancer detection is based on **biopsy and histopathological studies** of the tissue and blood and bone marrow tests for increased cell counts in the case of **leukemias (blood cancer)**
- **In biopsy,** a piece of the suspected tissue cut into thin sections is stained and examined under microscope (histopathological studies) by a pathologist.

- Techniques like radiography (use of X-rays), CT (computed tomography) and MRI (magnetic resonance imaging) are very useful to detect cancers of the internal organs.
- **Computed tomography** uses **X-rays** to generate a three-dimensional image of the internals of an object.
- **MRI** uses **strong magnetic fields and non-ionising radiations** to accurately detect pathological and physiological changes in the living tissue.
- **Antibodies** against cancer-specific antigens are also used for detection of certain cancers.
- **Techniques of molecular biology** can be applied to detect genes in individuals with inherited susceptibility to certain cancers. Identification of such genes, which predispose an individual to certain cancers, may be very helpful in prevention of cancers. Such individuals may be advised to avoid exposure to particular carcinogens to which they are susceptible (e.g., tobacco smoke in case of lung cancer).

Treatment of cancer :

- The common approaches for treatment of cancer are **surgery, radiation therapy and immunotherapy.**
- **In radiotherapy**, tumor cells are irradiated lethally, taking proper care of the normal tissues surrounding the tumor mass.
- **Several chemotherapeutic drugs** are used to kill cancerous cells. Some of these are specific for particular tumors. Majority of drugs have side effects like hair loss, anemia, etc.
- Most cancers are treated by combination of **surgery, radiotherapy and chemotherapy**.
- Tumor cells have been shown to avoid detection and destruction by immune system. Therefore, the patients are given substances called biological response modifiers such as α-interferon which activates their immune system and helps in destroying the tumor.

IMMUNOLOGY

- The overall ability of the host to fight the disease-causing organisms, conferred by the immune system **is called immunity**. Immunity is of two types:

(i) Innate immunity and
(ii) Acquired immunity.

i)Innate immunity/inborn immunity /non specific immunity

- This type of immunity is present **at the time of birth**.
- This is accomplished by providing different types of barriers to the entry of the foreign agents into our body.
- Innate immunity consist of **four types of barriers**. These are

(a) Physical barriers :

- **Skin** on our body is the main barrier which prevents entry of the micro-organisms.
- **Mucus coating** of the epithelium lining the respiratory, gastrointestinal and urogenital tracts also help in trapping microbes entering our body.

(b) Physiological barriers :

- **Acid** in the stomach,
- **Saliva** in the mouth,
- **Tears** from eyes–all prevent microbial growth.
- Saliva and tear contain antibacterial agent called **Lysozyme**

(c) Cellular barriers :

- Certain types of **leukocytes** (WBC) of our body like **polymorpho-nuclear leukocytes** (PMNL-Neutrophils) and monocytes and **natural killer** (type of lymphocytes) in the blood as well as macrophages in tissues can **phagocytose** and destroy microbes.

(d) Cytokine barriers :

- Virus-infected cells secrete proteins called **interferons** which protect non-infected cells from further viral infection.

ii) Acquired immunity/adaptive immunity/specific immunity

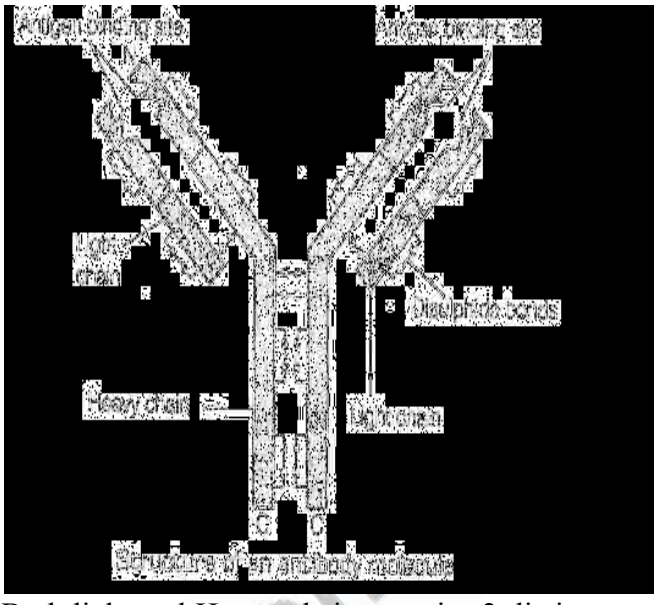
- It is pathogen specific.
- It is characterised by **memory**. This means that our body when it encounters a pathogen for the **first time** produces a response called **primary response** which is of low intensity. Subsequent encounter with the same pathogen elicits a highly intensified **secondary or Anamnestic response.**
- This is ascribed to the fact that our body appears to have memory of the first encounter.

B-lymphocytes and T lymphocytes

- The primary and secondary immune responses are carried out with the help of two special types of lymphocytes present in our blood, **i.e., B-lymphocytes and T lymphocytes.**
- Certain cells of bone marrow produce lymphocytes (Haematopoiesis). These cells mature in the bone marrow lymphocytes. The B-lymphocytes produce an army of proteins in response to pathogens into our blood to fight with them. These proteins are called **antibodies**. **The B lymphocytes give rise to plasma cells and memory B cells.**
- Some stem cells in the Bone marrow give rise to immature lymphocytes. These lymphocytes migrate via the blood **to the thymus**, where they mature as **T cells**. In the thymus, these cells mature as T lymphocytes. **The T-cells themselves do not secrete antibodies but help B cells produce them**

Structure of Antibody

Each antibody molecule has **four peptide chains**, two small called **light chains** and two longer called **heavy chains**. Hence, an antibody is represented as H_2L_2. Different types of antibodies are produced in our body. IgA, IgM, IgE, IgG are some of them



- Both light and Heavy chain contains 2 distinct regions-constant and variable region
- An antibody doesnot usually destroy an antigen directly but targets it for elimination by phagocytes

HUMORAL IMMUNITY & CELL MEDIATED IMMUNITY

- Immune response by the **B-cells** by production of antibody is called **Antibody mediated immune response (AMI) or humoral immune response.**
- Immune response **by T-cells** which detects and destroys the foreign cells and also cancerous cells **called cell mediated immune response.(CMI)**
- Rejection of organs in transplantation are due to **T-lymphocytes.**
- Tissue matching, blood group matching are essential for organ transplantation.
- Immune-suppressants is required before and after transplantation

Active and Passive Immunity

Active immunity :

- When a host is exposed to **antigens**, which may be in the form of living or dead microbes or other proteins, **antibodies** are produced in the host body. This type of immunity is called active immunity.
- Active immunity is **slow** and takes time to give its full effective response.
- Injecting the microbes deliberately during immunisation or infectious organisms gaining

access into body during natural infection induce active immunity.
Eg: **Vaccines**

Vaccines

- 1st vaccination was carried out by British Physician **Edward Jenner to protect people from small pox**
- The principle of immunisation or vaccination is based on the property of '**memory'** of the immune system.
- In vaccination, a preparation of antigenic proteins of pathogen or inactivated/weakened pathogen (vaccine) are introduced into the body. The antibodies produced in the body against these antigens would neutralise the pathogenic agents during actual infection.
- The vaccines also generate memory – B and T-cells that recognize the pathogen quickly on subsequent exposure and overwhelm the invaders with a massive production of antibodies.
- **Recombinant DNA technology** has allowed the production of antigenic polypeptides of pathogen in bacteria or yeast. Vaccines produced using this approach **allow large scale production** and hence greater availability for immunisation,
  e.g., **hepatitis B vaccine** produced from **yeast**

Passive immunity

- When **ready-made antibodies are directly given to protect the** body against foreign agents, it is called passive immunity.
- The yellowish fluid **colostrum** secreted by mother during the initial days of lactation has abundant antibodies (IgA) to protect the infant
- **The foetus** also receives some antibodies **(IgG)** from their mother, t**hrough the placenta** during pregnancy.
- If a person is infected with some deadly microbes to which quick immune response is required as in tetanus, we need to directly inject the preformed antibodies, or antitoxin (a preparation containing antibodies to the toxin).
- In cases of snakebites, the injection which is given to the patients, contain preformed antibodies (Anti venom) against the snake venom

Difference between active immunity and passive immunity

Active Immunity	Passive immunity
When a host is exposed to **antigens**, which may be in the form of living or dead microbes or other proteins, **antibodies** are produced in the host body. This type of immunity is called active immunity	When **ready-made antibodies are directly given to protect the** body against foreign agents, it is called passive immunity
It takes time to develop immunity	It is used when immune response has to be faster
Memory cells are formed	No memory cells formed

Effects of Drug/Alcohol

The immediate adverse effects of drugs and alcohol abuse are manifested in the form

- The reckless behaviour,
- vandalism
- violence.
- Excessive doses of drugs may lead to coma and death due to respiratory failure, heart failure or cerebral hemorrhage.

- A combination of drugs or their intake along with alcohol generally results in overdosing and even deaths.

Warning signs of drug/alcohol abuse

- Drop in academic performance,
- Unexplained absence from school/college,
- Lack of interest in personal hygiene,
- withdrawal,,isolation from family and friends
- Depression,
- Fatigue,
- Aggressive and rebellious behaviour,
- Loss of interest in hobbies,
- Change in sleeping and eating habits
- Fluctuations in weight, appetite, etc.

- If an abuser is unable to get money to buy drugs/alcohol he/she may turn to stealing. The adverse effects are just not restricted to the person who is using drugs or alcohol.
- A drug/alcohol addict becomes the cause of mental and financial distress to his/her entire family and friends.
- Those who take drugs **intravenously (direct injection into the vein using a needle and syringe), are much more likely to acquire serious infections like AIDS and Hepatitis B.**
- The viruses, which are responsible for these diseases, are transferred from one person to another by sharing of infected needles and syringes. Both AIDS and Hepatitis B infections are chronic infections and ultimately fatal. Both can be transmitted through sexual contact or infected blood.
- The use of alcohol during adolescence may also have long-term effects. It could lead to heavy drinking in adulthood. The chronic use of drugs and alcohol damages nervous system and liver (cirrhosis).
- The use of drugs and alcohol during pregnancy is also known to **adversely affect the foetus.**
- Another misuse of drugs is what certain sportspersons do to enhance their performance. **They (mis)use narcotic analgesics, anabolic steroids, diuretics and certain hormones in sports to increase muscle strength and bulk and to promote aggressiveness and as a result increase athletic performance.**

The side-effects of the use of anabolic steroids in females

- Masculinisation (features like males),
- Increased aggressiveness, mood swings,
- Depression, abnormal menstrual cycles,
- Excessive hair growth on the face and body,
- Enlargement of clitoris,
- Deepening of voice.

The side-effects of the use of anabolic steroids in Males

- Acne,
- Increased aggressiveness,
- Mood swings,
- Depression,
- Deduction of size of the testicles,
- Decreased sperm production,
- Potential for kidney and
- Liver dysfunction,
- Breast enlargement,
- Premature baldness,
- Enlargement of the prostate gland.

Prevention and Control

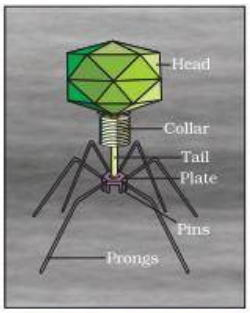
'Prevention is better than cure' holds true here also.

- **(i) Avoid undue peer pressure -** Every child has his/her own choice and personality, which should be respected and nurtured. A child should not be pushed unduly to perform beyond his/her threshold limits; be it studies, sports or other activities.
- **(ii) Education and counselling -** Educating and counselling him/ her to face problems and stresses, and to accept disappointments and failures as a part of life. It would also be worthwhile to channelize the child's energy into healthy pursuits like sports, reading, music, yoga and other extracurricular activities.
- **(iii) Seeking help from parents and peers -** Help from parents and peers should be sought immediately so that they can guide appropriately. Help may even be sought from close and trusted friends. Besides getting proper advise to sort out their problems, this would help young to vent their feelings of anxiety and guilt.
- **(iv) Looking for danger signs -** Alert parents and teachers need to look for and identify the danger signs discussed above. Even friends, if they find someone using drugs or alcohol, should not hesitate to bring this to the notice of parents or teacher in the best interests of the person concerned. Appropriate measures would then be required to diagnose the malady and the underlying causes. This would help in initiating proper remedial steps or treatment.
- **(v) Seeking professional and medical help -** A lot of help is available in the form of highly qualified psychologists, psychiatrists, and deaddiction and rehabilitation programmes to help individuals who have unfortunately got in the quagmire of drug/alcohol abuse. With such help, the affected individual with sufficient efforts and will power, can get rid of the problem completely and lead a perfectly normal and healthy life.

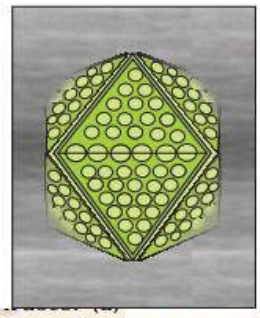
07
Microbes In Human Welfare

Introduction

Microbes are present everywhere – in soil, water, air, inside our bodies and that of other animals and plants. They are present even at sites where no other life-form could possibly exist–sites such as deep inside the geysers (thermal vents) where the temperature may be as **high as 100^{0}C**, deep in the soil, under the layers of snow several metres thick, and in highly acidic environments



A bacteriophage;


Adenovirus which causes respiratory infections;

01-MICROBES IN HOUSEHOLD PRODUCTS

LACTIC ACID BACTERIA (LAB)

- Micro-organisms such as **Lactobacillus** and others commonly called **Lactic acid bacteria (LAB)** grow in milk and convert it into **curd**.
- During the growth, LAB produces acids that coagulate and partially digest the milk proteins. A small amount of curd added to the fresh milk as **inoculums** or **starter** contains millions of LAB, which at suitable temperature multiply and convert milk into curd.
- LAB also **improves nutritional quality by increasing vitamin B_{12} (Cyanocobalamine).**
- In our stomach LAB check the disease causing microbes.

✓ The **dough**, which is used for making dosa and idli is also fermented by bacteria.

✓ The puffed-up appearance of dough is due to the production of **carbon dioxide**

✓ The dough, which is used for making bread, is fermented using **baker's yeast**- **Saccharomyces cervisiae**

✓ **Toddy** is made by **fermenting sap from palms**

✓ Various microbes are also used to ferment fish, soyabean and bamboo shoots to make food**.**

✓ Large holes in **'swiss cheese'** are due to production of a large amount of **CO_2** by a bacterium **Propionibacterium sharmanii**.

✓ The **'Roquefort cheese'** are ripened by growing a specific **fungi** on them, which gives them a particular flavor

02-Chemicals, Enzymes and other Bioactive Molecules

Microbes are also used for commercial and industrial production of certain chemicals like organic acids, alcohols and enzymes

a) Microbes for the production of acids and Alcohol

Aspergillus niger(Fungus)---------Citric acid
Acetobacter aceti(Bacteria)----- Acetic acid
Clostridium butylicum (Bacteria)--Butyric acid
Lactobacillus (Bacteria) ----------Lactic acid
Saccharomyces cervisiae---------- Ethanol

b. Microbes for the production of Enzymes

- Microbes are also used for production of enzymes
- **Lipase** are used in Detergent formulations for removing oily stains in laundry
- Bottled fruit juices bought from market are clearer as compared to those made at home. This is because the bottled juices are clarified by the use of **Pectinase and Protease**

c. Microbes used as Bioactive molecule

Bioactive molecules are substance that can be acted on a living organism or an extract from a living organism. It can be extracted from micro organism. Bio active molecues are secondary metabolites

- **Streptokinase** produced by the bacterium Streptococcus and modified by genetic engineering is used as **a 'CLOT BUSTER'** for **removing clots from blood vessels** of patients who have undergone myocardial infarction leading to heart attack
- **Trichoderma polysporum (fungus)** produces **Cyclosporin A** . It is used as a **immunosuppressive** agent in organ transplantation
- **Monascus purpureus (Yeast**) Produce **Statins**. It is used as **blood cholesterol lowering agent**. It acts by competitively inhibiting the enzyme responsible for synthesis of cholesterol.

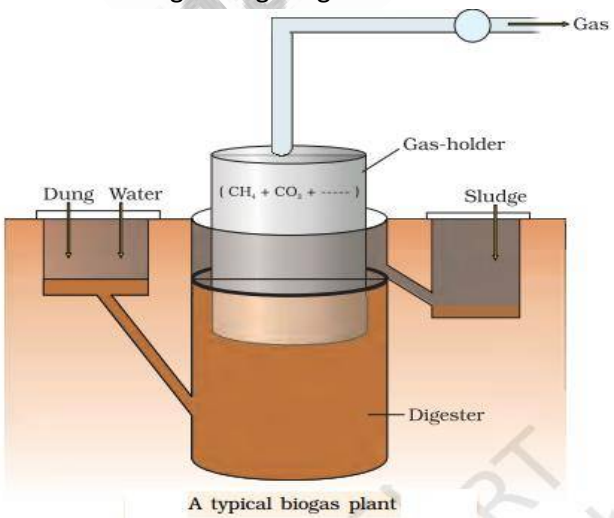
03. Microbes in production of Bio Gas

- Biogas is a mixture of gas (Mainly **Methane**) produced by the microbial activity.
- Certain bacteria, which grow **anerobically** on cellulosic material, produce large amount of methane along with CO_2 and H_2. These bacteria is collectively called **Methanogens (Eg;Methanobacterium).**
- **Methanogens** are found in
    - **Anerobic sludge digester** (In sewage treatment),
    - In the **Rumen of cattle**.
- In the Rumen, these bacteria help in the breakdown of cellulose and play important role in nutrition of cattle. Thus, the excreta (dung) of cattle , commonly called **Gobar**, is rich in these bacteria. So **Dung can be used in for generation of Biogas, commonly called Gobar gas.**

BIOGAS PLANT

The technology of Biogas production was developed in India due to the efforts of **Indian Agricultural Research Institute (IARI)** and Khadi and **Village Industries Commission (KVIC).**

The Biogas plant consist of a concrete tank of **10-15 feet deep** in which bio-waste are collected and a slurry of dung is fed. A floating cover is placed over the slurry, which keeps on rising as the gas is produced in the tank due to the microbial activity. The biogas plant has an outlet, which is connected to a pipe to supply biogas to nearby house. The spent slurry is removed through another outlet and may be used as fertilizer .Biogas produced thus produced is used for cooking and lighting.



A typical biogas plant

04-Microbes as Bio control agents

- ✓ **Biocontrol:** It refers to the use of **biological methods** for controlling plant diseases and pests. Biocontrol measures **greatly reduce our dependence on toxic chemicals and pesticides**.

  Eg: (1)-Introduction of **Bacillus thuringiensis** (Bt) is used to control **butterfly catterpiller** is an example for microbial Biocontrol. These are available in sachet as dried spores which are mixed with water and sprayed onto vulnerable plants such as Brassicas and fruit trees, where these are eaten by insect larvae. In the gut of the larvae, the toxin is released and the larvae get killed. The bacterial disease will kill the caterpillars but leave the other insects unharmed.

  Eg: (2)-Using genetic engineering skills, scientist introduced B.thuringiensis toxin gene into plants.Such plants are resistant to attack by insect pests. **Eg:Bt-Cotton**

  Eg: (3)-Trichoderma (Free living fungi present in the root ecosystem) used in the treatment of plant diseases

05. Microbes as Biofertilisers

- ✓ The thoughtless use of chemical fertilizers has contributed much to the environment pollution. The realization of this problem problem compelled us to switch to the **Organic farming –to use of Biofertilisers.**
- ✓ **Biofertilisers are organism that enriches the nutrient quality of the soil. The main sources of Biofertilisers are Bacteria, Fungi and Cyanobacteria.**
- ✓ Eg: (1)-The roots of Leguminous plants contains **Rhizobium**, it fix atmospheric nitrogen into organic forms which is used by the plant as nutrient
- ✓ Eg: (2)-**Azospirillum and azobacter** (Both are free living bacteria in the soil) are able to fix atmospheric Nitrogen. Thus enriching the nitrogen content of the soil
- ✓ Eg: (3)- Fungi are also known to form symbiotic associations with plants (mycorrhiza). Many member so of the genus **Glomus** forms Mycorrhiza. The fungal symbiont helps the plant **to**
    - ❖ **Absorb phosphrous** from the soil.
    - ❖ This association also resist to **root borne pathogens**,
    - ❖ **Tolerance to salinity and drought**.

- ❖ This association also **accelerate the growth and development** of the plant

✓ Eg:(4)-**Cyanobacteria (Eg;Anabaena, Nostoc, Oscilaatoria**) are **autotrophic microbes** widely distributed in aquatic and terrestrial environments. Many of which can **fix atmospheric nitrogen**. In paddy fields, **cyanobacteria serve as biofertiliser**. Blue green algae also add organic matter to the soil and increase its fertility.

Difference between Biofertiliser and Chemical fertilizer

Biofertilisers	**Chemical fertilizers**
They are microbes	They are chemicals
They do not cause pollution	They cause pollution
They are cheap	They are costlier
They improve soil structure and Functions	They destroy soil structure and function

08
Biodiversity And Conservation

Introduction

- Biodiversity is the term popularized by the sociobiologist **Edward Wilson** to describe the combined diversity at all the levels of biological organization
- **Biodiversity can be described as the sum total of genes, species and ecosystem of a region.** The most important of them are

(i) ***Genetic diversity***

- A single species might show high diversity at the genetic level over its distributional range
  Eg: The genetic variation shown by the medicinal plant ***Rauwolfia vomitoria*** growing in different Himalayan ranges might be in terms of the potency and concentration of the active chemical (**reserpine**) that the plant produces.
- India has more than **50,000** genetically different strains of **rice**, and **1,000 varieties of mango.**

(ii) ***Species diversity:***

- The diversity at the species level is called species diversity
- Eg: the Western Ghats have greater amphibian species diversity than the Eastern Ghats.

(iii) ***Ecological diversity:***

- The diversity at the ecosystem level is called ecological diversity.
- Eg: India has variety of ecosystem like deserts, rain forests, mangroves, coral reefs, wetlands, estuaries, and alpine meadows has a greater ecosystem diversity than a Scandinavian country like Norway.

Patterns of Biodiversity

(i) ***Latitudinal gradients:***

- The diversity of plants and animals is not uniform throughout the world.
- In general, species diversity decreases as we move **away from** the equator towards the poles.
- **With very few exceptions, tropics** (latitudinal range of 23.5° N to 23.5° S) harbour **more species than temperate or polar areas.**
- Colombia located near the equator has nearly 1,400 species of birds while New York at 41° N has 105 species and Greenland at 71° N only 56 species. India, with much of its land area in the tropical latitudes, has more than 1,200 species of birds.
- A forest in a tropical region like Equador has up to 10 times as many species of vascular plants as a forest of equal area in a temperate region like the Midwest of the USA.
- The largely tropical Amazonian rain forest in South **America has the greatest biodiversity on earth**- it is home to more than 40,000 species of plants, 3,000 of fishes, 1,300 of birds, 427 of mammals, 427 of amphibians, 378 of reptiles and of more than 1,25,000 invertebrates. Scientists estimate that in these rain forests there might be at least **two million insect species waiting to be discovered and named** !!!!

Reason for the great diversity in the tropical regions

Ecologists and evolutionary biologists have proposed various hypotheses; ; some important ones are

(1) Speciation is generally a function of time, unlike temperate regions subjected to frequent glaciations in the past, tropical latitudes have remained relatively **undisturbed for millions of years and thus, had a long time for species diversification.**

(2) Tropical environments, unlike temperate ones, are **less seasonal, relatively more constant and predictable**. Such constant environments promote niche specialisation and lead to a greater species diversity.

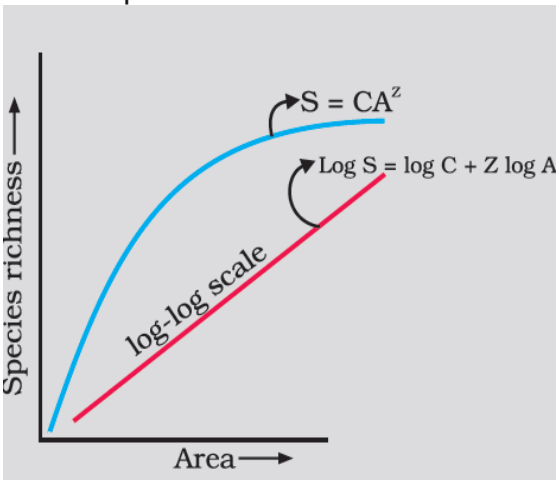
(3) **There is more solar energy available in the tropics, which contributes to higher productivity**; this in turn might contribute indirectly to greater diversity.

(ii) Species-Area relationships:

- During his pioneering and extensive explorations in the wilderness of South American jungles, the **great German naturalist and geographer Alexander von Humboldt** observed that within a region species richness

increased with increasing explored area, but only up to a limit.

- The relationship between species richness and area for a wide variety of taxa (angiosperm plants, birds, bats, freshwater fishes) turns out to be a **rectangular hyperbola.** On a logarithmic scale, the relationship is a **straight line** described by the equation



log S = log C + Z log A
where
S= Species richness A= Area
Z = slope of the line (regression coefficient)
C = Y-intercept

- Ecologists have discovered that the value of Z lies in the range of **0.1 to 0.2,** regardless of the taxonomic group or the region (whether it is the plants in Britain, birds in California or molluscs in New York state, the slopes of the regression line are amazingly similar)
- The species-area relationships among very large areas like the entire continents, you will find that the slope of the line to be much steeper **(Z values in the range of 0.6 to 1.2).**
- For example, for frugivorous (fruit-eating) birds and mammals in the tropical forests of different continents, the slope is found to be **1.15**

Causes of biodiversity losses:

The accelerated rates of species extinctions that the world is facing now are largely due to human activities. There are four major causes **(' The Evil Quartet' is the sobriquet used to describe them**).

(i) Habitat loss and fragmentation:

- This is the most important cause driving animals and plants to extinction. The most dramatic examples of habitat loss come from **tropical rain forests**. Once covering more than **14 % of the earth's land surface**, these rain forests now cover **not more than 6 %**. They are being destroyed fast. By the time you finish reading this Printout of zoology, **100 more hectares of rain forest** would have been lost.
- **The Amazon rain forest (it is so huge that it is called the 'lungs of the planet')** harbouring probably millions of species is being cut and cleared for cultivating ***soya beans*** or for conversion to grasslands for raising beef cattle.
- Besides total loss, the degradation of many habitats by pollution also threatens the survival of many species.
- When large habitats are broken up into small fragments due to various human activities, mammals and birds requiring large territories and certain animals with migratory habits are badly affected, leading to population declines.

(ii) Over-exploitation:

- Humans have always depended on nature for food and shelter, but when 'need' turns to 'greed' it leads to **over-exploitation of natural resources**.
- Eg: Many species extinctions in the last 500 years **(Steller's sea cow, passenger pigeo**n) were due to overexploitation by humans.

iii)Alien species invasions:

- When alien species are introduced unintentionally or deliberately for whatever purpose, some of them turn invasive, and cause decline or extinction of indigenous species.
- Eg 1: **The Nile perch introduced into Lake Victoria in east Africa** led eventually to the extinction of an ecologically unique assemblage of more than 200 species of **cichlid fish in the lake.**
- **Eg 2:** The environmental damage caused and threat posed to our native species by invasive weed species like **carrot grass (*Parthenium*), *Lantana* and water hyacinth (*Eicchornia*)**.

- *Eg 3:* The recent **illegal introduction of the African catfish *Clarias gariepinus*** for aquaculture purposes is posing a threat to the indigenous catfishes in our rivers.

iv)Co-extinctions:

- **When a species becomes extinct, the plant and animal species associated with it in an obligatory way also become extinct**.
- Eg 1: When a host fish species becomes extinct, its unique assemblage of parasites also meets the same fate.
- Eg 2: a coevolved plant-pollinator mutualism where extinction of one invariably leads to the extinction of the other.

How do we conserve Biodiversity?

Conservation of biodiversity can be done by two ways

a)In-situ conservation

b)Ex-situ conservation

a)In-situ (On site) conservation

- The conservation of genetic resources through their maintenance within natural or even human-made ecosystem in which they occur is called In-situ conservation.
- **Eg: National park, Sanctuaries, Biosphere reserves, Natural monuments, Hot spots, sacred grooves, cultural landscapes**
- India has **14 biosphere reserves**, **90 national parks** and **448 wildlife sanctuaries.**
- **sacred groves** are found in **Khasi and Jaintia Hills in Meghalaya, Aravalli Hills of Rajasthan, Western Ghat regions of Karnataka and Maharashtra and the Sarguja, Chanda and Bastar areas of Madhya Pradesh**. In Meghalaya, the sacred groves are the last refuges for a large number of rare and threatened plants

Hotspots:

Scientists identified certain regions with very high level of species richness and high degree of **Endemism (species that is confined to that region and not found anywhere else)** to protect biodiversity.Hot spots are the richest and most threatened reservoirs of plants and animal life on earth.

- Initially 25 biodiversity hotspots were identified but subsequently nine more have been added to the list, bringing the total number of **biodiversity hotspots in the world to 34**. **These hotspots are also regions of accelerated habitat** loss.
- Three of these hotspots – **Western Ghats and Sri Lanka, Indo-Burma and Himalaya – cover our country's exceptionally high biodiversity regions.**
- Although all the biodiversity hotspots put together cover less than **2% of the earth's land area**, the number of species they collectively harbour is extremely high and strict protection of these hotspots could reduce the **ongoing mass extinctions by almost 30 per cent.**

(b) Ex situ (off site) Conservation

- Conservation outside their habitat is called ex-situ conservation.
- In this approach, threatened animals and plants are taken out from their natural habitat and placed in special setting where they can be protected and given special care.

Eg : Cryoprservation, Zoological parks, botanical gardens and wildlife safari parks

Cryopreservation

Storage of materials (Like seeds, gametes) at very low temperature is called cryopreservation.

Gametes of threatened species can be preserved in viable and fertile condition for long periods using cryopreservation techniques.

Biodiversity knows no political boundaries and its conservation is therefore a collective responsibility of all nations.

- ✓ **The historic Convention on Biological Diversity ('The Earth Summit') held in Rio de Janeiro in 1992,** called upon all nations to take appropriate measures **for conservation of biodiversity and sustainable utilisation of its benefits**.
- ✓ In a follow-up, the **World Summit on Sustainable Development held in 2002 in Johannesburg, South Africa, 190 countries pledged their commitment to achieve by 2010, a significant reduction in the current rate of biodiversity loss at global, regional and local levels**.

ALL THE BEST

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